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CAPITAL-LABOR RATIOS IN SHORT-TERM VOLUNTARY HOSPITALS: AN EMPIRICAL STUDY OF 38 VOLUNTARY HOSPITALS IN NEW YORK CITY

BY

PAUL N. WORTHINGTON

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Date — Chairman of Examining Committee

Nov 1, 1971 — Date — Executive Officer

Professor Elliot Zupnick

Professor Bernard Okun

Professor Ralph Nelson

Supervisory Committee

The City University of New York

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CHAPTER I

INTRODUCTION AND BACKGROUND

1.

Since 1930 information has been available suggesting that the hospital industry is one of the major users of capital in the U.S. economy. In his pioneering study of that date C. Rufus Rorem estimated that the 7,000 hospitals comprising the industry were the fifth largest users of capital with a total investment stock of more than $3 billion.[1] Moreover, as data cited by Rorem (42; ch. XI), and as data currently available in the "Guide Issue" of Hospitals suggest, the historical capital intensification which characterizes much of the U.S. economy is also a feature of the hospital industry (2; p. 439).

In 1950 there were 6,788 hospitals registered with the American Hospital Association. Total reported assets were $7.8 billion. In 1965, the number of registered hospitals was 7,123, an increase of 5 percent; but total assets were valued at $24 billion - an increase of 200 percent. Lack of uniformity in reporting and the effects of changing prices in construction and hospital equipment make it difficult to state the extent to which this increase reflects a real expansion of capital. However the magnitudes are striking in view of the fact that this reported expansion was accompanied by a comparatively small (17 percent) expansion of bed capacity.

Despite the social sacrifice incurred by the allocation of this capital, very little is known about the forces that have directed it to

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[1]Rorem based this statement on data reported by the Bureau of Census in 1920. According to this source the only industries using more than $3 billion in 1919, were iron and steel, textiles, chemicals and allied products, and food and kindred products (42; p. 5).

the industry, or about how the capital is used by the hospitals which control its employment. As a consequence, public and private efforts to achieve an allocation of resources in the hospital sector that will efficiently provide for social goals, as they relate to the delivery of hospital services, are inhibited and plagued with uncertainty. On the one hand there is broad concern that not enough capital is being allocated to hospitals. The Federal Hospital Survey and Construction Act (Hill-Burton), enacted originally in 1946, and expanded by subsequent amendments, is a program of direct capital subsidies that expresses this concern. On the other hand there is an aggravating, equally urgent concern that hospitals do not use capital efficiently. Accordingly, significant amounts of the social cost of having directed capital into the industry are believed to be wasted in the form of under or over-utilized facilities, the duplication of sophisticated equipment, and, generally, too little attention directed towards raising the productivity of resources employed in the hospital.

This dissertation is an attempt to answer leading questions about this latter concern, foremost of which is the question of whether or not hospitals are guided by relative scarcity in deciding how to use the capital at their command.

There are several reasons for the primacy of this question, but the most important is that unless relative scarcity guides the use of capital there is no obvious way of determining how much or how little capital must be allocated to the industry in order to achieve a given supply capacity for the delivery of hospital services.[2] These remarks apply with equal

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2This point will be elaborated in Chapter III. It will be shown that where hospitals are guided by allocative principles, relative scarcity (of labor with respect to capital) will influence the proportion in which capital and labor are used in such a way that production will tend to be force to other questions related to this issue. For example, optimum scale in terms of bed-size cannot be determined on economic grounds if the use of capital is not guided by scarcity principles.

As will be elaborated in Chapter III, hospitals that are guided by relative scarcity will tend to use capital and labor in least costly combinations. This means, under normal assumptions and with other things equal, the higher the relative wage of labor the more capital, relative to labor will hospitals tend to use. The empirical problem that is posed, consequently, is one of measuring that substitution of capital for labor attributable to variations in the relative hospital wage.

Among a number of hospitals with differences in their patterns of services, their involvement in teaching, and management characteristics, a variety of additional factors are likely to be influential in determining the gross substitution of capital for labor. However, important as these may be, especially where their values are sensitive to planning or regulatory efforts, the first concern of the analysis is the extent to which substitution is induced by variation in the relative wage of labor. Operationally such a measurement not only provides evidence on what may be anticipated as regards the relative importance of the social cost of capital services in total hospital costs, but also evaluates an important factor influencing the demand for capital.[3]

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[2](Cont'd)
cost minimal. It will also be shown, that if this result is not approximated either deliberately or indirectly through some motivation with equivalent effect, the amount of capital to be used in combination with labor, for a particular level of output, cannot be determined.

[3]A more conventional approach in studies of capital, is to analyze investment demand. Since the acquisition of physical capital necessarily involves durable sources of capital services, the future is brought immediately into the analysis. In the profit maximizing model, the firm's objective is to obtain and maintain a profit maximizing stock of capital. In this approach capital is a fund concept which returns a certain yield, and which is to be adjusted when the appropriate opportunity cost

Secondarily, because of the traditional empirical interest in the connection between hospital cost performance and various operating characteristics (such as bed occupancy rates, average length of stay, the complexity of patient services, the production of medical education, and the bed size of hospitals), the analysis is also concerned with how these factors influence substitution. Also, because of the special role typically reserved for bed size (as a measure of scale or of capacity of services), the analysis is concerned with the relation between capital and beds.

2.

As a topic for empirical research the question of how hospital capital is used has been slow to surface. Literature in the field indicates that among the issues traditionally receiving attention under the general heading of capital policy (for voluntary non-profit hospitals in particular), those related to aggregate amounts of capital, or the availability of funds for capital expenditures, are those most publicized (1, 18, 51). Clearly these are relevant and critical questions in an industry where the bulk of capital funds have been and are currently being supplied by private philanthropic and tax sources (42, p. 214; 45, pp. 10-11; 51, p. 2; 16, p. 83; 26, p. 29). In recent years, however, particularly as government has enlarged its efforts to expand and perfect the supply of hospital services, questions related to the inefficient use of capital have come to be scrutinized with increased interest - because of a greater

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[3](Cont'd)
(interest rate) diverges from this yield. The adjustment of this fund is the process to be analyzed.

In this study the demand for capital refers, at least theoretically, to the demand for the physical flow of capital services which enters into the production of hospital services in cooperation with the physical flow of labor services. Assuming flows are proportional to stocks, the reference to the demand for capital is then a reference to the demand for physical capital stock.

awareness of the consequences for productivity and costs, and because there are doubts that hospitals tend to economize in their use of capital. The uncertainties not only inhibit the expansionary efforts of government, but also complicate and raise the cost of implementing programs.

In the implementation of Hill-Burton, for example, safeguards against the inefficient use of capital are provided in an administrative structure which through mandated state planning bodies not only estimates global capital requirements, but through detailed architectural and financial reviews also passes on the technical validity and economic soundness of each proposed capital project. The capacity of Hill-Burton to influence and improve the allocation of resources in the hospital industry is, however, modest. A major limitation, for example, is the fact that the program deals only with institutions who voluntarily apply for funds. And its regulatory power consists only in disallowing a grant (or restricting its contributory share). A second limitation is the fact that the actual expansion of plant assets in U.S. hospitals is several times the amounts obligated under the program. During the period 1960-1965, for example, the expansion of plant assets was 5 times the amount obligated under Hill-Burton - approximately $5.6 billion as compared to $1 billion (41, p. 51; 50, p. 70).[4]

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[4]The difference is even greater because plant assets are net of depreciation charges and because Hill-Burton funds are allocated to other types of facilities, as well as hospitals. However, Hill-Burton is not the only Federally sponsored program for making capital funds available to hospitals. Funds are also provided as awards for health research facilities, and as obligations to teaching hospitals under the Health Professions Educational Assistance Act. Loans are also provided under the Public Facility Loan Program of the Department of Housing and Urban Development. For a review of the amounts obligated under these and other programs see (50) and (32).

In New York State an effort has been made to close the regulatory loophole. Under the Folsom Act (35) all capital projects, regardless of how funded, are subject to approval, based on estimates of community facility requirements and a detailed architectural and financial review. The examination and evaluation of designs, construction cost, and financial viability exemplify the complications, the expense of time, and the further allocation of scarce resources that are believed to be necessary safeguards against the inefficient use of capital.

In the area of hospital costs, doubts about the efficiency with which hospitals use capital are also pinpointed as the basis for concern. The admirable summary in Somers and Somers (44, pp. 177-185) of the testimony and establishment of depreciation allowances and "plus" factors in determining reimbursement rates under the Federal Medicare program illustrates both the dilemma and concern. Under the program reimbursable costs were to be qualified as necessary and reasonable. Applied to capital, the object was to provide systematically for the cost of using the services of existing capital. Somers and Somers conclude, however, that depreciation allowances or plus factors were regarded by hospitals as an opportunity for securing additional revenues. That is, while the government expressed the intent of recognizing the cost of capital services, it also reflected a concern for the efficient use of capital by insisting that such costs be necessary and reasonable. Hospitals, taking a more traditional view of this effort to further subsidize the industry, saw capital cost allowances as a means for subsidizing future capital acquisitions. The paradox is that government policies in general are favorably inclined to further subsidize capital acquisitions by hospitals; implementation of this objective through subsidization of demand is inhibited by the equally urgent concern that hospital capital be employed efficiently.

What are the bases for the doubts and uncertainties about how hospitals use capital? First, despite its relative national importance, the hospital industry is not organized like other industries of comparable size. Short-term hospital care in particular is provided by individual hospitals which for the most part are operated privately as voluntary (non-profit) enterprises.[5] As regards capital there are two important characteristics that distinguish these enterprises: (1) the capital invested in them is the property of neither government nor individuals; (2) private philanthropy and taxes have traditionally provided the funds by which the capital is acquired. The results are that no explicit conditions exist requiring capital to earn a rate of return. There are no investors to whom dividends must be paid.

These circumstances, in conjunction with the condition that profits are not to be used to justify a course of action, undermine the a priori grounds for expecting hospitals to economize in their use of capital.[6]

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[5]In 1965, hospitals registered with the American Hospital Association reported plant assets as follows (2, p. 442):

	Hospitals		Plant Assets ($ Billion)	
	Total	Short-Term	Total	Short-Term
TOTAL	7,123	6,113	$20.0	$14.1
Government	2,484	1,830	10.1	4.7
Voluntary	3,670	3,426	9.5	9.1
Proprietary*	969	857	.4	.3

*Operated for profit.

[6]In conventional theory, how resources are used is a predictable consequence of the profit maximizing assumption. The problem is one of choosing resource proportions that are economically efficient - that is, proportions which will result in minimum production costs for a given output.
For governmental or non-profit enterprices the acceptability of the profit maximizing model is questionable, thus depriving investigators of the customary a priori basis for predicting how resources will be combined. Doubt has been expressed that there are any uniformities in this

Second, the experience of generally rising hospital costs, especially in recent years, has been the occasion for critical appraisals of how hospitals function. From these appraisals a number of serious allegations of an empirical nature (such as those alluded to previously - poor utilization, the unnecessary duplication of sophisticated equipment and special facilities, failure to increase productivity) have been made which suggest that hospitals do not in fact economize in their use of capital (48, p. 29; 46, pp. 55-56; 43, pp. 107-110). These tendencies, particularly those alleging unnecessary duplication of facilities and equipment, have been rationalized as a prestige bias (34; p. 70), and as a competitive device to attract medical staff (39; p. 479).[7]

To summarize, both theoretical considerations and empirical examples suggest hospitals do not or will not tend to economize in their use of capital. Moreover, the tacit acceptance of this conclusion underlies much of the public machinery designed to promote and perfect the supply of hospital services. At no point is it suggested that there can be a truncation of the system of safeguards and controls.

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[6](Cont'd)
respect, as regards voluntary hospitals. Millard Long, in addressing this question (29; pp. 212-213), points out that capital funds, once acquired, impose no further financial obligation on voluntary hospitals. He concludes, "there are no economic pressures which force them to make efficient use of capital."

[7]This latter point derives from another major characteristic of voluntary hospitals which is a further distinction of the hospital industry. Physician services are typically provided by attending doctors who with private arrangements with the hospital admit their own patients to the hospital and, although they are neither employees of the hospital nor are they responsible for its management as an economic enterprise, direct and control the physical resources of the hospital in the interest of their patients. However, regardless of the motivation ascribed to such physicians (say, profit maximization) there is no reason why alleged inefficiencies resulting from these arrangements should be biased towards the use of hospital capital. It has in fact been suggested that the physician may regard all hospital resources - capital and labor - as a form of capital with which he coordinates his own services (36, p.240).

The results are that the resources to be committed to safeguards and controls cannot be determined. Furthermore there is no logical basis for determining the demand for capital.

3.

In the ensuing chapters of this dissertation the substitution of capital for labor (which is the empirical core of the uncertainties surrounding the use of capital by hospitals) and the relation between capital and hospital beds are the subject for analysis. In Chapter II aggregate hospital data from published sources are used to describe substitution among geographical regions and over time. Data especially documented for a sample of New York City hospitals are also introduced for further description of substitution among hospitals. This evidence clearly establishes substitution as a fact of life in hospitals, a point which it seems necessary to establish since for empirical convenience or for research purposes it has been neglected. In Chapter III the economic theory of efficient use of resources is described and applied to the case of hospitals. Models are used to develop a framework for measuring the substitution of capital for labor. In Chapter IV substitution among 38 short-term voluntary hospitals in New York City, as observed for 6 successive years, is analyzed, using multiple regression techniques. Specific hypotheses relating capital-labor ratios to the relative hospital wage, complexity of patient care, the relative importance of outpatient services, bed size, activity rates (average length of stay and occupancy rates), the presence of teaching as a component of hospital production, and other characteristics are stated and subjected to analysis. The interest in the technical characteristics just cited flows not merely from the expectations that they will modify production relations among hospitals and, thus, must be taken into account in measuring substitution, but from the fact that such factors have also played important roles in empirical studies of hospital costs and because some of them (particularly average length of stay and occupancy rates) have been singled out as possible characteristics amenable to manipulation for the purpose of improving efficiency or saving on capital (12, p. 61; 5, p. 26; 28, p. 63). The chapter concludes with an interpretation of the statistical results. Chapter V, the conclusion, contains a summation of the research and concluding remarks.

CHAPTER II

TRENDS AND HOSPITAL DIFFERENCES IN REPORTED ASSETS PER EMPLOYEE AND ASSETS PER BED FOR U.S. SHORT-TERM GENERAL HOSPITALS

1.

An important feature of published data on the assets controlled by U.S. hospitals is the variable behavior of capital per employee and capital per bed implied by relative movements and cross-sectional differences in total assets, plant assets, beds, and employees. These data are to be found in Hospitals, "Guide Issue," published annually by the American Hospital Association; and they may be combined alternatively as assets per bed or per employee to provide empirical descriptions of the manner in which capital is used by the hospitals which are included in the data. They are, apart from their quality, crude shadows of corresponding theoretical concepts. For example, capital intensity, measured as assets per employee, is a ratio of stocks. This is different from theoretical capital intensity which is measured as the ratio of the flow of capital services to the flow of labor services. Assets per bed is a descriptive measure of how capital is employed with no precise analytical counterpart.[1] However, there are reasons why capital per bed is interesting. Data on hospital beds are available in published form on a widespread basis. They

[1]At best, the number of beds expresses a nominal capacity in that it expresses the number of inpatients that conceivably could occupy the hospital at a point in time. But it sheds little light on the number of inpatients that could be undergoing treatment, the amount of teaching or research activities that can be undertaken, or the flow of ambulatory patient care that can be provided. As is commonly the case in the hospital field, however, criticisms of such variables which are used repeatedly in empirical work have ancient origins. Rorem, writing in 1930 (42, p. 11), criticized the use of beds as a measure of the extent of a hospital's facilities. He emphasized such factors as ambulatory care apparatus, dormitories and class rooms for nurses, and living quarters for residents. In 1962, Dr. A. Querido of the University of Amsterdam (37, p. 33) noted that, within hospitals, working space was increasing

are an element common to all hospitals; and their number is used repeatedly in empirical work as a measure of size or scale. As a consequence, both analytic results and policy recommendations tend to be expressed in terms of beds. Thus, as an empirical matter, it seems highly desirable that the relationship between beds and capital be clarified.

That capital per employee or per bed varies between classes of hospitals (between short-term acute care and long-term chronic or convalescent care hospitals for example) and through time is not generally in dispute. However, the proposition that capital per employee or per bed within classes of hospitals behave systematically has occasioned little comment, and it has not been explored. It seems worthwhile stressing this point because a conventional approach in hospital literature (where some proposition regarding the use of capital must be maintained) has been to proceed as if there is very little variance in capital per employee or per bed for hospitals of similar types, or, the variations which do exist reflect random conditions unrelated to the functions or control of the hospital. It is a common practice, for example, to assume an invariant capital per bed based on an "average" construction or replacement cost per bed in instances where pecuniary estimates of capital funding or capital savings are a part of the results (23, p. 272; 51, Table 2; 18, p. 43; 29, p. 224). The possibility of variations in capital per bed or of capital-labor substitution is also commonly set aside in statistical studies of

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[1](Cont'd)
rapidly relative to bed space. He wrote, "This phenomenon renders it doubtful whether the bed is still to be considered the central element in the hospital." It has also been noted that using the crude number of admissions or patient days does not avoid this criticism. Counting hospital output in this manner, as observed by the late Professor Rice (40, p. 89), is like measuring wheat by adding up containers of wheat when the containers are of different sizes, are not filled to same level, and are not filled with the same grade of wheat.

hospital costs. For example, Carr and Feldstein (8) in studying the cost-size relationship in U.S. non-profit, short-term hospitals, adjust total cost by eliminating differences among hospitals in the annual wage rate paid. The effect of the adjustment (multiplying the grand mean wage by number of employees) is to make the variance of the most important cost component proportional to the variance in "labor." The possibility that capital-"labor" substitution might account for some of the observed variance in their adjusted total cost is not explored. In his study of British hospitals, Martin Feldstein assumes capital per bed is invariant. This is implied, for example, where he writes, "...higher levels of capacity utilization, i.e., higher case-bed ratios, reduce the capital cost per case," (12, p. 61) and by his use of beds as a measure of scale. In his analysis of the production function, it is assumed explicitly that capital input is measured by the number of beds (12, p. 92). Finally, while capital-labor substitution has been mentioned in the literature as a factor influencing investment demand in hospitals (6, p. 45), it has played no role to date in the analysis of hospital capital expenditures.

In the following sections of this chapter, the empirical basis for these views is studied by examining two bodies of data related to groups of hospitals. The results, which are only suggestive, pending a more detailed analysis in Chapters III and IV, indicate there is substitution of capital for labor which cannot be attributed to chance.

2.

In its annual "Guide Issue" of Hospitals, the American Hospital Association published information on total assets and plant assets for its member hospitals. These data, along with reported beds, number of employees, and payroll expense, are reported in aggregate for hospitals grouped in various ways - type of service, control, bed size, and by geographic region.

The data on assets are reported as total assets and as plant assets. The former include the working capital of the hospital - cash, account receivable, deferred expenses, prepaid items, and inventories - other assets not directly involved in conducting business - such as legacies or contributions held as cash or securities, and real property - and, finally, plant assets. Plant assets include net book value of building and equipment in use, assets under construction, land, and (frequently) financial reserves earmarked for capital purposes.

Clearly the information contained in these data is subject to a multitude of errors. Those common to all accounting data are germain - i.e., the reporting of asset values at historical costs (which reflect prices in the time and place of purchase), the arbitrary evaluation of receivables and inventories, and assignment of depreciation. In addition, the extent to which hospitals report assets according to either legal or conventional market principles is uncertain. Accounting practices with regard to inventories and depreciable assets vary widely.

These inaccuracies in details impair the usefulness of these data for research purposes, especially in those cases where specific interpretation and precision of statistical results are desired. However, with appropriate caution, these data can be used to explore in gross terms the underlying tendencies in capital intensity.

Since it is the substitution of capital for labor and the behavior of capital per bed that is of interest, the data reported below are presented on a per employee and a per bed basis.[2] In Tables 1 and 2, total

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[2]Beds are the reported bed capacity of the reporting hospitals. Employees, since 1954, have included full-time equivalents for part-time employees, and have excluded interns and residents since 1951.

Table 1

Total Assets per Employee for U.S. Hospitals Registered With the American Hospital Association 1951-1965

				Non-Federal Short-term General			
Year	All Registered Hospitals	Total Federal	Federal Short-term	Total	State and Local Government	Voluntary non-Profit	Proprietary
1965	$12,552	$12,824	$12,812	$11,807	$11,352	$12,340	$5,914
1964	12,334	12,979	12,765	11,169	10,039	11,874	6,164
1963	11,581	11,893	11,172	10,690	9,625	11,408	5,359
1962	11,333	11,314	10,688	10,441	9,630	11,035	5,053
1961	11,249	11,312	10,586	10,255	9,764	10,717	5,216
1960	11,085	11,419	11,008	10,054	9,100	10,634	5,063
1959	10,975	11,816	10,932	9,849	9,344	10,299	4,913
1958	10,560	11,149	10,937	9,572	9,041	10,029	4,867
1957	10,377	10,430	a	9,509	9,847	9,566	4,651
1956	9,480	9,611	a	8,582	8,187	8,984	4,220
1955	9,213	8,667	a	8,456	8,585	8,749	3,610
1954	8,684	9,256	a	7,950	7,828	8,290	3,625
1953	8,690	7,722	a	7,982	7,836	8,362	3,625
1952	8,416	7,437	a	7,623	7,315	8,027	3,769
1951	7,633	7,305	a	6,972	6,288	7,457	3,711

Source: Hospitals, J.A.M.A., "Guide Issue," Part 2, American Hospital Association, Annually, August, 1952-1966.

a. Not separately reported.

Table 2

Total Assets per Bed for U.S. Hospitals Registered With the American Hospital Association 1951-1965

Year	All Registered Hospitals	Total Federal	Federal Short-term	Non-Federal Short-term General: Total	State and Local Government	Voluntary Non-Profit	Proprietary
1965	$14,379	$14,667	$18,316	$22,084	$19,408	$24,225	$8,809
1964	13,723	14,314	17,476	20,649	17,341	22,892	8,978
1963	12,520	13,920	16,875	19,557	16,673	21,619	7,795
1962	11,829	13,157	15,157	15,866	18,614	16,109	7,200
1961	11,425	12,837	15,600	17,880	15,852	19,539	7,000
1960	10,684	12,000	14,448	16,992	14,058	18,883	6,568
1959	10,342	11,816	13,948	16,377	14,046	18,030	6,278
1958	9,841	11,149	13,462	15,441	13,200	17,031	6,083
1957	9,325	10,601	a	14,798	13,692	15,789	5,556
1956	8,106	10,342	a	12,858	11,179	14,175	4,676
1955	7,473	9,093	a	12,298	11,366	13,427	4,000
1954	6,857	9,550	a	11,170	9,518	12,458	4,028
1953	6,426	7,532	a	10,511	9,029	11,783	3,718
1952	6,026	7,192	a	9,676	8,074	10,027	3,868
1951	5,392	6,693	a	8,756	6,955	10,029	3,615

Source: Hospitals, J.A.M.A., "Guide Issue," Part 2, American Hospital Association, Annually, August, 1952-1966.

a. Not separately reported.

assets per employee and per bed (respectively) are shown for the years 1951-1965, by all registered hospitals, by total Federal, Federal short-term, by non-Federal short-term general service, and by state and local government, non-profit, and proprietary (for profit) control within this service class.

The most striking sources of variation indicated in these data are the differences over time, the differences between proprietary and other hospitals within the short-term general class, and, in the case of assets per bed, differences between short-term general and other hospitals.

Over the 15 years, 1951-1965, assets per employee increased more than 64 percent for all hospitals.[3] This increase is slightly less than

[3]These data incorporate variations in the distribution of hospitals covered as well as variations in the extent to which assets are reported. Little can be said about these latter variations, although with the changes that have taken place in office procedures and equipment, and the incorporation of depreciation charges into operating statements, it may be anticipated that the reporting of assets has become more systematic. Whether or not this has resulted in net increases or decreases is conjectural. More, however, can be said about the coverage of hospitals. The percentage distribution of hospitals in 1951 and 1965 was as follows:

	1965	1951
All registered hospitals	100%	100%
Non-Federal short-term	80.5	74.1
State and Local government	20.4	14.5
Voluntary	48.1	42.8
Proprietary	12.0	16.9

These data show an increase in the relative importance of non-Federal short-term hospitals, which, as the text tables indicate, would increase capital per employee and per bed in all hospitals, because short-term hospitals are relatively more capital intensive. They also show that within the short-term class, the number of state and local government and voluntary hospitals have increased relatively more than have the number of proprietary hospitals (in fact, the number of short-term proprietary hospitals declined by 298 hospitals). This also would increase the capital per employee and per bed of all hospitals, since proprietary hospitals are the least capital intensive.

the increase for all Federal hospitals (75 percent) and for non-Federal short-term hospitals (69 percent). Within the non-Federal, short-term class, the increase in assets per employee was greatest in state and local government hospitals (80 percent). It is not possible to give an equivalent comparison with Federal short-term hospitals since the revelant data for Federal hospitals were not reported prior to 1958. For these years, 1958 to 1965, assets per employee increased by 25 percent in state and local government short-term hospitals as compared with 17 percent in Federal short-term hospitals. However, during the two years, 1964-1965, where substantial amounts of the recent increases in capital intensity are reported, this distinction has tended to diminish. For these two years assets per employee increased by 14 percent in Federal short-term hospitals, as compared with 18 percent in state and local government hospitals.

In non-governmental short-term hospitals, the proportional increases for the years 1951-1965 were similar to that for all hospitals, with little difference being reported between voluntary and proprietary hospitals (65 percent, as compared with 59 percent).

Assets per bed, in all cases, have increased more rapidly than have assets per employee. For all registered hospitals the increase was 166 percent), as was also the case for non-Federal short-term hospitals (152 percent). Within the non-Federal short-term class, the increase in assets per bed (as in the case of assets per employee) was greatest for state and local governments (179 percent). A comparison with Federal short-term hospitals for the period 1958-1965, shows the increase in state and local government hospitals also tends to be greater than the increase in Federal short-term hospitals (147 percent, as compared with

136 percent).

In non-governmental short-term hospitals, the proportional increases of assets per bed were slightly less than for all hospitals, but with practically no differences reported as between voluntary and proprietary hospitals (141 percent as compared with 143 percent).

The most pronounced differences in assets per employee and per bed as between hospitals within the short-term general class are those between voluntary hospitals (where capital per employee and per bed are greatest) and proprietary hospitals (where capital per employee and per bed are the least). It appears, virtually in every year, that assets per employee in voluntary hospitals are twice the amount as assets per employee in proprietary hospitals. The difference, in terms of assets per bed, is even greater - with assets per bed in voluntary hospitals ranging from 2.5 to 5 times as much as assets per bed in proprietary hospitals.

As stated earlier, that differences in capital per employee and per bed exist between classes of hospitals is not disputed. This applies also to differences between voluntary and proprietary control. In 1928, Rorem estimated that while voluntary hospitals controlled 27.8 percent of the hospital beds in U.S. hospitals, and 45.5 percent of the invested capital, proprietary hospitals controlled but 8.7 percent of the beds, and 8.6 percent of the capital (42; p. 36). Somers and Somers also comment on this distinction (44, p. 49).

A point which may not be obvious, however, is that differences in assets per employee and per bed persist, even when hospitals in the same size class are compared. Moreover, the difference between classes is not greatly altered if plant assets rather than total assets are used to measure capital.

Assets per employee and per bed in 1965, for voluntary and proprietary short-term hospitals, distributed by bed size, are reported in Table 3. Assets are measured alternatively as total assets and as plant assets in panels a and b respectively. As these data show, assets per bed and per employee in voluntary hospitals tend to be larger than for proprietary hospitals in the same size class by a factor of two or more. (The principal exception is the 25-99 bed class, where these ratios range between 1.76 - total assets per employee - and 1.81 - plant assets per bed.)

There is some indication of a tendency for proportional differences to increase with size class, more so as regards assets per bed, than assets per employee. Both of these tendencies are consistent with the aggregate comparisons for 1965, presented in Tables 1 and 2, since, in general, the proprietary hospitals are smaller than voluntary hospitals.[4]

The measurement of assets as plant assets rather than total assets yields only a minute positive effect on proportional differences, reflecting the fact (in size classes below 200 beds) that voluntary and proprietary hospitals, within size classes, report plant assets and total assets in roughly the same proportions.[5]

While these data are too crude for launching directly into an analysis of why the capital involved is being used as it is, they

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[4]Of the 857 short-term proprietary hospitals reporting, 747 reported bed capacities of less than 100 beds. In the voluntary class, however, one half of the 3,426 reporting hospitals gave bed capacities of 100 or more beds.

[5]In the proprietary hospitals, plant assets as a proportion of total assets declines from .74 to .64 for hospitals with 200 or more beds. This drop occurs for voluntary hospitals only for hospitals with 500 or more beds.

Table 3

Total and Plant Assets per Bed and per Employee in 1965, for Voluntary and Proprietary Short-term General Hospitals, Distributed by Number of Beds.

a. Total Assets

Bed Size Class	Voluntary		Proprietary	
	per Bed	per Employee	per Bed	per Employee
Less than 25	$16,683	$13,098	$ 7,448	$5,444
25 - 49	15,207	11,196	8,525	6,358
50 - 99	19,034	11,953	9,248	5,852
100 - 199	21,263	11,456	9,322	5,917
200 - 299	24,371	11,991	8,047	5,427
300 - 399	24,465	12,583	12,586a/	8,663a/
400 - 499	25,072	11,910	-	-
500 and over	33,233	14,429	-	-

b. Plant Assets

Bed Size Class	Voluntary		Proprietary	
	per Bed	per Employee	per Bed	per Employee
Less than 25	$13,668	$10,731	$ 5,992	$ 4,380
25 - 49	11,722	8,632	6,489	4,840
50 - 99	13,851	8,698	6,668	4,220
100 - 199	16,200	8,728	6,907	4,384
200 - 299	18,032	8,872	5,120	3,453
300 - 399	19,634	9,335	7,292a/	5,019a/
400 - 499	19,110	9,078	-	-
500 and over	21,085	9,154	-	-

Source: Hospitals, J.A.H.A., "Guide Issue," Part 2, American Hospital Association, August 1, 1966, p. 472.

a/The size class for hospitals in this cell is "300 and over." There are only 2 hospitals reported in this class.

suggest rather strongly that bed size is not the principal reason why capital per employee or per bed is greater in voluntary hospitals than in proprietary hospitals.

To provide some refinement of the gross tendencies described above, additional information, disaggregated by four geographical regions was extracted from the "Guide Issue" of <u>Hospitals</u> for various years.[6] These data, showing plant assets per employee and per bed, are reported in Tables 4 and 5. They refer entirely to short-term voluntary hospitals.

As indicated by the data in the tables, assets per employee and per bed within each of the geographic regions have increased significantly over the years 1951-1965, reflecting the general consistency in each region with the national trend. It is difficult, however, to determine by inspection alone the evidence for other sources of variation.

[6]There are 9 geographic regions defined by the American Hospital Association for reporting purposes. The collection of data was limited to 4 of these regions because the collection of the necessary detail was costly, and because 4 regions seemed to be adequate for immediate purposes - i.e., to establish the point that significant regional variations in assets per employee and per bed exist in reported data. The regions selected, and states within regions, are as follows:

Region 1 New England	Region 2 Middle Atlantic	Region 3 South Atlantic	Region 4 Pacific Coast
Maine	New York	Delaware	Washington
New Hampshire	New Jersey	Maryland	Oregon
Vermont	Pennsylvania	District of Columbia	California
Massachussets		Virginia	
Rhode Island		West Virginia	
Connecticut		North Carolina	
		South Carolina	
		Georgia	
		Florida	

Table 4

Plant Assets per Employee as Reported by Short-term Voluntary Hospitals in Four Geographic Regions: 1951-1965.

Year	New England	Middle Atlantic	South Atlantic	Pacific
1965	$8,538	$9,241	$8,565	$9,257
1964	7,746	8,698	8,403	8,696
1963	7,333	8,226	8,274	8,113
1962	7,150	8,142	7,870	7,678
1961	7,194	7,890	7,644	7,315
1960	7,737	7,890	7,678	7,024
1959	8,240	8,127	7,398	6,755
1958	7,187	7,091	6,880	6,186
1957	6,539	7,418	6,455	6,220
1956	6,225	6,496	5,941	5,362
1955	6,043	6,533	5,890	5,167
1954	6,354	5,934	5,773	4,679
1953	6,106	5,914	5,559	4,383
1952	5,772	5,866	5,016	4,109
1951	5,227	5,528	4,057	3,546

Source: Hospitals, J.A.H.A., "Guide Issue," Part 2, American Hospital Association, August 1, Annually for the years, 1951 - 1965.

Table 5

Plant Assets per Bed as Reported by Short-term Voluntary Hospitals in Four Geographic Regions: 1951-1965.

Year	New England	Middle Atlantic	South Atlantic	Pacific
1965	$18,975	$18,586	$16,372	$19,293
1964	16,540	17,274	15,540	18,013
1963	15,610	16,124	15,512	16,596
1962	14,703	15,409	13,929	15,623
1961	14,342	14,743	13,413	14,536
1960	14,711	14,342	13,041	13,915
1959	15,710	14,575	12,154	13,207
1958	13,192	12,658	10,982	11,355
1957	12,126	12,459	9,952	11,337
1956	10,966	10,503	8,701	9,466
1955	10,244	10,244	8,361	8,951
1954	10,346	9,138	7,904	7,845
1953	9,466	8,597	7,217	7,291
1952	8,338	8,284	6,354	6,466
1951	7,435	7,733	5,237	5,605

Source: Hospitals, J.A.H.A., "Guide Issue," Part 2, American Hospital Association, August 1, Annually for the years 1951-1965.

These would include cross-sectional differences between regions, and differences in the extent to which regions participated in the growth over time. These sources of variation, particularly those which are regional (if significant), may reflect capital-labor substitutions which are ignored by assuming capital intensity to be invariant. Although the data are generated by groups of hospitals, they raise the distinct possibility that individual hospitals can, and for reasons to be determined, will substitute capital for labor.

In order to obtain measures of the relative importance and significance of these apparent sources of variation, the data in Tables 4 and 5 are analyzed statistically in a regression analysis framework. However, in view of the uncertainties surrounding the measurement of plant assets[7] the usefulness of the equations estimated is more or less limited to empirical descriptions of the separate effects under discussion, based on the data as reported.

To measure the effects of time and region on plant assets per bed and per employee, linear equations were estimated, allowing for differential time slopes and intercepts for the regions. The use of dummy variables for estimating intercept differentials is widespread in empirical work.[8] Recently, Gujarati has described an extension of the dummy variable technique which permits the simultaneous estimation of slope

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[7]There are also uncertainties in the measurement of "employees" which further cloud the measures of capital intensity. These include the possibilities of regional and time variations in the work-week, vacation time, sick leave, etc., in the uniformity with which part-time employees are reported, and in relative endowments of particular labor skills.

[8]For an illustration of the technique and the advantages of its application, see (20, pp. 221-23).

differentials as well (14).[9] This is accomplished by including an interaction term between the dummy variable which dichotomizes the sample and the measured variable being tested for differential slope effects. The coefficient of this interaction term, depending on its sign, is to be added (subtracted) to the common slope for the variable in question, when writing the equation for the class identified by the dummy variable.[10]

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[9] In general the question is one of establishing the equality between coefficients in two (or more) linear regression equations. The Chow Test which is reproduced in (20; pp. 136-38), is general in nature, in that it tells whether two regressions are different or not; but it does not indicate the source of the difference, if any.

[10] To illustrate the method and the interpretation of coefficients, assume the following relation is believed to apply for a certain problem:

$$1.\quad Y_i = a_1D_1 + a_2D_2 + b_1D_1X_i + b_2D_2X_i$$

$$D_1 = \begin{cases} 1, & i = 1 \ldots m \\ 0, & i = m+1 \ldots n \end{cases}$$

$$D_2 = \begin{cases} 1, & i = m+1 \ldots n \\ 0, & i = 1 \ldots m \end{cases}$$

This relation, for example, could represent a consumption function (Y = consumption and X = income) with shifts in the intercept and the marginal propensity to consume. As a practical matter where computer programs automatically compute an intercept term, the equation can't be estimated. Under the conditions stated $D_1 + D_2 = 1$ for any given i, and thus these two vectors in the data matrix sum to the implied vector of units which yields the computed intercept term. As a result the data matrix is singular (20; pp. 222-223).

Substituting $D_2 = 1-D_1$ for D_2 in (1) results in an equation suitable for estimating purposes.

$$2.\quad Y_i = a_2 + (a_1-a_2)D_1 + b_2X_i + (b_1-b_2)D_1X_i$$

The coefficient of D_1 is an estimate of the difference between a_1 and a_2; and the coefficient for the interaction term, D_1X_i, is an estimate of the difference between b_1 and b_2.

For a further description of this method, and the interpretation of results, see (9).

The following variables were included in the regression analysis:[11]

Plant Assets per Bed
Plant Assets per Employee
Year (1958 = 0)
Region 1: New England
Region 2: Middle Atlantic
Region 3: South Atlantic
Region 1 x year
Region 2 x year
Region 3 x year

The results of the regression analysis are given in Table 6. For reasons expressed above interest in these equations is constrained primarily to the measurement, significance, and relative importance of the separate time and regional effects. Consequently the coefficients are expressed for the variables in standardized form. Standard errors are reported in parenthesis below the coefficients. In each case the coefficient is highly significant.

The interpretation of coefficients is expressed in standard deviation units. Thus, reading from the table for equation 1 (plant assets per bed), an increase of one standard deviation in time results in an increase of 1.1409 standard deviation units in plant assets per bed. Also, the relative importance of a particular variable is determined by direct comparison of coefficients. Thus it is immediately clear that time is by far the more important effect in accounting for the variance in plant assets per bed.

However, the impressions suggested by inspection of the raw data are fully warranted. There are significant regional effects, unaccounted for by time alone. Furthermore, time itself carries significantly

[11]To avoid singularity in the data matrix, the dummy and interaction term for region 4 (Pacific Coast) were omitted.

Table 6

Results of Regression Analysis: Estimation of Time and Regional Effects on Plant Assets per Bed and per Employee, Short-term Voluntary Hospitals in Four Geographic Regions.

	Coefficients (Betas and Standard Errors)	
Independent Variables	Plant Assets per Bed	Plant Assets per Employee
Year	1.1409 (.0389)	1.2540 (.0595)
New England	.1042 (.0238)	.1925 (.0364)
Middle Atlantic	.0882 (.0238)	.3137 (.0364)
South Atlantic	-.1171 (.0238)	.1495 (.0364)
Year - New England	-.1451 (.0275)	-.3233 (.0421)
Year - Middle Atlantic	-.1146 (.0275)	-.2168 (.0421)
Year - South Atlantic	-.0962 (.0275)	-.1441 (.0421)
R^2	.9802	.9538
F (7 and 52 d.f.)	369.45	153.67

different implications in the separate regions.[12]

As anticipated, time and regional effects account for most of the variance in both measures of capital intensity, with multiple R^2 exceeding .95 in each case.

Although the impurities in the asset data, particularly the effects of changing prices for capital goods, prevent interpretation of the time trends as measures of increases in capital per employee or per bed, the strong impact of time on assets per employee and per bed is not a newly recognized phenomenon. On the basis of his research in 1930, Rorem (42; pp. 121-24) cited instances of increasing capital investment per bed ranging from $186 to $300 per year. He concluded that growth and development in hospitals were characteristically intensive rather than extensive. That is, hospitals tended to expand the scope of patient services and other activities such as medical education and research. He concluded as follows:

> "These factors, coupled with the fact that prices have increased during the last twenty years, account for a tremendous growth in capital investment in hospitals. The growth is particularly striking when expressed in terms of investment per bed, because so much of the expenditure has not been made with a view to accommodating additional patients."

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[12]The relative importance of each effect is also measured by the last order partial correlation coefficients. For the two equations in Table 6, these correlations are as follows:

Independent Variable (effect)	Partial Correlations Equation 1	Partial Correlations Equation 2
Year	.9710	.9460
New England	.5186	.5907
Middle Atlantic	.4565	.7663
South Atlantic	-.5630	.4943
Year - New England	-.5901	-.7289
Year - Middle Atlantic	-.5002	-.5811
Year - South Atlantic	-.4361	-.4287

More recently Ray Brown (6) has cited this trend for the early 1960's. In addition to inflationary price effects (in common with Rorem), Brown views the pressure to increase assets per employee and per bed as flowing from two principal sources - (1) the expansion, maintenance, and modernization of plant assets; and (2) the substitution of capital for labor as personnel wage scales rise. That is, assets per employee and per bed (apart from price effects) increase because technological advances which widen capital are adopted and because rising wage scales induce substitution of capital for labor.

Based on these views it may be possible to provide another account of the variance in plant assets per bed and per employee which will supply some content to the abstractions of time and region effects. For example, data are also available in the "Guide," on payroll expense and number of hospitals. Using this information, average bed size and payroll expense per employee can be calculated for each of the four regions in question.

Clearly these variables are not capable of distinguishing between the effects of technological change and capital-labor substitution. Bed size effects may reflect the influence of both scale and technological change. However, payroll expense per employee, if less ambiguous, is even more inadequate for this purpose. It is not, first of all, the "wage" rate, although movements and differences in wage rates surely influence its behavior. Equally damaging, however, is the fact that its behavior is also influenced by differences and changes in the composition of labor skills employed by the hospitals - i.e., precisely those type of changes which are expected from adopting new technology in hospitals.

It may be useful, however, even with these concessions, to learn the extent to which time and region effects can be replaced by size and unit labor cost effects.[13]

The data on average bed size and unit labor costs, for the four regions are given in Tables 7 and 8, respectively. Each of the series shows a rising rrend, in each region. There are also some indications of regional differences in the levels and rates of increase in the trends.

As before, linear equations are estimated, to account for the effects of size and unit labor costs on the variances of plant assets per bed and per employee. For several reasons it is also desirable to retain time, in some form, in the equations. In addition to providing for omitted, and perhaps unknown, time effects which frequently produce serial correlation in the residuals, this will also provide a crude allowance for differential effects of technological change and price movements of hospital construction and equipment.

To allow for these effects, time is arbitrarily dichotomized in two ways: (1) the 15 years are divided into 5 successive 3-year periods, with each period measured as a one-zero dummy variable;[14] (2) the 15 years are divided into 3 successive 5-year periods, with a dummy variable assigned to each period. These latter dummies are then used to

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[13]It may be useful also to note that some of the principal objections to the use of these variables would be overcome if other variables appropriate for making adjustments were available (such as an index of skill composition, or complexity of medical services provided, and a price for capital services). That is, it is not their inclusion in a regression equation that is so much an objection; rather it is the limitations placed on interpreting the results because other variables are omitted.

[14]The dummy variable for 1965-1963 is omitted to avoid singularity in the data matrix.

Table 7

Average Bed Size of Short-term Voluntary Hospitals in Four Geographic Regions: 1951-1965.

Year	Regions			
	New England	Middle Atlantic	South Atlantic	Pacific
1965	148.0	213.4	152.5	133.6
1964	143.6	205.4	148.0	132.4
1963	140.7	200.4	142.3	131.6
1962	140.3	198.1	140.0	130.8
1961	138.6	194.0	137.6	129.8
1960	135.3	191.1	132.3	126.2
1959	132.1	184.7	128.8	129.0
1958	131.3	183.4	127.5	131.5
1957	130.1	179.4	121.1	125.7
1956	130.2	176.9	121.0	125.0
1955	132.2	173.8	115.4	122.0
1954	130.4	172.0	114.1	122.1
1953	128.2	171.5	110.5	122.2
1952	124.0	166.8	109.1	121.0
1951	122.0	162.2	108.3	119.7

Source: Hospitals, J.A.H.A., "Guide Issue," Part 2, American Hospital Association, August 1, Annually for the years 1951-1965.

Table 8

Payroll Expense per Employee for Short-term Voluntary Hospitals in Four Geographic Regions: 1951-1965.

Year	Regions			
	New England	Middle Atlantic	South Atlantic	Pacific
1965	$4,332	$4,200	$3,577	$4,706
1964	4,146	4,015	3,384	4,615
1963	3,914	3,720	3,213	4,353
1962	3,749	3,570	3,039	4,186
1961	3,623	3,370	2,923	4,048
1960	3,599	3,179	2,813	3,846
1959	3,302	3,026	2,745	3,674
1958	3,191	2,759	2,505	3,451
1957	2,822	2,650	2,363	3,187
1956	2,759	2,553	2,238	3,099
1955	2,662	2,514	2,189	3,020
1954	2,579	2,327	2,117	2,923
1953	2,525	2,207	2,083	2,780
1952	2,348	2,103	1,966	2,798
1951	2,167	1,970	1,722	2,541

Source: Hospitals, J.A.H.A., "Guide Issue," Part 2, American Hospital Association, August 1, Annually for the years 1951-1965.

measure the interaction between bed size and 5-year interval.[15] It is postulated that the size-time interaction will adjust for the more important effects of technological changes embodied in extensive expansion, while the 3-year time dummies will adjust for the effects of intensive type technological changes and the effects of price movements. Since regional differences in size-technological effects, in addition to those associated with time, may also be encountered, regional-bed size interaction variables are also included in the analysis.

The explanatory variables are as follows:

Average Hospital Bed Size

Payroll Expense per Employee

Bed Size x New England Region

Bed Size x Middle Atlantic Region

Bed Size x South Atlantic Region

Bed Size x Dummy (1951-1955)

Bed Size x Dummy (1961-1965)

Time Dummy - 1960-1962

Time Dummy - 1957-1959

Time Dummy - 1954-1956

Time Dummy - 1951-1953

The results of the regression analysis are given in Table 9. As in the previous case (Table 6), the results are expressed for the variables in standardized form to emphasize the variations in the variables and to show the relative importance of each explanatory variable directly.

On the basis of R^2 (.9559 and .8896 for equations 1 and 2 respectively) the combined effects of the explanatory variables compares

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[15]The interaction term for 1960-1956 is omitted to avoid singularity.

Table 9

Results of Regression Analysis: Estimation of Bed Size and Unit Labor Cost Effects on Plant Assets per Bed and per Employee, Short-term Voluntary Hospitals in Four Geographic Regions.

	Coefficients (Betas) and Standard Errors	
	(1)	(2)
Independent Variables	Plant Assets per Bed	Plant Assets per Employee
Average Hospital Bed Size	.1214 (.1962)	.0014 (.3107)
Payroll Expense per Employee	.6298 (.1443)	.7254 (.2285)
Bed Size x New England	.1992 (.0529)	.3128 (.0839)
Bed Size x Middle Atlantic	.2036 (.2059)	.5821 (.3260)
Bed Size x South Atlantic	.2375 (.0911)	.5641 (.1442)
Bed Size x Dummy (1951-1955)	-.0087 (.0643)	.0433 (.1018)
Bed Size x Dummy (1961-1965)	-.0819 (.0726)	-.1749 (.1149)
Time Dummy (1960-1962)	-.1126 (.0664)	-.0728 (.0894)
Time Dummy (1957-1959)	-.1932 (.0904)	-.1389 (.1431)
Time Dummy (1954-1956)	-.3476 (.1194)	-.3140 (.1891)
Time Dummy (1951-1953)	-.4453 (.1442)	-.4178 (.2284)
R^2	.9559	.8896
F. (11 & 48 d.f.)	94.741	35.174

favorably with the combined time and region effects reported in Table 6. However it is difficult to comment on the relative importance of individual variables because of the numerous, high standard errors for the estimated coefficients.[16] Payroll expense per employee is clearly signigicant (positive) and the most important explanation in both equations. Bed size alone does not, evidently, have a common independent effect. However, in New England and South Atlantic it is positive and significant. It is also moderately significant (at the 10% level) in equation 2, plant assets per employee, for Middle Atlantic.

Bed size-time interactions coefficients are not significant, although for the sub-period 1961-1965, coefficients in both equations are (negative and) larger than their standard errors.

In equation 1, plant assets per bed, the coefficients for the four time dummies are significant (at 10% only for 1960-1962), negative, and with larger absolute values the more remote the time period. In equation 2, these coefficients exhibit the same pattern, but only the coefficient for 1951-1953 is moderately significant - at 10 percent.

In general the crude tendencies expressed in these results are consistent with the views that have been expressed with regard to capital per employee and per bed in hospitals. There are significant (positive) wage and (regional) size effects, apart from the upward secular shifts. While the separate effects of capital widening and capital deepening cannot be distinguished, it seems clear that neither effect may be dismissed without further exploration.[17]

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[16]One reason for this result is the high correlation between bed size and bed-size interaction with regions, the Middle Atlantic region in particular.

[17]The omission of a variable for evaluating the cost of capital to the hospitals, particularly in equation 2, plant assets per employee, is a grievous omission.

Although the trends described above suggest there may be substitution of capital for labor among hospitals of the same general class that cannot be attributed to chance, the data upon which they are based are not suitable for other than gross impressions. A principal reason for this is that it cannot be determined how well reported assets measure capital.

In order to observe and measure the substitution of capital for labor, it is most relevant to measure capital as a physical concept (17; pp. 344-345). In particular the desired measure of capital should include only the building and equipment capital in use by the hospital, and it should be free of discrepancies resulting from price changes of capital goods, the timing of capital acquisitions, and variations in accounting reporting practices.

To provide relevant evidence of the substitution of capital for labor, taking into account the objections to reported assets, data observed for a group of 38 short-term voluntary hospitals in New York City are examined. The aggregate capital reported in each year, Table 10, is the sum of the real building and equipment capital in use as determined for each hospital. The procedures used to determine the real stock in use consisted primarily in building up year-end balances, beginning with book balances in 1945, by adding the increments of net equipment purchases that were capitalized, and the increments of new construction brought into use, deflated by a construction cost index (1945 = 100). The details of the procedure are set forth and discussed in the attached appendix.

Since these data were prepared specifically for this study and have no counterpart in the hospital literature, there is no direct basis

Table 10

Real Capital Stock, Employees, and Beds, in 38 Short-Term Voluntary Hospitals in New York City: 1950-1965.

Year	Capital Stock[a] (000 000)	E Employees[b] (000)	Beds (000)	Capital per Bed	Employees per Bed	Capital per Employee
1965	$314.9	48.9	16.7	$18,813	2.92	$6,442
1964	302.8	46.5	16.7	18,163	2.79	6,509
1963	272.0	44.3	16.0	17,021	2.77	6,134
1962	257.2	42.6	15.8	16,302	2.70	6,040
1961	242.4	41.1	15.7	15,424	2.62	5,894
1960	234.3	39.7	15.4	15,166	2.57	5,907
1959	223.1	38.8	15.3	14,537	2.53	5,744
1958	216.7	38.1	15.2	14,233	2.50	5,691
1957	207.7	37.6	15.1	13,741	2.49	5,527
1956	203.6	35.1	15.1	13,451	2.32	5,804
1955	196.5	34.8.	15.0	13,086	2.32	5,642
1954	184.2	34.4	14.9	12,366	2.31	5,350
1953	177.3	33.8	14.8	11,968	2.28	5,253
1952	169.9	32.1	14.3	11,844	2.24	5,298
1951	165.5	30.6	14.3	11,609	2.15	5,411
1950	159.5	29.4	13.9	11,456	2.11	5,423

Source: Annual Reports of Member Hospitals, United Hospital Fund, New York City.

a/Real capital stock in use at the end of the year; excludes plant under construction.

b/The number of full-time and full-time equivalent employees reported as of the end of the year.

for evaluating their validity. They are subject to the criticism of all measures of capital based on historical costs, and, even more, uncertain and irregular reporting. Fortunately, a test is available for a cross-section check in 1955 (mid-point in the series), utilizing a concept of value as the measure of capital, rather than historical cost or book value.

In a special survey conducted by the United Hospital Fund of New York, 35 of the 38 sample hospitals reported their fire insurance coverage, effective during the year 1955 (47). The value insured is the monetary value placed on the hospital building and its contents, as estimated by the hospital. Although the insured values may reflect unknown idiosyncracies in the formulation of values, and variations in the extent to which risk is avoided, they are probably the most reliable independent approximations of building and equipment value to be found. Certainly they are formulated by those who are in the best position to know the intimate details regarding the physical capital belonging to the hospital - its age, technical adequacy, replacement costs, the extent to which each part is actively involved in producing services, and the outlook for the future.

Since insured values are expressed as the current monetary value of plant, and the estimates calculated from the annual financial reports are expressed in real terms (1945 dollars), the dollar amounts for given hospitals cannot be expected to coincide. (Real stock probably should lag behind insured values.) However, if two variables are measuring the same thing, they ought to be highly correlated.

In Table 11, the distribution of the 35 reporting hospitals, by

Table 11

Distribution of 35 Short-term Voluntary Hospitals by Amount of Fire Insurance Coverage and Estimated Real Capital Stock in 1955.

Fire Insurance Class Interval (Dollars in 000)	Estimated Real Capital Stock Class Interval (dollars in 000)					
	Total	Under $1,000	$1,000-1,999	$2,000-3,999	$4,000-9,999	$10,000 and over
TOTAL	35	4	9	10	7	5
Under $1,000	3	1	1	0	1	0
$ 1,000 - 1,999	9	3	6	0	0	0
2,000 - 3,999	10	0	2	7	1	0
4,000 - 9,999	8	0	0	3	5	0
10,000 and over	5	0	0	0	0	5

Source: United Hospital Fund, Report on Insurance Coverage by Member Hospitals in 1955 (not distributed).

insured value and by estimated real capital stock is given. The pattern is as anticipated - hospitals reporting larger insured values have larger estimated real capital stock, with real stock tending to lag behind insured value.

The simple correlation between insured value and real capital stock was found to be a reassuring .9603. However, this correlation may simply reflect the size of the hospitals. A stronger test of the correspondence between insured value and the measure of real capital stock is provided by the correlation between insured value per bed and real capital stock per bed. This correlation was found to be a highly significant .8153.

Returning to the information in Table 10, it is clear that capital per bed in these hospitals has increased over the years. However, capital increased proportionately more than employees. Thus capital per employee also increased, from $5,423 to $6,442 in 1965.

In general, these data, purged of price effects and limited to one local area, reflect the same rising tendencies that are suggested by the nation-wide and region-wide tendencies. Certainly, from a dynamic point of view (whether one is interested in analyzing changes in hospital performance that have occurred in the past, or in making projections for the future), the assumption of invariant capital per employee or per bed for the "representative" hospital is not tenable.

A similar conclusion is reached when the hospitals in the sample are dichotomized according to characteristics which more or less permanently distinguish hospitals. The evidence for these results is presented in Tables 12, 13, and 14, where the hospitals are classified alternatively as to teaching status, catholic non-catholic auspicies, and

Table 12

Real Capital Stock per Bed and per Employee for 38 Short-term Voluntary Hospitals in New York City, Classified by Teaching Status.

Year	Capital per Bed		Capital per Employee	
	Status 1[a/] Hospitals	Status 2[a/] Hospitals	Status 1 Hospitals	Status 2 Hospitals
1965	$20,547	$13,121	$6,684	$5,430
1964	19,822	12,683	6,768	5,435
1963	18,529	12,018	6,363	5,179
1962	17,762	11,572	6,256	5,150
1961	16,650	11,422	6,129	5,204
1960	16,536	10,782	6,139	4,985
1959	15,829	10,469	5,937	4,975
1958	15,567	9,999	5,937	4,721
1957	15,009	9,679	5,759	4,604
1956	14,803	9,148	5,891	4,637
1955	14,460	8,816	5,853	4,675
1954	13,498	8,798	5,492	4,752
1953	13,268	7,795	5,471	4,307
1952	13,158	7,531	5,570	4,139
1951	12,863	7,405	5,678	4,249
1950	12,908	6,694	5,715	4,101

Source: Annual Reports of Member Hospitals, United Hospital Fund, New York City.

a/Status 1 hospitals are those hospitals with a major medical school affiliation, or at least 5 approved residency programs. All other hospitals are assigned to Status 2. There are 22 hospitals in Status 1, and 16 hospitals in Status 2.

Table 13

Real Capital Stock per Bed and per Employee for 38 Short-term Voluntary Hospitals in New York City. Classified as Catholic and Non-Catholic Auspices.

Year	Capital per Bed		Capital per Employee	
	Catholic Hospitals[a]	Non-Catholic Hospitals	Catholic Hospitals	Non-Catholic
1965	$16,668	$19,371	$6,140	$6,514
1964	15,970	18,739	6,187	6,583
1963	15,015	17,530	5,711	6,234
1962	14,523	16,772	5,709	6,121
1961	13,835	15,909	5,645	6,021
1960	13,447	15,616	5,669	5,964
1959	13,033	14,941	5,683	5,759
1958	12,810	14,613	5,506	5,736
1957	11,094	14,449	4,937	5,666
1956	10,422	14,269	5,092	5,766
1955	9,905	13,939	5,209	5,733
1954	9,950	13,007	5,149	5,393
1953	9,507	12,591	4,992	5,304
1952	8,812	12,603	4,695	5,419
1951	8,627	12,360	4,899	5,512
1950	7,938	12,348	4,781	5,545

Source: Annual Reports of Member Hospitals, United Hospital Fund, New York City.

a/There are 11 Catholic hospitals, and 27 non-Catholic.

Table 14

Real Capital Stock per Bed and per Employee for 38 Short-term Voluntary Hospitals in New York City. Classified by Philanthropic Status.

	Capital per Bed		Capital per Employee	
Year	Status 1 Hospitals[a/]	Status 2 Hospitals[a/]	Status 1 Hospitals	Status 2 Hospitals
1965	$21,784	$14,291	$7,026	$5,402
1964	21,017	13,755	7,109	5,423
1963	19,476	13,039	6,770	4,997
1962	18,670	12,571	6,567	5,084
1961	17,956	11,597	6,590	4,812
1960	17,643	11,239	6,547	4,751
1959	16,995	10,744	6,317	4,703
1958	16,995	10,744	6,317	4,703
1957	16,454	9,587	6,159	4,353
1956	16,125	9,313	6,276	4,442
1955	15,749	9,032	6,203	4,550
1954	14,705	8,781	5,874	4,353
1953	14,466	8,160	5,826	4,150
1952	14,203	8,144	5,912	4,125
1951	14,213	7,580	6,109	4,065
1950	14,214	7,136	6,146	3,968

Source: Annual Reports of Member Hospitals, United Hospital Fund, New York City.

a/Philanthropic status is based on the distribution of hospitals by endowment fund assets per bed during the period 1960-65. Status 1 hospitals are those with $1,000 or more endowment assets per bed (18 hospitals). All others (20) are classified as Status 2.

philanthropic status, respectively.[18] The data are expressed as capital per bed and per employee.

From Table 12 it appears that in both teaching and non-teaching hospitals capital per employee and per bed have increased over time. In fact, while the data strongly suggest these ratios are significantly higher for teaching hospitals, non-teaching hospitals (or those not extensively engaged in teaching activities) increased capital per employee and per bed proportionately more than teaching hospitals. Thus, while capital per bed in teaching hospitals increased by 59 percent (from 1950 to 1965), it increased by 96 percent in non-teaching hospitals. (The corresponding percentages for capital per employee are 17 and 32 percent, respectively.) Despite this narrowing of the proportional difference, the absolute differences between the two classes of hospitals (ranging approximately $6 to $7 thousand in capital per bed, and slightly more than $1 thousand in capital per employee) appear to be nearly as important as the differences that have occurred during the 16 years.

In Table 13, the data show that Catholic controlled hospitals, like other hospitals, have experienced secular increases in capital per employee and per bed. In fact proportionate increases are greater for Catholic than for non-Catholic hospitals. Catholic capital per bed doubled over the 16 years (from $7,938 to $16,668) while in non-Catholic hospitals it increased by 57 percent (from $12,348 to $19,371). The corresponding percentages for capital per employee are 28 and 17

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[18]Hospitals with major medical school affiliations or at least 5 approved residency programs are assigned to status 1; all other hospitals are assigned to status 2. Philanthropic status is based on the distribution of hospitals by endowment assets per bed, during 1960-1965. Hospitals with $1,000 or more endowment assets per bed are assigned to status 1; all others are assigned to status 2.

percent, respectively.

The differences in these ratios which may exist between Catholic and non-Catholic hospitals however, are rather modest, particularly for capital per employee (always less than $1,000), and for capital per bed after 1958. These differences, which show capital per employee and per bed to be less in Catholic hospitals, have tended to diminish over the years.

In Table 14, the sample hospitals are classified according to their distribution by endowment assets per bed. While the class assignments were based on detailed information for the years 1960-1965 (with $1,000 or more per bed signifying status 1), numerous checks of data available for earlier years indicate the implied ranking is consistent for the 16 years. The principle involved in this dichotomy quite simply concerns the scarcity of capital funds. All 38 hospitals in the sample have relied primarily on private philanthropy either directly as a source of funds for capital expenditures, or indirectly to retire debt incurred for capital purposes. However, some hospitals have been able to acquire larger flows of these funds than other hospitals. This suggests that in this unorthodox "market" some hospitals find it easier (or less costly) to acquire given amounts. In the table and in subsequent references this distinction between hospitals is referred to as philanthropic status, with endowment assets per bed used as a criteria for assigning hospitals to either status 1 or status 2.

As indicated in Table 14, hospitals that are heavily endowed (status 1) consistently have more capital per employee and per bed than other hospitals; but all hospitals have experienced secular increases in capital per bed and capital per employee. As in the case of teaching status and Catholic non-Catholic auspices, proportional differences have tended to diminish. While capital per bed for status 1 hospitals was increasing by 53 percent, it was doubling in status 2 hospitals. (The respective percentages for capital per employee are 14 and 36 percent.) Nevertheless, absolute differences appear to be substantial; and in the case of capital over bed, the difference between status 1 and status 2 hospitals increased from $7,078 in 1950, to $7,493 in 1965.

On the basis of these data the secular growth in capital per employee and per bed appears to be pervasive. There is, moreover, some indications of characteristic differences between hospitals.

If capital per employee or per bed is really invariant or if its distribution is sufficiently dominated by random factors, then hospitals classified by different characteristics should have similar mean capital-bed and capital-employee ratios as observed in a cross-section, for a given year. From a statistical point of view, the difference between such sample means should not be significant. As a final exploration of the evidence for capital-labor substitution, this hypothesis is tested by classifying the 38 hospitals into alternative sets of two sub-samples - teaching status, Catholic non-Catholic, and philanthropic status - and, in each case, testing for the significance of the difference between the means (capital-bed and capital-employee ratios) of the sub-samples. The test is repeated for four different years, at five-year intervals - 1950, 1955, 1960, and 1965.[19]

[19]In testing for the equality of means observed for two samples, it is assumed that the samples have a common variance. Thus, preliminary to the principal test, the sample variances are analyzed to determine their homogeneity. The ratio of variances, or the F test, is applied.

The results of the three experiments, along with pertinent descriptive statistics, are reported in Tables 15, 16, and 17. In Table 15, the 38 hospitals are classified by teaching status (22 hospitals in status 1, and 16 hospitals in status 2). With the exception of 1955, the hypothesis of equal variances for capital per bed ratios is rejected. Accordingly the t statistics and corresponding degrees of freedom were calculated by the procedures set forth in footnote 19. In each year the hypothesis of equal means is rejected at the 5 percent level. For capital per employee, the hypothesis of equal variances seems acceptable, and, accordingly, the t statistics were calculated in the usual way, with 36 degrees of freedom. On the basis of these calculations the hypothesis of equal means cannot be rejected.

In Table 16, the hospitals are classified as Catholic (11) and non-Catholic (27). With the exception of capital per bed in 1950 and 1955, the hypothesis of equal variances cannot be rejected at the 5 percent level. However, the two exceptions cannot be rejected at the 1 percent level. The evidence does not appear substantially in favor of

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19(Cont'd)

If by this test there is a common variance, the variance of the difference in means is calculated using a weighted average of the sample variances as the common variance. The t test for the difference between means is then applied, with 36 degrees of freedom. If the hypothesis of equal variances is rejected, the variance of the difference between means is calculated (following Walker and Lev, 49; pp.157-58) as $S_1{}^2N,$ + $S_2{}^2/N_2$ and the t statistic is used, with degrees of freedom given by the following formula:

$$n = \frac{\left(\frac{S_1{}^2}{N_1}\right)+\left(\frac{S_2{}^2}{N_2}\right)}{\left(\frac{S_1{}^2}{N_1}\right)\frac{1}{N_1+1}+\left(\frac{S_2{}^2}{N_2}\right)\frac{1}{N_2+1}} - 2$$

Table 15

Comparisons of Means and Variances of Capital per Bed and Capital per Employee for 38 Short-term Voluntary Hospitals Classified by Teaching Status.

	Capital per Bed				Capital per Employee			
	1950	1955	1960	1965	1950	1955	1960	1965
Mean:								
Teaching Status 1[a/]	$10,356	$12,394	$14,892	$18,565	$4,721	$5,122	$5,680	$6,094
Teaching Status 2	6,399	8,583	10,260	12,500	4,020	4,767	4,825	5,282
Difference	3,957	3,811	4,631	6,065	701	355	855	812
Standard Deviation:								
Teaching Status 1	$5,134	$5,203	$5,462	$6,742	$1,854	$1,651	$1,733	$1,817
Teaching Status 2	2,531	3,875	3,395	3,450	1,415	1,913	1,570	1,404
Coefficient of Variation:								
Teaching Status 1	.4958	.4198	.3668	.3632	.3927	.3223	.3052	.2981
Teaching Status 2	.3955	.4515	.3309	.2760	.3521	.4012	.3254	.2658
Ratio of Variances[b/]	4.1162	1.5017	2.5879	3.8187	1.7160	1.3425	1.2188	1.6745
Value of t for Difference in Means	3.1298	2.5877	3.2139	3.6174	1.2663	0.6116	1.5605	1.4913
(Degrees of Freedom)	(34)	(38)	(37)	(35)	(36)	(36)	(36)	(36)

a/Hospitals with major medical school affiliations, or having five or more approved residency programs, are assigned to Status 1. All other hospitals are assigned to Status 2.

b/The ratio of the variance for Status 1 to the variance for Status 2 for all cases except for capital per employee in 1955. In this year the capital per employee variance for Status 2 exceeded that for Status 1, and thus was used as the numerator in the ratio. The degrees of freedom are 21 and 15 except for the instance just cited where they are reversed.

Table 16

Comparisons of Means and Variances of Capital per Bed and Capital per Employee for 38 Short-term Voluntary Hospitals Classified as Catholic and Non-Catholic.

	Capital per Bed				Capital per Employee			
	1950	1955	1960	1965	1950	1955	1960	1965
Mean:								
Non-Catholic	$9,411	$11,614	$13,317	$16,485	$4,436	$5,016	$5,376	$5,788
Catholic	6,918	8,765	12,020	14,849	4,398	4,865	5,180	5,666
Difference	2,493	2,849	1,298	1,635	38	151	196	121
Standard Deviation:								
Non-Catholic	$4,990	$5,363	$5,242	$6,786	$1,839	$1,617	$1,697	$1,693
Catholic	3,140	3,430	5,200	5,057	1,373	1,555	1.780	1,744
Coefficient of Variation:								
Non-Catholic	.5302	.4618	.3936	.4116	.4144	.3222	.3156	.2924
Catholic	.4539	.3902	.4326	.3406	.3122	.3196	.3437	.3078
Ratio of Variances[a]	2.5258	2.4584	1.0165	1.8005	1.7927	1.0805	1.1012	1.0616
Value of t for Differences in Means:	1.5312	1.6250	.6937	.7195	.0617	.2461	.3191	.1985
(Degrees of Freedom)	(36)	(36)	(36)	(36)	(36)	(36)	(36)	(36)

a/Non-Catholic variances are larger, and thus used in the numerator (with 26 and 10 degrees of freedom), except for capital per employee in 1960 and 1965. In these two instances the Catholic variance is used in the numerator, with 10 and 26 degrees of freedom.

Table 17

Comparisons of Means and Variances of Capital per Bed and Capital per Employee for 38 Short-term Voluntary Hospitals Classified by Philanthropic Status.

	Capital per Bed				Capital per Employee			
	1950	1955	1960	1965	1950	1955	1960	1965
Mean:								
Philanthropic Status 1	$11,105	$13,158	$15,280	$18,578	$5,088	$5,523	$6,086	$6,337
Philanthropic Status 2	6,516	8,657	10,837	13,701	3,829	4,477	4,630	5,226
Difference	4,589	4,501	4,443	4,878	1,259	1,047	1,456	1,111
Standard Deviation:								
Philanthropic Status 1	$5,155	$4,475	$4,913	$7,210	$1,825	$1,960	$1,318	$1,735
Philanthropic Status 2	2,747	3,309	4,593	4,381	1,360	1,407	1,735	1,490
Coefficient of Variation:								
Philanthropic Status 1	.4642	.4237	.3215	.3881	.3587	.3548	.2166	.2737
Philanthropic Status 2	.4216	.3823	.4238	.3198	.3550	.3142	.3748	.2850
Ratio of Variances[a/]	3.5204	2.8373	1.1443	2.7085	1.8021	1.9414	1.7317	1.3558
Value of t for Difference between Means:	3.3709	2.9837	2.8704	2.4865	2.4269	1.9052	2.8874	2.1240
(Degrees of Freedom)	(26)	(28)	(37)	(29)	(36)	(36)	(36)	(36)

a/ Status 1 variances are larger, and thus used in the numerator (with 17 and 19 degrees of freedom), except for capital per employee in 1960. In this case status 2 variance is used as numerator, with 19 and 17 degrees of freedom.

rejection, hence the t statistics were calculated in the usual way, with 36 degrees of freedom. In all cases the hypothesis of equal means cannot be rejected.

In Table 17, the hospitals are divided into two groups, according to philanthropic status (18 hospitals in status 1, 20 hospitals in status 2). The hypothesis of equal variances, for capital per bed, is, with the exception of the test for 1960, rejected. The tests for capital per employee indicate the hypothesis cannot be rejected. The t statistics and degrees of freedom are calculated accordingly.

In each year the difference between capital per bed means is significant at the 5 percent level. Differences between capital per employee means, excepting 1955, are also significant at the 5 percent level. In 1955, the difference is significant at approximately a level of 7 percent. In all cases, larger means are observed for the more heavily endowed hospitals.

Several aspects of these results merit attention. First, in keeping with the main purpose of this chapter (to describe evidence of capital-labor substitution and variations in capital per bed) it is observed that the coefficient of variation for capital per bed or per employee is usually between 30 and 45 percent. While there is some tendency for it to decline in more recent years, there is no suggestion that it will collapse. Second, the view that such variations as do exist are, or may be regarded, as random, is contradicted by the findings, in two instances where mean capital - bed ratios are significantly different, and, in one instance, where mean capital - employee ratios are different. Third, although the hypotheses tested make no reference to, nor do they depend on an explanation or a reason for observed differences, they suggest that the behavior of capital-employee or capital bed ratios (among hospitals) may be predictable. In fact if philanthropic status is interpreted as an economic variable signifying differences in the ease or cost of acquiring capital funds, the results in Table 17 are not unexpected.

To summarize, this chapter has focused attention on the variable nature of capital per employee and capital per bed, particularly in voluntary short-term hospitals. The purpose has been to determine, from published data and other sources, whether or not the substitution of capital for labor in such hospitals has an empirical basis. In particular, can variations in observed capital intensity be regarded as random, or are there differences among hospitals that cannot be attributed to chance? The results consistently affirm the latter view.

The analysis of regional time-series data, in which capital was measured as plant assets, indicates there are significant regional effects in the variance of capital-employee and capital-bed ratios. An effort to provide an alternative specification of these effects, utilizing unit payroll costs and average bed size was partially successful - indicating in particular a significant, positive effect attributable to unit payroll costs.

The analysis of real capital in use (per employee and per bed) for 38 voluntary hospitals in New York City provides more convincing results that variations in capital per employee or per bed cannot be attributed to chance. The fact that mean capital per bed is consistently greater for teaching hospitals than for non-teaching hospitals suggests technical factors, such as those implicit in the different mix of hospital activities may influence the behavior of capital intensity. But there is a possibility that allocative principles are also effective. This is suggested by the finding that more heavily endowed hospitals use more capital per employee.

While these suggestions provide a point of departure for a more rigorous exploration of the extent to which hospitals substitute capital for labor, they remain, at this point, conjectures which are consistent with, but which do not necessarily follow the findings. One result, the fact that among hospitals differences in capital per bed are significant, seems, however, to be binding - even at this level of analysis. The importance of this when making projections for estimated future capital requirements is obvious; however a consideration of this point is, perhaps even more important when the question of controlling the capital allocations or the scale of hospitals as a public policy is raised. In estimating alleged economics of scale from cost functions, for example, the use of beds as a measure of size as observed by Mann and Yett (30; pp. 8-9) is an attempt to allow for differences in capital services employed. However, if capital per bed is correlated with other variables entering the equation, the estmated importance of size will be biased. Since capital stock imposes a variety of indirect costs - such as heating, ventilating, cleaning, maintenance, repair, insurance, etc. --as well as the direct (but implicit) cost of its services on operating costs, efforts to adjust for the rate at which "capacity" is used by introducing a bed occupancy rate, the average daily census,or admissions per bed, may also be sensitive to this criticism, particularly if these nominal measures of the intensity or speed of activity themselves have an influence on capital per bed.

In the following chapter the means by which substitution of capital for labor can be measured are developed, utilizing the economic theory of optimal resource use. The role of wage rates and capital costs are explained in this framework. The application of these ideas to the circumstances of voluntary hospitals is discussed; and a model is derived for the purpose of testing particular hypotheses about the relationship between capital-labor ratios, the relative wage of labor, and other characteristics of hospitals and hospital services.

CHAPTER III

ALLOCATIVE PRINCIPLES AS GUIDES FOR THE USE OF CAPITAL BY VOLUNTARY HOSPITALS: A FRAMEWORK FOR ANALYSIS

1.

The main reason for studying the behavior of capital-labor and capital-bed ratios in voluntary hospitals is to determine how important allocative principles are in the process of employing capital. Empirically this is evaluated by measuring the extent to which capital is substituted for labor as a consequence of variation in the relative wage of labor.

This is an important question, bearing directly on the problem of how capital is allocated in a major U.S. industry - an industry in which a broad segment is organized on a non-profit basis, obtaining capital funds from private philanthropy and tax sources. It is also a question that is related to a number of issues that involve public policies. In particular, if hospitals are not aware of the possibilities for capital-labor substitution, or if they choose to ignore possibilities for reducing costs, there is no basis for establishing an efficient demand for capital (stock). Moreover, there would appear to be no alternatives to the conscious direction and control of the details of capital formation, hospital by hospital, in order to secure an efficient use of the capital being supplied to the industry.

This disregard for efficiency would also reflect in higher than necessary operating costs, and thus reinforce the motivation for inspection and control of capital formation.

Since the latter approach to capital allocation, if pursued to any depth, is costly in its own right, and since its outcome is at best uncertain, it would be extremely provident to learn that voluntary hospitals are guided by allocative principles in deciding on their own initiative how to use capital. In addition to the immense qualitative simplifications such results would suggest for programs designed to subsidize the allocation of capital, the quantitative importance of the extent to which capital is substituted for labor as a result of relative scarcity would provide an operational basis for innovating in several directions which currently seem beyond reach. For example, the substitution of capital for labor, in a crude sense measures the extent to which labor can be replaced, marginally, by capital, given output. Also, it shows that supply can be expanded with capital, or alternatively, that the productivity of labor can be increased by capital deepening. Most important, it shows the extent to which these types of adjustments are achieved impersonally through response to relative factor scarcity.

There are, in addition to this major objective, other reasons as well for studying the behavior of capital intensity. For example, evidence has accumulated from various studies of hospital costs which suggests there may be significant widening components in the behavior of capital intensity.[1] However, with one important exception the interest expressed in these studies for cost-output relationships - including bed size effects - has not been accompanied by a like concern for the

[1]Martin Feldstein finds case-mix (proportional distribution of admissions by diagnoses) in British hospitals to be an additive component to average cost per case (12; pp. 21-23). Berry (4), and Carr and Paul Feldstein (8; pp. 61-63) find different average cost functions for U.S. voluntary hospitals that have different numbers of special service facilities.

character of resource use that is implicit in the cost performance.[2]

As a practical matter the implications for capital widening may be of more immediate interest to policy makers since, for many, public control or regulation of hospital capital seems already to have been found an acceptable policy - at least in some degree.[3] Nevertheless, capital deepening to improve allocative efficiency must remain at the center of the analysis since even capital widening, as a predictable phenomenon, depends on motivation as well as the technical factors said to be its cause.[4]

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[2]The exception is Feldstein's work on British hospitals. In this study Feldstein examines several production relationships, measuring inputs as expenditures on various categories of resources - except for capital, which is measured as the number of beds - and measuring output as either cases (admissions) or cases adjusted for case-mix. Observed input proportions are compared with the optimum proportions implied by the regression results (12; pp. 92-103).

However, Feldstein's view as regards capital intensity, the constancy of capital per bed in particular, raise doubts about the elasticities that are estimated and the conclusions that are based on them. There are other difficulties as well that result from regressing admissions on beds - instead of capital - and other inputs. As Professor Victor Fuchs has pointed out, admissions can be redefined as 365 times beds, multiplied by the average occupancy rate, all divided by average length of stay. Thus beds appear on both sides of the equation. Moreover, in this particular study there was very little variance in occupancy rates,hence most of the variance being analyzed in the equation was the variance in average length of stay (13; pp.13-14).

[3]The principal objective of the Federal Hill-Burton Act of 1946, and subsequent amendments, is to subsidize hospital capital. The act requires that each state develop a state-wide plan for hospitals (and other related facilities), and that mechanisms be developed for sorting out acceptable capital projects according to planning guides. The control, however, is limited to refusing funds. In New York State, a more deliberate attempt to control capital allocation has been incorporated into law (Folsom Act; Chapter 795, Laws of 1965). Under the provisions of this law, capital projects are subject to approval before they can be undertaken, regardless of how they are to be financed.

[4]Consider the simplest hypothetical case where the minimum inputs necessary to produce a given output are in a constant proportion for all possible outputs. Thus a given output can be produced with X units of capital and Y units of labor. But this output can also be produced with 2X units of capital and Y units of labor. The question is, what assures us that <u>only</u> X of capital and Y of labor will be used if - say - cost minimizing behavior is not assumed?

In Section 2 theoretical and other considerations are used as the basis for deriving relationships to be employed in analyzing capital-labor (bed) ratios. For reasons which are stated these relations are eclectic in nature and are not interpreted necessarily as rigorously derived production relationships. In the concluding section (3) a defense of the maintained hypothesis is presented.

2.

The economic theory of optimum resource proportions may be derived directly from the assumption of profit maximization, and a postulated production function - the single point relationship that is assumed to exist between various quantities of inputs and the maximum output possible, all per unit time. For example, the profit function to be maximized where both product price and unit factor prices are given to the firm is the product of output price and quantity (given by the production function in terms of capital and labor), minus total cost (the sum of the products of unit factor price and the quantity of each factor employed). When the derivatives of this function (with respect to capital and labor) are set equal to zero, the familiar equalities between value of marginal products and unit factor prices are obtained as the first-order conditions for profit maximization.

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[4](Cont'd)
Not all economists agree that such an assumption is necessary in order to examine factor relationships in production. For example, Feldstein asserts, "a further advantage of the production function for studying scale effects is that the results are not affected by differences in the efficiency with which hospitals of different size combine inputs" (12; p. 90). Clearly, Feldstein means allocative efficiency - the use of least-cost input proportions. Thus he ignores the question of motivation as it relates to input-output relationships. Leibenstein, on the other hand, asserts, "The importance of motivation and its association with degree of effort and search arises because the relation between inputs and outputs is not a determinate one." (25; p. 407) In

By considering the ratio of these two conditions, the price per unit of output is eliminated, and it is seen that the first-order profit maximizing conditions always imply cost minimization - the use of resources in least-cost combinations. These results can be symbolized in terms of a profit function, as follows:

1. $\pi = P_q f(K,L) - rK - wL$

where f is the production functionl K and L are capital and labor; and P_q, r, and w are price per unit of output, rental price per unit of capital, and wage rate per unit of labor respectively.

Setting first derivatives with respect to K and L to zero yields

$$P_q \cdot f_K = r, \text{ and } P_q \cdot f_L = w$$

and by taking their ratio, the first-order conditions for cost minimization are made explicit.

2. $$\frac{f_L}{f_K} = \frac{w}{r}$$

Following this rule is what is meant by being guided by allocative principles. Although cost minimization is deduced as an implication of profit maximization in this case, it is clear that cost minimization as such does not require profit maximization. For example, maximizing output for a given cost budget also implies cost minimization.[5] Regarding the production function, it is conventionally postulated that its properties are such that the ratio of derivates (marginal products) is determined by the proportions in which capital and labor are employed, independent of the rate of output. (This is exactly the case where the production function is homogeneous of degree

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4(Cont'd) general, however, economic theory has always recognized the production function as a relation between various amounts of inputs and the <u>maximum</u> output possible - not the <u>only</u> output possible.

5Newhouse has shown that cost minimization is also implied if hospital managers seek to maximize utility functions, with both quantity and quality as arguments, given a loss constraint (34; p. 69).

one - the case of constant returns to scale.)[6] Thus the application of allocative principles to the question of how factors are to be used reduces to one of choosing optimum factor ratios - in the sense that (2) is satisfied.

This may be symbolized as follows:

$$3.\ K/L\ (\text{optimum}) = g(\frac{w}{r})$$

In order for this concept to be applicable, it must be possible at a given output, to substitute capital for labor. Or, stated alternatively, it must be possible to produce a given (contemplated) output with various input combinations. This is generally taken to be the single most important property of the production function. From these considerations it is obvious that the properties of $g(\frac{w}{r})$ are not to be regarded as consequences of economic theory. They are rather determined by the parameters of the postulated production function.[7] Also,

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[6]In the "normal" case, with positive first partial derivatives (marginal products), negative second partial derivatives, and non-negative mixed second partial derivatives, efficient factor ratios for homogeneous functions of any degree are independent of the level of output (38; p. 42).

[7]This is demonstrated by observing the optimum capital-labor ratios for the generalized Cobb-Douglas production function, $P = AK^aL^b$. The solution is $K/L = (a/b)(w/r)$, which shows the elasticity of K/L with respect to w/r to be unity, and the proportionality factor as depending on the ratio of output elasticities for capital and labor respectively.

For a number of reasons g(w/r) is rarely used directly as a basis for empirical testing. First of all, the economic conclusion is true by hypothesis, and thus can't be disputed. Second, it is not clear that (3) should always be expressed in terms of w/r, because the assumption that factor prices are given to the firm (perfectly competitive factor markets) may not be satisfied. Where this is the case, average factor costs (w and r) are replaced by corresponding marginal factor outlays - which requires, in addition to w and r, a knowledge of the supply elasticities for capital and labor. Third, appropriate measures of K and r are usually not available - at least in the same degree of appropriateness, as L and w. Forth, the form in which the parameters of the production function appear in (3) may obscure rather than illuminate the parameters which are of immediate interest. For example, fitting g(w/r) in the Cobb-Douglas case yields estimates of the ratios of output elasticities - not the elasticities themselves - and constrains the elasticity of substitution to unity.

$g(\frac{w}{r})$ could be expanded to include scale as a variable if the assumption of constant returns seems questionable (17; p. 296).

To describe an empirical form for $g(\frac{w}{r})$ that illuminates the property of the production function that is of interest, it is useful to begin directly by considering the definition of the elasticity of substitution - the percentage change in the capital-labor ratio associated with a one percent change in the marginal product of labor relative to the marginal product of capital.[8] For the firm that uses least costly factor combinations, the relative marginal product of labor is adjusted to equal the relative wage of labor (2 above). Hence an estimate of the elasticity of substitution can be obtained by substituting w/r for f_L/f_K. Letting σ symbolize the elasticity to be estimated, the definition is as follows:

$$4. \quad \sigma = \frac{d(K/L)}{d(w/r)} \cdot \frac{w/r}{K/L}$$

The solution to this equation is

$$5. \quad K/L = A(\frac{w}{r})^{\sigma}$$

where A is a constant whose value may be regarded as being determined by other variables - say, $A = f(X_1, X_2, \ldots)$. These variables could include measures of such things as product differentiation, scale, or other characteristics of the firms.

This form is compatible with a number of views that have been expressed about those factors measuring the multiproduct or differentiated

[8]The elasticity of substitution measures the ease of substituting capital for labor at a given output. As defined by Hicks (17; pp.289-290), in the two factor model, it is the elasticity of the capital-labor ratio with respect to the marginal technical rate of substitution. But the marginal rate of technical substitution of capital for labor (the slope of an isoquant) is the ratio of the marginal product of labor to the marginal product of capital.

product character of short-term hospitals which are said to be the reason for differences in hospital cost functions. For example, Feldstein proposes a generalized Cobb-Douglas function for British acute-care hospitals in which the output elasticities of the inputs are themselves functions of case-mix (12; p. 96). Being a little more general, assume there are a number of factors, or vaiables $(X_1,X_2, \ldots)$ that determine output elasticities, and that the functions involved are multiplicative. The variables in question could be measures of scale or bed size, the importance of outpatient services, severity of cases, etc. Using a two-factor production function, the relationship postulate is symbolized as follows:

$$6.\ P = AK^{k(X_1X_2\ldots)}\ L^{\ell(X_1X_2\ldots)}$$

Optimum capital-labor ratios are then given as

$$7.\ K/L = (\frac{W}{r})F(X_1,X_2,\ldots)$$

As it is expressed, this relationship has a strict rational, with meaningful economic content, and a certain flexibility for introducing variables which on empirical grounds are judged to influence output elasticities. While it assumes there is a measurable input-output relation, output does not appear explicitly in the equation. There are, however, several reasons why a great deal of caution must be exercised if (7), or an expression similar to it, is to be used for testing hypotheses about w/r, and other variables.

The most important reasons is that cost minimization is assumed in deriving (7). Thus it provides no opportunity for rejecting the hypothesis that hospitals are guided by allocative principles. The conviction in this maintained hypothesis (and thus the suitability of 7) must depend on the reasons why hospitals are expected to minimize costs in the first place. Since these reasons are more conveniently discussed as a separate line of inquiry, their exploration is given in the final section of this chapter.

A second objection to (7) is that the implicit production function is assumed to be identical for all hospitals, differing only in the value of its parameters. Third, it devotes most of its attention to output elasticities, constrains the elasticity of substitution to unity, and ignores other potential parameters - which may be appropriate for some hospitals, but not for others. Finally, it is implicitly taken for granted that the output to which the elasticities refer is unambiguous.

The differentiated or multi-product nature of hospital production militates against any simple, homogeneous measurement of output.[9] This problem is magnified when in addition to patient services or in conjunction with patient services, hospitals are also producing medical capital, through teaching and research activities. In studies of hospital costs one approach has been to adjust for this heterogeneity by weighting output (according to case-mix proportions (12; p. 66), or to introduce independent variables for that express purpose (19; p. 49) (8; pp. 54-56). This is consistent with an approach which regards the "production function" to be the same for all hospitals, differing only in the magnitude of its parameters. However, an other approach has been to classify hospitals according to special characteristics, and to estimate different cost functions for each class (4) (8). This seems to suggest

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[9]In effect, Feldstein's introduction of case-mix as determinants of output elasticities was an adjustment required because number of cases is not a good measure of output, when different hospitals are to be compared.

that the implicit production functions may differ as to form as well as the magnitude of parameters.[10]

Despite these objections to the use of (7) as a basis for empirical estimation, the construction of (7) is interesting. It suggests a plausible way of estimating the tendency for various factors, including the relative wage, to be systematically related to the capital-labor ratio, when there is an interest in identifying the other factors that may be involved as well as their relative importance. In appearance the relationship suggested is equivalent to a generalization of (5), as follows:

8. $K/L = G(w/r, X_1, X_2, \ldots)$

By preserving the multiplicative form this relation captures the essence of (7); but it is not necessarily rationalized as the reduced form of a production function, with cost minimization. The latter interpretation may, of course, be retained, maintaining one of a variety of possible assumptions, as will be described in Section 3. However, even in the absence of strong convictions as regards hospital motivation, (8) provides a basis for empirical estimation of the extent to which substitution is a practice in hospitals. In effect the strict arguments in terms of production function parameters are redescribed in weaker terms, as allocative effects which deepen capital, and technological or operational effects which widen capital. Thus, considered in this light, K/L is not to be regarded as necessarily optimal, nor are the coefficients estimated for w, r, and other variables to be regarded as a

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10After examining several specifications, M. Feldstein adopts a recursive model with beds and medical staff (expenditures) as exogenous inputs. But he cautions, "it would be unwise to be dogmatic about the 'proper' specification of a model of hospital production" (12;p.124).

strict basis for determining the magnitudes of production function parameters. Rather, the coefficients are empirical descriptions of the tendencies for these variables to influence capital-labor ratios.

This weaker formulation is a disadvantage to be sure, but its provision for a thoroughly eclectic approach in measuring and selecting variables is an advantage when there are reasonable doubts not only about the appropriateness of a single form production function, but also about the measurement of the variables which are designed to test the principal hypothesis. (These latter problems and their relevance are discussed in Chapter IV.)

By using this approach it is also possible, in the same spirit, to inquire as a purely empirical matter into the tendencies for these variables to influence capital-bed ratios. For example, the hypothesis that hospitals try to achieve allocative efficiency implies that a higher relative wage, ceteris paribus, would result in more capital intensive production - higher capital-bed ratios, as well as higher capital-labor ratios. Whether or not capital-labor and capital-bed ratios can be expected to be influenced by other factors, in similar ways, is a question to be considered on other grounds, and ultimately determined by empirical analysis.

3.

The hypothesis maintained in order to place a rigorous interpretation on the relationships derived in Section 2 is that voluntary short-term hospitals are guided by allocative principles in deciding how to use capital. And this motivation to use capital and labor in least-cost proportions provides the basis for postulating further that capital widening aspects in capital-labor (bed) ratios are also predictable from organizational and production characteristics of individual hospitals. Since this is a controversial point of view, it is instructive to begin by stating the reasons why it is questioned.

There are two primary a priori reasons why it is believed that voluntary hospitals do not use capital in conjunction with labor in least cost proportions. The first is summarized in Long's view - viz., once having acquired capital funds (from government or private philanthropic sources) the hospitals are under no explicit constraint to pay or produce interest on the physical capital that is purchased (29; pp. 212-213). That is, there are no incentives requiring recognition of the opportunity cost of capital. The second reason is that hospital costs are subsidized - through negotiated rates, based on costs, with insurance companies and various levels of government, and through private transfers to cover deficits - whatever they happen to be. That is, there are no (impersonal) demand pressures that force hospitals to compete on the basis of price of services.

The credibility of these views is strengthened by empirical arguments which allege that facilities and sophisticated equipment tend to be unnecessarily duplicated, especially where hospitals have easy access to funds. This tendency has been rationalized as a prestige bias (34), and as a competitive device to attract medical staff (39).

Obviously these arguments cannot be dismissed lightly. They are based on a solid awareness of the institutional framework within which privately operated, voluntary hospitals function.

However, the negative conclusions expressed in these arguments should be regarded more so as warning signals than as logical propositions. More precisely, we are advised as to what hospitals won't do without being told what they are doing.

The first argument, that no interest must be paid on capital, is probably the most serious. However, in this regard, it should be pointed out that recognition of opportunity costs does not require an explicit financial obligation.[11] Moreover, there can be little doubt that it is the recognition of the opportunity cost of capital that is questioned, because even those who have suggested it is not recognized have propounded views which imply some concept of cost is to be minimized.[12]

If the opportunities sacrificed by employing capital are to mean anything to hospitals (i.e., to be counted as a part of the costs to be minimized), they must have a bearing or an influence on whatever it is managers want to obtain from operating the hospital. The assumptions of output maximization or utility maximization, with quantity and quality as arguments, are vague in this respect because they do not link up capital's opportunity cost and the costs to be minimized in a direct way. This is because the sacrifice itself is not directly linked with what is to be maximized. Indirectly, however, the link is there.

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[11] Suggesting that hospitals do not recognize the sacrifice of opportunity because capital is given to them with no further financial strings, is similar to suggesting a business man will think it is cheaper to operate his firm with capital that was inherited from his parents than it is to operate with capital he has purchased in the market. We know this is in error, because we know what he wants from the operation of this business - profits. And profits - not cash flows - are affected by the (implicit) sacrifice of income occasioned by the use of capital in this capacity rather than in another.

[12] Long proposes hospitals will try to maximize the number of patients seen, subject to several constraints, one of which is a specified loss constraint (29; p.212). Newhouse has shown cost-minimization is also implied by assuming hospital managers try to maximize a utility function, with patient days or admissions and quality of care as arguments, subject to a budget or loss constraint (34; pp. 64-65). Klarman also proposes that hospitals will try to maximize output by serving as many patients as possible, subject to a deficit constraint (22; p. 121).

Consider the problem of maximizing output. With a given operating budget and given capital it is possible to employ a certain amount of labor at current wages, and produce a certain output. With capital and labor substitutable in some degree, however, it may be possible to produce a greater output. If, for example, the opportunity cost of capital is sufficiently high (relative to marginal labor costs), it may be possible to employ less capital directly, internalize what was previously sacrificed on the capital increment, use it to employ more labor, and, as a consequence, expand output. Thus it seems obvious that the budget that is relevant to the problem of output maximization includes the implicit rent bill for capital as well as the explicit operating budget.

Like most theoretical mechanisms the above is a logical proposition which is not likely to be accepted as a literal description of how hospitals operate. However, its value as an acceptable theory for prediction purposes does not depend on its merits as a literal description of events. As a practical matter substitution can only occur when capital is being allocated. But it is precisely at this point when the price of capital goods is explicit and relevant to the hospital. As it engages in the process of buying new equipment, rennovating or expanding facilities, the hospital is necessarily aware of the funds that are sacrificed, their alternative yield if invested in securities or real estate (and the flow of labor services such yields could provide), the future cost of debt service if funds must be borrowed, and the probable impact on philanthropic sources of funds. If output maximization does motivate the hospital, it seems unquestionable that the possibilities for substitution will be thoroughly explored and exploited at this point.[13] In any case,

[13]Professor Rice once expressed the view that voluntary hospitals do endeavor to combine resources so as to minimize production costs (40; p.87),

regardless of the difficulties encountered in describing easily perceived demonstrations of how or when substitution occurs, the conviction that it does occur stems from the fact that if it does not, hospitals won't succeed in maximizing output.[14]

There are further objections to the literal validity of the implications because the problem of varying input proportions to increase output is viewed as a problem of managing resources that exist in concrete forms, and because "opportunities sacrificed" are mistakenly interpreted from an expost point of view. One effect is the frequent observation that it is difficult to substitute capital for labor in hospitals. Another is to minimize the importance of opportunities sacrificed in employing capital, even if they are considered. That is, it is not reasonable to suppose hospitals can "internalize" much of anything by disposing of an increment of capital because, once in place, hospital capital has little value for any other purpose.

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[13](Cont'd) and offered a constrained sales maximization hypothesis as an explanation. In applying this model to voluntary hospitals, Rice found it to be consistent both for hospitals who must generate funds internally to pay for capital, and for hospitals who receive private transfers to subsidize deficits. Letting P represent the price per unit of service implicit in the hospital's structure of charges (based on historical costs), output is $f(K,L)$, r and w respectively the per unit service prices of capital (K) and labor (L), and D the deficit that will be subsidized (this could be positive, zero, or negative), the hospital's objective function is as follows:

$$F = Pf(K,L) - \lambda(Pf(K,L) - rK - wL - D)$$

The derivatives of F, when set equal to zero, yield the first order conditions for cost minimization - i.e., relative marginal product equal to relative factor price.

[14]It may also be worth reporting that in a number of conversations with hospital presidents and managers comments were made indicating that likely impacts on operating budgets after proposed capital projects were brought into operation were among the considerations leading to decisions about particular projects. One vice president of a major hospital in New York City stated, in particular, that upon receiving a proposal for a capital acquisition he immediately inquired as to the probable impact on labor costs.

The theory, however, is an ex-ante proposition that applies to the problem of resource allocation when the problem is being solved - when, as Professor Hicks states, capital is in a "free" state (17; p. 25). There is, moreover, an important empirical circumstance indicating that voluntary hospitals do proceed in the manner suggested. It is observed, for example, that some hospitals hold accumulated wealth in the form of financial and other non-hospital assets, rather than in expanded physical capital. The literal explanation of this is that this wealth is being held for revenue purposes - the revenue being used to staff and otherwise finance hospital production of outputs which are not provided for by current pricing policies. But a plausible economic interpretation of this is that in some circumstances hospitals find the relative productivity of labor to be higher than the implicit factor price ratio. That is, output is expanded more by using the wealth to employ some labor than would be the case were it all used to expand physical capital.

The empirical challenge to the maintained hypothesis is the alleged tendency for voluntary hospitals, those with easy access to funds in particular, to invest in capital plant, facilities, or sophisticated equipment that are under-utilized - unnecessarily duplicated.

The principal evidence of this tendency is in nominal measures of utilization - such as low bed occupancy rates (27; pp. 95-96), or number of operations per operating room, per year (46; p. 53). The question is whether or not these empirical observations are consistent with the hypothesis that voluntary hospitals try to use capital in least cost proportions.

Typically each aspect of performance that is criticized is considered in isolation from other capacity constraints which exist in the hospital, and without reference to the past or the future. However, even from a static point of view this evidence may not be a challenge to the general validity of the hypothesis maintained; and, in fact it may suggest the opposite of what is proposed.

The observations are, in the first place, made on the allocation and utilization of resources in concrete form. In this state production relations are expressed in a discrete manner. They appear in the guise of linear segments and sharp corners - with imperfect coordination and few opportunities for substitution. However, even if allowances are made for this consideration, something called under-utilization might be observed. The reason is that a requirement of cost-minimization (unless labor is free) is that the marginal product of labor not be zero. Thus if voluntary hospitals are trying to allocate capital and labor efficiently it will not be surprising to find instances in which nominal utilization in a given facility can be expanded with the employement of more labor.

This result is also compatible with the view that this under-utilization will tend to be associated with easy access to funds. The reason is that wages relative to the implicit rental cost per unit of capital is high for such hospitals (other things equal) and, thus, least-cost adjustments require (1) higher capital-labor ratios and (2) higher marginal product of labor relative to the marginal product of labor.

To summarize, despite a priori and empirical views which challenge it, the maintained hypothesis that voluntary hospitals will try to use capital and labor in least-cost proportions is plausible. However, the uncertainties regarding motivation, and what appear to be outrageous duplications, are compelling reasons for using great caution in interpreting results whose meanings, in a rigorous sense, depend on the acceptability of the cost-minimizing assumption.

In the following chapter, the relationships developed in Section 2, above, are used to estimate the empirical importance of the practice of substitution in a sample of voluntary short-term hospitals.

CHAPTER IV

EMPIRICAL ANALYSIS OF CAPITAL-LABOR AND CAPITAL-BED RATIOS

1.

In this chapter the substitution of capital for labor and the behavior of capital per bed are analyzed by multiple regression techniques, utilizing the general relation (8) developed in Chapter III. According to this relation capital intensity is a function of the hospital wage relative to the price of capital, and other variables which modify production relationships among hospitals.

In Section 2, the hospitals comprising the sample are described in a number of distributions by those variables which are expected to play a central role in the analysis. The reasons for these expectations, and the interest attached to their respective roles are discussed. Problems relating to the measurement and relevance of the variables used are examined, and the specific hypotheses to be tested are given.

The results of the statistical analysis are given in Section 3. The chapter concludes with a summary and interpretation of the empirical findings.

2.

The sample hospitals upon which the substitution of capital for labor is observed are all of the short-term voluntary class (those referred to previously in Chapter II), and they constitute a major part of the voluntary system of general hospital care in New York City. They include in their number large teaching hospitals, small community hospitals, Catholic hospitals, hospitals with large financial endowments, and hospitals who receive very modest philanthropic support. Their combined bed capacity in 1965 was 16,738 beds, or 71 percent of the total voluntary general care bed capacity in the city.

As indicated by their distribution in Table 18, one half of the hospitals were in the 200-400 bed size range. However, there were 5 hospitals with fewer than 200 beds, and 5 with 700 or more beds. The coefficient of variation, .74, indicates the substantial variation in bed size which exists among these hospitals.

The relative variation of capital-labor and capital-bed ratios is not as large as the relative variation of bed size (Table 19).

Twenty-one hospitals had capital-labor ratios in the \$2-\$3 range. However, 5 had ratios of less than \$2, and 3 had ratios of \$4 or more. Capital-bed ratios ranged from \$6,314 to \$30,876, with 9 hospitals having \$20,000 or more per bed, and 14 having less than \$12,000 per bed.[1]

[1]Capital and labor, as measured here (real value of capital stock - centered for each year, and crude labor - proportional to the number of employees) are imperfect proxies for the theoretical concepts. Thus, while measured capital avoids most of the major defects created by changing prices, it represents, for each hospital, an aggregation of physical properties whose proportions may vary considerably across hospitals. Its flow of services, assumed to be proportional to stock, is, accordingly, subject to measurement errors. Crude labor, if taken at face value, is a poor description of labor services because the proportions in which various types of labor skills are employed can vary, and because certain labor services aren't counted. Attending physicians who work in the hospital, but are not employed by the hospital, are not counted. This is the case also for some private duty nurses, who are paid on a fee basis by the patient, and for volunteer services. The general nature of these omissions, suggest they are scale related. As an approximation the undercounting may be proportional to employees. This is, however, a source for measurement error. Regarding the use of crude labor, generally, such a measure is acceptable, in the case of homogeneous output, if labor proportions are the same across hospitals --or, assuming cost minimization, their relative wage rates are the same (17; p. 339). In the present case, however, output is a heterogeneous complex of services. There is no presumption that production relationships for different hospitals are the same. Thus labor proportions, independent of relative wages, can vary in order to satisfy production relations in each hospital, or hospital class. Since, as will

Table 18

Distribution of 38 Voluntary Hospitals by Number of Beds, in 1965

Beds - Class Size	Under 200	200-299	300-399	400-499	500-699	700 or more
Number of hospitals	5	10	9	4	5	5

Mean	440.47
Standard deviation	326.40
Coefficient of variation	.74

Table 19

Distribution of 38 Short-term Voluntary Hospitals by Capital per Employee, Capital per Bed, and Capital per Payroll Dollar in 1965

a. Capital per Employee[a/]

Capital-Labor Ratio	1.00-1.99	2.00-2.49	2.50-2.99	3.00-3.49	3.50-3.99	4.00 or more
Number of hospitals	5	10	11	5	4	3

Mean	$2.813
Standard Deviation	.798
Coefficient of Variation	.284

b. Capital per Bed

Capital-Bed Ratio	6,000-9,999	10,000-11,999	12,000-14,999	15,000-19,000	20,000-24,000	25,000 or more
Number of hospitals	6	8	6	9	5	4

Mean	$15,652.00
Standard Deviation	6,051.00
Coefficient of Variation	0.387

c. Capital per Payroll Dollar

Capital-Payroll Ratio	.70-.89	.90-1.09	1.10-1.29	1.30-1.49	1.50-1.69	1.70 or more
Number of hospitals	4	11	7	6	8	2

Mean	$1.240
Standard Deviation	.322
Coefficient of Variation	.260

a/Capital is measured as the average value of real stock in use at the beginning and the end of the year. Employees are measured as the number of full-time and full-time equivalent employees, multiplied by 2000. The basis for this scaling as an approximation to "hours" is discussed in the appendix. It has no effect on the statistical analysis.

It is interesting to observe, in panel c, that the coefficient of variation for capital per payroll dollar (.26) is almost as large as the coefficient of variation for capital per employee (.28). While this may lend itself to a number of different interpretations, it suggests that the variation in capital per employee is approximating real variations in capital-labor ratios. For example, the variation in capital per employee is not a spurious reflection of qualitative differences in labor which are eliminated when employees are weighted by salaries - i.e., when labor is approximated by the payroll.

The variables by which the allocative substitution of capital for labor is to be measured are the hospital wage and endowment assets per bed - as a proxy, taken to be inversely related to the implicit price per unit of capital.

The measure of wage to be used in this study is (proportional to) unit payroll costs - total payroll divided by total employees (full-time and full-time equivalent). Obviously this measure is influenced by the proportions in which employees are distributed by wage class. Efforts

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[1](Cont'd) be described in the text, average hourly payroll costs is the only variable representing directly the scale of wage rates that is available for the sample hospitals during the study years, no adjustment could be made for potential variations in relative wage. Thus the working assumption employed is that although absolute wage levels vary, relative labor wage rates are approximately the same across hospitals. More precisely, such variations as do occur are random and uncorrelated with other factors that influence capital-labor ratios. The implication of this (strong) assumption is that the major reasons for labor proportions to vary are to be found in those factors which influence production relations within the hospital. Under these circumstances the use of crude labor is acceptable so long as variables are also included in the analysis which allow for variations in these factors. However, since the link between labor skill proportions and these other variables is unknown, and may be tenuous, two further adjustments are made by introducing the proportion of nurses and the proportion of residents and interns to total staff as corrections in the regression analysis.

made to obtain this information were unsuccessful; thus no direct adjustments could be made. However, a major reason why these proportions are expected to vary is because the occupational composition of crude labor varies. As outlined in the discussion of measuring labor as crude labor (footnote 1), the composition of labor skills is expected to vary primarily because of differences in the requirements that are imposed on production relations by differences in the nature of hospital services.[2/] In addition to the fact that variables measuring such differences in the nature of hospital services are to be included in the analysis, the proportion of nurses, and residents and interns to total staff are to be included as further corrections.

However, assuming modest variations in relative wages (more precisely, variations that are not correlated with variations of other variables used in the estimating equations) the relevance of the measure of wage offered here requires further explanation. At the theoretical level the question is why, within the City of New York, should there not simply be one supply curve for, say, the services of X-ray technicians; and, thus why, if occupational mix is properly accounted for should there be any differences among hospitals in the hospital wage.

The conclusion that all hospitals are confronted with the same supply curve for a particular occupational skill, assumes necessarily that each member of that skill class is indifferent as among hospitals in which services may be supplied. The reasons for doubting this assumption in the case of New York City are differences in transportation costs, and differences in the neighborhoods within which hospitals are

[2] In 1965, for example, the correlation between the wage rate and X-ray films per admission is .3614, which is significantly different from zero. The assumption is that in hospitals where X-rays per admission are higher, higher labor skills are relatively more important in the total labor employed.

located. A religious bias may also make some members of an occupational class distinguish between those hospitals among which they are indifferent and those hospitals in which they are reluctant to work.

These are grounds for suspecting that not all hospitals within the city face the same supply curve for each occupational class. However, there is some modest empirical evidence which indicates that the hourly wage for given occupations is variable across hospitals. Based on a payroll analysis of a few hospitals, some of which are in the sample for this study, Bunker reports minimum hourly wage rates for 6 occupational classes in 10 hospitals (for 1959, 1960, 1963, and 1966) (7; pp. 94-99).

In 1960, for example, the highest minimum wage for kitchen helpers was 35 percent greater than the lowest minimum wage. For X-ray technicians the comparable difference was 44 percent. For nurse's aides it was 28 percent. By 1966, under the influence of the unionization movement in New York City voluntary hospitals, the proportional differences reported among these same hospitals, although much smaller, still existed. The proportional difference for kitchen helpers, for example, was 12 percent. For X-ray technicians it was approximately 29 percent. And for nurse's aides it was about 19 percent.

Apart from these general questions, the hospital wage, as measured, contains an error because hospital living quarters are granted to some employees as a part of total compensation. In the analysis to follow, an adjustment for this error is made by including the proportion of staff living in hospital quarters as a variable.

In Tables 20 and 21, the distribution of hospitals by average unit payroll costs, as the wage proxy, and the proportion of staff living in,

Table 20

Distribution of 38 Short-term Voluntary Hospitals by Payroll Costs per Employee: 1960 and 1965

Payroll Cost per Employee[a]	Number of Hospitals 1960	1965
Less than $1.40	7	-
$1.40 - 1.49	8	-
1.50 - 1.69	12	-
1.70 - 1.79	9	-
1.80 - 1.99	1	6
2.00 - 2.19	1	8
2.20 - 2.39	-	11
2.40 - 2.59	-	11
2.60 or more	-	2
Total	38	38
Mean	$1.5685	$2.2688
Standard Deviation	.19290	.22215
Coefficient of Variation	.123	.098

a/Employees multiplied by 2000 (approximation of hours per employee).

Table 21

Distribution of 38 Short-term Voluntary Hospitals by the Proportion of Staff Living in Hospital Quarters: 1960 and 1965

Proportion of Staff Living in	Number of Hospitals	
	1960	1965
.0 - .04	1	9
.05 - .09	8	5
.10 - .14	6	9
.15 - .19	8	6
.20 - .24	8	4
.25 - .29	3	3
.30 and over	4	2
Mean	.1783	.1345
Standard Deviation	.0872	.0876
Coefficient of Variation	.4891	.6513

respectively, are given for the years 1960 and 1965 - the first and terminal years of the study.[3] These distributions show an upward shift in the wage, accompanied by a modest downward shift in the proportion of staff living in, during the six-year period. However, while the means of these variables are shifting as indicated, their distributions across hospitals appear to be stable, with only small changes in standard deviations.

The intercorrelations between these variables, as observed for the two years (Table 22) are further indications of the stability of these distributions and the connection between them.

In each year the correlation between hospital wage and proportion of staff living in is negative and significantly different from zero. And, although there are four interviewing years, and there have been adjustments in the proportion of staff living in, the correlation between wage-1965 and wage-1960 is .6064. The correlation between proportion of staff living in in 1960 and 1965, is even higher at .7625.

Another question in connection with the hospital wage (and one that arises in connection with other explanatory variables as well) is whether or not it is reasonable to regard the wage as being exogenous.[4]

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[3]The "hourly" wage is proportional to unit payroll costs, the unit payroll cost being divided by 2000. This is the same proportionality factor (a crude estimate of annual hours per employee) used in converting the capital-labor ratio to estimated capital per labor hour. It is based on the judgment of a number of personnel directors (as described in the appendix) that declines in the work week have been compensated by increases in overtime. The object in so converting unit labor costs and employees was to provide an approximation to more traditional and familiar scales for these variables. The conversion has no effect at all on the statistical analysis.

[4]Using ordinary least squares to estimate a regression coefficient for an explanatory variable that is simultaneously determined by the hospital will result in a biased estimate of the coefficient (20; pp.231-234).

Table 22

Correlations Between Unit Payroll Costs (WAGE) and Proportion of Staff Living in Hospital (SLIN), for 1960 and 1965: 38 Hospitals

	WAGE		SLIN	
	1965	1960	1965	1960
WAGE 1965	1.0000	.6046	-.3233	-.4053
WAGE 1960		1.0000	-.3006	-.3753
SLIN 1965			1.0000	.7625
SLIN 1960				1.0000

This merits attention, since it does not appear that all hospitals are facing the same supply curve for given occupational skills. From the empirical relations expressed in Tables 20 and 22, it seems that all hospitals have experienced secular increases in the wage that is paid, but that the differences that exist among hospitals tend to persist.[5]

Hence, as an empirical matter the system of differentials seems (at least for a short number of years) to be largely of historical origin. Secular increases, on the other hand, seem to be shared by all the hospitals. This outcome could have an a priori explanation if, for example, there existed an exogenously determined opportunity wage by an alternate employer, under working condition that tended to neutralize the reasons given for differentials in the first place - say, location and religion. That is, the outcome is predictable if there is a major employer in the area who acts exogenously to set a generally positive wage differential, and who is at the same time neutral with regard to religion, and who offers employment opportunities in a number of locations.

In New York City, the city itself seems to act in this capacity. Bunker compares average hourly wages for 7 occupational categories in voluntary and municipal hospitals, for 3 different years, 1960, 1963, and 1966. With a single exception, the city paid higher wage rates in each category, and, although they tend to diminish over the years, these differentials still existed in 1966. The proportional difference in the nurse's aide category, for example, declined from 40 percent to 24 percent (7; p. 105).

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[5]Unionization began in New York City voluntary hospitals in 1958, thus, perhaps amplifying the secular rise. This may also have resulted in some distortions in differentials. However, those hospitals (generally) with a low wage in 1960, also paid a low wage in 1965.

The unionization movement gained considerable momentum during these years, however on the basis of the limited data available unionization per se does not appear to have upset the role assigned here to the city as an employer. For example, minimum hourly wage for kitchen helpers in 2 unionized hospitals increased by 30 and 22 percent, from 1963 to 1966. But the increases in 2 non-unionized hospitals were similar, 37 and 24 percent.[6]

In view of these considerations it seems feasible to proceed with the assumption that the wage is exogenous for the individual hospital. The proportion of staff living in hospital quarters, as an adjustment of the wage, is, on the other hand, endogenous and, thus, its coefficient as estimated in the regression equation will not necessarily be unbiased.[7]

Endowment assets per bed is intended to measure variations in the implicit cost at which the hospital can obtain capital. In terms of the theoretical model it is a proxy for the reciprocal of the price per unit of capital. Thus it is postulated that a hospital with relatively high endowment per bed, will find it relatively less costly to obtain capital.[8]

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[6]It may also be pointed out that these similarities cannot be explained away by lower minimums in 1963 for the non-unionized hospitals. In 3 of the hospitals, 1963 minimums for kitchen helpers were identical, while it was larger in the fourth (non-unionized) hospital.

[7]Living quarter capacity seems to change very slowly for the sample hospitals, with downward shifts in the proportion of staff living in resulting primarily from the expansion of total staff.

[8]An example in terms of rental rates may be used to illustrate the point. Suppose 2 hospitals were to consider renting a unit of capital for one hour. The commercial rental rate is the same for both hospitals; but while one hospital can obtain this rent from its philanthropic constituency for a small expense, the other hospital, not so favorably connected with philanthropic sources, can obtain this rent only by making a larger expense. Thus the rental price is higher for the latter hospital. It is higher to the output maximizing hospital in a real sense because the alternative use of the added expense - say, additional nursing services has an effect on output.

There is, of course, considerable room for speculating on the interpretation of this variable. Endowment fund assets, as such, constitute an accumulated stock. Thus while relative to beds they undoubtedly are an indication of the hospital's present capacity to obtain funds, they also reflect a portion of its historical philanthropic strength as well. There is not, however, a direct tautology involved as would be the case if endowment assets were in fact simply stocks of accumulated assets being held temporarily pending the acquisition or replacement of physical capital. This they are not.[9] Thus it is not being suggested that the price of obtaining capital must be lower (say) because the hospital has more accumulated capital funds.

On the other hand, it cannot be stated to what extent an increase in endowment asset per bed will reduce the cost of capital, because the relationship that is assumed to exist between these two variables is not actually known or observable. In general the assumption requires that the cost of capital be less if endowment assets per bed are higher, but the form in which the variable should be introduced into the analysis is not clear. As approximations, two options seem to be appropriate - the log of endowment assets per bed, or the natural value of endowment assets per bed.[10]

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[9]Endowment assets are held generally in the form of stocks and bonds, some cash, and other types of property - such as mortgages or real estate. They are typically (and a study of the financial records of the sample hospitals indicates this is virtually always the case) used to produce revenue with which inputs other than physical capital are acquired.

[10]Theoretically the wage is to be measured relative to the price per unit of capital services (c). As an approximation, $c = P(\delta + r)$, where P is the price per unit of capital stock, δ the rate of replacement, and r is the cost of capital (15; pp. 392-393). Although Jorgenson derives this expression under static expectations about the price of capital goods, and optimal capital stock based on profit maximizing principles, it is an instructive approximation where there is an optimal capital stock on cost minimizing grounds. Thus, c varies as r

The distributions of sample hospitals, and their bed capacity, by endowment assets per bed are given in Table 23. For more than one-half the hospitals, but for less than on-half the bed capacity, endowment assets per bed are less than $1,000 in both the initial and terminal years of the study.[11] However, 9 hospitals in 1960 (with 41 percent of total beds) and 10 hospitals in 1965 (with 43.8 percent of total beds) had endowment assets per bed of $10,000 or more. Thus, in terms of hospitals, the distribution is skewed to the right.

The tendency for hospitals with larger bed capacities to be relatively higher endowed per bed offers one possible explanation for

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[10](Cont'd)
varies, becoming larger as r increases, and vice versa. However, even if r were at a minimal level, say, 1 percent, c would always be greater than $P\delta$. The basic assumption about endowment assets per bed is that their increase signifies a decrease in r, and conversely. However, it is not to be supposed that r can ever become zero, because even an extremely wealthy hospital must pay for communications, allocate other resources for campaign expenses, the management of funds, and general public relations work in order to coordinate its demand for funds with the specific sources of supply. Thus, r is best conceived as having two components: a constant, minimal, component (equivalent, say, to transaction costs in exchanging financial assets), and a variable component which is inversely related to endowment assets per bed (E). Speaking generally, it is the latter connection between E and r that is assumed to be the source of differences among hospitals in c. However, if for some hospitals there is no such relation, c is taken to be the same - at its minimal level - for all such hospitals. Regarding the possible relationship between r and E, two forms seem appropriate: $r = AE^{-a}$, and $r = 10^{\lambda - aE}$. Since in the analysis, the equations are to be estimated in logarithmic form, the first alternative introduces log E as a variable, while the second alternative introduces E in its natural form. If for some hospitals a does not exist (variations in E do not result in variations in r) the interpretation is that r is at its minimal level. However, where it exists, the results of the regression analysis will make it possible to evaluate the implied magnitude of a.

[11]Eleven hospitals in 1960 and 9 in 1965 had no endowment assets listed in their balance sheets. In terms of the variable - endowment assets per bed, as a proxy for the reciprocal of rental rate - this poses a problem since it implies these hospitals could acquire no capital (i.e., rent is infinite). In fact, however, an inspection of the accounts for these hospitals showed that they, like other hospitals, were able to obtain contributions, and other gifts for capital purposes. Thus,

Table 23

Distribution of 38 Short-term Voluntary Hospitals and Hospital Beds, by Endowment Fund Assets per Bed: 1960 and 1965

Endowment/Bed Class	1960			1965		
	Number of Hospitals	Hospital Beds		Number of Hospitals	Hospital Beds	
		Number	Percentage		Number	Percentage
Less than $1,000	22	6,998	45.3	20	6,638	39.7
1,000 - 4,999	5	1,167	7.5	6	2,141	12.8
5,000 - 9,999	2	952	6.2	2	624	3.7
10,000 - 29,999	6	3,092	20.0	7	3,595	21.5
30,000 and over	3	3,240	21.0	3	3,740	22.3
Totals	38	15,449	100.0	38	16,738	100.0

	1960	1965
Mean (Endowment/Bed)	$ 6,298.8	$ 7,688.5
Standard Deviation	10,919.0	13,064.0
Coefficient of Variation	1.73	1.70

this type of distribution; however the tendency is rather weak (as is suggested by the bimodal character of the distribution in terms of beds). In 1960 there were 5 hospitals with bed capacities exceeding 400 beds, but with less than $1,000 in endowment assets per bed. By contrast, the largest hospital in the $1,000 to $5,000 class had 310 beds, and only 2 of the hospitals in the $10,000 to $30,000 class had more than 400 beds.

Further investigation of the character of the sample hospitals, particularly those with endowment assets per bed in excess of $10,000, suggests medical education may offer a more consistent explanation. Of the 9 hospitals in 1960, with endowment assets per bed in excess of $10,000, 7 were heavily engaged in teaching acitivites. In 1965, the corresponding figures were 8 of 10. With one exception (in1965) these teaching hospitals were major medical school affiliates, and they included all but 2 of the major medical school affiliates in the sample of 38 hospitals.

These findings suggest that the raw measurement of endowment assets per bed reflects not only the strength of philanthropic linkages to sources of capital funds, but also the strength of linkages with a constituency that is concerned with medical education. It is, consequently, important that the effect of teaching activities be taken into account when estimating and interpreting the relative impact of this variable on the capital-labor ratio or capital per bed.

The hospital wage and endowment assets per bed are, according to the hypothesis, expected to have positive signs. As was indicated the

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[11](Cont'd) while the implicit "price" may have been relatively high, it was clearly finite. Arbitrarily a value of $1 was assigned to these hospitals. This served the dual purpose of making some move for the logical requirement of a finite price and at the same time making it possible to use log transformation of the data in the regression equations.

proportion of staff living in is, first of all, an adjustment to the wage variable. However, in most instances, the bulk of quarters provided are nurses quarters. Thus there are potential organizational or service overtones which may make the coefficient estimated interesting in its own right, even though it may not be unbiased. Since the emphasis is on nurses quarters the net effect may be an overall labor intensive adjustment. Thus the hypothesis tested is that it will have a negative influence on capital-labor and capital-bed ratios.

The variables expected to influence capital-labor and capital-bed ratios through their impact on production relations (and thus on the alternative proportions in which capital and labor can be combined) are those which measure the heterogeneity of hospital output and bed capacity. The interest in the role these characteristics of hospitals and hospital services play in determining the allocation of capital stems first of all from the fact that evidence from cost studies indicates it may be necessary to take such characteristics into account if substitution is to be properly measured. Interest also stems from the fact that there is a tendency in hospital planning circles to encourage the use of parameters based on such characteristics in setting forth guide lines for the establishment of hospitals as functional units within a community. Clearly the manner in which capital allocation is influenced by these characteristics is relevant information since the effect of altering the requirements for capital will influence the demand for capital.

Three aspects of heterogeneous output are distinguished for analysis - the complexity of patient services, the relative importance of outpatient services, and the extent of teaching activities.

With respect to complexity of services, the proposition is that hospitals are different in the extent to which they specialize in treating medical cases of varying difficulty; and that variations in complexity (reflecting the extent of specialization) affect the opportunities for combining capital and labor in alternative proportions. This view is consistent with studies of hospital costs in which different cost functions are found for hospitals who specialize in different service arrangements - e.g., in Carr and Feldstein (8). However, the problem here, as it is in cost studies, is to select the means by which variations in complexity are to be measured.

In general the conceptual problem is always the same - hospital output measured nominally as patient days or admissions is not comparable across hospitals because each unit of nominal output measures something different in each hospital.[12] In his study of British hospitals, Martin Feldstein selected the case (admission) as the nominal unit of output because of the "possibility of a trade-off between the length of stay and cost per week" (12; p. 24). Moreover his explanation of why case-mix differences affect cost per case is that different types of cases require different kinds and amounts of services (12; p. 23). Thus his position seems to be that the admission (the case) is the central unit with respect to which inputs are controlled, and that length of stay is, at least in part, an implication of how inputs being associated with the patient during the course of the stay are controlled.

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[12]There are, accordingly, two facets to the measurement question: (1) which nominal unit is it with respect to which differences are to be taken into account; and (2) how are the differences to be measured? The reason why the patient day is frequently considered to be a nominal measure of output may be because it is commonly the unit in which hospital charges are quoted. However, there are practical reasons why, from the point of view of inputs or their cost implications, the patient day as well as the admission may be relevant. For example, the use of some services, such as the operating room, may be identified with the admission, while other services, such as food and lodging, are related to the time spent in the hospital. Since the only time these measures

This position merits attention even if the possibilities for a tradeoff between cost per day and length of stay are not believed to be important. That is the patient (measured as the case or admission) is the natural unit with respect to which other inputs are controlled because, for example, there must be a patient before there can be patient days.[13] For these reasons the point of view is also adopted in this study.

The second aspect of differentiating the "work" of the hospital requires measuring the ways and the extent to which the nominal unit of output (the admission) measures something different in each hospital. In general this may be taken to mean adjusting for the kinds and amounts of services received by the patient. However the "services" are not themselves observable. What is observable are certain intermediate "products" which become visible at various stages in the process of treating patients - such as X-ray films and laboratory tests. It is important to emphasize the intermediate nature of these products. They are not themselves measures of the amount of "output" received by a patient. They are the forms taken by various inputs at various moments in the production of patient services. Thus they are evidence of the complexity or medical difficulty of the treatment. Differences between hospitals, evaluated in terms of the average intensity with which they produce these

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[12](Cont'd) would be equivalent, across hospitals, is when the average length of stay is the same in each hospital, it seems clear that there is a real dilemma, and that other grounds must be suggested for deciding which unit to use.

[13]The logical precedence of patients over patient days as the unit in production with respect to which inputs are controlled has its counterpart in other activities. It is common, for example, in agriculture to find market supply expressed in pounds or bushels, while the units about which production activities are controlled are quite different. It is, for instance, impossible to produce a single ounce of pork without produging an entire hog. Similarly, it is impossible to produce an apply without cultivating an apple tree.

intermediate products for their patients, are, then, indications of differences in the complexity of services provided, or, equivalently, differences in the medical difficulties of the patients being treated.[14]

Three variables are used to measure aspects of this concept directly - major operations per admission (OPRA), X-ray films per admission (XR-A), and laboratory tests per admission (LT-A). The distributions of hospitals by these variables, and by outpatient department, clinic visits per admission (OPDA) - the relative importance of ambulatory care - are given in Table 24, for 1965. These distributions show that in each case hospitals in the highest class intervals have observed values that are more than twice the values observed for hospitals in the lowest class interval. A comparison of coefficients of variation shows that LT-A, relative to its mean, tends to vary least although the coefficient of variation, 39.6, and the distribution of hospitals show that there are considerable differences among hospitals with respect to this variable. The coefficient of variation for OPDA is highest, at 68.2; moreover, in the distribution of hospitals, visits per admission for the 7 hospitals in the highest class is more than 5 times visits per admission

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[14]Although there is precedence for using this concept of complexity to distinguish the work of hospitals, or the medical complexity of the cases they treat (33; p.2), the approach obviously does not provide a perfect answer for a most difficult problem. One obvious defect is that the number of different intermediate products available for use are those which are reported in hospital service statistics - statistics relating to special facilities, such as operating and X-ray facilities. These measures may not capture important aspects of complexity which are provided for by relatively more intense applications of certain types of personal services. For this and other reasons, the use ofcase-mix proportions (as in Feldstein) is an appealing alternative. By emphasizing the type of medical problem for which a patient is treated it is possible to avoid counting the "services" he receives. (But then, of course, it is necessary to assume that all patients of a particular type represent the same degree of medical complexity and receive the same mix of services). Unfortunately data on patients by types of cases were not reported for the sample hospitals during the study years, thus the effects of this alternative specification of complexity could not be explored.

Table 24

Distributions of 38 Short-term Voluntary Hospitals by Major Operations, X-ray Films, Laboratory Tests and Clinic Visits --per Admission: 1965.

a. Major Operations per Admission (OPRA)

OPRA Class	Under .150	.150-.199	.200-.249	.250-.299	.300 and over
Number of Hospitals	4	7	8	7	12

Mean	.266
Standard Deviation	.111
Coefficient of Variation	.417

b. X-ray Films per Admission (XR-A)

XR-A Class	Under 4	4.0-5.9	6.0-7.9	8.0-9.9	10.0 and over
Number of Hospitals	4	11	10	8	5

Mean	7.348
Standard Deviation	3.668
Coefficient of Variation	.499

c. Laboratory Tests per Admission (LT-A)

LT-A Class	Under 15	15.0-17.9	18.0-24.9	25.0-34.9	35.0 and over
Number of Hospitals	4	8	9	12	5

Mean	24.691
Standard Deviation	9.774
Coefficient of Variation	.396

d. Outpatient Clinic Visits per Admission (OPDA)

OPDA Class	Under 1	1.0-1.9	2.0-2.9	3.0-4.9	5.0 and over
Number of Hospitals	4	9	7	11	7

Mean	3.285
Standard Deviation	2.240
Coefficient of Variation	.682

for the 4 hospitals in the lowest class.

Simple comparisons of hospitals on the basis of these variables are subject to a number of limitations. Perhaps the two most severe are that no allowances can be made for qualitative differences or differences in degree of complexity which distinguish the individual units that are summed to obtain observations on the respective variables. That is, the statistical treatment assumes (for example) that a major operation measures a homogeneous unit within and among hospitals.

Regarding quality, very little in addition to this can be said since quality is not measurable, at least not cardinally. However, the possibility that qualitative differences are a source for variations in production relations cannot be dismissed.[15] In the regression results this will not be a source of bias unless quality is correlated with other variables in the equations; thus the interpretation of relationships in this study proceeds on the assumption that this is not the case.[16]

Differences in the degree of complexity of the units summed to obtain the variables are no doubt considerable.[17] However, no direct adjustment is possible because the data on operations, X-ray films, and lab tests were available only as annual totals. Insofar as New York City hospitals differ in this respect from other groups of hospitals, the multiple regression framework provides an adjustment, since for example, it

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[15] Newhouse (34) suggests, for example, that qualitative improvements, generally, will shift average cost curves upward.

[16] In the DeBakey report the opinion is expressed that in order to "maintain the competence and experience of a well-trained team," the frequency of cardiac surgery within an institution should exceed once or twice a month (46; p. 56). Even if one were to generalize on the basis of this judgment, however, it does not follow that all increases in time frequencies imply increases in quality. Further, increases in time frequencies(or differences between hospitals) do not necessarily result in, say, more X-rays per admission.

[17] (See next page.)

may be expected that relatively more complex operations within hospitals will be associated with relatively more X-rays and lab tests per admission.[18] Unfortunately the most important point - differences across hospitals - cannot be taken into account. In order to view the general regression results for all hospitals as being unbiased, such differences in the composition of operations, X-rays, and lab tests, as remain between hospitals, must be taken to be uncorrelated with their amounts (per admission).

A third limitation on direct comparisons is the fact that the variables (OPR, XR-A, and LT-A) are intercorrelated, and because the totals employed (e.g., X-ray films) were available only on a hospital-wide basis. Thus, for example, the importance of LT-A can be assessed only if clinic visits per admission are taken into account.

In Table 25, the correlation matrix for these variables (in 1965) is given.

There are, on the basis of these statistics, significant relationships indicated in all but one case - the correlation between OPRA and LT-A is not significant.[19] However, as between the aspects of service complexity (OPRA, XR-A, and LT-A), these correlations are of modest magnitudes, indicating substantial residuals in their variations.[20]

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[17]A major operation, for example, can be (generally) any surgical procedure involving entry into a body cavity, or the reduction of a compound fracture.

[18]Empirical work shows a relation between the complexity of surgery and the charges for major classes of service, such as laboratory and X-ray (31; pp. 108-109).

[19]With 36 degrees of freedom $r > .321$ is significantly different from zero at the 5 percent level.

[20]For example, OPRA and LT-A combined explain about 35 percent of the variance in XR-A. Thus 65 percent of the variance in XR-A is unexplained by the relation with OPRA and LT-A.

Table 25

Correlation Matrix for Complexity of Service Variables and Outpatient Visits per Admission (1965)

	OPRA	XR-A	LT-A	OPDA
OPRA	1.0000	.5322	.1113	.5945
XR-A		1.0000	.3223	.7065
LT-A			1.0000	.3741
OPDA				1.0000

The general hypothesis to be tested is that treating more complex medical problems will tend to shift production relations within hospitals toward more capital intensive methods. It is expected that the coefficients estimated for major operations, X-ray films, and laboratory tests - per admission - will have positive signs in both capital-labor and capital-bed equations.[21]

Outpatient visits per admission is expected to have a negative influence on capital intensity, primarily because the patients receiving

[21]The interpretation of major operations, X-ray films, and lab tests as transitory forms assumed by inputs <u>in the process of</u> creating services for patients is crucial to the view that the hypothesis is being tested by the variables as defined. Otherwise it may seem that a positive association between capital intensity and (say) X-rays per admission is tautological - because counting X-rays is just another way of measuring the services of capital. But this is not the case. An X-ray film follows from the advice of a doctor. Moreover, once taken, it must be examined. There may follow more consultations with the patient and, perhaps, other doctors. In any case, as a simple physical phenomenon, it is not possible to produce an X-ray film without both labor and capital.

An appreciation of the intermediate character of these "products" in the total process is also important for another reason. In particular are major operations per admission, etc., determined by the hospital, jointly with the capital intensity decision; or, are they determined for the hospital, either by decisions made in the past, or by the medical practice of the physicians who attend patients in the hospitals? The nature of the process during which surgery is performed, X-ray films and service in clinics provided for this purpose are ambulatory, and because much of the services received is supplied through personal contact with doctors, nurses, social workers, and other staff. This hypothesis, however, is offered with more confidence as regards capital-labor ratios than as regards capital per bed. The reason is that, at least superficially, it may seem that a relative expansion of clinic services would be associated with an expansion of capital relative to bed capacity. This, however, may be a short-run consequence that does not prevail after the hospital fully integrates its internal services for the particular mix of outpatients and inpatients in question. It may be possible, for example, to achieve a better coordination of services (X-ray, laboratory, pharmacy, etc.) so that capital employed in producing these services can be used more intensively - say, by specializing a given stock through size and design modification. The overall effect could be to raise the capacity of a given stock to support beds. In this case, as observed in cross-

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[21] (Cont'd)
lab tests are made, is unavoidably diagnostic and prognostic in character - which serves to emphasize the role of the attending physician and the type of medical case being treated. Since the bulk of physicians are treating patients they have themselves admitted it seems reasonable to assume that the average operations per admission, X-ray per admission. etc., reflect, in fact, the composition of the attending medical staff and the makeup of their private practices. Thus while the hospital may be able to plan for some gross measure of activity (admissions or patient days) over a period of time, by maintaining the size of its attending staff, it cannot much influence its composition and must consequently, respond to the requirements of the medical practices associated with that composition.

One implication of this argument is that, with respect to the average intensity with which patients are provided operations, X-ray films, and lab tests, differences between hospitals are likely to be much more prominent than are differences within hospitals - over a few years. An inspection of the data for the sample hospitals indicates this is the general case for the years 1960-1965.

section, the net relation anticipated between outpatient visits per admission and capital per bed would be negative. This hypothesis is tested in the regression equations, although the grounds upon which it is based are weak.

The extent of teaching activities, the third aspect of heterogenous output, is taken into account by a dummy variable, based on the assignment of hospitals to a teaching status class (as in Chapter II). Those hospitals with a major medical school affiliation or at least 5 approved residency programs were assigned to status 1 (22 hospitals). All other hospitals were assigned to status 2 (16 hospitals).[22] The dummy variable is equal to 1 for status 1 hospitals, and equal to 0 for all others.

The hypothesis tested is that hospitals engaged in more intensive teaching activities will find it generally necessary to use more capital intensive methods in choosing the combinations of capital and labor to employ.

The reasons for expecting this are not, however, overwhelming. They are, possibly, more convincing for capital per bed equations than for capital-labor equations - that is, the added capital requirements for library materials and reading rooms, special laboratory equipment, lounges and lecture halls may be expected to increase capital per bed. However, the concept of capital being studied is the aggregate for the hospital; and, thus it involves the total organization of the hospital. With this in mind it is clear that space and facility requirements (and other labor requirements) to accommodate the presence and activities of students throughout the hospital are relevant. Under these circumstances substitution of labor for capital or vice versa appear equally plausible. Thus,

[22]Data on affiliations and residency programs were taken from the A.M.A. Directory (3).

while the hypothesis subjected to testing is that the general influence on capital-labor and capital-bed ratios will be positive, the hypothesis is not offered on the basis of strong prior convictions.

The question of whether or not the use of a dummy variable in the manner proposed is an appropriate way to allow for the influence of teaching activities on the manner in which capital is allocated is examined more thoroughly in Section 3. However, for the present, it is assumed that the effect of teaching status can be taken into account by the dummy variable. It is in any case necessary to reflect the presence of teaching status in the analysis because of the imperfections, described previously, in endowment assets per bed.

A reasonable interpretation of the view that beds can be used to measure capital is that, after allowing for various hospital characteristics and the relative wage, there is no relation between bed capacity and capital per bed. However, it is consistent with the position of this study to consider why this may not be the case.

The hypothesis offered is that a positive relation will exist between both capital-labor and capital per bed, and bed capacity. One reason for expecting this is because stand-ready or emergency capacity may be required in relatively greater amounts. With more patients, more employees, a wider variety of services, larger and more diverse inventories, more types of equipment, there are more opportunities for things to go wrong, or for more emergencies to occur on a given day. Also, larger hospitals may find it more economical or, in some cases, necessary to internalize aspects of certain functions that smaller hospitals handle in other ways. They may, for instance, invest relatively more capital in communications systems or in waste storage and disposal functions.

In addition to the variables just discussed, two dummy variables are introduced into the analysis which distinguish hospitals by Catholic-non-Catholic control, and as to the personal character of hospital management. The object is to allow for the effects of less tangible principles which along with physical principles govern the potential range of production relations within hospitals. These less tangible principles arise because many of the services provided to patients are in the form of direct personal services, or are provided in connection with personal services. In this context intellectual concepts - professional and philosophic principles - impose conditions on the manner in which hospital technology is to be exploited.

For reasons that may not be too obvious, the philosophic principles characterizing Catholic hospitals as a group may lead to systematic differences in the way capital is allocated. For one thing a substantial part of the nursing staff is supplied by nuns, through the auspices of a mother house. In view of their religious commitments these nurses may tend to organize their work so as to emphasize consolation and bed side care of patients. This same philosophic framework may also lead to a different emphasis in the interpretation of physicians' instructions. For example, an instruction that a patient be observed intermittently (between meals, administration of drugs, etc.) may receive a more literal and frequent interpretation.

These possibilities for a type of specialization in principles which modify the manner in which technology can be exploited seem to suggest a more labor intensive result. That is, other things equal, Catholic hospitals will tend to be less capital intensive. Unfortunately other possible extensions of this type of specialization in principles suggest the opposite result. For example, the more literal interpretation of physician's instructions could lead to more of various types of equipment reserve capacity, more space for offices and consultations. Which, if either of these conflicting possibilities will dominate is an empirical question.[23]

The classification of hospitals by the personal character of management is an attempt to take into account the adoption of conceptual principles that arise from other circumstances that are common to all hospitals. In particular, most of the technical aspects of the personal services directed to the care of patients are the responsibility of two professional groups - doctors and nurses. Since these groups differ as to training, experience, and the nature of their responsibilities, it is not likely that they will share identical perspectives about how the work of the hospital should be conducted, how resources should be used, how services should be coordinated, or how patients should be handled.

It is through the management of the hospital, however - the director who carries out the design of the trustees or other sponsors - that these groups are able to influence the conduct of the hospital. The pattern of concepts that is employed necessarily reflects the relative importance attributed by management (and the trustees or sponsors) to the

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[23]The same ambiguity persists if instead of arguing that Catholic principles modify the way technology will be exploited, it is argued that the Catholic dummy is an adjustment of hospital wage relative to cost of capital. It may be argued, for example, that since a substantial portion of nursing service is supplied by donated sisters' services, the hospitals will tend to undervalue or ignore the wage of labor, even though a wage is imputed and added to reported payroll. That is, capital intensity will not be as great as would otherwise be predicted by measured relative wage, because the hospitals act as if it were much lower. However, if the hospitals are output maximizing ignoring the implicit sacrifice of donated labor is just as irrational as ignoring the implicit sacrifice of donated capital. Both are in conflict with the hospital's objective.

On the other hand, it is conceivable that the hospitals are aware flows of ideas and information emanating from these sources. Since the basis for such differences in concepts can be regarded as professional in nature it seems plausible, in the first instance to distinguish hospitals on the basis of profession of director - for example, distinguishing those hospitals that are directed by medical doctors.

This emphasis on purely professional distinctions in the management-employee relationship may, however, overlook another important aspect of this relationship. Although differences in concepts are no doubt professional in origin, it is also the case that, in general, doctors are men and nurses are women. Hence the trustees or other sponsors may be able to influence the professional tone or orientation of the hospital by choosing a male rather than a female director.

Empirically, the hypothesis is that, with other factors equal, differences in the personal character of management will result in a difference in capital intensity. This is construed to be the consequence of the relative importance attributed to by management to general flows of expert information, emanating from different professional backgrounds. Whether or not either of the proposed dichotomies will succeed in capturing this effect is an empirical question.

Finally, the association between capital-labor ratios and capital per bed, and the pace of activity within the hospital is examined using alternatively admissions per bed per year (ADMB) - case flow - and the components of case flow - the average annual bed occupancy rate (ORAT), and the average length of stay (ALOS). The role of these variables in

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[23](Cont'd)
of and take into consideration the true implict wage of sister's services, while for other reasons they understate the implicit wage in reported payroll. Thus capital-labor ratios will be greater because the true relative wage is higher than the measured relative wage.

determining capital intensity is of particular interest because they figure prominently in discussions throughout the literature as parameters of hospital efficiency. Feldstein, as indicated previously, has suggested a trade-off between ALOS and cost per week (12; p. 24). Newhauser has attempted to quantify a relation between ALOS and employee per patient day (33). Increases in ORAT are typically viewed as improvements in efficiency (29)(28). However, despite the apparent appeal of these variables as parameters of efficiency, the implications of their variations for the allocation of resources, particularly the involvement of capital, has not been examined in a framework sufficiently detailed as to pinpoint their relative importance.

The general hypothesis tested is that increases rates of activity and capital intensity are positively related. However, measuring the pace of work within the hospital raises a number of questions. The difficulty lies in the attempt to find one unambiguous variable that is a macroscopic measure of speed in the hospital. Admissions per bed is one way of measuring the work-flow rate. Unfortunately this measure is far from being unambiguous.

This is because, as an accounting identity, admissions per bed (ADMB) equals 365 times the ratio of the occupancy rate to the average length of stay. Thus using ADMB as a measure of speed is equivalent to using the ratio of ORAT to ALOS. (With respect to the hypothesis, this implies a positive coefficient for ORAT and a negative coefficient for ALOS.) The question is whether the character of these latter variables as identity components of ADMB is to be taken literally (and thus speed is appropriately measured by ADMB), or does the use of ADMB confuse two distinct principles, representing different problems and solutions for the question of capital intensity? In the empirical analysis which follows an attempt is made to shed some light on this question by introducing ADMB and its components, ORAT and ALOS, separately into the regression equations.[24]

This concludes the discussion of variables, and their respective hypotheses as regards the role they are expected to play in influencing the substitution of capital for labor. For convenience they are summarized in Table 26. For reasons that are given in connection with the approach used in the statistical analysis, a time dummy is also introduced as a variable.

In the following section the regression techniques applied are described, and the results of the analysis are given.

3.

The statistical examination of the foregoing hypotheses is based on observations on the capital-labor ratio, capital per bed, and each of the independent variables, across 38 hospitals for six successive years (1960-1965). The data, in logarithmic form, are analyzed by fitting multiple regression equations to the pooled observations for the six years. With the passage of time occurring within the sample, however, one additional modification is introduced to allow for the possibility that the impact of technological change may assume a particular form. Although a six-year period does not seem to be of sufficient length to establish either the direction or magnitude of a trend, the drift in technological change for the years in question may be systematic. This possibility is allowed for by including a time trend among the independent variables.

[24]The results, unfortunately, will not necessarily be unbiased because the various aspects of speed are (at least in some respect) endogenous.

Table 26

List of Variables Used in Regression Analysis

Mnemonic	Name
CAPL	Capital-Labor Ratio
CAPB	Capital-Bed Ratio
WAGE	Hospital Wage
SLIN	Proportion of Staff Living-in Hospital Quarters
ENDB	Endowment Assets per Bed
OPRA	Major Operations per Admission
XR-A	X-Ray Films per Admission
LT-A	Laboratory Tests per Admission
OPDA	Outpatient Clinic Visits per Admission
BEDS	Bed Capacity
TEST	Teaching Status - Dummy
CATH	Catholic Non-Catholic Control
MD	Medical Doctor as Director
MALE	Sex of Director
ADMB	Admission per Bed - Case Flow
ALOS	Average Length of Stay
ORAT	Average Bed Occupancy Rate
TIME	Time Trend
REIN	Residents and Interns as a Percent of Staff
GEPR	General and Practical Nurses as a Percent of Staff

The advantage to pooling the successive years' data, in addition to providing more degrees of freedom, is that it provides a systematic basis for inquiring into the empirical stability of the equation that is estimated. That is, by allowing for time dummy interactions with the independent variables it is possible to determine whether or not coefficients are stable over the sample years.[25] This is of considerable importance in the present study since the a priori grounds for assuming stable relationships are not overwhelming.

In Table 27 the results of the regression analysis for the capital-labor ratio and capital per bed are given. In each case, two version of the equation are reported in which, respectively, ADMB, and ALOS and ORAT as separate variables, are included in the estimating equation.

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[25] If, for example, the coefficient for a variable (X) varies over (say) a three-year period, the difference between its estimate in any two years and the remaining year, and the coefficient for the third year, can be estimated as follows:

1. $Y_{it} = a_0 + a_1X_{it} + a_2D_1X_{it} + a_3D_2Y_{it}$

$D_i = 1$ for year i and zero for the other two years.

Stated explicitly the hypothesis is

2. $Y_{it} = a_0 + b_1D_1X_{it} + b_2D_2X_{it} + b_3D_3X_{it}$

Since in any given year $D_1 + D_2 + D_3 = 1$, $D_3 = 1 - D_2 - D_2$ can be substituted into (2), eliminating D_3, and with rearrangement of terms, yielding

3. $Y_{it} = a_0 + b_3X_{it} + (b_1 - b_3)D_1X_{1t} + (b_2 - b_3)D_2X_{1t}$

If the coefficient for X is stable, $b_1 = b_2 = b_3$, and thus, the coefficients estimated for the interaction terms will not be significantly different from zero.

Table 27

Multiple Regression Equations, With Capital-Labor Ratios and Capital per Bed as Dependent Variables: Pooled Cross-Section Data (Logs) for 38 Hospitals (1960-1965)

	Capital-Labor Ratio		Capital per Bed	
	Coefficient and t Statistics			
Variables	1	2	3	4
WAGE	1.0834 (6.8787)	1.0997 (6.7373)	.7785 (4.3610)	.6416 (3.5680)
ENDB	.0139 (2.3341)	.0143 (2.3802)	.0300 (4.4551)	.0323 (4.8939)
SLIN	.1708 (5.5099)	.1712 (5.4088)	.0988 (2.8129)	.0837 (2.3992)
XR-A	.2997 (7.4426)	.3021 (7.0031)	.3595 (7.8751)	.3060 (6.4401)
OPRA	.1530 (3.1440)	.1574 (3.1972)	.2211 (4.0102)	.2471 (4.5562)
LT-A	-.0810 (-1.7990)*	-.0775 (-1.6992)*	.0029 (.0564)**	.0277 (.5514)**
OPDA	-.0688 (-2.7736)	-.0653 (-2.6491)	-.0282 (-1.0041)**	-.0412 (-1.5194)**
BEDS	.1046 (2.6341)	.1087 (2.7556)	.1605 (3.5676)	.1621 (3.7324)
TEST	-.0067 (-.3483)**	-.0099 (-.4933)**	.0354 (1.6274)**	.0126 (.5653)**
CATH	-.1287 (-2.6501)	-.1229 (-2.4914)	-.0119 (-.2165)**	-.0551 (-1.0144)**
MALE	-.2237 (-5.7375)	-.2227 (-5.5282)	-.1817 (-4.1133)	-.2244 (-5.0544)
TIME	-.0297 (-4.7873	-.0306 (-4.8927)	-.0168 (-2.3859)	-.0151 (-2.1869)

Table 27 (Cont'd)

Variables	Capital-Labor Ratio 1	Capital-Labor Ratio 2	Capital per Bed 3	Capital per Bed 4
	Coefficient and t Statistics			
ADMB	-.0371 (-.3787)**	-	.1937 (1.7466)*	-
ALOS	-	-.0152 (-.1710)**	-	-.1075 (-1.0954)**
ORAT	-	.0521 (.2255)**	-	.9725 (3.8222)
REIN	-.0077 (-.1774)**	-.0081 (-.1874)**	-.0157 (-.3199)**	-.0123 (-.2569)**
GEPR	.1759 (3.6398)	.1730 (3.5584)	.1059 (1.9333)*	.0894 (1.6691)*
R^2	.6231	.6230	.6855	.7027
R^2-adjusted	.5964	.5944	.6633	.6801
F	23.3665	21.7917	30.8044	31.1730
d.f.	15 and 212	16 and 211	15 and 212	16 and 211

*Significant at the 10% level.

**Not significant.

Referring first to the capital-labor ratio equations, approximately 62 percent of the total variance in capital-labor ratios has been explained. With the F statistic greater than 20, this is a highly significant result.

Clearly, the most important aspect of these results is the measure of substitution provided by the elasticity estimated for the WAGE variable. In both equations 1 and 2 its magnitude is slightly above unity, and it is highly significant. Whether one takes the view that hospitals are constrained output maximizers, or that these estimates are best regarded as empirical tendencies of the practice of substitution in hospitals, these results are surprising. It means, for example, that in this regard hospitals are similar to firms in manufacturing industries - where, although results are mixed, the evidence seems to favor an elasticity of substitution of near unity.[26]

Taking the view that hospitals act as constrained output maximizers, the wage elasticity, as estimated in equations 1 and 2, can be interpreted as a measure of the elasticity of substitution (σ). The estimate of this elasticity is (approximately) unity, which, in view of the impressions to be had generally from the literature previously discussed (ranging from doubts that capital is either substituted or substitutable for labor) is unexpectedly high. It is moreover to be regarded as an average; hence, for some hospitals in the sample it is even higher. In addition there are (as indicated in previous discussion) misgivings about the way the wage is measured. For example, if there an error in the measurement of wage, uncorrected by adjustments resulting

[26]See Dhrymes (10; p. 364). However, whether the elasticity of substitution is to be regarded as equal or less than unity in manufacturing is a matter of controversy (21; p. 346)(11; p. 370).

from the inclusion of other variables in the analysis - such as the proportion of staff living in hospital quarters, service intensity variables, or staff ratios - the estimated coefficient may be biased. But this bias would be negative - implying a true value of even greater magnitude than that of unity (20; pp. 149-150). If, however, the true (average) value of σ is near unity, as estimated, and not an optical illusion created by the partialling process of the regression analysis, the principal findings should not be much effected by a simple transformation of the model, using the wage as an operator. For example a value of 1 for σ implies that dividing both sides of the model, which is multiplicative in form, by the wage would, if the resulting equation were estimated, result in no important changes in the elasticities as currently estimated for the remaining variables.

Such an equation was estimated, with capital per payroll dollar as the dependent variable, using equation 2, Table 27, as a basis for comparison (see equation 1, Appendix Table I).

With three minor exceptions the equation estimated appeared to be virtually the same as equation (2), omitting wage. Those coefficients that were significant in (2) were also the significant ones in the test equation. Magnitudes of elasticities tended to differ slightly, beginning with the third digit after the decimal. In the three exceptions, the differences were very small. For example, the elasticity for OPRA was .1652, as compared with .1574 in equation (2).

On the basis of this test, the estimate of approximately unity for the average wage elasticity seems to be convincingly stable.

The elasticity estimated for ENDB is small in magnitude (.0143 in equation 2), but highly significant. In this equation (2), ENDB has been entered as the log of endowment assets per bed, thus implying, by assumption, a relation between the cost of capital and ENDB as follows: $r = AE^{-a}$.[27] The estimated coefficient is thus interpreted as the product σa. Accordingly, with σ estimated to be approximately unity, the coefficient of ENDB is the implied magnitude of a.

As an estimate of a, this elasticity seems to be rather low. It implies, for example, that if ENDB doubles, r will only decline by about 1.4 percent.[28] The estimate is, as with all other coefficients, an average for all the hospitals in the sample, and this could be one reason for its relatively small value. In the discussion of this variable it was pointed out that higher teaching hospitals tended to have relatively larger endowments per bed. Hence there may be a significantly different relationship between the cost of capital and ENDB in teaching hospitals. As an extreme possibility, their philanthropic sources may be so munificent that the cost of capital is close to its minimal (transactions) value, and is very insensitive to variations in ENDB. This point will be examined in more depth presently.

Referring to other coefficients in equations 1 and 2, it is obvious that measuring pace of work as ADMB or as ALOS and ORAT, separately makes little difference in these equations. The coefficients are not significant, although the signs for ALOS and ORAT are correct. Hence at this point in the analysis it cannot be shown that pace of work has any influence (directly or through modifying effects) on capital-labor ratios.

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[27]Using the alternative form, ENDB in natural form, resulted only in minor changes in the equation, but the coefficient for ENDB was not significant. The principal conclusion as regards the wage elasticity was not affected (see equation 2, Appendix Table I).

[28]Alternatively, suppose in $r = AR^{-a}$, that $A = .15$ - a high risk rate for a hospital with minimal E. If $E = 100$, $r = .14$; but if it is one hundred times this (a value not approached by any hospitals in the study), r is still high (i.e., 12.8 percent).

The coefficient for the proportion of staff living in (SLIN) is highly significant, but, contrary to the expectation, it is positive. This suggests that the emphasis on providing nurses quarters, which was referred to in formulating the initial expectation with respect to SLIN, does not imply organizational overtones that are labor intensive in effpct. A more direct view of the mechanical aspects of providing living quarters for staff may be relevant. That is, with other things equal, providing some staff with living quarters simply increases the capital investment of the hospital relative to labor (or beds).

The elasticities estimated for XR-A and OPRA are modest in size (approximately .30 and .16 respectively). However they have positive signs, as expected; and they are highly significant. Contrary to expectations, the estimated elasticity for LT-A is negative; however it is significant only at the 10 percent level. This is somewhat surprising since it is in the area of lab work that labor productivity has reportedly been raised through the introduction of the auto-analyzer and other automatic procedures. However, it is the use of aggregate capital that is being analyzed. Hence the importance of LT-A involves a consideration of its ramifications, direct and indirect, as capital and labor are adjusted throughout the hospital. The results of the regression analysis indicate that the net combined effect of these ramifications may be labor intensive.

Both the elasticities estimated for outpatient visits per admission (OPDA) and for BEDS have the expected signs (nagative for OPDA, and positive for BEDS). And, although their magnitudes are small (for OPDA in particular, -.06) they are highly significant.

By-passing teaching status effects for the moment, there are, it appears, significant shifts in the regression equation for Catholic hospitals, and for hospitals managed by male directors. The estimated coefficients (powers of ten), are negative in both instances and highly significant.[29]

The time trend coefficient is negative, indicating a labor intensive drift during these years in the position of the regression equation. Of the two staff ratios entered as adjustments of crude labor, general and practical nurses as a proportion of total staff (GEPR) alone has a significant independent effect. The positive coefficient signifies that increases in the relative importance of nurses in total staff may be capital intensive in effect. As an adjustment, however, it is a measure of the correction in the capital-labor ratio.

The failure of teaching status, measured by a dummy variable, to contribute significantly to the explanation of capital-labor ratios is disappointing. It is possible that after adjusting for other factors teaching activities are of no consequence for capital intensity. However, the empirical evidence of studies in hospital costs, indicates that teaching activities are important determinants of costs (8; pp. 62-63) or rates of increase in costs (24; p. 392). Thus, an alternative explanation is that measuring the effect of teaching status as a dummy variables does not suitably measure teaching activities.

Turning to equations 3 and 4 of Table 27, estimates for the capital per bed equations, the results are, with some exceptions, in general agreement with those in equations 1 and 2. That is variables influencing

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[29]The attempt to distinguish hospitals by medical doctor as the personal character of management yielded inferior results. R^2 was about .57. Some coefficients were moderately increased while others were reduced. The coefficient for the MD dummy was itself not significant. The principal conclusions as regards wage and ENDB were not changed, although

capital-labor a particular way tend also to influence capital-bed the same way. R^2 is in the .68 - .70 range, and, as indicated by the F statistics, it is highly significant.

Three variables that were significant (two of them highly significant) in the capital-labor equations (LT-A, OPDA, CATH) are not significant in the capital-bed equations. However, on the positive side, a new result is the highly significant effect of ORAT, in equation 4. The elasticity is positive and near unity (.9725).

This role for the occupance rate, although dominating the results for ADMB in equation 3, is clearly indicated only by introducing ALOS and ORAT as separate variables - as in equation 4. The coefficient for ALOS, although negative as hypothesized, is not significant.

Before pursuing the examination of teaching status effects, it is appropriate to inquire directly into the basic assumption that regression coefficients are stable over the 6-year period for which the data were pooled. A test of this assumption can be supplied, as explained in footnote 25, by adding to the estimating equation a series of interaction terms between dummy variables assigned for each year and the various independent variables. To test the stability of the coefficient for WAGE, for example, let WAGE be symbolized as X_1, its coefficient as b, and b_1 the value of b in 1965, b_2 the value of b in 1964, etc. The hypothesis tested is that $b_1 = b_2 = b_3$, etc. In a form suitable for estimation (again, following the illustration in footnote 25), the equation appears as follows:

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[29](Cont'd)
the magnitudes of their coefficients were increased slightly. (See equation 3 of Appendix Table I).

$$Y_{it} = \text{constant} + \sum_j a_j X_{ijt} + \sum_k d_k (D_k X_1)$$

$i = 1, \ldots 38$ hospitals

$t = 1, \ldots 6$ years

$j = 1, \ldots 14$ (independent variables)

$k = 2, \ldots 6$ years (omitting 1965)

$D_k = 1$ for year k, and zero for all others

$d_k = b_k - b_1$

If $b_1 = b_2 = b_3$, etc., then $b_k - b_1 = 0$. That is, if the coefficients d_k (differential slopes) are not significantly different from zero, then the coefficient of WAGE is stable.

Regression equations of this form were estimated for the variables reported in Table 27. In only one case were significant differential slopes observed - in the case of the proportion of staff living in (SLIN), in the capital-labor equation.

The coefficient of SLIN, according to the results shifted downward over the sample years. As indicated in Table 28, it declined by about 50 percent.

Table 28

The Trend in the Regression Coefficient for Proportion of Staff Living in Hospitals (SLIN)

Year	Differential	Coefficient
1965	-	.1327
1964	.0433	.1760
1963	.0675	.2002
1962	.0851	.2178
1961	.1044	.2371
1960	.1302	.2629

The direct significance of this shift is difficult to ascertain. It implies that the capital-labor ratio would be less in 1965, even if the proportion of staff living in were at its 1960 level. However, this decline in importance is accompanied by an upward revision of the wage elasticity from 1.10 in equation 2, Table 27, to 1.21.[30] Since the primary role of SLIN is to correct for an implied error in the measure of wage, this suggests that the relationship between SLIN and the wage subsidy may have changed during the sample years. The upward revision of the wage elasticity suggests the removal of bias.[31] It is necessary in any event to allow for this effect of SLIN in drawing inferences from the results of pooling the data.

Returning to the main line of inquiry, the failure of teaching status to contribute to the explanation of capital intensity in the regression estimates must be regarded as a potential source of error. Hence it is appropriate to consider another specification of the basic equations that will permit teaching status to be taken into account in an alternative manner.

The implicit assumption maintained by using a dummy variable to measure the effect of teaching status on capital-labor substitution is that the effect of teaching is neutral with respect to the relative importance of other variables in the estimating equations. That is, the estimated elasticities for other variables are unbiased estimates of true elasticities that are the same for teaching and non-teaching hospitals

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[30]Other coefficients were comparatively unchanged. R^2 was increased, significantly, from .6230 to .6329.

[31]Although the reporting of the provision of living quarters appears to have been standardized in the UHF Annual Reports, the proportion of wage subsidy could have declined. For example, the pressure of the union movement could have resulted in proportionately more of the full wage bill per employee to be paid in monetary form.

alike. This may not be a good assumption. In principle the capital intensity equations for different categories of hospitals could be distinguished by different coefficients for one or more of the variables influencing capital intensity, and, since the data from six years are pooled, by shifting intercepts. Hospitals engaging in a high level of teaching activity may, in particular, be so distinguished. Major operations and X-rays, for example, are conducted not only with the welfare of the patient in mind but also in a manner designed to elucidate the medical principles involved so as to benefit the educational process. Also, the possibilities for pure substitution may be affected. That is, other things equal, it may be more difficult to substitute capital for labor in response to an increase in the hospital wage because the techniques of teaching involve large components of personal services - the communication of knowledge, counseling and guidance.

On the basis of these considerations, the failure of teaching status in the equations of Section 2 is not surprising. It is due to the fact that the effect of teaching within the hospital is not neutral, and because, perhaps, such neutral differences between teaching and non-teaching hospitals as do exist change over time.

In order to test this hypothesis, the relationships reported in Table 27 are reestimated allowing the coefficients for variables in teaching hospitals to vary. This is achieved by further application of the method employed to determine the stability of coefficients over time. Thus the hypothesis tested is that the coefficients for teaching and non-teaching hospitals are the same; however the results also provide a measure of those differences that exist. To illustrate the principle involved let Y, the dependent variable, be a linear function of several variables, X_i. If the coefficients of X_i are different as between teaching and non-teaching hospitals, the general relationship is as follows:

$$Y_i = a + \sum_i b_i(D_1X_{ij}) + \sum_i b_i'(D_2X_{ij}) \qquad j = 1, \ldots n \text{ (hospitals)}$$

$D_1 = 1$ for teaching and zero for non-teaching

$D_2 = 1$ for non-teaching and zero for teaching

Since $D_1 + D_2 = 1$, $1-D_1$ can be substituted for D_2. When this is done, and terms are rearranged, the result is

$$Y_i = a + \sum_i b_i'X_{ij} + \sum_i (b_i-b_i')D_1X_{ij}$$

The coefficients, b_i', are seen to be the estimates for non-teaching hospitals, while the coefficients of D_1X_{ij} (teaching interaction terms) are estimates of the difference between the teaching hospital coefficients and the non-teaching hospital coefficients. If $b_i = b_i'$ (the coefficients are the same for both classes of hospitals), then $b_i - b_i'$ provides a measure of the increment to be added to b_i' in order to obtain the coefficient, b_i, for teaching hospitals.

In addition to allowing for differences in coefficients by including the teaching interaction variables, D_1X_{ij}, provision was also made for neutral shifts in the equations to vary over time. For this purpose a new set of dummy variables was included, permitting the coefficient of the teaching dummy to vary over the six sample years. These dummies were defined as D_1xT_k, $k = 1,2,\ldots 5$ (the term for 1965 was omitted to avoid a singular data matrix). T_1, for example, is equal to one in 1960, and zero for all other years. Hence $D_1xT_1 = 1$ for all teaching hospitals in years other than 1960.

The remaining potential source of interaction effects is due to the fact that the three classes of hospitals are not mutually exclusive. The overlap of classes is illustrated in Figure 1.

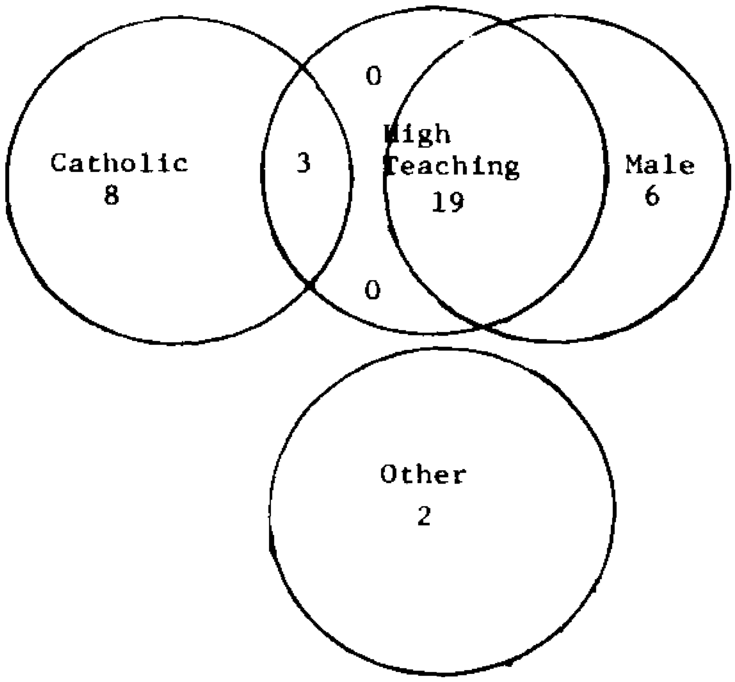

Figure 1

Distribution of 38 Hospitals by Catholic, Non-Catholic Auspices, by Teaching Status, and by Sex of Director.

Three Catholic hospitals, for example, are also in the high teaching category. Thus the hypothesis is that the neutral shift expected for Catholic hospitals in general will be different if the hospitals in question are also teaching hospitals. This argument is repeated in the case of personal character of management, measured here as male directors. Thus the effect of male directors, generally, is expected to be different in 19 such hospitals, who are also teaching hospitals.

The results of the regression analysis, with data in logarithmic form, are reported in Table 29.[32]

Clearly these are improved results (to be compared with equations 2 and 4 of Table 27). For capital-labor ratios, approximately 79 percent of the variance is explained by the equation. This is an increment to R^2 (after allowing for the shifts in the elasticity for SLIN) of about 16 percentage points - which is highly significant. However, as was true originally, the remarkable result is the elasticity for wage. For non-teaching hospitals it is estimated to be about 2; and, as indicated by

[32]There remains some possibility that an additional source of variance has been omitted from these equations. The object in maintaining such a large number of variables in the analysis, and then extending the analysis to allow for interaction effects, has been not only to provide an unbiased measure of substitution, but also to make explicit the technical reasons why capital intensity varies among hospitals. However, despite these efforts, something unknown about each hospital may possibly have a systematic capital intensive effect, which is unique for the particular hospital.

Thus, while in pooling the data it is assumed that each observation is independent, capital intensity in hospital i, in year t may not, strictly speaking, be independent of capital intensity in hospital i, for year t-j. In particular, if this effect is operable, its impact will have been absorbed in the residual error term; and, thus the error in t will not be independent of the error in t-j, for hospital i.

A basic assumption of the general linear model is $E(uu') = \sigma_u^2 I$. If residual terms are not independent, however $E(u_t u_{t-j}) \neq 0$, and, thus $E(uu') = V$. V is an unknown matrix with elements involving terms in σ_u^2 and the parameters of the relationship that exists between the residuals. The consequences of applying least-squares procedures to data where this problem exists are (1) coefficients will be unbiased, but their variances will not be minimal; (2) variances of coefficients may be underestimated; and (3) the error variance (σ_u^2) may be underestimated (20; p. 179).

The residuals from the equations reported in the text were examined to see how important this problem might be. There was some tendency in year to year comparisons for the residuals to be positively correlated; however, with an intervening year, the tendency was drastically reduced. Hence, while there is some indication that $E(uu') = \sigma_u^2 I$ is not strictly satisfied, no clear pattern of dependence emerges. Nevertheless, this is source of uncertainty, implying that while the reported coefficients are not biased, they may not be as stable as the results indicate.

Table 29

Multiple Regression Equations, With Capital-Labor Ratios and Capital per Bed as Dependent Variables: Pooled Cross-Section Data (Logs) for 38 Hospitals, Allowing for Teaching Status Interactions (1960-1965).

Coefficients and t Statistics

Variable	Capital-Labor Ratio		Capital per Bed	
	Common	Teaching Interaction	Common	Teaching Interaction
WAGE	2.0558 (9.4019)	-.8682 (-2.9957)	1.0373 (4.1010)	-.1654 (-.4934)**
ENDB	.0866 (5.6176)	-.0854 (-5.0446)	.0795 (4.4557)	-.0628 (-3.2077)
SLIN-1965	-.0084 (-.1414)**	.1847 (2.7508)	-.0097 (-.1417)**	.1074 (1.3828)**
XR-A	.2541 (2.9898)	.0618 (.6557)**	.3745 (3.8087)	-.0587 (-.5388)**
OPRA	.4164 (6.3098)	-.3069 (-3.5004)	.5679 (7.4392)	-.4279 (-4.2197)
LT-A	.0477 (.7272)**	-.1577 (-1.8485)*	.1675 (2.2079)	-.1574 (-1.5951)**
OPDA	-.1341 (-5.2884)	.1712 (3.5290)	-.1233 (-4.2043)	.1674 (2.9822)
BEDS	.4708 (7.1949)	-.5039 (-6.5505)	.3578 (4.7275)	-.3502 (-3.9354)
CATH	.1916 (2.4269)	2.2212 (7.7330)	.1770 (1.9387)*	1.6242 (4.8884)
MALE	-.0980 (-2.3062)	2.4276 (8.0339)	-.1296 (-2.6365)	1.8238 (5.2178)
TIME	-.0977 (-6.8764)	- -	-.0646 (-3.9315)	- -
ALOS	-.0328** (-.3100)	.0091 (.0564)**	-.2722 (-2.2222)	.3476 (1.8562)*
ORAT	-.2354 (-.7708)**	.5141 (1.1976)**	.5991 (1.6959)*	.3297 (.6641)**

Table 29 (Cont'd)

Coefficients and t Statistics

Variable	Capital-Labor Ratio: Common	Capital-Labor Ratio: Teaching Interaction	Capital per Bed: Common	Capital per Bed: Teaching Interaction
REIN	-.0308 (-.6126)**	-.1182 (-1.4292)**	.0302 (.5191)**	-.2556 (-2.6731)
GEPR	.3393 (5.6371)	-.3500 (-4.2004)	.3863 (5.5485)	-.6457 (-6.6985)
TEST-64	- -	-.0463 (-1.4767)**	- -	-.0330 (-.9102)**
TEST-63	- -	-.0969 (-2.7834)	- -	-.0562 (-1.3947)**
TEST-62	- -	-.1705 (-3.7208)	- -	-.1205 (-2.2722)
TEST-61	- -	-.2327 (-4.4794)	- -	-.1577 (-2.6241)
TEST-60	- -	-.2713 (-4.4622)	- -	-.1632 (-2.3210)
SLIN-64	.0429 (1.8088)*	- -	.0290 (1.0575)**	- -
SLIN-63	.0746 (2.5520)	- -	.0672 (1.9883)	- -
SLIN-62	.0669 (1.8514)*	- -	.0599 (1.4328)**	- -
SLIN-61	.0830 (1.8778)*	- -	.0746 (1.4601)**	- -
SLIN-60	.1132 (2.1208)	- -	.1216 (1.9704)	- -
R^2	.7937		.8207	
R^2-adjusted	.7509		.7835	
F	18.552		22.067	
d.f.	39 and 188		39 and 188	

*Significant at the 10 percent leve.
**Not significant.

the t statistics, the estimate is highly significant. In teaching hospitals, however, the estimate is less by .87 (also highly significant), implying a wage elasticity in teaching hospitals of about 1.2. This implied estimate is close to the wage elasticity estimated previously, after allowing for the shifts in SLIN, indicating the dominance of teaching hospitals in the results that were obtained by failing to distinguish between teaching and non-teaching hospitals.

The endowment elasticity for non-teaching hospitals has been increased substantially, its estimate of .087 being 6 times the original estimate of .014. However, since the wage elasticity, interpreted as σ, has doubled, the assumed elasticity of r (cost of capital) with respect to ENDB is but 3 times its earlier estimate. According to the assumed relation, $r = A(ENDB)^{-a}$; and the estimate of a is .043. Since this still appears to be a low estimate of the relation between r and ENDB (doubling ENDB results in a 4.3 percent reduction in r), it is probable that the relation between r and ENDB is not much clarified by these results. This means that in the regression analysis there are probably variations in r to be accounted for by omitted variables, and thus responsible in part for the residual error. Although this line of conjecture (in which it is suspected that omitted variables and ENDB are correlated) could explain the low estimate of a, it does not imply that some other coefficient in the regression equations, say, the wage elasticity, will be biased, unless there is some basis for assuming the omitted variables and the wage are also correlated.

As anticipated, the results imply that the cost of capital in teaching hospitals is very insensitive to variations in ENDB. The regression estimate of the differential elasticity for teaching hospitals is negative, and approximately the same magnitude as the positive coefficient estimated for non-teaching hospitals. This is interpreted to mean that within the teaching class, the cost of capital is near its minimum level - fixed primarily by communications and transaction costs.

The elasticity for XR-A is slighly less than its earlier estimate (.25 as compared with .30); and it is highly significant. The differential elasticity estimated for teaching hospitals is not significantly different from zero, hence the common elasticity is the estimate for all hospitals. The common OPRA elasticity is now .42 (compared to the earlier estimate of .15); but the differential is -.31 (and highly significant). This implies an elasticity of .11 for teaching hospitals.

The coefficient for LT-A in non-teaching hospitals is not significant; however the teaching class differential is negative and mildly significant - at the 10 percent level. Outpatient services have a significant, negative effect in non-teaching hospitals; but the teaching class differential is positive, highly significant, and larger in magnitude than the common elasticity. This means that in teaching hospitals the effect of OPDA is positive, with an implied elasticity of about .04.

This reversal of the nature of an effect is also indicated for bed size. In non-teaching hospitals bed size has a highly significant, positive effect on capital-labor ratios. But the teaching class differential is negative (highly significant) and larger in magnitude than the common estimate (-.50 as compared with .47). Thus for minor changes in bed size within teaching hospitals this effect is almost trivial, and, if anything, negative. In non-teaching hospitals, however, its effect is substantive, with a 1 percent increase in bed size associated with a one-half of one percent increase in the capital-labor ratio.

Again, the intercept adjustments, the neutral shifts in capital-labor ratios, are significant for Catholic hospitals and for hospitals managed by male directors. However, the shift for both teaching and non-teaching Catholic hospitals is now found to be positive, with a much larger shift indicated for Catholic teaching hospitals. The shift for male directed non-teaching hospitals is negative (as in the earlier estimates), but it is positive if the hospital is a teaching hospital. Also, as was the case in the first estimates, the coefficients for ALOS and ORAT are not significant.

Of the two staff ratios entered as adjustment of crude labor, nurses as a proportion of staff (GEPR) alone has significant independent effects; but these appear to be limited to non-teaching hospitals. The elasticity is estimated to be about .34, while the teaching class differential is about -.35.

The general effect of time is still negative, although the common coefficient is now larger in magnitude (-.09 as compared with the previous estimate of -.03). This confirms a generally labor-intensive drift in adaptations during the sample years; but there are, in addition, significant neutral shifts for these years. The coefficients estimated (powers of ten) are negative, decreasing in absolute value, and significant for 1963 and earlier years. This means that counter to the common trend, teaching hospitals were adapting in a capital intensive direction.

The regression results for capital per bed are also improved. R^2 is now .82, a significant increment in explained variance of 12 percentage points. With minor qualifications the results are in general conformity with the results for capital-labor. Both wage and ENDB elasticities are positive and highly significant for non-teaching hospitals. The wage elasticity differential is not significant (as it is for capital-labor); but, as before, the significant negative differential for ENDB shows a trivial and possibly zero effect for this variable in teaching hospitals. Again, this is interpreted to mean that within teaching hospitals the cost of capital is at a minimal level, and is comparatively insensitive to variations in ENDB.

Looking at the allocative effects implied by the capital-labor and capital-per-bed equations from a purely static point of view, a one percent increase in hospital wage in non-teaching hospitals calls for a one percent increase in capital and a one percent reduction in labor. In teaching hospitals, however, capital and labor are less substitutable. Hence a one percent increase in wage, while resulting in a one percent increase in capital, is accompanied by only a .2 percent reduction in labor.

The elasticities estimated for the complexity of service variables (XR-A, OPRA, and LT-A) are positive, with the common coefficient for LT-A now significant. As regards XR-A, the elasticity of .37 applies equally to teaching and non-teaching hospitals; however, as before the capital intensive effect of major operations (OPRA) is much less in teaching hospitals. This indicates that the static adjustment to a one percent increase in OPRA in teaching hospitals is a .14 percent increase in capital and a .04 percent increase in labor, while in non-teaching hospitals the percentage adjustments are .57 and .16, respectively.

The effect of outpatient services in capital per bed is negative in non-teaching hospitals while in teaching hospitals it is positive - reflecting the same pattern of sign reversal as in the capital-labor equation. (In effect, since the implied elasticities are approximately the same, .04, the implication is that the static adjustment to a one percent increase in clinic visits can be achieved with a .04 percent increase in capital. In non-teaching hospitals required capital is less by .12 percent, but labor requirements are increased by .01 percent.)

Bed size has a positive elasticity (.36) in non-teaching hospitals; but, as was the case for the capital-labor ratio, there appears to be no effect on capital per bed in teaching hospitals. These results imply that in teaching hospitals a one percent increase in beds, ceteris paribus is equivalent to a one percent increase in capital. Hence for teaching hospitals there may be circumstances in which the number of beds is a good proxy for capital. Not so however, for non-teaching hospitals.

Pace of activity, as before, has a total resource effect in that it influences capital per bed, but not the capital-labor ratio. However, with the effect of teaching taken into account, the results are quite different. For non-teaching hospitals, the important result is the highly significant, negative elasticity of ALOS (-.27). Since capital and labor are influenced in the same way, an increase of ALOS (ceteris paribus) represents a stretching out of the production process, with the expected consequences for the use of resources. The positive differential for teaching hospitals (.35), suggests variations of ALOS in these hospitals may mean something different (such as another aspect of medical difficulty, or more extensive care for teaching purposes); however this coefficient is significant at the 10 percent level only. The occupancy rate (previously with a highly significant elasticity near unity) has a coefficient of about .60 in non-teaching hospitals; but it is only significant at the 10 percent level. The teaching differential is positive, but it is not significant.

The results for the staff ratios are similar to those in the capital-labor equation, with the exception of the residents and interns ratio (REIN). The ratio appears to have a significant negative effect on capital per bed in teaching hospitals. The implied coefficient for the nurse ratio is also negative, highly significant, and in approximately the same magnitude (-.26). These results suggest that within teaching hospitals medical professionals and capital may be good substitutes. However, as indicated in discussing these variables, they are endogenous, hence the coefficients estimated are not necessarily unbiased.

The neutral shifts for Catholic hospitals and hospitals with male directors follow the same pattern as in the capital-labor equation. However the coefficient for non-teaching Catholic hospitals is significant only at the 10 percent level. The common time coefficient reflects the same negative drift; however, as before, the neutral time shifts in teaching hospitals are counter to this trend.

To summarize, the results of analyses presented in this chapter are a convincing empirical demonstration of the substitution of capital for labor in short-term voluntary hospitals. Not only is the practice of substitution systematic, but the ease with which it can be achieved is comparatively high. The measurement of substitution (the ease with which it is achieved) is provided by the wage elasticity. For non-teaching hospitals this is estimated to be 2, while in teaching hospitals it is less, estimated to be near unity. Hence, for teaching hospitals the measure of substitution is similar to elasticities of substitution estimated for a number of U.S. manufacturing industries, for example, Apparel and Related Products, and Stone, Clay, and Glass Products (10; p. 364). For non-teaching hospitals, however, the measure of substitution is higher than those estimated for most manufacturing industries, although comparatively high elasticities of substitution have been estimated for some industries - e.g., Rubber Products, and Transportation Equipment (10; p. 364).

Among the additional tendencies observed, accounting for technical shifts in the gross substitution of capital for labor, were those relating to complexity of hospital services, the relative importance of outpatient services, and number of beds. Not all variables influenced both capital-labor and capital-bed ratios. For example, lab tests per admission appears to have no effect on capital-labor ratios, but a significant positive effect on capital per bed in non-teaching hospitals. Similarly, neither ALOS nor ORAT influence capital-labor, but ALOS has a significant negative effect on capital per bed in non-teaching hospitals, and, possibly a small positive effect in teaching hospitals. The occupancy rate may have a positive effect on capital per bed, although the elasticity estimated (.60) is significant at only the 10 percent level.

In several instances, the elasticities implied for teaching hospitals were less than those estimated for non-teaching hospitals - in some cases indicating no relationship exists. Examples of this extreme result are the coefficients for endowment assets per bed and number of beds.

Over the sample years it was also found that neutral increases in capital-labor and capital-bed ratios were occurring in teaching hospitals. This was counter to the common drift implied by the negative time trend.

Important neutral shifts were also found in the case of Catholic hospitals, and those hospitals managed by male directors. With other things equal, non-teaching Catholic hospitals use more capital per employee and per bed than other non-teaching hospitals; also, Catholic teaching hospitals use significantly higher capital-labor and capital-bed ratios than non-teaching Catholic hospitals. Non-teaching hospitals that are managed by male directors use less capital per employee and per bed than non-teaching hospitals generally; but teaching hospitals that are managed by male directors use significantly more capital than non-teaching hospitals that are managed by male directors.

Although the framework of analysis does not make it necessary to regard the allocation of capital as being optimal, it may be so regarded by assuming output maximizing behavior. In any case the tendencies are plausible; and their empirical stability is reassuring in the absence of strong convictions about the objectives motivating the hospital. As explained in several previous instances, there are reasons for exercising caution in interpreting the statistical results. The fact that endowment assets per bed did not appear to have a relationship with capital-labor ratios in teaching hospitals is also disappointing. Some residual variations in the cost of capital may have been undetected. However, despite these uncertainties, the evidence consistently supports the role of allocative principles among the sample hospitals in determining the substitution of capital for labor. Moreover, other aspects of the hospitals, including the variety of work and number of beds, appear to have predictable consequences for the gross substitution of capital.

The economic implications of these results are wide-ranging - some on the level of basic principles, others with immediate empirical content. Deferring comment on their more important policy ramifications to the concluding remarks, these implications are as follows:

Regarding principles, the two major implications of the substitution of capital for labor in response to scarcity factor prices are (1) production will tend to be cost minimal (although scale may be "wrong," and the assortment of services produced may not be socially ideal); and (2) the demand for capital (stock) can be determined. The results, of course, do not prove that sample hospitals are using capital efficiently, or that hospital costs are being minimized. However, such views receive support from the findings. In these findings it has not been possible to reject the hypothesis that capital is substituted for labor in response to the relative hospital wage. And this behavior is what would be expected in circumstances where capital is being used economically. The second implication, regarding the demand for capital, may seem paradoxical to many people in the hospital field where demand (for anything) is frequently described as depending on "need." However it is the essence of the substitution problem, that "need" can be satisfied using alternative combinations of capital and labor. Hence need itself (the output or assortment of services) provides advice on this question only where substitution is impossible. With substitution possible, however, the demand for capital is not an ambiguous concept. It depends, at least in principle, on output and relative factor prices.

Regarding the empirical content of the analysis, a number of important propositions follow from the estimated tendencies. The most crucial involve the estimated ease of substitution itself. According to the capital per bed equations, a one percent increase in the wage increases the demand for capital by one percent (expressed as capital per bed), equally in teaching and non-teaching hospitals. Since beds are impounded in ceteris paribus, this is equivalent to a one percent increase in demand for capital. However, according to the capital-labor equations, the ease of substitution is less in teaching hospitals. Hence the implied static adjustment reduces labor by a smaller percent in teaching hospitals; .2 percent, as compared with 1 percent in non-teaching hospitals. (Also, since the wage and price per unit of capital services enter symmetrically, the adjustment implied for a one percent reduction in the implicit price of capital services is the same.)

This means that while elasticities of demand for capital (output constant) are similar, the elasticity of demand for labor is higher in non-teaching hospitals. Among other things this indicates that fewer of the cost effects of relative wage increases are offset by substitution in teaching hospitals. Also, the relative importance of the wage bill in total costs may decline very little in teaching hospitals, while the substitution elasticity of 2 in non-teaching hospitals indicates it will decline as the relative wage increases. (In terms of capital, cost of capital services become increasingly more important in non-teaching hospitals.)

The results also contain implicit suggestions on another matter - the question of economies of scale. Since holding average length of stay and average occupancy rate constant is equivalent to impounding admissions per bed (and since service statistics and outpatient visits are expressed relative to admissions), an increase in beds carries with it most of the concepts related to the concept of scale. The results show that in teaching hospitals neither the capital-labor ratio nor capital per bed are effected by bed size. That is, a one percent increase in beds is associated with a one percent increase in both capital and labor. Thus, in teaching hospitals, the assumption of constant returns to scale appears to be a good one.

In non-teaching hospitals the results are mixed because an increase in bed size is not neutral. A one percent increase in bed size is associated with .47 percent increase in the capital-labor ratio, and .36 percent increase in capital per bed - that is, 1.36 percent increase in capital, and .89 percent increase in labor. Thus the proportionate increase in total cost resulting from the adjustment to the increase in beds (ceteris paribus) is a function of the relative wage bill. The function is non-linear; but within most practical ranges it would predict approximately a one percent increase in total costs.

In the concluding chapter, which includes a summation of this research, comments and suggestions are offered on the policy ramifications of these results.

CHAPTER V

CONCLUSIONS AND COMMENTS

1.

The purpose of this research has been to determine the role of allocative principles in the decisions of voluntary hospitals as regards the choice of capital intensity. Thus the object was to measure the substitution of capital for labor that could be attributed to the relative wage of labor.

The evidence from published sources, examined in Chapter II, suggests that for voluntary hospitals there are regional differences in capital per employee and capital per bed which cannot be attributed to chance. These may be related to differences in wage scales. Unfortunately, capital in published sources is measured as plant assets. These data contain uncertainties which limit their value as measures of capital.

For a sample of 38 short-term voluntary hospitals in New York City measures of capital stock were developed from individual accounting records. These data were then used as the bases for analyzing capital per employee and capital per bed.

The framework for measuring substitution, as developed in Chapter III, was based on general views as regards the nature of the production processes in hospitals, and how the relative wage of labor should be related to capital-labor ratios, if in fact relative factor prices do influence the allocation of capital. The hypothesis of output maximization was shown to be a logical basis for predicting substitution.

The major findings of the statistical inquiry indicate that among the sample hospitals allocative principles not only play a role in determining capital intensity but also that the magnitude of the role is comparatively high. The estimated elasticity of the capital-labor ratio with respect to the hospital wage is 2 in non-teaching hospitals, and near unity in teaching hospitals. Under the maintained hypothesis this is a measure of the elasticity of substitution. Thus it evaluates the ease of substituting capital for labor.

Since the individual hospital constituted the observed economic unit, the heterogenous character of hospitals made it possible (and necessary) to investigate a number of additional hypotheses. It was hypothesized that capital-labor ratios, and capital per bed as well, would be influenced by specialization in more complex cases - measured by the average intensity with which patients were furnished with operations, X-rays, etc. - by bed size, the importance of outpatient services, and by the pace of activity within the hospital. It was also hypothesized that differences in mission or professional orientation could also result in shifts in capital-labor and capital-bed ratios. Two possibilities were examined: auspices, distinguishing between Catholic and non-Catholic hospitals; and personal character of management, distinguishing hospitals by sex of director. Both of these latter dichotomies proved to have significant shift effects on the use of capital.

In general, complexity of service variables were found to have positive effects, although not always to the same extent for teaching and non-teaching hospitals. The results for other variables were diverse. For example, neither average length of stay nor bed occupancy rate influenced the capital-labor ratio; but average length of stay did have an effect on capital per bed. The effect was negative for non-teaching hospitals; but the implied elasticity for teaching hospitals was positive. The differential elasticity upon which this is based was, however, significant at the 10 percent level only.

The effect of bed size is interesting because of its economic implications. In view of the nature of other variables impounded in the ceteris paribus clause, an increase in bed size is equivalent to an increase in scale. The results signify there are probably few if any economies of scale.

2.

The economic implications of these results have been stated. They include the implications for basic principles when allocative rules guide the allocation of resources, the implications for the demand for capital, the implications for hospital costs and the relative importance of the wage bill, and the implications for economies of scale. Given the empirical record of the sample hospitals, they do not have an unfamiliar ring to economists; but the potential picture of the voluntary hospital that emerges is rather remarkable. For example, in one very important respect the results support the veiw that the hospital tends to manage its resources in the same way as does a commercial firm. That is, resources are coordinated so their relative productivity reflects their relative scarcity.

How then are claims of inefficiency, the squandering of capital funds, insensitivity to opportunities for raising productivity, and choosing inappropriate scales to be reconciled? These claims can be understood as the result of differing views on how output is to be defined. What the hospital regards as output, and what it considers in evaluating productivity is not necessarily regarded as being output by bystanders who have subjective commitments as to what constitutes a legitimate hospital service - a normative evaluation of what is "real."

Clearly this is not a revelation. Economists in studying hospital cost structures have not hesitated to experiment with the measurement of output - weighting patient days or cases according to various assumptions. Equally significant is the intuition that invariably leads insurance underwriters and government agencies, involved in negotiating hospital rates, to insist on classifying some costs as allowable or necessary while others are considered to be not allowable, or unnecessary.

These attempts to guide the hospital in the production of services indicate clearly that there are differences between what the forces of demand wish to finance and what hospitals may wish to produce. The temptation to say that hospitals, in some cases, simply spend without producing anything exists. But this can be viewed as another way of saying that there is disagreement on what is to be called output.

Accordingly, while there are a number of useful comments to be made as regards the policy ramifications of this research, it is most important to remember that the question of assortment of services or whatever may constitute output has been touched upon only in a tentative way. Also, while the statistical analysis supports the conclusions that have been stated, it is worth reemphasizing that data imperfections and limitations of the sample impede the strict extension of findings to voluntary hospitals in general. Such extensions must be viewed cautiously and interpreted with respect for differences that may exist between the sample hospitals and other U.S. voluntary hospitals.

Learning that voluntary hospitals substitute capital for labor (as suggested by this research), and that the extent to which substitution occurs is comparatively high, has three major ramifications. First it suggests that safeguard mechanisms to insure the efficient use of capital can best serve the social goals of providing a widespread deliverty of hospital care, by concentrating on the mix or assortment of services that are the proposed output of capital plans, rather than on the architectural and engineering designs which outline the way capital is to be used. Second, it indicates that hospitals are aware of many ways for increasing the productivity of labor. Third, it indicates that the demand for capital is highly sensitive to allocative effects.

1. Safeguards: the purpose of safeguards is to perfect or make efficient the supply of hospital services. At the hospital level this involves two distinct types of economic efficiency. Efficiency in production which, if achieved, implies that capital and labor are being combined in cost-minimal proportions and that economies or diseconomies of scale have been taken into account in choosing the size of hospital; and efficiency in the assortment of services, which if achieved implies that among all possible assortments, the hospital is producing the particular assortment that is most preferred by the community it serves.

Undoubtedly the preferred assortment of services in a given hospital will depend on the assortment produced in other hospitals within the community. Hence, in the absence of a price policy to induce the desired supply response there seems to be no alternative to the regulation of assortment. Regulators should be aware however that shifting the composition of services may have significant consequences for the demand for resources, and for capital in particular. For example a shift in composition which increases the relative frequence of major operations will induce an increased demand for capital.

On the other hand, aside from assurances of technical competence, subjecting capital plans to time consuming and otherwise costly reviews once the assortment has been established would seem to be unnecessary. There is little evidence from the analysis to suggest economies of scale are a problem. And, as regards the comparison of costs and productivity, the findings support the view that hospitals themselves voluntarily pursue these objectives.

2. Labor productivity: the results of the analysis suggest that the sample hospitals have been able to achieve substantial increases in cost-reducing productivity. The trade literature of hospitals, like the trade literature for other industries, continually reflects ideas and attempts to improve the quality of hospital services - improving ventilation systems while maintaining rigorous sterile conditions, improving internal communications systems, improving material distribution systems, and improving the quality of data (X-ray pictures, lab-tests, and the examinations of tissue). However, this literature also reflects a continuing flow of ideas and experiments that are concerned for productive efficiency. These ideas appear to cover the entire range of activities that constitute the internal works of the hospital - the distribution of work time in dietary departments, automating materials handling, control of patient records, waste disposal, scheduled plant maintenance, scheduled admissions, computerizing business records, and much more. It is obviously difficult, and perhaps impossible, to separate the effects of technical and allocative improvement in each case. Nevertheless, the evidence of this study indicates these more visibly expressed concerns are in fact based on a general concern for productive efficiency. The findings also indicate that allocative effects are important, i.e., using known but alternative techniques to reduce costs.

The concern for productivity, while maintaining a serious concern for quality, is a natural consequence of public policies to finance patient services directly from tax sources, and to influence such financing indirectly through the regulation of hospital insurance systems. Hence there may be advantages to policies aimed at the systematic collection and distribution of information which descirbes the productivity implications of various technologies and allocations of factors. An important point suggested by this study is that collection strategies which emphasize information on the use of existing technology may provide a source for substantial increases in productivity.

In further regard for potential increases in productivity, the fact that the sample hospitals appear to respond voluntarily to the relative cost of capital indicates there is another way of approaching this problem. That is productivity increases can be achieved through policies which effectively reduce the cost of capital. Three points should be emphasized, however. First, effective reduction in the cost of capital involves the entire future of the hospital; hence lump sum subsidies for offsetting immediate short-falls in capital funding may have little impact on the permanent or long-run conduct of the hospital. Policies are recommended which focus on the cost of capital, not on the amount of funds which may exist or are "available" for particular purposes. Such policies for example could be expressed in the charge structure for hospital services - emphasizing the future cost of capital to the hospital rather than depreciation or other allowances based on historical costs.[1]

[1]Recent evidence (unpublished) indicates that the use of debt to finance plant equity has risen substantially since 1960. This corresponds to the introduction of a special capital cost allowance in Blue Cross rates.

Second, the cost of capital is not the same for all hospitals. An important reason for this is that the "market" for funds is dominated by private philanthropy. In this unorthodox market capital funds are not equally accessable to each hospital.

The fact that cost of capital is not the same for all hospitals suggests that the opportunities for increasing productivity may vary. Larger gains may be possible by concentrating on those hospitals with limited access to traditional capital markets.

Third, although the findings indicate increases in labor productivity are the consequences of reducing the cost of capital, labor productivity remains an implicit concept. No direct measurement is provided. This is an important point, not only because measurement would appear to be necessary to evaluate the results of a policy, but because the productivity of capital, which is intimately connected with the productivity of labor, is also a matter of concern. Preoccupation with labor productivity, at the expense of the productivity of capital can also increase the social costs of hospitals unnecessarily. For these reasons policies aimed at reducing the cost of capital to secure increases in labor productivity should be cautious and, perhaps, selective in nature.

3. The demand for capital: interest in the demand for capital in the past, and in the present, has usually been confined to the question

[1](Cont'd) In a sample of 42 New York City voluntary hospitals, which includes the 38 hospitals in this study, total debt financed plant equity increased from $16.5 million to $58.3 million (a 3.5 fold increase), from 1960 to 1966. This is spectacularly greater than the increase of $4.4 million that occurred over the preceding 15 years. During this period, of the early 1960's, the beginning of which marked the initiation of the capital cost allowance in Blue Cross formulas, capital expenditures were $239.2 million, while the cost allowance itself provided only $34 million in funds. (Charlotte Muller, Principal Investigator, The City University of New York, Center for Social Research, Hospital Project; funded by the Public Health Service, Grant Number HS 00202.)

of how a certain quantity of assets shall be financed. There is little agreement on the desirability of the amount of capital in question and an overwhelming tendency to speak of capital requirements as if capital were related to hospital beds and - vaguely - special facilities, by a set of fixed coefficients. In effect the demand for capital is approached on an ad hoc basis, in terms of equipment lists and construction cost estimates. This treats each project or hospital as a special case. The findings are prejudicial to these views without, however, touching on the necessity or usefulness of this type of documentation for managerial purposes. More precisely, for policy purposes, the substitution of capital for labor reveals the importance of allocative effects as systematic influences on the demand for capital.

The demand for capital is not something that can be decided once for all, even if the number, size, and distribution of hospitals were totally regulated. Hospitals grow and develop in a number of ways that are intensive, without a view towards accommodating additional patients. And, over time, relative factor prices change, resulting in the desirability of substituting capital for labor.

The importance of this is that the demands for hospital services can be translated into demands for capital. It may even be possible to increase the speed of actual capital formation by introducing funding policies for that purpose.

As a final remark it seems worthwhile pointing out that the results of this research are consistent with much of the empirical work done by economists in the micro-economics of hospitals. The concept of a stable cost function seems entirely justified, although there is little evidence of economies of scale. Lave and Lave have suggested that the rate of cost increase is higher in teaching hospitals than in non-teaching hospitals (24; p. 386). This is consistent with the fact that ease of substitution is greater in non-teaching hospitals.

The indications are that capital will become an increasingly important consideration in formulating public policies, not only for technological reasons, but also for cost-reducing reasons - as in large numbers of hospitals the relative social cost of capital increases.

APPENDIX

The primary source of data utilized in this study is the annual financial and statistical report of member hospitals to the United Hospital Fund. This report is composed of several parts, among them the balance sheet, the operating statements of costs and revenues, reports of service statistics, and a personnel report. With the exception of the information relating to teaching status, all observations on the variables that are analyzed were collected directly from these reports, or were based on information extracted from these reports.

Initially the sample included 42 voluntary general hospitals. However, because of deficiencies in data coverage, 4 were dropped, leaving 38 hospitals in the sample. In 1965, these hospitals, ranging in size from 93 to 1,575 beds, accounted for 16,738 hospital beds in New York City.

The estimate of capital, used in the numerator of the capital-labor ratio, was constructed from the plant accounts of the individual hospitals. Capital stock was defined as the real value of capital stock in use during the year in question. The estimate for this value was the average of real stock reported at the beginning and end of the year. (It was assumed that the flow of capital services was proportional to this average stock.)

Year-end balances of real capital stock in use were built up, beginning with book balances in 1945, by adding the increments of new construction brought into active use, deflated by a construction cost index, and the net purchases of new equipment to the balance estimated for the previous year. The cost index used was the Dow Building Cost

Calculator, which dates from 1900, and is based on unweighted price averages for basic construction inputs (labor, steel, sand, and cement) in 15 New York and New Jersey cities.

For several reasons, no adjustment was made for depreciation. First, since most hospitals did not report depreciation throughout the 20 years, 1945-1965, and in some instances never reported it at all, uniform treatment of hospitals would have required applying a standard arbitrary rate. This would be necessary to preserve inter-hospital differences observed in cross-sections, because of different time paths of adding to capital stock - if reported gross values were cumulatively maintained. However, a study of the accounts shows that the hospitals tended to write off their assets, even when reporting depreciation, either in relatively steady annual amounts or in comparatively large amounts at 4 or 5 year intervals.

Second, the hospitals, in reporting their costs to UHF, were permitted to write off outlays for extraordinary repairs and replacement as an operating expense. On occasion, when the amount for a given year was considered large, the hospital was permitted to defer two-thirds of the outlays for write-offs in succeeding years. In part this was compensation for capital costs; but a number of checks on the items involved yielded a substantial number of instances where the repairs or replacements were undoubtedly items that should have been capitalized. In any case, whether written off as a current expense or deferred to a succeeding year, these outlays were never recorded in the plant fund.

The biases probably imparted by the procedure described above have opposing tendencies. The use of a cost index to deflate new construction may result in an underestimate, because the index fails to take changes in productivity into account. Accepting new equipment purchases at current value, however, does not take into account price increases, where these increases are not reflections of technological improvements and new inventions. There is no available price index of hospital equipment purchases for these years; however, technological changes in the areas of diagnostic, therapeutic, monitoring, and cummunications activities have created a dramatic flow of new equipment during this period. Hence the price increases, which are relevant for administrative and budgetary purposes, include substantial real increases in the capital that is acquired.

The balance of effects is difficult to assess. Omitting depreciation is not serious because of the direct write-offs and the expensing of replacements. Also there is some tendency to under-report assets purchased occasionally from other than plant funds or received as donations. The best assumption, perhaps, is that errors are random, and not likely to be large.

For labor services, the denominator of the capital-labor ratio, the figure for full-time and full-time equivalent employees as of the end of the year, multiplied by 2000, was used. The data on employees were obtained from the annual UHF reports.

Efforts to obtain actual duty hours or proportions of staff in various work-week classes by questionnaire and personal contact with hospital administrations were unsuccessful. Either the data were never recorded, or they were not preserved. However, personnel directors and administrators expressed the view that a gradual reduction in the hours per standard work week during the years 1960-1965 had been accompanied by a rise in overtime. It was also learned that the hospitals followed a practice of hiring part-time and summer help not reflected in the year-end report of the number of employees.

The best advice from these sources seemed to be that a 40-hour week is representative. If two weeks are allowed for sickness and vacancies, and if it is assumed that holidays and vacations are offset by short-term help, an estimate of 2000 annual duty hours per employees is reached.

APPENDIX TABLE I

Test Equations for Alternative Specifications of Equation 2, Text Table 27

	Capital/Payroll	Using Natural ENDB	Using MD Dummy
	Coefficients and t Statistics		
Variables	1	2	3
WAGE	-	1.0874 (6.5285)	1.2543 (7.2728)
ENDB	.0145 (2.4203)	.0104 (1.2824)**	.0221 (3.3709)
SLIN	.1628 (5.7183)	.1848 (5.9213)	.1440 (4.2930)
XR-A	.3029 (7.0357)	.4554 (6.4606)	.2651 (5.8161)
OPRA	.1652 (3.4802)	.1427 (2.8680)	.0943 (1.8130)*
LT-A	-.0763 (-1.6777)*	-.1115 (-2.6034)	-.0549 (-1.1241)**
OPDA	-.0666 (-2.7166)	-.0554 (-2.2653)	-.0310 (-1.2093)**
BEDS	.1073 (2.7304)	.1073 (2.4729)	.1084 (2.3562)
TEST	-.0098 (-.4862)**	-.0086 (-.4190)**	-.0198 (-.9088)**
CATH	-.1289 (-2.6702)	-.1699 (-3.8765)	.1146 (4.3995)
MALE	-.2268 (-5.7190)	-.2386 (-5.9797)	-
MD	-	-	-.0082 (-.3669)**
TIME	-.0278 (-6.7090)	-.0279 (-4.4407)	-.0353 (-5.2920)
ALOS	.0008 (.0096)**	.0040 (.0442)**	-.0836 (-.8830)**

APPENDIX TABLE I (Cont'd)

Variables	Capital/Payroll 1	Using Natural ENDB 2	Using MD Dummy 3
	Coefficients and t Statistics		
ORAT	.0750 (.3296)**	.0366 (.1559)**	-.2318 (-.9613)**
REIN	-.0070 (-.1624)**	-.0201 (-.4568)**	.0143 (.3091)**
GEPR	.1709 (3.5282)	.1473 (3.0648)	.2642 (5.3732)
R^2	.6052	.6158	.5687

*Significant at the 10% level.

**Not significant.

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