The Effect of State Certificate-of-Need Laws On Hospital Costs: An Economic Policy Analysis

by

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Executive Summary

In most states, hospitals that want to undertake capital expenditures or offer new services must obtain regulatory approval under a certificate-of-need (CON) program. State CON laws were enacted during the 1960s and 1970s with federal encouragement in part to prevent investments that could raise hospital costs. This study evaluates the effects of CON regulation on the costs incurred by hospitals in treating patients. It finds that hospital costs are not lower in states that subject a larger proportion of proposed hospital expenditures to CON review. The study thus finds no evidence that CON programs have led to the resource savings they were designed to promote, but rather indicates that reliance on CON review may raise hospital costs.

A hospital operating in a state with a CON law must submit an application to a state health planning agency before making certain expenditures that exceed specified dollar thresholds. The state agency may then transfer the application to a local health planning agency (if one exists) consisting of consumers and providers of health care. The local agency recommends whether a community need exists for the project, and the state agency ultimately decides whether the applicant should be awarded the certificate of need necessary to proceed with its project.

Though the federal government began to mandate CON review at specific threshold levels in 1974, states have been free to establish their own thresholds or to abolish their CON programs altogether since 1982. Eleven states have either sunset or repealed their CON programs, and other states have raised their review thresholds or otherwise reduced the scope of their CON review.[1] As states raise their thresholds, they subject fewer hospital expenditures to review. This study assesses the relation

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[1] The states that have sunset or repealed their CON laws since 1982 are Arizona (1985), California (1987), Colorado (1987), Idaho (1983), Indiana (1987), Kansas (1985), Minnesota (1984), New Mexico (1983), Texas (1985), Utah (1984), and Wyoming (1987). Louisiana never enacted a CON law.

between hospital costs and the dollar thresholds that trigger CON review.[2]

CON laws could raise hospital costs in two ways. First, CON review may serve as a barrier to the entry of new providers of health care who must demonstrate that a need exists for their services. A challenge by an existing hospital to a new CON application may lead to substantial administrative and judicial delays in issuance of a certificate of need or denial of the application. This regulatory impediment, which applies to expansion as well as new entry, reduces competition among hospitals, and may lessen the incentive of hospitals to reduce costs. A second way in which CON laws could raise hospital costs is by encouraging hospitals to avoid use of regulated capital and equipment inputs by using larger amounts of unregulated inputs such as nursing services and laboratory tests to treat patients, a substitution that could raise costs if hospitals would efficiently use resources absent the regulation.

CON regulation has been justified in the past primarily by the theory that unregulated hospital competition would lead to the provision of unnecessary facilities and services in order to attract patients and physicians, with the costs of underutilized facilities being passed along to patients. The basis for this rationale for CON regulation has been weakened as patients and insurers have become increasingly sensitive to the price of hospital services since the 1970s, limiting the ability of hospitals to pass along unjustified cost increases. Given that CON laws inherently restrict competition, they may now harm consumers.

The effects of regulation on hospital costs were evaluated by statistically estimating a cost function for a sample of 3708 hospitals using data for 1983-84. This methodology relates the total costs of individual hospitals to the volume of services they produce along with other factors thought to influence hospital costs, including certain state regulations.

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[2] Separate thresholds generally are set for capital expenditures to build new facilities or expand existing ones, for new services, and for major medical equipment.

Our empirical results support policies of relying less on government regulation to allocate hospital resources. The results suggest that if states were to significantly relax the regulatory constraints hospitals face by doubling the thresholds at which hospital expenditures were subject to CON review, total hospital costs would not increase, but rather would decline by 1.4 percent. Given total annual expenses of $95 billion for short-term community hospitals in states with CON laws in 1985, this result suggests that hospital expenses would decline by $1.3 billion a year were these states to double all of their review thresholds.

The study uses data on hospital costs from 1983 and 1984, a time when there were few states without CON programs. For this reason, we cannot assess the effect on hospital costs of a complete elimination of CON review. Our result for the doubling of CON thresholds, however, represents a lower bound estimate for this effect. Earlier studies have suggested that abolition of CON review could lower hospital costs by as much as 4 percent (Noether (1987)). Using the 1985 expense figure as a base, this suggests that elimination of CON review could lower hospital costs by $3.8 billion a year.

Two other forms of state hospital regulation are also examined in the study. The first is the capital review program operated by some states under Section 1122 of the Social Security Act. Fifteen states maintain these programs, under which state agencies (often the same ones that review CON applications) recommend whether the federal government should provide Medicare and Medicaid reimbursement for the interest and depreciation expenses associated with proposed projects. The empirical results show that the Section 1122 program appears to lower costs only for certain hospitals (those with a large volume of Medicare patients) in states which also maintain a CON program. The other form of hospital regulation examined in the study is prospective review of hospital rates. The study found that the presence of mandatory rate regulation was not associated with lower hospital costs.

Among the other findings of the study is that for independently operated hospitals, state and local government hospitals and for-profit hospitals have costs between 5.5 and 13 percent lower than those of voluntary hospitals. Costs for for-

profit and government hospitals appear to be higher when these hospitals are either owned, leased, or managed as part of a hospital system. The observation that for-profit hospitals that are part of a larger system have higher costs than independently operated for-profit hospitals (and also voluntary hospitals that are part of a larger system) may not reflect any systematic inefficiency on the part of for-profit hospital chains, but rather the fact that for-profit hospital chains often expand by acquiring inefficient, high-cost hospitals. It is also possible that these differences in costs reflect differences in the quality of service and in case mix not otherwise captured by the variables in the empirical model.

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I. Introduction

State certificate-of-need (CON) laws inherently restrict competition among hospitals by requiring that they obtain regulatory approval to build or expand facilities, to purchase new equipment, or to provide new services.[1] CON laws generally apply both to existing hospitals and to new entrants into hospital markets. They were established in part to control hospital costs by regulating the supply of hospital facilities and services. CON laws are intended to prevent competing hospitals from unnecessarily duplicating one another's facilities and services and therefore to save consumers the costs of underutilized facilities. This study attempts to determine what, if any, effects state CON regulation, along with other forms of hospital regulation, have had on the operating costs of short-term, general hospitals. The study also examines the relationship between total hospital costs and the volume and mix of services they provide.

The major impetus for the establishment of state CON programs was the passage by Congress of the National Health Planning and Resources Development Act (NHPRDA) of 1974.[2] This Act provided standards of review for hospitals' acquisition of capital assets. States with existing programs were obligated to comply with the standards set by the law, while remaining states were required to establish CON programs. States failing to comply with the standards set by the Act stood to lose federal funding for a broad set of state and local health programs. With the 1979 amendments to the Act, states were also required to review hospitals' acquisition of major medical equipment and entry into new services. By 1980, all but one state (Louisiana) maintained a CON program.

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[1] Other institutional providers often covered by CON laws include skilled nursing facilities, intermediate care facilities, kidney dialysis centers, psychiatric hospitals, and home health care services. Only general hospitals are covered in this study.

[2] Public Law 93-641. Simpson (1986) provides a history of the development and coverage of state and federal CON programs.

Since 1980, there has been a general trend toward elimination of CON regulation both at the federal and state level.[3] Federal funding for state CON programs decreased through the 1980s and ended in 1987. The federal government never penalized the states for noncompliance with the NHPRDA standards, and in 1982 was expressly forbidden by Congress to do so. Eleven states had sunset or repealed their CON laws by January 1988, and others reduced the scope of coverage of their laws and increased the expenditure level that would trigger a review of the project.[4] Table I presents information on state CON laws as of July 1986.[5]

The primary rationale for CON regulation is the belief that competition among hospitals takes place -primarily - and excessively - in terms of the quality of facilities and services offered to patients and physicians, rather than on the price of hospital services, and that this quality competition inefficiently raises the cost of health care to the consumer.[6] Price

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[3] See, for example, Alpha Center (1985).

[4] The states that have repealed or sunset their CON laws since 1980 are Arizona (1985), California (1987), Colorado (1987), Idaho (1983), Kansas (1985), Minnesota (1984), New Mexico (1983), Texas (1985), and Utah (1984), and Wyoming (1987). Indiana sunset its CON law in 1987, but continued to review long-term care proposals through its Board of Health and new psychiatric beds and facilities by the Commissioner of Mental Health.

[5] CON review thresholds are given in thousands of dollars. Capital and major medical equipment thresholds indicate the level of capital expenditure under which capital or equipment purchases are reviewed. Service thresholds indicate the level of annual operating expenses at which a service comes under review.

[6] Quality competition is used here to refer to the non-price dimensions of competition among hospitals. This competition need not enhance consumer welfare. For example,

(continued...)

TABLE I

State Certificate of Need Review Thresholds
(July 1, 1986)

State	Capital Expenditures ($000)	New Institutional Services ($000)	Major Medical Equipment ($000)	Section 1122 Program
Alabama	736	0	245	No
Alaska	1000	1000	1000	No
Arizona	------	------	------	No
Arkansas	736	307	400	Yes
California	------	------	------	No
Colorado	2000	1000	1000	No
Connecticut	714	0	400	No
Delaware	150	0	150	Yes
Florida	736	307	400	No
Georgia	736	0	429	Yes
Hawaii	600	0	400	No
Idaho	------	------	------	Yes
Illinois	736	307	400	No
Indiana	1000	250	1000	No
Iowa	600	250	400	Yes
Kansas	------	------	------	No
Kentucky	634	264	423	Yes
Louisiana	------	------	------	Yes
Maine	350	155	300	Yes
Maryland	735	305	------	No
Massachusetts	600	250	400	No
Michigan	150	0	150	Yes
Minnesota	------	------	------	Yes
Mississippi	1000	200	750	No
Missouri	736	306	400	No
Montana	750	100	500	No
Nebraska	542	271	400	Yes
Nevada	736	307	400	No
New Hampshire	1000	------	400	No

TABLE I--Continued

State	Capital Expenditures ($000)	New Institutional Services ($000)	Major Medical Equipment ($000)	Section 1122 Program
New Jersey	600	0	400	Yes
New Mexico	------	------	------	Yes
New York	300	0	300	No
North Carolina	1000	315	600	No
North Dakota	750	300	500	No
Ohio	736	307	400	No
Oklahoma	2000	250	3000	No
Oregon	1000	340	1000	Yes
Pennsylvania	736	307	400	No
Rhode Island	150	75	150	No
South Carolina	600	250	400	No
South Dakota	670	279	400	
Tennessee	1000	500	1000	No
Texas	------	------	------	No
Utah	------	------	------	No
Vermont	300	150	250	No
Virginia	700	0	400	No
Washington	1071	536	1071	No
West Virginia	714	298	400	Yes
Wisconsin	1000	------	1000	No
Wyoming	745	310	400	No
District of Columbia	600	250	400	No

Note: Review thresholds are in thousands of dollars.

Source: Intergovernmental Health Policy Project (1986).

competition has long been considered to be weak in the hospital industry because most patients are insured and face a relatively low out-of-pocket cost for the services they consume.[7] Perhaps more importantly, hospitals traditionally have been reimbursed retrospectively for whatever costs they incurred in providing services, a mechanism that may weaken their incentive to contain costs. Absent a strong incentive to compete over prices and contain costs, quality competition is alleged to lead to the construction of facilities and provision of services that are duplicative and therefore underutilized. By reviewing the capital expenditures of hospitals, CON regulation attempts to assure that facilities and services are not established unless they are needed.[8]

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[6](...continued)
hospitals may purchase capital equipment that either is not fully utilized or produces incremental benefits to patients' health valued at less than the cost of the equipment.

[7] Noether (1987) studied hospital markets using 1977 data, and found that hospitals at that time were not immune to price competition. Noether also presents evidence that hospitals' incentives to compete on prices and to contain costs have increased since the 1970s.

[8] States use a wide range of criteria in evaluating community "need" for a project (Simpson (1986)). Assessment of this need may include the evaluation of the quality of service a new facility could provide relative to that offered by incumbent providers and the accessibility of new facilities to the user population. To the extent CON laws reduce the quality of services that would be provided to consumers or increase the travel or waiting time necessary to use health care services, they would make consumers worse off even if the laws had no direct effect on the costs incurred by covered hospitals. In our empirical work, we do not attempt to measure the quality or convenience effects of CON laws which (along with any price effects) would be needed to conduct a full cost-benefit analysis of CON laws.

Whether or not CON regulation actually reduces hospital costs is an empirical question. To the extent that CON laws reduce expenditures on capital and equipment, they might reduce hospital costs, albeit at the cost of some sacrifice in quality or convenience of service. CON laws could, however, also increase costs if hospitals subject to CON review substitute away from regulated capital and equipment inputs to higher cost but unregulated labor and material inputs. CON laws could also raise the cost of hospital care if they retard competition that leads to more efficient resource use, including competition from new hospitals and other covered providers of health care services which could compete with existing hospitals.[9]

Past studies of the effects of CON regulations on hospital costs (discussed in the next section) have used data from the 1970s. CON programs at this time were primarily restricted to reviewing only hospitals' major capital expenditure proposals. The general consensus of these studies was that CON laws did not lower hospital costs, but rather may have been associated with higher costs.

The use of 1984 data in this study allows us to account for the changed environment among CON programs in which states maintain different review thresholds for each of three types of expenditures.[10] The data allow us to measure what, if any,

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[9] If CON laws served to foster cartelizing behavior on the part of hospitals, output would be restricted below the competitive level. Though the total expense of providing this smaller volume of services would be less than the expense of providing services at the competitive level, consumer welfare would decrease as a result of this output restriction.

[10] The primary data source used in the empirical analysis is the 1984 Annual Survey of Hospitals conducted by the American Hospital Association (AHA). The survey contains information on the components of hospital expenses along with other characteristics of hospitals. Data on state regulations were

(continued...)

effects different types of CON laws have on hospital costs.[11] If CON laws do serve to reduce costs, we would expect to find that states that set low review thresholds, and thereby subject a greater proportion of projects to review, would have lower hospital costs.

The data are used to estimate cost functions that relate the total expenses of an individual hospital to the levels of different outputs it produces, the prices of its inputs, and the general characteristics of the hospital. Regression methods allow us to measure the effect of CON regulation on hospital expenses, taking into account other factors which may be related to hospital costs. This enables us to test whether more stringent CON laws are associated with lower hospital costs.

The empirical results provide no evidence that subjecting more of a hospital's projects to regulatory review serves to decrease hospital costs. The results indicate that states that provide less regulation of hospitals by setting higher review thresholds across-the-board appear to have lower costs than those states which review more of a hospital's expenditures by setting lower thresholds for all types of hospital expenditures. This suggests that the recent general lifting of CON thresholds in many states may lower hospital costs and therefore benefit consumers.

The study also examines the effect on costs of two other forms of state regulation of hospitals. The first is the capital review program operated by some states under Section 1122 of

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[10](...continued)
obtained from other sources and matched to the AHA data. Approximately 3700 hospitals were included in the analysis.

[11] In addition to changes in CON laws, health care markets have changed since the 1970s with the development of preferred provider arrangements and the growth of health maintenance organizations, which may lead to greater price competition among hospitals.

the Social Security Act Amendments.[12] Fifteen states currently maintain Section 1122 programs under which state planning agencies review hospitals' expenditure plans to determine whether the federal government should reimburse hospitals' depreciation and interest costs under the federal Medicare and Medicaid programs for individual capital projects. CON legislation, which can disallow a project, is a stronger form of hospital regulation than 1122 review, which only limits public reimbursement of a portion of a project's cost. Because CON review more broadly covers hospital expenditures, most states gave up participation in the 1122 program when they enacted CON laws.[13]

The empirical results show that reliance on a Section 1122 agreement alone without a CON law has no discernible effect on hospital costs. A Section 1122 agreement appears to lower costs only for certain hospitals (ones with a large volume of Medicare patients) in those states that also have a CON program.

The other form of regulation examined in the study is the setting of hospital rates through the process of prospective rate review. This form of regulation generally establishes in advance the maximum rates hospitals can charge. Because a hospital is paid a fixed rate irrespective of the cost it actually incurs, rate regulation may reduce the incentive hospitals may have to increase costs in their efforts to attract patients. The study found that the presence of mandatory rate regulation did not have a significant effect in lowering hospital costs.

Section II of this report discusses the rationale for CON regulation of hospitals and discusses previous studies of the effects of this regulation on hospital costs. Section III describes how the theoretical model of a firm's cost function can be applied to hospitals and discusses the data and variables used in this study to measure empirically the effects of CON regulation

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[12] Public Law 92-603 (1972).

[13] Lewin and Associates (1985).

on total hospital costs. Section IV presents the empirical results of the study, and Section V concludes the report with a summary of results and a discussion of directions for future research.

II. The Potential Effect of CON Laws on Hospital Costs

To motivate this study, it is helpful to outline the potential effects of CON programs on hospital costs. The first part of this section reviews the rationale for CON laws and their potential impacts on hospital costs. The net direction of these effects is theoretically ambiguous and therefore cannot be established without empirical analysis. The second part of this section selectively reviews the empirical literature examining the effects of CON regulation on hospital costs. The conclusion of this section explains why additional research is needed to better understand the effects of three types of CON review, which currently operate in an economic environment different from the one that existed during the period covered by previous studies of CON laws.

A. The Rationale for and Effect of CON Laws

State CON programs provide review and approval of capital investment and expansion of facilities and services by hospitals. CON laws were first established by the states[14] and ultimately mandated by the federal government. One theory underlying CON laws is that unregulated competition among hospitals leads to costly overinvestment in hospital resources.[15] CON regulation attempts to correct for the effects of this competition by regulating the supply of hospital services through the requirement that a hospital receive a certificate of need from a state agency before it can undertake a covered project.

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[14] New York established the first CON program in the nation in 1964.

[15] Congress, in amending the National Health Planning Resource Development Act in 1979, found that "[T]he effect of competition on decisions of providers respecting the supply of health services and facilities is diminished....As a result, there is duplication and excess supply of certain health services and facilities, particularly in the case of inpatient health services." See 42 U.S.C. section 300k-2(b)(1)-(3) (1982).

By controlling the entry and expansion plans of hospitals, certificate-of-need laws attempt to compensate for the perceived tendency for hospitals to overinvest. There are several reasons why unregulated competition among hospitals might not lead to an optimal allocation of resources. Most hospital patients are insured and do not have to pay the full cost of the hospital resources they consume.[16] Patients (or their physician agents) have the incentive to consume hospital services as long as the benefit of doing so exceeds the subsidized out-of-pocket cost. If insurers pay for all (or most) services patients and their physicians demand on the basis of costs incurred, hospitals will have the incentive to compete for patients and their doctors by increasing the quality of facilities and services at the hospital. Quality here refers to the amenities available to the patient and to the diversity and availability of hospital equipment, services, and personnel to the patient and his or her physician.

Hospitals may also compete for the physicians who admit patients to the hospital by similarly providing them with an environment in which a wide range of sophisticated services can be provided. Providing such services may in itself bring prestige to a hospital and be a source of utility to its administrators.[17]

CON laws seek to control hospital costs by reducing quality competition and limiting the "unnecessary" expansion and duplication of services and facilities that might occur in an unregulated market. Such duplication not only could lead to underutilization of equipment and facilities but also prevent

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[16] Congress, in amending the NHPRDA in 1979, cited "the prevailing methods of paying for health services by public and private insurers" as the primary source of the lessening of the beneficial effect of competition on the allocation of resources.

[17] Lee (1971) presents a conspicuous production model of hospitals that argues that hospitals compete for physicians and for prestige by acquiring sophisticated equipment.

hospitals from fully realizing economies of scale.[18] If there are diseconomies of scope in the joint production of different types of hospital services, costs could be reduced if hospitals specialized in fewer services rather than competing to provide a broad a range of services.[19]

CON regulation implicitly assumes that by reducing the amount of capital and equipment available to hospitals, the total cost of resources used to treat a given volume of patients will decrease. This assumes that other inputs, such as labor, cannot be substituted for the restricted inputs. Hospitals are not particularly capital intensive; for the sample used in this study, interest and depreciation expenses are less than ten percent of total expenditures for most hospitals. By restricting the use of capital and equipment, CON laws may encourage hospitals to switch to less capital-intensive but more expensive ways of treating patients.[20]

CON laws may weaken competition among hospitals if they serve as a barrier to expansion by existing hospitals or the entry of new providers of health care. In states with CON laws, a potential entrant must submit an application to a health planning agency if it wants to provide new facilities or services within the state. The burden is placed upon the potential entrant to demonstrate that the need for service is not currently being met in the market. A CON application may be challenged by existing

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[18] Economies of scale exist in the production of an output if unit costs decline as more output is produced. Economies of scale are fully realized when unit costs are as low as possible and additional production would increase unit costs.

[19] Economies of scope exist in the production of two or more outputs if the costs of separately producing the outputs are more than the costs of jointly producing the outputs.

[20] Empirical studies of CON laws (discussed below) have found evidence of increased use of non-capital inputs in hospitals covered by CON laws.

hospitals, and entry of a competitor may be delayed or even defeated because of the CON process.[21] If incumbent hospitals know that it will be difficult for new and innovative providers of health care to enter the market, the potential for price competition, which would put downward pressure on costs, would be lowered.[22]

The theoretical effect of CON laws on hospital costs therefore is ambiguous.[23] The laws may lower costs if they reduce quality competition and the wasteful duplication of facilities, or they may raise costs if they lead to a more costly mix of inputs than would be determined by market forces or to reduced competitive pressure to contain costs or adopt cost-reducing innovations. The issue of whether CON laws affect hospital costs is an empirical one. The next part of this section selectively discusses several of the previous empirical analyses of the effects of CON laws on hospital costs.

B. Literature Review

There is a large empirical literature that evaluates the effects of regulation on the costs of institutional health care, primarily

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[21] The Federal Trade Commission found evidence that hospitals in the Chattanooga, Tennessee area had agreed to use the CON process both to challenge the entry of new competitors and to divide markets. Hospital Corporation of America, 106 F.T.C. 361, - (1985), *aff'd*, 807 F.2d 1381 (7th Cir. 1986), cert. denied, 107 S.Ct. 1975 (1987).

[22] Posner (1974) has suggested that in addition to preventing new entry into health care markets (and therefore fostering cartelizing behavior on the part of incumbent hospitals), CON laws may also limit the dissipation of rents through quality competition among incumbents that would destabilize a cartel.

[23] Theoretical models of hospital behavior generally provide ambiguous results for the effects of regulations restricting input usage. See, for example, Sloan and Steinwald (1980).

in hospitals. A number of these studies have examined the effects of CON laws on hospital costs, and some have taken account of other regulations in evaluating the effect of CON programs. The consensus of these studies is that CON laws have not been successful in restraining hospital costs, regardless of the way in which costs are measured. This part of the study selectively reviews several of the major empirical studies of CON laws.[24]

Early studies of CON laws by Salkever and Bice (1976, 1979) used data from the 1969-72 period to examine the effects of state CON laws on hospital investment and costs.[25] The authors used hospital data aggregated to the state level, and used two variables to describe a state's CON program. The first was a dummy variable that indicated whether the state had a CON law for at least six months of a given year. The second variable measured the fraction of the four-year period during which a CON law was in effect. This latter variable was created to account for the possibility that CON laws take time from their enactment to have an effect on hospital investment and costs.

Salkever and Bice estimated the effects of CON laws on changes in hospitals' total investment, bed supply, and plant assets per bed. They found that CON laws were not significantly associated with any change in total hospital investment, but rather with a transfer of investment away from new beds toward

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[24] Sloan and Steinwald (1981) provide a general review of the empirical literature measuring the effects of CON and other forms of hospital regulation on hospital costs.

[25] The time period covered by this study was after some states began to adopt CON programs on their own initiative, but before Congress required that states establish CON programs under the NHPRDA of 1974.

uncovered, non-bed assets.[26] The authors found that the presence of a CON law was associated with an increase in average per day inpatient costs of about 3 percent.

Sloan and Steinwald (1980) analyzed the effect of CON laws and other forms of regulation on hospital costs and investments using a sample of over 1,200 hospitals for the 1969-75 period. They created several variables to characterize (e.g., in terms of age and comprehensiveness) a state's CON program. CON programs that were more than 2 years old were distinguished from those which had operated for less than two years. Also, CON programs which reviewed services and had a low capital review threshold were distinguished from other programs. The study also included variables on states' Section 1122 programs and rate regulation.

Sloan and Steinwald found that comprehensive CON programs appeared to have no effect on average hospital costs (per day or per admission), and that less comprehensive programs (focusing primarily on bed expansion) were associated with higher costs than hospitals in states without CON laws. The age of the CON programs was not related to hospital costs. In examining the input use of hospitals, the authors found no evidence that uncovered assets were substituted by hospitals for beds as had Salkever and Bice; they did find that hospitals covered by CON programs increased their use of labor inputs.

Sloan (1981) used a long time-series (1963 through 1978) of state cross-sections to examine the effects of CON programs, Section 1122 agreements, and rate regulations on average hospital costs (per day and per admission) within states. Sloan concluded that over this time, neither CON laws nor the Section 1122

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[26] A coefficient of an independent variable in a regression is described in this literature review as statistically significant if the null hypothesis that the independent variable has no effect on the dependent variable cannot be rejected using the conventional two-tailed t-test at the 95 percent standard of confidence.

program had an impact on the level of hospital costs or their rate of increase. Of the regulatory programs examined in the study, only mandatory prospective rate regulation appeared to lower costs significantly.

Joskow (1981) used an annual time-series of total hospital expenditures by state over the period 1973-79 to evaluate the effect of the presence of a CON law and of mandatory state rate regulation on the level and growth of hospital expenditures. Though the presence of rate regulation was associated with lower total hospital expenditures and with lower growth of these expenditures, Joskow found no significant effect for CON regulation.

Eastaugh (1982) used an annual time-series on several measures of hospital investment by state defined over the period 1974-78 to assess the effects of CON programs and Section 1122 agreements on hospital investment. Eastaugh concluded that neither CON nor Section 1122 programs appeared to be effective in constraining plant assets, beds, or assets per bed in hospitals. His regression results were statistically insignificant (using the standard discussed in our footnote 26), but they suggested that CON programs were associated with increased hospital investment.

Kelly and Farley (1985) used a national sample of over 400 hospitals to model the financial performance of hospitals over the period 1970-78. Embedded within their structural model is an equation that relates the average cost per adjusted hospital admission to a set of variables, including an indicator of whether a CON law was present or not in a state.[27] Evaluating their model at the 1975 mean level of hospital costs, the coefficient of the CON variable implies that the presence of a CON law was associated with a statistically significant increase in average cost of 3.5 percent.

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[27] Adjusted admission in both this and in Noether's (1987) study means that the admission figure is a revenue-
hted average of inpatient and outpatient admissions.

Noether (1987) obtained a similar result in her study of hospital competition within Standard Metropolitan Statistical Areas (SMSAs). Using 1977 data both for individual hospitals and aggregated to the level of the SMSA, Noether found that CON laws that had been in effect for three years were associated with a 3.3 percent increase in average costs per adjusted admission at the SMSA level, and a 4.0 percent increase in average costs per adjusted admission for individual hospitals.[28] Noether's study is interesting in that it also assessed the impact of CON laws on the prices of different services provided to Medicare patients. Her empirical evidence indicated that CON laws may be associated with price increases that are larger than the corresponding increase in costs. This suggests that CON laws may lead to higher profit margins, an outcome consistent with the theory that CON laws may serve as barriers to new competition.[29]

C. Conclusion

The existing studies of the effects of CON laws on hospital costs have used data from the 1970s, a time when CON regulation covered only the capital acquisitions of hospitals and were fairly uniform in their coverage across states. Since this time, there have been substantial changes both in the operation of CON laws and in the hospital markets they regulate.

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[28] The coefficient of the CON variable in the SMSA-level regression barely missed meeting the 95 percent level of significance. The coefficient in the hospital-level regression was significant; a misprint in the published report overstates its t-ratio above its actual value of 2.4 (conversation with author).

[29] Noether also found that prospective rate regulation was associated with lower hospital prices, but that this form of regulation was not associated with any effect on hospital expenditures. Noether did find that the presence of a Section 1122 agreement was associated with a significant decrease in expenditures at the level of the individual hospital, but not at the SMSA level.

III. The Model and Data

This study attempts to measure the impact of state CON laws and other forms of regulation on individual hospitals' costs. This analysis involves the empirical specification of a cost function in which the total expenses of individual hospitals are related to other factors, including state CON regulations, which are thought to influence these costs. This section first discusses the methodology used in modelling hospital costs, and subsequently discusses the empirical specification and data used in this study.

A. General Models of Hospital Costs

Hospital costs may be analyzed using the neoclassical economic theory of the firm. Within this framework, the problem facing a firm in producing any level of output is to use inputs in such a way that total costs are at a minimum. A cost function mathematically relates total costs to the output levels and input prices for the firm. Measures of the average and marginal costs of producing output may be obtained from total cost function estimates. Under the assumption that firms minimize costs, a cost function can be used to estimate not only economies of scale, but also economies of scope and input substitutability, along with other elements of production technology. There generally exists a "duality" between the production and cost functions of a firm; i.e., information on one can be used to retrieve information on the other.[32]

The cost function of a firm can be expressed as

$$(1)\ \text{Cost} = \sum_{i=1}^{n} p_i x_i = C(Y,p),$$

where Cost is the total cost of producing output Y, and the p_i are the prices of each of the n inputs, x_i, used in production. The firm optimally chooses levels of inputs to minimize cost, given that Y units of output are produced. In estimating a cost function, the distinction must be made between long- and short-run costs. In the long-run, all inputs may be varied to produce

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[32] McFadden (1978) generally discusses this duality.

With the 1979 amendments to the NHPRDA, Congress expanded CON programs to include review of entry into new services, and the purchases of major medical equipment. Congress subsequently gave states authority to deviate from federal guidelines and set the threshold levels for CON review without the risk of losing federal funds. As a result, there is now variation in CON review thresholds across states, while several other states have abandoned CON review altogether.

There have also been substantial changes in the way health care markets operate. Price competition among hospitals has increased as consumers, employers who pay health insurance premiums, and third-party payers have become more sensitive to the price of health care.[30] Hospitals may have greater incentives in the face of changes in health care markets to use resources more efficiently.

This study assesses the effects of CON laws on hospital costs in this new environment by using data from the 1983-84 period. The ensuing section discusses the multiproduct cost function framework and data that are used in the empirical work. The use of a cost function that accounts for the multiproduct nature of hospital output is more consistent with recent theoretical and empirical work involving multiproduct firms than are previous studies of hospital regulation that have used single-product models of the firm.[31]

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[30] See, for example, Noether (1987) for a fuller discussion of these and other change in health care markets since the late 1970s.

[31] Cowing, Holtmann, and Powers (1983).

a level of output. The implicit assumption in equation (1) is that all inputs have been chosen to minimize cost, an assumption which defines the meaning of long-run.

In a short-run cost function, certain inputs (such as capital) may be fixed during the decision period, and the firm will choose among levels of those inputs that can be varied to minimize its variable costs of treating a given volume and mix of patients. The short-run costs of a firm, $Cost_s$, can be written as

$$(2)\ Cost_s = \sum_{i=1}^{n} p_i x_i = C(Y, p, K)$$

where K represents the level of inputs (such as building size or bed capacity) that are fixed in the short-run, but which may be changed in the long-run.

The above equations present very general theoretical frameworks within which hospital costs may be analyzed. The exact specification of these equations in any particular context is determined both by the nature of the research problem being addressed, and by the availability of data. Studies of hospital costs typically have used measures of either (1) total costs, (2) the average cost of a service (or set of services), or (3) the average cost of either an admission into or a day in the hospital. The unit of observation in cost studies has included both individual hospitals and averages for hospitals located within a state or locality. In addition to including measures of hospital outputs and input prices, cost studies often include other factors that are believed to influence hospital costs. These variables may include the ownership status (i.e., for-profit or not-for-profit) of hospitals, the teaching status of hospitals, the source of payments hospitals receive, and the market and regulatory environments in which hospitals operate.[33]

There are several ways in which a given specification of a cost function may be interpreted. One interpretation is that the

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[33] A comprehensive general survey of empirical analyses of hospital costs is Cowing, Holtmann, and Powers (1983).

cost function is derived from an exact model of the firms' production technology such as the Cobb-Douglas production function. An empirical cost function may also be thought of as an approximation to a true cost function derived from a production process of unknown functional form (e.g., the translog function). Such cost functions are typically specified to be flexible enough to be able to approximate a wide variety of underlying cost functions derived from different production technologies.[34] Finally, a statistical cost function may be thought of as a simple description of the distribution of costs given the levels of factors that influence costs. Such a cost relationship need not explicitly be derived from a behavioral model of a cost-minimizing firm.[35]

One of the most important features of hospitals is that they do not produce a single homogenous output, but instead produce distinct outputs, such as outpatient care and intensive care unit services, which may differ greatly in the resources required to produce them. Early models of hospital costs typically used a single measure of hospital output, such as total number of beds or total inpatient days, without taking account of variation in hospitals' mix of cases.

Many empirical models of hospital costs have attempted to account for the heterogeneous nature of hospital services by weighting the various services produced by hospitals into a single index that measures the diversity of an individual hospital's output. A simple example of such an index combines the total number of inpatient days and outpatient visits by weighting each by the share of overall hospital revenue it generates. More complicated indices compare the mix of cases across different

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[34] The concept of flexibility in production economics is discussed along with other aspects of functional form in econometric model building by Lau (1986).

[35] Cowing *et al.* (1983) note that many studies of hospital costs are not well motivated by economic theory and tend to be ad hoc in nature.

Section III

The general cost framework outlined above may readily be modified to account for the multidimensional nature of hospital output by defining the element Y in (1) and (2) as a vector of outputs rather than a scalar. Each of a hospital's outputs separately enters the cost function. The theory of the firm producing multiple outputs from common inputs has been recently developed in the economic literature and implemented in econometric models of the firm.[38]

Each service produced by hospitals could, in theory, enter an estimated hospital cost function. Hospitals, however, typically produce hundreds of separate services. In order to make estimation of a cost function manageable, it is necessary to aggregate these services into a much smaller number of outputs.[39] Aggregation of a set of services into a composite output implicitly assumes that there are no economies or diseconomies of scope among the outputs included in the composite.

Several recent empirical studies have estimated multiproduct cost functions for hospitals, primarily to assess economies of scale and of scope in the production of hospital outputs.[40] They

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[38] Bailey and Friedlaender (1982) provide a good introduction to the economics of the multiproduct firm.

[39] A highly disaggregated approach would greatly increase the number of coefficients to be estimated in a cost function and likely lead to collinearity among variables, particularly among those services provided by a small number of hospitals. Collinearity among variables in a regression makes it more likely that the hypothesis that there is no relation between an explanatory variable and the dependent variable will be rejected.

[40] In addition to the study by Grannemann *et al.* (1986), discussed in the next part of this section, two other multiproduct analyses of hospitals should be noted. Cowing and Holtmann (1983) analyzed cross-section data from 1975 for 138 hospitals in

(continued...)

diagnostic categories at an individual hospital to the average mix of cases across hospitals.[36]

Though the introduction of a case-mix index into a cost function may control for variation in case mix across hospitals, it is not clear how use of an index that aggregates hospital outputs into a single index can be used to retrieve the underlying elements of the structure of costs, such as economies of scale and scope for individual outputs.[37] This suggests that an alternative to using case-mix indices is to estimate cost functions into which the separate outputs of hospitals are directly entered.

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[36] Hornbrook and Monheit (1985) create a Laspeyres index of case-mix proportions using sample average length-of-stay weights to compare differences in the number of longer-staying cases admitted among hospitals. Another index that could be used to control for case mix differences among hospitals is the Resource Need Index (RNI) developed by the Commission on Professional and Hospital Activities. This index compares the mix of discharges and their severity across hospitals using a set of weights obtained from a sample of hospitals. An outside reviewer of this report has noted that this index is, however, currently available for only 600-700 hospitals.

[37] A second problem in using case-mix indices is noted by Sloan *et al.* (1983) who use the Resource Need Index (RNI) in estimating a cost function. Two hospitals may have the same value of a case-mix index, yet treat different mixes of cases. The authors give the hypothetical example of a hospital that treats only one type of case and a second that treats a wide range of cases. Each hospital may have the same value of the RNI, but the second hospital may have higher costs if, for example, it maintains excess capacity across departments to treat this more diverse mix of cases. Sloan *et al.* use the example to motivate the inclusion of teaching variables into an empirical cost function, arguing that these variables may pick up systematic diversity in case-mix diversity not captured by the RNI.

have not, however, included information on state CON laws or other hospital regulations as factors influencing hospital costs.

The basic behavioral assumption necessary to derive a neoclassical cost function for a hospital is that hospitals take their output levels as given and use their inputs to minimize the costs of producing these output levels. The assumption that hospitals minimize costs is a more general assumption than one that they maximize profits; a firm can minimize its costs without maximizing its profits. Most hospitals are not operated for profit, and there are many competing theories of what objectives they pursue.[41] Cost minimization is, however, arguably consistent with many theories of nonprofit hospitals.[42]

Given the assumption that hospitals minimize costs, the elements of the underlying production technology, such as economies of scale and scope, may be retrieved from an estimated cost function. Absent this assumption, it is not clear that a cost function can be used to retrieve parameters of the dual production technology. An estimated cost function can, in any case, be used to assess the relationship between costs and a given variable conditioned on the other variables included in the cost relationship.

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[40](...continued)
New York state to estimate a translog cost function involving four categories of inpatient days and outpatient visits. Chang and Tuckerman (1986) used 1981 data on 153 Tennessee hospitals to estimate a translog cost function with total adult, children, and Medicare inpatient days as the three output measures.

[41] See for example, Newhouse (1970), Pauly and Redisch (1973), Harris (1978), Pauly (1980) and Goldfarb, Hornbrook, and Rafferty (1980) for different models of the goals and constraints under which hospitals operate.

[42] Cowing *et al.* (1983) discuss this point in some detail.

B. Cost Function Specification

The cost function used in this study is similar to the one recently used by Grannemann *et al.* (1986) to assess economies of scale and of scope in the production of five hospital services. The authors used data on 867 hospitals from the 1981 American Hospital Association (AHA) survey, an earlier version of the survey that provides the data for the present study. These data were matched to other data sources to estimate a cost function that can be generally specified in its estimating form for an individual hospital as:

$$(3)\quad \ln Cost = A + B \ln P + C f(Y) + D Z + e$$

The dependent variable is the natural logarithm of the total annual costs of the hospital. P is a vector of input prices, while Z is a vector of factors which influence the level of costs (but not the shape of the cost function with respect to outputs). The expression f(Y) is a complex function of the individual outputs.[43] A, B, C, D are coefficients to be estimated. An error term e is

[43] The authors write f(Y) to include the level of each output, the square of each output, and the cube of each output; certain interactions among the outputs are also included. In order to evaluate changes in the length of a stay in a hospital, that is to examine the additional cost of providing additional days of treatment to a fixed number of patients, they also include the number of discharges for each category of inpatient care in their specification. This approach is not followed in this study. Such a specification does not allow calculation of the cost of producing either hospital discharges or patient days without the other because neither exists without the other. This calculation is necessary for calculation of economies both of scale and scope for these outputs.

added to the regression equation, which is estimated by the method of ordinary least squares.[44]

This cost function is quite flexible with respect to outputs; i.e., the function f(Y) is written so that it can approximate a wide range of relationships between costs and outputs. The specification of f(Y) can readily accommodate hospitals in which some outputs are not produced. This feature considerably simplifies estimation of parameters, as well as calculation of

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[44] The error term is assumed to be identically and independently normally distributed. A specification of the distributional form of the error term is necessary in order to make statistical inferences concerning the estimated regression coefficients. The use of the normal distribution permits symmetric random variation away from the hospitals' true cost-minimizing positions and captures the effect of random shocks outside a hospital's control on costs.

A one-sided error term could be added both to the cost equation to capture systematic technical inefficiency on the part of hospitals and to the accompanying input share equations (which could be estimated if input price data were available) to capture systematic allocative inefficiency in their utilization of inputs. The econometric methods of stochastic-frontier estimation developed by Aigner, Lovell, and Schmidt (1978) have not been applied to hospitals.

Wilson and Jadlow (1982) used a deterministic model of frontier estimation to assess the extent to which hospitals failed to produce the maximum possible output of nuclear medicine services. Register and Bruning (1987) used a deterministic model of frontier estimation to assess differences in the technical efficiency of hospitals across different forms of ownership.

scope economies, when the cost function must be evaluated when some outputs are not produced.[45]

The regulation variables in our study enter the cost function as part of the vector Z. By using the method of multiple regression, we can assess the effect of regulations on the level of hospital costs, controlling for output levels and other variables entered into the equation, by examining the estimated coefficients of the regulation variables.[46] The vector Z also contains variables which measure hospital characteristics, such as ownership and teaching status, along with variables on the patient mix treated by hospitals. These variables enter the cost function in part to capture differences in case mix and method of treatment not reflected in the distribution of outputs.

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[45] One difficulty in using the translog cost function is that it is not possible to evaluate directly costs if any output is not produced. The function can, however, be modified by a Box-Cox transformation of the output variables to approximate their natural logarithmic transformation while still accommodating zero output levels (see Caves *et al.* (1980)).

The specification of a cost function in equation (3) does not include any interactions among input prices and outputs. This lack of interaction implies that changes in input prices affect the overall level of costs by a scale factor and do not affect marginal or average incremental costs; input proportions are therefore independent of scale. Formally, this assumes that the production function dual to the cost function is homothetic (Varian, 1978). Though outputs could of course be interacted with the different input prices, Grannemann *et al.* (1986) chose not to do so, citing the relatively poor quality of the input data compared with the output data. We follow this strategy in our estimation for the same reason.

[46] The interpretation of individual coefficients is discussed in the section that presents results.

C. Cost and Output Variables

The primary source of data used in this study is the 1984 Annual Survey of Hospitals conducted by the American Hospital Association (AHA). This national database provides detailed information on hospital outputs and expenses along with general characteristics of hospitals, such as ownership status. For most hospitals in the sample, the data cover a 12-month period ending in September 1984.[47] Approximately 6,300 short-term, general acute-care hospitals were included in the survey.[48]

The sample was restricted to those general medical and surgical hospitals located within the fifty states and the District of Columbia that reported data for a full-year. Specialty institutions, such as psychiatric and children's hospitals, were excluded from the sample, as were hospitals maintained by the federal government.[49] The sample was further restricted to include only hospitals that reported information on all of the variables used in the analysis. A total of 3,708 hospitals were used in the analysis. The data file gave the state in which the hospital was located; information on regulations was matched to the hospital file by sta

The AHA file breaks down the total expenses of hospitals into several categories that may be aggregated to form two different dependent variables measuring (in logarithmic form) the total

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[47] About 50 percent of the hospitals in the sample provided information for the year ending in September 1984; 27 percent of hospitals reported for the year ending in June 1984, and 11 percent for the year ending in December 1984.

[48] The AHA defines a short-term hospital as one in which the average length of stay is less than 30 days.

[49] Federal hospitals are primarily military, Veterans' Administration, and prison hospitals with restricted clientele.

operating costs of hospitals.[50] The first variable, LNETCOST, includes all expenses hospitals incur net of depreciation and interest costs. The variable represents the short-run variable costs of keeping a hospital open. We assume that if a hospital were to close briefly, interest and depreciation expenses would unavoidably be incurred.[51] The second variable, LTOTCOST, includes all expenses incurred by hospitals. Since this variable implicitly contains the cost of capital, it is usually presented as a long-run cost variable. The two cost variables are closely correlated (r=.99); the share of depreciation and interest in total cost is close to seven percent for most hospitals in the sample.

Most studies of hospital costs have used overall hospital expenses at a point in time as a measure of the long-run costs of hospitals to estimate equation (1) above. This assumes that hospitals are operating along their long-run cost curves, and that the measured scale and other production effects reflect levels of all inputs chosen to minimize costs. These assumptions are necessary if cost estimates are used to assess economies of scale and issues of optimal hospital size and pricing in the long-run.

The assumption that hospitals are in long-run equilibrium at a point in time may not be valid.[52] Several studies suggest that it takes a period of several years for hospitals to adjust their

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[50] Though the AHA survey gathers information on the capital expenditures of hospitals, these data are not released in the public version of the tape. These expenditures are the investments hospitals make and should not be included in a cost function.

[51] The AHA does not break out information that would allow us to assess the costs of maintaining a hospital were it to close.

[52] Cowing *et al.* (1983) discuss this point at some length.

capital inputs to an optimal level.[53] The implication of this result is that hospitals are not likely to be minimizing long-run costs at a point at time. The input usage and costs observed over a one-year sample period may be those of a firm adjusting inputs to an optimum level over a longer time period.

An alternative to combining all hospital expenses into a measure of cost is to use only short-run costs to estimate equation (2). Other than their different dependent variables, the two equations are the same except that a measure of fixed inputs must be added to the short-run cost equation. The AHA data do not contain a direct measure of capital stock; the variable LBEDTOT, the natural logarithm of the number of beds in the hospital, is entered into the regression as a measure of capacity. Changes in total costs associated with changes in outputs can be thought of as purely short-run scale effects in which non-capital inputs are adjusted to minimize costs given the fixed bed capacity. They do not represent the changes in costs hospitals would experience in the long-run as all inputs were adjusted to accommodate different patient volumes and case mixes.

This study uses both the short- and long-run specification of the hospital cost function. Our primary interest is in the effects of regulation on the overall hospital costs rather than scale economies. The use of both types of cost functions allows us to assess the relationship between regulation variables and measures of hospital costs which first include and then exclude the interest and depreciation costs associated with past capital investment. CON laws regulate hospitals' use of capital and equipment inputs, and this regulation may affect both the level of investment and the way in which regulated and unregulated inputs are used.

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[53] Kelly (1985) provides a review of empirical models of hospital investment that measure the speed with which hospitals adjust existing capital stocks to their optimal levels. The consistent finding of these studies (which use partial adjustment models of investment) is that at least three years is required for capital inputs to adjust to optimal levels.

Section III

The AHA survey contains information on 30 separate categories of hospital care that make up the output of hospitals. Though each category could be entered into a regression (along with squared, cubed, and cross-output interactions), the strategy here is to aggregate the outputs into five categories on the basis of the intensity of care hospitals provide to patients. The five output variables are denoted as Y_1 through Y_5.

The first variable, Y_1, measures the total number of inpatient days spent in acute care, which represents the largest share of patient days spent in hospitals. Most acute care days represent general medical and surgical care; the variable also includes obstetric and acute psychiatric care. The variable Y_2 measures the total number of patient days spent in intensive care units. These days include medical and surgical care, cardiac intensive care, neonatal care, and burn and other special care. The third variable, Y_3, includes patient days spent in subacute care and other units within the hospital. The variable includes long-term nursing care, sheltered care, rehabilitation care, and hospice care.[54] The variables Y_4 and Y_5 measure the outpatient care provided by hospitals. Y_4 includes all visits to hospital emergency rooms and Y_5 the clinic and other outpatient visits made to hospitals.

Each output variable (Y_i) is entered into the regression in its level form along with its square (Y_i^2) and its cube (Y_i^3). This specification of the cost function allows the percentage change in the total cost to vary with the level of any single output, holding the other outputs constant. If marginal costs are positive, then a pattern of positive, negative, and positive coefficients on an output variable, its square, and its cube, respectively, would mean that the marginal costs of producing that output decline up to some point at which scale economies are exhausted, and then turn upward. Each output variable is also separately multiplied by each other output variable to create interaction variables of the form Y_iY_j. These interaction

[54] Long-term nursing care days provided in nursing homes separately maintained by hospitals are not included in Y_3.

variables add to the flexibility of the model by allowing the marginal cost of an output to vary with the level of all other outputs. Economies of scope between two outputs in a production process exist if the marginal cost of producing extra output from a given level is lowered if it is produced with the second output.[55]

D. The Input Price Variable

In order to estimate a cost function, it is necessary to have measures of the prices of the inputs that hospitals use in providing services. The AHA data are very limited in providing these prices. They separate the annual total expenses of hospitals into several broad categories. The largest portion of these expenses consists of payroll expenses. The AHA file provides a breakdown of annual payroll expenses for different categories of labor along with the full-time equivalent employment in each of the categories.[56] By dividing payroll expenses for each type of employee by the number of employees, an annual salary can be calculated that is the average price of employing an extra unit of each type of labor.

Separate salary measures can be calculated from the data for physicians and dentists, nurses, residents, trainees, and all other hospital personnel. Each of the calculated salary figures could be included in the regression. One problem, however, is that many hospitals do not have physicians and dentists, residents, or other

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[55] For economies of scope to exist between two outputs, the derivative of the marginal cost of one output with respect to the other must be negative. For the general cost function used here, which has more than two outputs, a necessary but not sufficient condition for this outcome to exist is that the coefficient of the interaction variable between two output variables be negative.

[56] Full-time-equivalent employment is calculated by adding the number of full-time personnel to one-half the number of part-time personnel.

trainees on their payrolls. To include variables for the salaries of these employees in the regression would substantially reduce the number of observations used in the estimation. One salary measure which can be calculated for nearly all hospitals in the sample is the average salary of nurses. Other salary measures are quite closely correlated with the salaries of nurses, and rather than entering each salary into the equation, the natural logarithm of nurses' wages, LNURSEWG, is entered into the regression as a single measure of the price of hospital labor.[57]

The AHA data do not include the information necessary to further calculate prices for items outside of the payroll category. Therefore, only the nursing cost variable is entered into the regression as a measure of the prices of hospital inputs. Omitting variables for nonpayroll costs can be justified on two grounds. The first is that two components of nonpayroll costs, employee benefits and contracted nursing services, are closely correlated with the labor cost variable.[58] A third expense, professional fees, is itself a cost of labor, and its price is likely to be correlated with LNURSEWG. Other expenses included in the nonpayroll category are interest and depreciation, energy costs, and "all other" expenses. Price variables for these expense categories are excluded from the regression on the assumption that they do not vary across hospitals, an assumption that may be valid for capital costs.[59]

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[57] Grannemann *et al.* (1986) used the nursing wage along with several other wage variables to measure input prices; only the coefficient of the nursing wage variable approached the standard 95 percent level of statistical confidence.

[58] Measures of average employee benefit and average yearly expense per contracted nurse are highly correlated with the nursing wage variable.

[59] An implicit assumption in using input cost variables is that hospitals are price takers in factor markets and do not exhibit any monopsonistic control over the factors of production.

E. Organizational Forms of Hospitals

One difference among hospitals that could potentially affect their expenses is their organizational form. The AHA data allow us to distinguish among three categories of hospital ownership: voluntary (i.e., private not-for-profit), for-profit, and non-federal government (federally operated hospitals have been excluded from the sample). Nationally, voluntary hospitals maintain about 70 percent of all short-term hospital beds in the country, while for-profit hospitals maintain 9 percent of the nation's hospital beds. Hospitals maintained by state and local governments contain 20 percent of short-term beds.[60]

There are several reasons why different ownership structures might affect the level of hospital costs. In a for-profit hospital, managers have an incentive to maximize net return for the benefit of shareholders who have a claim to the hospital's profits. Managers are unlikely to be rewarded if they fail to produce an adequate return to shareholders. In a nonprofit[61] setting, there are no direct claimants to the residuals created in providing hospital services.[62] The goals of nonprofit hospital managers may be to produce a net return less than the m- mum and to generate non-pecuniary benefits for themselves. Unless managers are compensated by hospital trustees for maximizing net returns, they may use resources to enhance their own utility, perhaps by increasing the prestige of their institutions by undertaking costly research projects. Such behavior may lead to

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[60] American Hospital Association (1985).

[61] Nonprofit is used here to refer to both voluntary and government hospitals.

[62] Some hospital models (e.g. Pauly and Redisch (1973)) focus on the role of physicians in hospital decision making. Within the context of these models, a hospital is viewed as a cooperative among attending physicians who cooperate in order to maximize their collective incomes and therefore serve as claimants to residuals produced in a nonprofit setting.

inefficiencies that would raise the costs of providing hospital services relative to for-profit hospitals.

Costs may differ between nonprofit and for-profit hospitals because of differences in the patients they treat and the services they offer. Nonprofit hospitals may attempt to subsidize the prices charged to indigent (or poorly insured) patients by raising prices to wealthier (or more completely insured) patients. For-profits may specialize in treating patients who are more fully able to pay their hospital bills, either by attracting these patients by offering high quality services and amenities or by treating fewer indigent patients. If they do not subsidize as many indigent patients, for-profit hospitals may find it feasible to offer higher-cost, higher quality care to those who desire it and can pay for it.[63]

Empirical evidence on the effects of ownership status on hospital costs is mixed. Becker and Sloan (1985) found that ownership did not significantly affect the total cost of either an adjusted (for outpatient volume) patient day or an adjusted admission. Two studies that estimated multiproduct hospital cost functions came to different conclusions with respect to the effect of ownership structure. Cowing and Holtmann (1983) found that costs were about 15 percent lower in for-profit hospitals than in other hospitals, whereas Grannemann *et al.* (1986) found costs were about 15 percent higher in for-profit hospitals than voluntary hospitals.[64] These latter authors conclude that the

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[63] The available empirical evidence generally suggests that for-profit hospitals and nonprofit hospitals provide similar amounts of uncompensated care (Sloan *et al.* (1986)) and treat similar patient and payor mixes (Watt *et al.* (1986)).

[64] The study by Grannemann *et al.* (1986) reports a statistically significant coefficient that indicates that hospital costs are 0.8 percent lower for non-federal government hospitals than for voluntary hospitals. Their text, however, states (p. 118) that these costs are 8 percent lower.

particularly for-profit ones, tend to raise the cost of care."[67] Becker and Sloan (1985) found that affiliation with a chain had no statistically significant effect on costs for either government or voluntary hospitals but was associated with higher costs for for-profit hospitals. Ermann and Gable suggest that systems tend to grow by purchasing inefficient, high-cost hospitals, and Becker and Sloan present evidence that it may take time for chains to achieve cost-savings once inefficient hospitals have been acquired.[68]

Three dummy variables denoted **GUVMULT, VOLMULT,** and **PROFMULT** are added to the regression to indicate whether a hospital is affiliated with other hospitals. All take the value of zero if the hospital is independent. If the individual hospital is part of a multi-hospital system, the variables respectively take the value of one if a hospital is a government hospital, a voluntary hospital, or a for-profit hospital. The use of these

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[67] Ermann and Gable (1985), p. 415.

[68] An alternative explanation of why hospitals that are part of a multi-hospital system may have higher costs than independent hospitals is that they provide a higher quality of services, the dimensions of which are not fully captured in empirical cost relationships. Noether (1987) rejects this hypothesis after finding that managed and system hospitals generally do not charge higher prices than independent hospitals even though they appear to have higher costs. Becker and Sloan (1985), however, present evidence that for-profit chain hospitals have revenue-cost ratios that are similar to independent for-profit hospitals even though the former group of hospitals were found to have higher costs. This suggests that for-profit chain hospitals may provide higher-cost services at a higher price than their independent counterparts, an outcome consistent with the provision of higher-quality services.

higher costs of for-profit hospitals may be related to style or amenities in care not captured in the output measures.

Two variables accounting for ownership status are used in the regression equations estimated in this study. The first, **FORPROFIT**, takes the value of one if a hospital is operated for profit and zero otherwise. The second variable, **GOVERNMNT**, takes the value of one if a hospital is operated by a state or local government and zero otherwise. These variables will allow us to assess the percentage effect these two forms of ownership have on total hospital costs compared to the excluded category of voluntary hospitals.[65]

A second set of variables is added to the regression equations to measure whether the association of a hospital with a multi-hospital system has an effect on hospital costs.[66] It is possible that the greater volume of a chain could lower input costs including capital, and that economies of scale could exist in the management and operations (e.g., data-processing) of a chain of hospitals.

The empirical literature generally indicates that affiliation with other hospitals is associated with higher costs. A literature review by Ermann and Gabel (1985) examined 21 studies of the relationship between chain ownership and hospital costs and concluded that "the consensus of these studies is that systems,

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[65] These variables may also reflect differences in the cost of capital across ownership categories; many states issue tax-exempt revenue bonds on behalf of voluntary and government hospitals.

[66] The coding of the AHA dataset does not allow us to distinguish between hospitals that are owned by chains versus those that are managed by chains. Differences in the incentives the two types of hospitals may have in operating have been an issue in calculating market share statistics in antitrust cases.

variables allows the measured effect of affiliation with other hospitals to vary with ownership status.[69]

F. Case-mix Variables

Several additional variables enter the regression equations to reflect differences in hospitals' case mix that may not be reflected in variation in the included output measures. The first variable, SMSA, takes a value of one if a hospital is located in a Standard Metropolitan Statistical Area and is taken from the AHA file. This variable is included to capture differences between urban and rural areas in the case mix and the severity of cases treated. Urban hospitals are more likely than rural hospitals to have facilities to provide highly specialized services, such as organ transplants and advanced radiation therapy.[70]

Another factor that may affect a hospital's case mix is its teaching status. Teaching hospitals may attract patients who require unusual care, and these hospitals may also undertake research functions that affect resource use. Three dummy variables that measure a hospital's commitment to teaching are entered into the regressions to compare costs between teaching and non-teaching hospitals.[71]. The variable **TEACH1** takes the value of one if a hospital has an approved residency program but is not associated with a medical school. The variable **TEACH2** takes the value of one if a hospital is affiliated with a medical school but is not a member of the Council of Teaching Hospitals

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[69] If the cost of capital varies by ownership status or affiliation with a multi-hospital system, the dummy variables **FORPROFIT** through **PROFMULT** will in part capture this variation.

[70] The coefficient of the SMSA variable may also measure differences in resource costs across urban and rural areas not fully captured in the labor cost variable.

[71] This follows the construction of teaching variables in Sloan, Feldman, and Steinwald (1983).

(COTH). The variable TEACH3 takes the value of one if a hospital is a COTH member. COTH hospitals typically are very large, research-oriented institutions. Previous research has found them to have higher costs than other hospitals.[72]

Two variables, MCARESHR and MCAIDSHR, respectively measure the portion of total inpatient days accounted for by Medicare and Medicaid patients. In October 1983 (the beginning of the year for which the AHA data were collected for most hospitals in the sample) Medicare began to reimburse the expenses of Medicare patients on the basis of a Diagnosis Related Group (DRG) system which classified patients into 468 DRGs. Under DRG reimbursement, hospitals are paid a fixed amount per patient admission on the basis of the DRG to which the patient belongs. Hospitals have an incentive to keep expenses for Medicare patients beneath the DRG reimbursement level. We expect that under a DRG system, a hospital's expenses will be lower as the share of Medicare patients increases relative to other patients.

Hospitals in most states at the time the AHA survey was conducted were, however, still reimbursed for treating Medicaid patients on the basis of the cost of treatment rather a prospective payment system.[73] Earlier research[74] has found that the proportion of hospital patients covered by Medicaid is positively related to the average number of tests and consultations per patient. Medicaid requires no copayment on the part of patients, and the empirical evidence indicates that the

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[72] See, for example, Grannemann *et al.* (1986), and Sloan, Feldman, and Steinwald (1983).

[73] Laudicina (1985) reviews state hospital reimbursement policies across different categories of payers for the years 1980 through 1985. From January 1980 to June 1985, the number of states using traditional cost-based retrospective reimbursement systems to cover Medicaid expenses declined from 40 to 14.

[74] Sloan and Becker (1983).

cost-based reimbursement of these patients is associated with higher expenses.[75] We therefore expect that a higher share of Medicaid patients in a hospital is associated with higher costs in our sample.

G. The Regulation Variables

State CON laws require that hospitals obtain approval to build or expand facilities, to purchase new equipment, and/or to provide new services. States control the capital investment of hospitals not only through their CON programs, but also through participation in the Section 1122 program, under which they recommend whether federal Medicare and Medicaid reimbursement of depreciation and interest expenses associated with specific capital projects of hospitals should be withheld. In the time period studied here, all states regulated the capital investment of hospitals through CON programs and/or through the Section 1122 program. All but three states maintained a CON program, and a total of 16 states (including the three without CON laws) participated in the 1122 program.

State CON laws specify the dollar threshold above which proposed capital and equipment expenditures by hospitals are reviewed by state and local health planning agencies. CON laws also specify that a hospital must receive approval to provide a new service if the annual operating costs of providing the service exceed some threshold. The dollar amounts of the review thresholds as of December 1983, several months after the survey period began, are given in Table II.[76]

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[75] Grannemann *et al.* (1986), Becker and Sloan (1985).

[76] Most states in the sample maintained their review thresholds at these levels over the sample period. Minnesota's CON program expired in June 1984 and was replaced by a moratorium on new construction. Colorado substantially increased its thresholds (to 2 million, 1 million, and 1 million dollars for capital, service, and equipment). Because CON laws do change

(continued...)

TABLE II

State Certificate of Need Review Thresholds
(December 1983)

State	Capital Expenditures ($000)	New Institutional Services ($000)	Major Medical Equipment ($000)	Section 1122 Program
Alabama	600	0	200	No
Alaska	1000	0	1000	No
Arizona	750	750	750	No
Arkansas	600	250	400	Yes
California	-----	0	-----	No
Colorado	750	750	750	No
Connecticut	600	0	400	No
Delaware	150	0	150	Yes
Florida	695	250	400	No
Georgia	695	0	406	Yes
Hawaii	600	0	400	No
Idaho	-----	-----	-----	Yes
Illinois	650	278	400	No
Indiana	600	250	400	Yes
Iowa	600	250	400	Yes
Kansas	600	250	400	No
Kentucky	604	252	402	Yes
Louisiana	-----	-----	-----	Yes
Maine	350	125	300	Yes
Maryland	600	250	400	No
Massachusetts	600	250	400	No
Michigan	150	150	150	Yes
Minnesota	600	250	400	Yes
Mississippi	600	150	400	No
Missouri	600	250	400	No
Montana	750	250	500	No
Nebraska	500	250	400	Yes
Nevada	600	250	400	No
New Hampshire	600	250	400	No

TABLE II--Continued

State	Capital Expenditures ($000)	New Institutional Services ($000)	Major Medical Equipment ($000)	Section 1122 Program
New Jersey	150	0	150	Yes
New Mexico	-----	----	-----	Yes
New York	100	0	100	No
North Carolina	716	298	400	No
North Dakota	691	288	400	No
Ohio	691	250	400	No
Oklahoma	600	250	400	Yes
Oregon	250	0	400	No
Pennsylvania	695	290	400	No
Rhode Island	150	0	150	No
South Carolina	600	250	400	No
South Dakota	631	263	400	No
Tennessee	150	150	150	No
Texas	600	0	400	No
Utah	1000	----	-----	No
Vermont	150	0	125	No
Virginia	600	250	400	No
Washington	1000	500	1000	No
West Virginia	181	90	150	Yes
Wisconsin	600	250	600	No
Wyoming	150	75	150	No
District of Columbia	600	150	400	No

Note: Review thresholds are in thousands of dollars. Source: Intergovernmental Health Policy Project (1984).

The threshold level above which projects are reviewed under CON programs provides one measure of the stringency of program review.[77] Under a higher threshold, fewer projects are reviewed, and CON laws affect fewer of the resource allocation decisions hospitals make. The trend toward relaxation of CON coverage since 1980 has included not only repeal of CON laws but, more commonly, increases in review thresholds.

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[76](...continued)
somewhat over time, the regressions presented in this report also were run using CON thresholds from March 1983 and June 1984. Results from these regressions were quite similar to those obtained using the December 1983 data.

Data on the December 1983 thresholds were compiled by the Intergovernmental Health Policy Project (1984) at George Washington University, which serves as a clearinghouse on state health legislation, and were gathered through surveys of state health planning agencies. Data for the earlier and later periods were taken from the annual Status Report on State Certificate of Need Programs prepared by the U.S. Department of Health and Human Services.

Given the evidence that hospitals may take several years to fully adjust capital stocks to their desired levels, it might be more appropriate to use the CON thresholds in effect during earlier periods in explaining costs in 1983-84. The time needed for changes in CON laws to affect hospitals' decisions could vary, however, with the type of threshold under consideration. An interesting way to extend the present research might be to experiment with different combinations of earlier thresholds in the regression (perhaps first on a subsample of the data) to see which would best explain differences in hospital costs.

[77] Another (perhaps immeasurable) indicator of stringency of CON review would be the likelihood that a project above the review threshold is approved. Two states could have identical thresholds, but one could more stringently review projects by rejecting a larger portion of similar projects.

The natural logarithms of the capital, service, and equipment review thresholds (in thousands of dollars) are entered into the regression as **LCAPITAL, LSERVICE,** and **LEQUIP.**[78] The use of the double-logarithmic specification allows us to assess the percentage change in hospital expenses associated with a given percentage change in a threshold for states that have a full-blown CON program.[79] One problem in using the logarithm of the service threshold is that twelve states review all new services, i.e., they have a review threshold of zero dollars, and **LSERVICE** therefore is undefined. For these states, the value of **LSERVICE** was set to zero and a new variable, **ZEROSERV,** was set equal to one. Otherwise the latter was set equal to zero.

Three states, Louisiana, Idaho, and New Mexico, did not have CON laws during the survey year.[80] For these states, three dummy variables, **LOUISNA, IDAHO,** and **NEWMEX,** were set equal to one for those hospitals located within them: otherwise, these variables were set to zero. The variables **LCAPITAL** through **ZEROSERV** were set to zero for observations in these states. The coefficients on these state-specific dummies allow us to measure the differences in hospital costs in these states relative to states that have CON laws.

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[78] The threshold levels are expressed in thousands of dollars before they are converted to logarithms.

[79] Were these variables entered in their linear form rather than their logarithmic form, the assumption underlying their functional form would be that a dollar increase in a threshold had the same percentage effect on cost whatever the base threshold. The use of the double-logarithmic specification allows the effect of (say) a $100,000 increase in a threshold to have a different percentage effect on cost if the base threshold is $100,000 rather than $1,000,000.

[80] Louisiana never enacted a CON law, and Idaho and New Mexico sunset their CON laws in June 1983.

Two states in the sample, California and Utah, had CON laws but did not review all three types of hospital projects. California reviewed only entry into new services, and Utah reviewed only the capital expenditures of hospitals. Since it is not possible to take logarithms of missing variables, two dummy variables, **CALIFORN** and **UTAH**, were entered into the regression. They took the value of one (otherwise zero) for hospitals that were, respectively, in California or Utah. For hospitals in these states, all other CON variables were set to zero.[81]

The Section 1122 program affects reimbursement for the expenses of Medicare and Medicaid patients. We expect that any effect of this program becomes more important as the share of Medicare and Medicaid patients in a hospital increases. If a hospital treated no Medicare or Medicaid patients, we would not expect the Section 1122 program to have any effect. For this reason, the variable measuring state participation in the Section 1122 program should be interacted with the variables measuring the share of patient days accounted for by Medicare and Medicaid patients. We also want to allow for the possibility that the effect of the 1122 program on costs may vary with whether a CON law is in effect.

Four variables are therefore created to measure the effect of the Section 1122 program. The first two, **MCAR1122** and

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[81] The state-specific dummy variables shift the intercept term in the regression equations and therefore permit comparison of the average level of hospital costs in each of these states to other states that maintain full CON programs. The use of dummy variables to account for missing values in a regression is summarized in Maddala's (1977) discussion of the modified zero-order regression method of handling missing values. The method also applies to our use of the variable **ZEROSERV** to account for the fact that some states review provision of all new services, an outcome that would force us to take the logarithm of zero in our specification, therefore creating missing values for the variable **LSERVICE**.

MCAD1122, are respectively the portions of Medicare and Medicaid patient days for hospitals in states which do not have a CON program but do have a Section 1122 program. The variables MCARBOTH and MCADBOTH are respectively the portions of Medicare and Medicaid patient days in hospitals that have CON laws and participate in the 1122 program. All four of these variables take the value of zero if a state does not participate in the 1122 program. Holding the level of Medicare and Medicaid patients constant, the coefficients of these variables allow us to compare hospital costs in states which participate in the 1122 program (either with or without a CON program) to hospital costs in those states which maintain only a CON program.

The final regulation variable entered into the regression is RATEREG, which takes the value one (otherwise zero) for those states in which the rates charged (for at least some non-Medicaid patients) and/or the budget of each hospital are reviewed by a state authority.[82] Four of these states (Maryland, Massachusetts, New Jersey, and New York) reviewed the rates charged to all payers. Washington state and Connecticut reviewed the charges to all payers except Medicaid, and Rhode Island reviewed the charges to both Medicaid and Blue Cross. Empirical studies of mandatory rate setting have generally found that the level of hospital costs on a per-day or per-admission basis are lower in states with mandatory rate setting, and also that the rate of increase of these costs over time is less in these states than in other states.[83]

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[82] Other states reviewed the rates paid to Medicaid patients on a prospective basis. These states are assigned the value of zero for the rate regulation variable, which indicates only whether states set rates for either commercial payers or Blue Cross.

[83] Eby and Cohodes (1985) provide a recent summary of these studies.

H. Conclusion

This section has discussed the empirical specification of the cost function used to estimate the effects of state regulation on total costs for individual hospitals. Table III presents descriptive statistics for the variables used in the analysis. Empirical results are presented and discussed in the next section.

TABLE III

Variable List and Descriptive Statistics

Name	Description	Mean	Std. Dev.
LNETCOST	Logarithm of total hospital costs ($) net of interest and depreciation	16.13	1.31
LTOTCOST	Logarithm of total hospital costs ($)	16.21	1.31
Y_1	Total acute care inpatient days (000s)	40.82	45.48
Y_2	Total intensive care inpatient days (000s)	3.84	6.18
Y_3	Total subacute care inpatient days (000s)	1.20	4.22
Y_4	Total emergency room visits (000s)	14.10	16.43
Y_5	Total non-emergency outpatient visits (000s)	27.07	55.15
LNURSEWG	Logarithm of nurses' average salary ($)	10.20	0.41
LBEDTOT	Logarithm of total inpatient beds	4.77	0.96
FORPROFIT	Dummy = 1 if proprietary hospital	0.12	0.33
GOVERNMNT	Dummy = 1 if operated by state or local government	0.27	0.44

TABLE III--Continued

Name	Description	Mean	Std. Dev.
GUVMULT	Dummy = 1 if government hospital part of multi-hospital system	0.05	0.22
VOLMULT	Dummy = 1 if voluntary hospital part of multi-hospital system	0.22	0.41
PROFMULT	Dummy = 1 if proprietary hospital part of multi-hospital system	0.09	0.29
SMSA	Dummy = 1 if hospital located in SMSA	0.54	0.50
TEACH1	Dummy = 1 if hospital has approved residency program but is not affiliated with medical school	0.01	0.11
TEACH2	Dummy = 1 if hospital associated with medical but not a COTH member	0.09	0.29
TEACH3	Dummy = 1 if hospital member of Council of Teaching Hospitals	0.07	0.25
MCARESHR	Percentage of total inpatient days covered by Medicare	48.44	12.18
MCAIDSHR	Percentage of total inpatient days covered by Medicaid	8.56	7.30

TABLE III--Continued

Name	Description	Mean	Std. Dev.
LCAPITAL	Logarithm of state capital expenditure review threshold	5.41	2.13
LSERVICE	Logarithm of state service operating expense review threshold	3.66	2.64
LEQUIP	Logarithm of state major medical equipment review threshold	5.14	1.99
ZEROSERV	Dummy = 1 if state reviews all entry into new services	0.21	0.41
LOUISNA	Dummy = 1 if hospital in Louisiana	0.02	0.15
IDAHO	Dummy = 1 if hospital in Idaho	0.01	0.08
NEWMEX	Dummy = 1 if hospital in New Mexico	0.01	0.09
CALIFORN	Dummy = 1 if hospital in California	0.08	0.27
UTAH	Dummy = 1 if hospital in Utah	0.01	0.08
MCAR1122	MCARESHR for states with 1122 programs without CON programs, zero otherwise	21.57	8.40

TABLE III--Continued

Name	Description	Mean	Std. Dev.
MCAD1122	MCAIDSHR for states with 1122 programs without CON programs, zero otherwise	0.33	2.01
MCARBOTH	MCARESHR for states with both 1122 and CON programs, otherwise zero	11.96	22.03
MACDBOTH	MCAIDSHR for states with both 1122 and CON programs, otherwise zero	2.05	4.59
RATEREG	Dummy = 1 if state sets mandatory hospital rates	0.13	0.34

IV. Results

Empirical estimates of the cost functions discussed in the previous section are presented in this section. The discussion of these results is broken down into three parts. The first part generally discusses the measured effects of the regulation variables, and the second part discusses the effects of the remaining variables other than the output variables. The third part of the section focuses on the coefficients of the output variables. The latter coefficients can be used to calculate both economies of scope and scale for hospitals, aspects of the production of hospital services that are of intrinsic interest.[84]

Table IV presents regression results from the two specifications of the cost function used in this study.[85] The first uses the variable LNETCOST, which excludes interest and depreciation costs, as the dependent variable and is a measure of a hospital's short-run variable costs. The second specification uses the variable LTOTCOST as the dependent variable. This is a measure of long-run cost because it includes all hospital costs, including capital costs. The two specifications differ in their assumptions of how firms adjust input usage to treat patients over the one-year period of the sample. Though there is evidence, cited in the previous section, that hospitals take longer than a year to fully adjust capital stocks, there also is evidence

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[84] The discussion of economies of scale and scope in hospital production is somewhat technical in nature, and it may be skipped by less technically oriented readers.

[85] The regression results presented here are the final specifications used in fitting the cost function to the full dataset. In another specification, we used CON thresholds from different time periods as noted in footnote 76. The model initially excluded the Section 1122 interaction variables, which were added in the final equations. A different specification, which excluded the interactions among the output variables, was used to fit the model to a 20 percent sample of the data. Addition of these terms improved the fit of the model for the subsample, and they were used in fitting to the full dataset. No other specification searches were undertaken.

TABLE IV

Regression Estimates of Hospital Cost Functions

	Dependent Variable: LNETCOST		Dependent Variable: LTOTCOST	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
CONSTANT	9.995	59.1	14.176	63.6
Y_1	0.008	8.4	0.050	48.2
Y_2	0.018	3.5	0.049	6.7
Y_3	-0.003	0.9	0.032	6.6
Y_4	0.010	7.6	0.022	11.2
Y_6	0.002	6.2	0.002	4.6
Y_1^2	-0.068*	9.9	-0.296**	35.3
Y_2^2	-0.615*	2.0	-1.651*	3.8
Y_3^2	0.062*	0.4	-0.507*	2.2
Y_4^2	-0.148*	4.5	-0.340*	7.2
Y_6^2	0.007*	5.2	-0.009*	4.6
Y_1^3	0.135**	10.2	0.551**	33.8
Y_2^3	7.667**	2.1	21.939**	4.2
Y_3^3	-0.396**	0.3	6.362**	3.0
Y_4^3	0.416**	5.2	0.942	8.5

TABLE IV--Continued

	Dependent Variable: LNETCOST		Dependent Variable: LTOTCOST	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
Y_6^3	0.004**	4.9	0.005**	4.2
Y_1Y_2	0.016*	0.4	-0.014**	0.3
Y_1Y_3	-0.023*	0.7	-0.186*	3.9
Y_1Y_4	-0.000*	0.0	-0.009*	0.5
Y_2Y_3	0.149*	0.7	0.284*	1.0
Y_2Y_4	-0.053*	0.9	-0.077*	0.9
Y_2Y_6	-0.010*	0.6	-0.033*	1.5
Y_3Y_4	0.018*	0.3	0.031*	0.4
Y_3Y_6	0.001*	0.1	0.015*	0.5
Y_4Y_6	0.010*	1.4	0.030*	2.8
LBEDTOT	1.004	60.5	--	--
LNURSEWG	0.117	10.0	0.069	4.1
FORPROFIT	-0.016	0.5	-0.139	3.3
GOVERNMNT	-0.056	4.2	-0.105	5.5
GUVMULT	0.079	3.5	0.072	2.2
VOLMULT	0.004	0.3	0.007	0.4
PROFMULT	0.030	0.9	0.343	7.5

TABLE IV--Continued

	Dependent Variable: LNETCOST		Dependent Variable: LTOTCOST	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
SMSA	0.139	11.2	0.199	11.2
TEACH1	-0.016	0.4	-0.035	0.6
TEACH2	0.001	0.1	-0.092	3.4
TEACH3	0.206	7.5	0.133	3.4
MCARESHR	-0.003	6.9	-0.005	8.0
MCAIDSHR	-0.008*	0.0	-0.761*	0.7
LCAPITAL	-0.046	3.6	-0.005	0.2
LSERVICE	-0.003	0.2	-0.032	1.1
LEQUIP	0.029	1.4	0.015	0.5
ZEROSERV	-0.053	0.5	-0.248	1.6
LOUISNA	-0.121	0.9	0.143	0.7
IDAHO	-0.125	0.9	-0.079	0.4
NEWMEX	0.067	0.5	0.224	1.1
CALIFORN	0.191	1.9	0.213	1.5
UTAH	-0.106	0.9	-0.239	1.4
MCAR1122	-0.001	0.3	-0.003	1.0
MCAD1122	0.001	0.1	-0.008	1.3

TABLE IV--Continued

	Dependent Variable: LNETCOST		Dependent Variable: LTOTCOST	
Variable	Coefficient	t-statistic	Coefficient	t-statistic
MCARBOTH	-0.002	4.6	-0.002	3.9
MCADBOTH	0.002	1.0	0.005	2.0
RATEREG	0.059	3.6	-0.015	0.6
	R^2 (adj.) = 0.956		R^2 (adj.) = 0.910	
	N = 3708		N = 3708	

Note: t-statistics are expressed as their absolute values.

* Coefficient has been multiplied by 1,000.

** Coefficient has been multiplied by 1,000,000.

that capital inputs are not entirely fixed within a one-year period.[86] LTOTCOST is the variable used in most studies of hospital costs, and we believe that for this study it represents a preferred specification even if hospitals may not operate in long-run equilibrium. The separation of short-run costs from long-run costs is typically not easy, and the aggregated AHA cost data do not allow us to break down costs other than interest and depreciation that should be excluded from total costs to define a short-run cost variable such as LNETCOST.

The results for the two specifications are generally similar with respect to the signs and statistical significance of the estimated coefficients. Both models fit the data closely (as measured by the adjusted R-squared statistic), which is not surprising given the high degree of partial correlation between outputs and hospital costs.

A. The Regulation Variables

The influence of CON programs is measured by the coefficients of the variables LCAPITAL through CALIFORN. Coefficients on the variables LCAPITAL, LSERVICE, and LEQUIP allow us to assess changes in hospital costs associated with changes in the dollar thresholds for the three different types of CON reviews. CON programs cover fewer expenditures as these thresholds increase, and the coefficients of these variables thus provide a measure of the effect of changing the stringency of

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[86] The adjustment of hospital inputs is borne out by the fact that about 25 percent of all hospitals changed their number of beds within the sample period of the AHA data. Grannemann *et al.* (1986) note this continuous adjustment of hospital capital stocks, and argue that to include a measure of capital stock which is not fixed within a year's cross-section of data is to include an endogenous variable. These authors argue that inclusion of a capital variable into a model fit on cross-sectional data would bias results, and that cost-functions should be estimated which include capital costs in the cost variable but which exclude measures of capital stock as explanatory variables.

CON review. The coefficient of ZEROSERV measures the difference in hospital costs in states that review all additions of new services in hospitals relative to those states with CON programs with service review thresholds greater than zero. Coefficients on the five state dummy variables measure the differences in costs for hospitals in states that either do not have a CON program at all or do not review all three categories of expenditure normally covered by CON laws, compared to hospitals in states with full-blown CON programs.

The regression results do not support the hypothesis that subjecting more of a hospital's expenditures to CON review by establishing lower thresholds helps to contain hospital costs. With one exception that is discussed below, the coefficients of the threshold variables are statistically insignificant at the standard of 95 percent confidence: the hypothesis that the individual coefficients are equal to zero cannot be rejected.[87]

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[87] The specific null hypothesis being tested is whether the coefficient of an individual variable included in the specification equals zero; that is, whether a change in the review threshold is associated with any change in hospital costs. A two-tailed t-test is used to assess statistical significance of the individual coefficients at the standard of 95 percent significance under classical hypothesis testing. Failure to reject the null hypothesis occurs if the calculated t-statistic is less than 1.96 and implies that the variable has no measurable effect on the dependent variable.

Leamer (1978) makes the interesting point that rejection of this null hypothesis (i.e., some effect, however small, is detected) becomes more likely as the sample size increases. Using a Bayesian interpretation of hypothesis testing, he suggests the critical t-value needed to reject this null hypothesis also increases with sample size. For the large numbers of degrees of freedom in used in this study, the critical value derived by Leamer for the t-statistic is 2.85, which corresponds to the 99.6 level of confidence in classical hypothesis testing.

States that have lower review thresholds do not have measurably lower levels of hospital costs.

Moreover, the coefficient of the capital review variable, LCAPITAL, has a statistically significant, negative coefficient in the first equation. This implies that as states review more of hospitals' capital expenditures by lowering the threshold for review, hospital costs increase. The point estimate of the variable's coefficient suggests that a ten percent increase in the capital threshold is associated with a decline of .46 percent in overall hospital costs.[88] In 1984, the federal standard for capital review was $600,000. Several states subsequently raised their review limits to $1,000,000, an increase that this result suggests would be associated with a decline in total hospital costs of 2.4 percent.

One potential problem in assessing the effects of changes in different review thresholds on costs is that the levels of review move together across states. States that tend to have a higher-than-average threshold for capital review, for instance, tend also to have a higher-than-average equipment review threshold. This may lead to a problem of collinearity, which makes it difficult to assess the effect of a change in a single threshold on hospital costs. Analysis of the data shows that strong collinearity exists among the threshold variables.[89]

Because the threshold reviews tend to move together, it may be more appropriate to examine the effect of moving all three threshold variables together rather than trying to examine the

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[88] In discussing coefficients, point estimates rather than the 95 percent confidence regions are used. The latter would indicate the uncertainty in a parameter estimate.

[89] The collinearity diagnostics developed by Belsley, Kuh, and Welsch (1980) indicate that the threshold variables are primarily collinear among themselves rather than with the other variables in the regression. The threshold variable which shows the most independent variation is LCAPITAL.

effect of increasing one while holding the others constant. In the first specification, the effect of increasing all review thresholds by 10 percent is to decrease hospital costs by 0.2 percent. As a further extrapolation, a doubling of all thresholds is associated with a 1.4 percent decline in costs. The point estimate of this effect differs from zero at the 95 percent level of statistical confidence. In the second specification, the estimated effect of increasing all review thresholds by 10 percent is also estimated to be associated with a decrease in costs of 0.2 percent, though this estimate is not statistically significant.[90]

The above results are for states that provide for the CON review of all three types of projects. The coefficients of the five state dummy variables LOUISNA through UTAH measure the differences in costs for states that either did not have a CON law (Louisiana, Idaho, and New Mexico) or did not review all types of projects (California and Utah) relative to states that maintained full-blown CON programs. In 1983, Utah reviewed only capital expenditures above $1,000,000 and California reviewed only hospitals' entry into new services. None of the coefficients of these variables differed from zero by a statistically significant amount. This indicates that, controlling for the other factors in the regression, costs in these states were neither higher nor lower than in states which maintained full CON programs.[91]

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[90] The estimated percentage change in total costs associated with a small percentage change in all review thresholds is obtained by summing together the coefficients of the three review threshold variables. A test of whether a proportionate increase in these variables has a measurable effect on costs can be obtained by dividing the sum of these coefficients by the square root of the estimated sampling variance of this sum.

[91] One problem in comparing hospital costs in these five states to other states is that, with the exception of California, they have small populations and contain a small portion (5 percent) of the nation's hospitals. Of the 3708 hospitals in the

(continued...)

The second regulatory program examined is the Section 1122 program of the Social Security Act, under which participating states recommend to the federal government whether it should provide Medicare and Medicaid reimbursement to hospitals for particular capital expenditures. The effect of the 1122 program on costs is measured by entering variables that allow the effect of the program to vary with whether the state also has a CON law or not along with the 1122 program.[92]

The coefficients of MCAR1122 and MCAD1122 measure the differences in hospital costs in the three states that maintain an 1122 program without a CON program compared to the majority of states which maintain a CON program without an 1122 program. The fact that the coefficients of these variables are statistically insignificant indicates that a state's choice between reliance on an 1122 agreement alone and reliance on a CON law alone does not affect hospital costs.[93]

The coefficients of MCARBOTH and MCADBOTH measure the differences in hospital costs between the majority of states which

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[91](...continued)
present sample, Louisiana has 85 hospitals, Idaho 22 hospitals, New Mexico 29 hospitals, and Utah 25 hospitals. Furthermore, Idaho and New Mexico sunset their CON laws during the period covered by the sample. We would prefer to have a larger sample of hospitals not covered by CON laws for a longer period of time against which costs could be compared.

[92] The effect of the Section 1122 program is also expected to vary with whether the hospital has a large share of patients whose expenses are reimbursed by either Medicare or Medicaid, and the specification takes this into account.

[93] More precisely, these results indicate that the effects of changes in the share of either Medicare or Medicaid patients on hospitals' costs are not measurably different in states with only an 1122 program from the effects of these changes in states which have only a CON law.

maintain a CON program only and those 13 states which maintain both a CON program that reviews capital expenditures and an 1122 program. The results indicate that, for a given volume of Medicare patients, hospital costs are lower in states which maintain both programs than in those states which maintain only a CON program. They also indicate that the costs of treating a given volume of Medicaid patients are higher in those states which maintain both programs than in states which rely only on CON review.[94]

It is somewhat surprising that the 1122 program has an effect on costs in those states with CON capital reviews. The CON program is a more stringent program in that it can prevent a project from being undertaken, while 1122 disapproval leads only to withholding of interest and depreciation reimbursement provided by the federal government. Previous studies of hospital costs have, however, provided some evidence (though not consistently) that the presence of an 1122 agreement may be associated with lower hospital costs, even though CON programs appear to have either no effect or a positive effect on costs.[95] One possible explanation is that because 1122 disapproval (in contrast to CON disapproval) does not prohibit a project, the 1122 program may reduce costly use of hospital inputs without establishing the barriers to entry and expansion that decrease competitive pressure to reduce costs.

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[94] The coefficient of MCADBOTH is positive in both equations but statistically significant only in the second equation.

[95] Noether (1987), for example, found that the presence of an 1122 agreement was associated with a 7 percent decrease in the average costs per admission at the level of the individual hospital. In their review of earlier studies of the effects of regulation on hospital costs, Steinwald and Sloan (1981) conclude that though the Section 1122 program appears to have more favorable effects on costs than do CON programs, this conclusion is based on much less empirical evidence.

The final regulation variable in the regressions, **RATEREG**, which indicates whether a hospital is covered by a mandatory rate setting program, provides mixed results across the two specifications. The coefficient of this variable is positive and statistically significant in the **LNETCOST** equation and negative and statistically insignificant in the **LTOTCOST** equation. The positive coefficient in the first equation indicates that the presence of mandatory rate regulation is associated with hospital costs that are about 6 percent higher than hospital costs in states which do not regulate rates.[96] The result that rate regulation is associated with higher hospital costs is contrary to the general findings of other researchers. This suggests the possibility that this finding may be an artifact of the particular sample and specification used here and should therefore only be accepted with caution.

B. Other Variables

The variable **LNURSEWG** has a positive and statistically significant coefficient in both equations. Given the point estimates of the coefficients, a ten-percent increase in the labor costs captured by this variable would be associated with a 12.4 percent increase in short-run hospital costs and a 7 percent increase in long-run hospital costs.[97]

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[96] The coefficient of a dummy variable in the semi-logarithmic specification used here is exponentiated to the base e to give an estimate of one plus the percentage impact of the dummy variable on the level of hospital costs. There is a bias in this estimator which can be reduced by the transformation suggested by Kennedy (1983). This bias is a small-sample one which is negligible for most of the coefficients presented in this study.

[97] The lower end of the 95 percent confidence interval for this coefficient in the short-run equation includes values that suggest that a 10 percent increase in these input costs would be associated with an increase in hospital costs of less than 10

(continued...)

The coefficients of the form-of-ownership variables suggest that both government and for-profit hospitals have lower costs than voluntary hospitals.[98] The coefficient of **GOVERNMNT** is significant in both equations and indicates costs are between 5.5 and 10 percent lower in state and local government hospitals than in voluntary hospitals. The coefficient of **FORPROFIT**, the variable indicating whether a hospital is managed for profit, is negative in both equations but insignificant in the first. Ignoring the insignificant coefficient in the first equation, the results indicate that for-profit hospitals have expenses which are about 13 percent lower than voluntary hospitals.

The inclusion of the variables **GUVMULT** through **PROFMULT** allows the effect of the ownership variables to vary with whether the hospital is part of a system or not. The coefficient of **GUVMULT** is statistically significant in both equations and suggests that costs of government system hospitals are between 7 and 8 percent higher than the costs of government hospitals that are not part of a system. The coefficient of the variable **VOLMULT** is insignificant in both equations, which suggests affiliation with a system has no measurable effect on the costs of voluntary hospitals.

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[97](...continued)
percent. One reviewer of this report suggested that the coefficient of this variable could be biased if capital restrictions lead to the hospital using inputs inefficiently. Since the coefficient of this variable is not of direct interest in itself for our study, we have not attempted to gauge the extent of the bias, if any, of the input price variable. Such an evaluation would require that we estimate equations for the demand for each input into the hospital production process, and that we also account for the systematic inefficiencies in input usage that regulation might induce.

[98] These comparisons are for those hospitals not affiliated with a system.

The evidence of the effect of system affiliation on hospital costs is mixed for for-profit hospitals. The coefficient of **PROFMULT** is positive and insignificant in the first equation, and is positive and very significant in the second equation, with a coefficient of 0.34. Combined with the coefficient of -0.14 for the variable **FORPROFIT**, the result from the second equation indicates (as a point estimate) that for-profit hospitals which are part of a system have costs which are about 22 percent higher than costs of voluntary hospitals. This latter result is consistent with previous empirical findings of the effects of system affiliation on the costs of for-profit hospitals.

The regression results indicate that hospital costs are significantly higher in urban areas. The coefficient of **SMSA** is positive and significant in both equations; the results indicate that hospital costs are between 15 and 22 percent higher in Standard Metropolitan Statistical Areas.

Hospital teaching and research activities would appear to have an influence on costs. The variable **TEACH3**, which indicates whether a hospital is a member of the Council of Teaching Hospitals (COTH), has a positive and significant coefficient in both equations; costs appear to be 14 to 23 percent higher at these hospitals. The variable **TEACH1** indicates that hospitals which have a residency program, but are not affiliated with a medical school, appear to have costs which do not differ from those of hospitals without any teaching activity. The statistical evidence of the association between medical school affiliation and hospital costs is mixed. The variable **TEACH2** is positive and insignificant in the first equation and negative and significant in the second equation. The latter coefficient suggests total costs are 9 percent lower for these hospitals.[99]

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[99] These results are generally similar to those of Sloan *et al.* (1983), who examined the effect of medical education on hospital costs using a national sample of 367 hospitals from 1974 and 1977. These authors found, however, that the costs of non-COTH teaching hospitals (variable TEACH2 = 1) were significantly higher than those of non-teaching hospitals.

The coefficients for MCARESHR, the share of total inpatient days covered by Medicare, are negative and statistically significant in both equations, indicating that an increase in the share of Medicare patients is associated with lower hospital expenditures. An increase in this share from 45 percent (roughly the variable mean in the data) to 55 percent of total inpatient days is associated with a decline of between 3 and 6 percent in total costs. This negative effect on costs may flow from the incentives of Medicare's prospective payment system to reduce costs of treating Medicare patients, or from older patients taking longer times to recuperate in the hospital, a factor which, for a given treatment, would lead to fewer resources being used on a per day basis. The coefficient of MCAIDSHR, the share of Medicaid inpatient days, is statistically insignificant in both equations.

C. Economies of Scale and Scope in Hospital Production

The inclusion of output variables in the cost function allows us to examine how (predicted) hospital costs vary as outputs are set at different levels. In a cost function with a single output, average and marginal costs can be calculated for a given level of output and used to compute a measure of scale economies.[100] For a multi-product firm, however, care must be taken in defining the marginal and average costs of individual outputs. These costs must be defined to take account of the levels of the other outputs in the production process.[101]

In this study, we have estimated two cost functions for hospitals, one a short-run cost function, the second a long-run cost function. As discussed above, there are certain problems with defining either a short- or long-run cost function. Estimates of production parameters derived from the cost

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[100] For a single product cost function, economies of scale at a given output level can be measured by the ratio of average to marginal costs.

[101] Bailey and Freidlaender (1982).

functions, such as economies of scale and scope, should be interpreted with caution if questions exist concerning cost-minimimization by hospitals over the sample period. The estimates obtained from the long-run specification are generally more believable in several respects. Though these results may not represent true long-run production parameters under which hospitals plan and develop their optimal use of inputs, they may describe the relationship between costs and outputs in an intermediate time frame.

With respect to the output variables, both equations generally show a pattern of positive, negative, and positive coefficients for each output, its square, and its cube. This pattern is consistent with total costs which first decline and then increase with each output. The exception to this pattern is for Y_3, the number of subacute inpatient days, in the first equation, where the coefficients of all terms of the cubic expression for this variable are statistically insignificant.[102]

One way in which economies of scale may be evaluated for hospitals is by examining how hospital costs increase if all outputs are increased by the same proportion. This keeps the mix of hospital outputs constant to create a composite output. Overall economies of scale exist if the proportionate increase in costs is less than the proportion by which all outputs are increased. A natural candidate for a composite output of hospital services is the mean level of services observed in the data. By setting all other variables at their means, each output multiplied by a scale factor (along with its square, etc.) may be entered into the equation to predict costs for a larger or smaller bundle of outputs.

Results from the first specification suggest that there are strong overall economies of scale in producing hospital services; increasing all outputs in a hospital by 10 percent above their mean values is associated with an increase of only 3.3 percent in

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[102] Grannemann *et al.* (1986) obtained a similar result in their study of hospital costs.

short-run costs as measured by LNETCOST.[103] Cowing and Holtmann (1983) similarly found overall economies of scale in estimating a short-run cost function. Their estimates implied that hospital costs would increase by 8.6 percent for a ten percent increase in all outputs.

The cost-function estimates for the second specification lead to a different conclusion, however. Here a 10 percent increase in all outputs is associated with a 15.7 percent increase in hospital costs. This indicates that there are fairly strong diseconomies of scale to expansion of hospitals if they keep their mix of outputs constant.

The alternative to measuring cost changes for equiproportionate increases in all services is to calculate marginal and average costs for changes in one output at a time holding other outputs constant. Marginal cost for an output can readily be calculated by assessing the increase in total costs of producing an extra unit of that output holding other outputs constant.

In the multiproduct context, the average cost of producing an output cannot be calculated by dividing total costs by the level of that output as it can be for the single product case. The multiproduct analogue to average cost is average incremental cost. The incremental cost of producing a given output is the difference between the costs of producing all outputs and all outputs but the one of interest. Dividing this incremental cost by the level of the output gives its average incremental cost (AIC_i). For example, to calculate the AIC of producing Y_1, we calculate

$$(1)\ AIC_1 = [C(Y_1,Y_2,Y_3,Y_4,Y_5) - C(0,Y_2,Y_3,Y_4,Y_5)] / Y_1$$

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[103] Short-run scale effects may also be thought of as economies of capacity utilization; they represent the changes in costs associated with changes in output, holding the capacity of a hospital (measured by number of beds) constant.

where C( ) is the cost function evaluated at a set of output levels.

Dividing the average incremental costs of output i by its marginal cost yields a measure (EOS_i) of the product-specific economies of scale for that output.[104] Economies of scale exist in producing an output if EOS_i exceeds one. Estimates of the marginal and average costs of producing each output at its mean level are given in Table V.

The estimates of short-term marginal and average incremental costs for each of the five services are lower than their long-run counterparts.[105] The most striking difference between the two sets of results is that the estimated costs of acute care are much lower in the short-run specification than in the long-run specification.

The reasonableness of the two sets of cost estimates can be assessed by comparing costs to the average revenue figures for inpatient and outpatient services provided by the AHA in its volume Hospital Statistics. This volume provides summary tabulations for 1984 hospital revenue data not available on the publicly released AHA tape. The AHA data provide an estimate of average revenue of $520 per inpatient day and $105 per outpatient visit for all community hospitals.[106] To compare these revenue figures to our estimated cost figures, it is necessary to

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[104] The assumption necessary to retrieve the economies of scale parameters of the production function that is dual to a cost function is that the costs of producing the outputs are indeed minimized.

[105] The negative values for the subacute care variable should be ignored in the first specification; the coefficients of the own, square, and cube values of this variable are statistically insignificant.

[106] Neither the public AHA cost data nor the published summaries of hospital costs provide the information needed to allocate costs among individual hospitals or groups of hospitals.

TABLE V

Estimated Costs ($) and Economies of Scale for Hospital Outputs with All Outputs Set to their Mean Level

	Dependent Variable: LNETCOST			Dependent Variable: LTOTCOST		
	MC	AIC	EOS	MC	AIC	EOS
Acute care days	39.96	59.23	1.48	509.14	348.87	.69
Intensive care days	152.80	171.98	1.13	626.38	674.68	1.08
Subacute care days	-35.88	-36.80	1.03	459.69	462.96	1.01
Emergency room visits	75.13	91.44	1.22	235.65	278.87	1.18
Other outpatient visits	21.80	23.24	1.07	37.02	39.98	1.08

weight the number of each of the three types of inpatient days by its marginal cost to obtain an overall estimate of the costs of an inpatient day.[107] The two types of outpatient visits must similarly be weighted by their marginal costs to obtain an estimate of the cost of an outpatient visit.

The weighted cost estimates obtained from the full-cost specification are much closer to the revenue figures provided by the AHA than those calculated from the purely short-run specification. For inpatient days, the full-cost specification generates an estimate of the cost of an inpatient day of $517; the corresponding estimate of the cost of an outpatient visit is $105.[108] The estimates of both costs obtained from the short-run specification are much lower at about $40 per inpatient day and $50 per outpatient visit.[109]

Other than for acute care inpatient days, the two specifications provide similar evidence that there are modest

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[107] The AHA volume does not allocate costs between inpatient and outpatient services in its tabulations of hospital expenses.

[108] Grannemann *et al.* (1986) evaluate their $82 estimate of the marginal cost of a non-emergency outpatient visit by comparing it to the $35 1981 cost of visiting a private physician's office. Inflating the latter figure by the physician fee component of the Consumer Price Index, we can see that our estimate of a marginal cost of $37 is close to the inflated figure of $44.

[109] It should be noted that since short-run average incremental costs are lower than their long-run counterparts, the associated short-run incremental costs of producing each output (used to calculate scope economies) are also lower than the corresponding long-run costs.

economies of scale to expanding individual hospital services.[110] Economies of scale are greatest in the provision of emergency room services and lowest in the provision of subacute care days. Both specifications provide similar measures of economies of scale for intensive care treatment and for both categories of outpatient visits. With respect to acute care days, the long-run specification indicates that there are diseconomies of scale in expanding these services; the short-run cost estimates indicating scale economies are too low to be credible. There also appear to be economies of scale in expanding subacute care in hospitals; the scale measure obtained from the short-run specification is based on negative marginal and average costs and should be ignored.

Relying on the second specification, these results indicate that for the average hospital, the expansion of a single hospital output other than acute patient days leads to a lowering of the marginal cost of that output. This suggests that a regulation that restricts provision of these services may prevent hospitals from realizing product-specific scale economies and therefore unnecessarily raise hospital costs.

Measures of product-specific economies of scale reflect only the change in the costs of supplying a given output as more of that output is provided. These measures do not take account of how changes in the level of one output may affect the costs of providing other services. These effects are measured by economies of scope, a concept which does not have a counterpart in single-product cost functions. Economies of scope arise from the joint utilization of inputs in producing different outputs. Managerial scope economies may also arise if it is easier to manage diverse hospital services jointly rather than separately.

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[110] The measures of product-specific economies of scale obtained from either specification for the five outputs change little if all outputs are simultaneously increased or decreased by 50 percent from their mean values and therefore are not presented here.

Section IV

For the two-product case, economies of scope exist in a production process if the total costs of producing two services jointly are less than the sum of the costs of separately producing the same volume of services. Formally, economies of scope exist between the two outputs Y_1 and Y_2 if the following condition holds:

$$(2)\quad C(Y_1,Y_2) < [C(Y_1,0) + C(0,Y_2)]$$

where C( ) is the cost function evaluated at levels of the two outputs.

Economies of scope can be measured as the difference between the costs of separately producing each output and producing them together, divided by the total costs of producing the two products together, i.e.,

$$(3)\quad SCOPE = [C(Y_1,0) + C(0,Y_2) - C(Y_1,Y_2)] / C(Y_1,Y_2)$$

The expression SCOPE measures the percentage cost saving in jointly producing the two outputs rather than providing them separately.

One way to measure economies of scope in hospitals is to compare the total cost of producing each hospital output in separate facilities to the cost of producing these services at a single facility. A measure of overall economies of scope for the case of five outputs is formally given in (4):

$$(4)\quad SCOPE = [C(Y_1,0,0,0,0) + C(0,Y_2,0,0,0) + C(0,0,Y_3,0,0) + C(0,0,0,Y_4,0) + C(0,0,0,0,Y_5) - C(Y_1,Y_2,Y_3,Y_4,Y_5)] / C(Y_1,Y_2,Y_3,Y_4,Y_5)$$

where C( ) is the cost function evaluated for each output combination. For each output, the costs of producing that output alone is calculated by setting the level of other outputs to zero. The costs of producing each output separately are then added, and the costs of jointly producing all outputs are subtracted from this sum. These incremental costs of separate production are

then divided by the costs of joint production to calculate overall economies of scope.

Economies of scope can also be evaluated for each individual output. We compare the combined cost of producing one output outside of the hospital and producing all other outputs together to the cost of producing all outputs together. This measure of economies of scope is formally given for the first output in (5):

$$(5) \qquad SCOPE = [C(Y_1,0,0,0,0) + C(0,Y_2,Y_3,Y_4,Y_5) - C(Y_1,Y_2,Y_3,Y_4,Y_5)] / C(Y_1,Y_2,Y_3,Y_4,Y_5)$$

Product-specific economies of scope may similarly be calculated for the other outputs.[111]

Table VI provides estimates of overall and product-specific economies of scope calculated from the second (long-run) specification of the cost function.[112] Outputs are set to their mean levels to calculate these measures, and then the output levels are equiproportionately decreased and increased by 50 percent to assess how scope economies change as the volume of a hospital's services changes, holding the mix of outputs constant.

Our results indicate that product-specific economies of scope exist for all outputs at low levels of output, but that these economies of scope decline as outputs increase. For smaller-than-average hospitals, the savings to producing individual

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[111] Given the specification of the cost function, it is not possible to calculate tractable standard errors for our estimates of overall or product-specific economies of scope.

[112] Estimates of product-specific economies of scope obtained from the first (short-run) specification indicated that over the three levels of output presented in Table VI, producing any single output separately from the four others would lead to an increase in total costs of between 50 and 70 percent. These estimates of the savings from joint production seem too high to be plausible and are not presented here.

TABLE VI

Product-Specific Scope Economies,
Various Output Levels

Output	"Low" Output Level[1]	"Mean" Output Level[2]	"High" Output Level[3]
Acute Care Days	0.168	-0.180	-0.353
Intensive Care Days	0.253	0.002	-0.110
Subacute Care Days	0.295	0.098	0.027
Emergency Room Visits	0.223	-0.060	-0.191
Other Outpatient Visits	0.285	0.071	-0.018
Overall Economies of Scope	1.08	0.178	-0.177

[1] "Low" Output Level: All outputs are set to one half of their mean sample value.

[2] "Mean" Output Level: All outputs are set to their mean sample value.

[3] "High" Output Level: All outputs are set to 1.5 times their mean sample value.

outputs within the hospital rather than producing any one output outside the hospital are substantial. Overall hospital costs decrease between 16.8 and 29.5 percent if the individual services are produced along with the remaining services for "low" levels of outputs. The overall level of economies of scope in producing these "low" levels of outputs are quite large: it is estimated that costs would more than double if all outputs produced at this "low" level were produced separately rather than together within a hospital.

Evaluated for the average hospital, economies of scope exist in providing intensive care, subacute care, and non-emergency outpatient services. The savings associated with producing these services within hospitals rather than outside hospitals are, respectively, 0.2, 9.8, and 7.1 percent. The results indicate that diseconomies of scope exist in the provision of acute care and emergency outpatient visits. If acute care or emergency care were produced separately outside of hospitals, the overall costs of providing all five services are estimated to be respectively 18.1 and 6.1 percent lower than the total cost of providing all five services within a hospital.[113]

The result that there are diseconomies of scope for the average hospital in providing these two services, which make up a major part of hospital output, is somewhat surprising, though other researchers have come to similar conclusions.[114] The finding that scope diseconomies exist for acute care days and emergency outpatient visits implies that the costs of other

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[113] The estimated savings to producing all outputs within hospitals rather than producing all outputs separately are 17.8 percent.

[114] Cowing and Holtmann (1983) observed diseconomies of scope between emergency room visits and all other hospital services and between medical/surgical inpatient days and all other services. Grannemann *et al.* (1986) observed diseconomies of scope between all inpatient days and both emergency room visits and other outpatient visits.

hospital services increase as the volume of either of these services increases. It could be the case that these results reflect greater complexity in the case mix or treatment costs for larger hospitals not fully captured in the variables included in our regression.

Finally, at the "high" level of output, there are product-specific diseconomies of scope for all outputs except subacute care inpatient days. At these levels of output, there are also overall diseconomies of scope. Care should be taken in interpreting these results (along with the "low" output level results), which are calculated under the assumption that hospitals produce the same mix of outputs whatever their size.

V. Conclusions

The primary regulatory mechanism used by most states to monitor the expenditures of hospitals is a certificate-of-need (CON) program. CON laws inherently restrict competition among hospitals by partially supplanting the market mechanism by a regulatory process that constrains the supply of hospital facilities and services. The evidence provided by this study suggests that as states review fewer hospital expenditures through the CON process, hospital costs do not increase. Rather our study suggests that hospital costs are lower in those states which set higher review thresholds for all types of hospital expenditures.

Since the 1983-84 time period covered by this study, several states have either raised the thresholds at which proposed hospital expenditures must be reviewed or eliminated their CON programs. Our results suggest that such increases in CON review thresholds and repeals of CON programs would not lead to increased hospital costs and should therefore be supported. This conclusion is similar to that obtained by other researchers using data from the 1960s and 1970s; CON laws do not appear to have become more effective in reducing the levels of hospital costs in the 1980s than they were in earlier years.

We have examined the relationship between hospital costs and CON regulation using a multiproduct cost function that relates total hospital costs to five categories of hospital services, along with other factors, including the presence of various forms of hospital regulation, thought to be related to these costs. We found that the presence of mandatory rate regulation within a state was not associated with lower hospital costs, but that the review of capital expenditures under the 1122 program when combined with a CON program was associated with lower costs for hospitals than when exclusive reliance was placed on a CON program.

This study examined the relationship between a hospital's form of ownership and its level of costs. The evidence suggests that among independently operated hospitals, both for-profit and state and local government hospitals have lower costs than voluntary hospitals. The results indicate that costs of for-profit and government hospitals may be higher when such hospitals are

affiliated with other hospitals rather than when they are operated independently.

The estimated coefficients of the cost function were used to measure economies of scale and scope in the production of hospital services. Though both short- and long-run cost functions were estimated, the estimates of marginal and average incremental costs were more believable when obtained from the long-run cost function. The results indicated that modest product-specific economies of scale exist in the provision of most hospital services, with the exception of acute inpatient care, a major output of hospitals. For the average hospital, economies of scope were found to exist in producing all hospital services together rather than separately, but diseconomies of scope were found to exist between the production of either acute inpatient care or emergency room services and all other hospital services. Both overall and product-specific economies of scope were found to decline as hospitals increased their levels of output (keeping output mix constant).

There are several ways in which this research could be extended. First and foremost, as they become available, more recent data should be used to replicate the study. There have been significant changes in state CON laws since 1983, including the sunset or repeal of CON laws in nine states, several of which are among the most populous states in the nation.[115] Use of more recent data would provide information on the costs of a larger number of unregulated hospitals, and this would provide a better basis for comparisons with the costs of regulated hospitals. Changes in CON laws may take time to affect costs as hospitals adjust their input usage to a different regulatory environment, and the use of later data would allow comparison of hospital costs involving states which had longer experience with deregulation.

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[115] These states are Arizona (1985), California (1987), Colorado (1987), Indiana (1987), Kansas (1985), Minnesota (1984), Texas (1985), Utah (1984), and Wyoming (1987).

One difficulty in evaluating the effect of regulations on hospital costs is that states with high hospital costs may be the ones most likely to attempt to contain costs through regulatory mechanisms. An observed relation between higher costs and regulation could indicate that higher costs cause regulation rather than the other way around.[116] We have followed the approach of other studies of the effects of regulation on hospital costs, and have assumed that hospital costs do not influence a state's regulatory climate.

The possibility that costs and hospital regulation are simultaneously determined could be formally modelled by using simultaneous equations estimators. Specifying such a model would require as a first step that we model the process by which states choose to regulate hospitals and the methods they choose to accomplish this regulation. There has, however, been very little research on the determinants of hospital regulation.[117]

The fundamental problem in simultaneously modelling hospital costs and regulations is that costs are determined at the level of the hospital while regulations are established at the level of the state. The two levels of observation could be combined only if we aggregated data on individual hospital costs and

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[116] If this is true, our estimates of the effects of regulation on costs would likely have a bias away from finding that tighter regulation (as captured by lower levels of the CON review threshold variables) was associated with lower costs.

[117] Two studies have examined the determinants of state regulation of hospitals. Wendling and Werner (1980) present a model of the political economy of the passage (or defeat) of state CON laws prior to the enactment of the National Health Planning and Resources Act in 1974. The authors found no evidence that the passage of CON laws was related to growth of hospital expenditures within the state. In their study of hospital rate-setting laws, Cone and Dranove (1986) found that hospital costs were not a determinant of the likelihood that states would adopt these laws.

characteristics to the level of the state, a situation that would present several problems in itself.[118] Though in principle it would be preferable to model simultaneously the determinants of costs and regulation, we believe that the estimation approach used in this report most likely provides an accurate assessment of the effects of regulation on hospital costs.[119]

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[118] First, given that there would be only 51 observations, there would be few (if any) degrees of freedom available were a multiproduct cost equation estimated along with several fully identified structural equations to explain different regulations. Second, simultaneous equations estimators are themselves biased in small samples; it is not clear from the available Monte Carlo evidence that these estimators provide superior results to the ordinary least squares (OLS) estimator in small samples (Johnston (1972)).

[119] The size of the bias of the regulation variables in a cost function estimated using the OLS estimator rather than a simultaneous equations estimator depends both on the true (but unknown) values of the coefficients of the regulation variables in the cost equation and the coefficients of the cost variable in equations determining the regulatory climate. If hospital costs do not have a significant effect on a state's regulations, then there will be no bias in using the OLS estimator to assess the effects of regulation on hospital costs. The studies of the determinants of hospital regulation cited in footnote 117 suggest that this condition may hold, for they found that passage of state hospital regulations were not influenced by hospital costs.

The bias will also depend on the error variance of the cost equation relative to that of the regulation equations. Just as data on the price and quantity of a good may be used to identify either a supply or demand curve if one function shifts less than the other, so will the cost function be relatively well identified if there is much more variation in the regulation functions than in the cost function. The hospital cost functions we have estimated may be similarly identified if costs can be predicted

(continued...)

A final direction for the analysis of hospital costs and the effects of regulation on these costs is the development of dynamic empirical models, which would measure how hospitals choose and modify their input usage over time. Regulation of hospital inputs may affect these choices, which ultimately may affect the levels of hospital costs.[120] Models of this kind are complex and demanding in their data requirements; they would likely serve, however, to increase our understanding of the determinants of hospital costs and the effects of regulation on hospital costs.

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[119](...continued)
more accurately than can state regulations. We believe that state regulations are determined by many elements such as political factors that are difficult to precisely measure, and as a result, a state's regulation climate is likely to be less well-predicted than the costs of individual hospitals operating within a state.

[120] Kelly (1985) used data on 42 Maryland hospitals from 1970-81 to assess how changes in hospital regulation over an 11-year period affected the speed with which hospitals adjusted their capital stocks to desired levels. Since there were no changes in Maryland's CON program over the time period, she was not able to assess the impact of the CON program on investment.

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