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THE EFFECTS OF HOSPITAL COMPETITION AND THE MEDICARE PPS PROGRAM ON HOSPITAL COST BEHAVIOR IN CALIFORNIA*

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Previous studies of hospital competition have found that greater competition leads to higher hospital costs. In this paper we report how the behavior of California's hospitals has changed since the introduction of programs intended to contain the rate of increase of hospital costs. Using data that cover the period preceding and following the introduction of these programs, we found that hospitals in more competitive markets have lowered their costs significantly.

1. Introduction

Despite widespread interest, there is only limited published evidence on the effects of hospital competition on the health care system. Previously published studies, using hospital data from the 1970s and early 1980s, found that hospitals in relatively competitive markets tended to have higher costs than those in less competitive markets [Farley (1985), Joskow (1980), Luft et al. (1986), Robinson and Luft (1985, 1987), Wilson and Jadlow (1982)]. These results are consistent with the theory that hospitals competed on a basis of quality and amenity rather than one of price [Held and Pauly (1983)]. This paper provides the first econometric analysis of the effects of hospital competition on the behavior of California hospitals.

One criticism of the health care system is that the weakness of price competition encourages the wasteful use of health care services. In June 1982 the California legislature passed a law to promote price competition among health care providers. The legislation authorized third-party payers to

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negotiate contractual agreements with individual health care providers that would channel beneficiaries to the selected providers, usually in exchange for a reduction in price.

The state Medicaid program and private payers have both used the ability to contract to negotiate discounts with hospitals. The providers signing such agreements with private payers are designated as 'preferred providers' since the payers generally offer incentives to their beneficiaries to use the preferred providers. Competitive pressure will be greater in areas with, other things equal, many competitors and/or substantial excess capacity. Providers in such areas are more likely to agree to accept lower fees and increased utilization oversight or risk being 'locked-out' of a substantial portion of the market.

Although it is only four years since California first promoted Preferred Provider Organizations (PPOs), PPOs have spread rapidly both in California and throughout the United States. Enrollment in California PPOs grew from 250,000 in 1983 to over six million members by mid-July 1986 [Arnstein-Kerslake (1986)], equalling about a quarter of the market. PPO growth in the remainder of the country has also been dramatic. By mid-1986 more than twenty states had enacted laws fostering price competition, and enrollment nationally was estimated to be between 10 and 15 million members in over 350 PPOs [Arnstein-Kerslake (1986)]. This growth is expected to continue.[1]

The following hypothesis underlies this study: before the passage of selective contracting legislation, hospitals tended to compete on a quality and amenity basis; since passage of the legislation, price has increased in importance as a competitive factor. As a result, one would expect to find that hospitals in more competitive markets would have higher costs until 1982, and that, after 1982, hospitals in more competitive markets would be adjusting to a market with increasing price competition by restraining the rate of increase in their costs to a greater degree.

To test this hypothesis, an econometric model was constructed to control for factors other than competition that might also influence hospital costs. Of particular importance is the ability of the model to separate the effects of the Medicare Prospective Payment System (PPS)[2] – introduced in April 1983 – from that of selective contracting – in June 1982.

[1]Some HMOs, those that do not own or operate hospitals, also contract selectively with hospitals. From 1980 until 1985, non-Kaiser HMOs increased share of the rapidly growing HMO market from 19 to 39 percent [Interscience (1985)]. The growth in enrollment in non-Kaiser HMOs should also increase the importance of price competition.

[2]Because Medicare is the largest single source of patients to California hospitals, changes in the Medicare program will clearly affect hospital behavior. In 1983, for example, 35 percent of all discharges and 40 percent of all inpatient revenue came from Medicare [California Hospital Association (1985)].

2. Review of the literature

2.1. Hospital cost functions

Several generations of hospital cost functions have reflected the different policy and methodological concerns dominant at various times. Cost functions were developed to estimate the extent to which hospitals exhibit economies of scale, the appropriate measurement of hospital output, the impact of regulatory programs and he effects of competition, and the marginal costs of each of a hospital's multiple outputs. A review of hospital cost functions by Cowing, Holtmann and Powers (1983) provides a useful overview of the field.

The earliest studies of hospital costs were primarily directed at the discovery of the optimal size for hospitals. These studies reflected the concerns of health planning, particularly rationalized service delivery and optimal efficiency [Carr and P.J. Feldstein (1967), Ingbar and Taylor (1968)].

Another series of studies were concerned with the correct measurement of hospital outputs. Different hospitals do not provide services in uniform proportions. Some hospitals provide relatively uncomplicated services, such as births and appendectomies; others are tertiary care centers, performing complex procedures such as kidney transplants. The cost per case and per patient day will vary between hospitals purely because of such 'case mix' differences. Evans (1971), Feldstein and Schuttinga (1977), and Watts and Klastorin (1980) are examples of studies of hospital costs that focused on the measurement of case mix. These studies have confirmed that case mix is an important determinant of hospital costs.

A variety of case mix measurements have been proposed, but the case mix index (CMI) resulting from the use of Medicare's Diagnosis-Related-Groups (DRGs) has dominated recent cost studies [Pettengill and Vertrees (1982), Cotterill, Bobula and Connerton (1986)]. These studies have generally shown the CMI to perform well in regression studies of variations in the average cost per case.

Several studies were performed to examine the impact on hospital behavior of the regulatory interventions. Salkever and Bice (1976) and Sloan and Steinwald (1980) are examples of such studies. They generally found that regulation did not significantly reduce hospital costs.

More recent studies have focused on the effect on hospital costs of the intensity of competition in the hospital's market [Robinson and Luft (1985, 1987)]. They found that hospitals in more competitive areas tended to have higher costs. These studies will be discussed in greater detail in the following section.

An important development in the study of cost functions in general has been the introduction of flexible functional forms that involve 'weak' assumptions regarding the characteristics of the production process and that can be applied to organizations producing multiple products [McFadden (1978)]. These cost functions relate cost to output quantities and input prices, and are used to reveal basic properties of the production process like the presence or absence of returns to scale. These advances have been applied to the study of hospital costs by Cowing and Holtmann (1983) and Grannemann, Brown and Pauly (1986) who have developed hospital cost functions based on these flexible forms.

2.2. *Empirical studies of hospital competition*

All of the previous empirical studies on the effects of hospital competition have concluded that greater hospital competition leads to higher hospital costs. These findings suggest, explicitly or implicitly, that competition among hospitals was based on factors that increased costs such as the provision of technologically sophisticated services or of amenities like good meals.[3]

Joskow (1980) utilized 1976 data from a stratified random sample of 346 private, non-profit hospitals to examine the impact of hospital competition on hospital bed supply. The market area for this study was defined as the SMSA in which the hospital operated and the Hirschman–Herfindahl Index (HHI) was used as the measure of the competition.[4] Joskow found that hospitals in SMSA's with lower HHI values (i.e., greater competition) maintained a higher reserve supply of beds to accommodate their medical staff.

Wilson and Jadlow (1982) used the 1973 Census of Nuclear Medicine to examine the relationship between competition and technical efficiency in service provision. Markets are related to the patient catchment areas – although the relationship is not described explicitly. Competition was defined as a function of three factors, hospital density, population density and market size. They found that increased competition was associated with lower technical efficiency.

Using data from 1970 through 1977, Farley (1985) analyzed the effects of market structure on various measures of hospital performance. Market area was defined as the country in which a hospital was located and the measure of market competition was the HHI. After controlling for factors such as hospital size, hospitals in more competitive counties were found to produce more expensive hospital services by employing more labor and capital per patient and by performing more procedures for specific diagnoses.

Robinson and Luft (1985), using data from 1972, analyzed the impact of hospital market structure on inpatient admissions, inpatient cost per day, and inpatient cost per admission. Hospital markets were defined for each

[3]See Held and Pauly (1983) for an illustrative model of cost-increasing amenity competition.

[4]The HHI is the sum of the square of the market share of each hospital within the market. As such, it ranges in value from zero (highly competitive) to 1 (monopoly). It depends on both the number of hospitals in the market and their relative shares of the market.

hospital as the fifteen-mile radius around the hospital. Market competitiveness was measured as dummy variables indicating the number of hospitals within the fifteen-mile radius (1, 2–4, 5–10, or more). They found that hospitals in markets with fewer competing hospitals had greater volume and lower costs – both per day and per admission – than did hospitals in markets with a greater number of competing hospitals. In a later study, Robinson and Luft (1987), employed the same approach but added more recent data to determine whether hospital behavior had changed between 1972 and 1982. They found that the relationship between average costs per admission for hospitals operating in more competitive markets and less competitive markets were approximately the same in 1982 as in 1972.

Luft et al. (1986) using data from 1972, studied whether the probability of a hospital's offering a service is increased or decreased by its availability at a competing hospital. Using the same approach to defining hospital markets, they found that hospitals tended to provide the same services as their competitors.

The unanimity of the studies of hospital competition is striking: they have consistently found that hospitals operating in areas with greater competition tend to use more resources and to have higher costs. Despite the presence of methodological problems in all of these studies,[5] they provide convincing evidence that competition will tend to increase costs in a market environment competing on non-price bases. These studies, based on data from 1982 or before, however, are silent with regard to the implications of selective contracting, a policy that is intended to increase the importance of price competition in the market for health care services.

California provides a unique test site for these policies. It was the first state to enact selective contracting legislation, and the proportion of its population covered by selective contracting has grown explosively since 1983. This paper will provide an initial assessment of one dimension of selective contracting by analyzing the relationship between competition and hospital costs in California from 1980 until 1985.

3. Model specification and estimation

In the period prior to selective contracting the firm-level demand for hospital services was relatively inelastic with respect to price [Newhouse (1981)]. Hospitals were paid more or less on the basis of costs and as such

[5]The most serious methodological problem common to all of these studies is the arbitrary manner in which hospital markets are defined using either political boundaries or fixed distances. Such definitions, by introducing error in the measurement of competition, tend to bias downward the estimated effect of competition on hospital behavior. The unanimous conclusion that competition had increased costs is more impressive given this downward bias in the estimate of the competition effect. This underestimate, however, may make it difficult to detect any changes following the passage of selective contracting legislation.

could allow their costs to increase, and therefore, raise their prices, without fear that demand would decline significantly. Under selective contracting third party payers now chose which providers they will contract with based on the relative prices of each provider. When a hospital raises its price under selective contracting, it increases the risk of losing contracts and thus patients to other hospitals. Consequently, the demand curve faced by hospitals under selective contracting has become more price elastic.

The main objective of this paper is to test the hypothesis that, with the enactment of selective contracting legislation, hospital competition changed in California from a force that tended to increase hospital costs to one that tended to decrease them. Although the focus of the analysis will be on the relationship, over time, between the intensity of competition for a hospital and its costs, the analysis must of necessity be multivariate since other explanatory variables – output levels, for example – strongly affect hospital costs.

The structure of the cost function that will be used is an adaptation to the hospital industry of the 'flexible forms' developed by McFadden and others.

The cost function has the following general structure:

$$C = f(S, P, V, M, T),$$

where

C is total hospital costs,
S is a vector of output variables,
P is a vector of input price variables,
V is a vector of control variables,
M is a measure of the degree of competition
T is a vector of time variables.

The approach assumes that the primary – and exogenous – determinants of costs are output levels and input prices.[6] Other, 'control' variables are used in the model to account for the underlying heterogeneity of hospital services that is ignored by the aggregate measures of output. For example, since some categories of admissions are consistently much more costly than others, a well-specified hospital cost function must contain a method of specifying hospitals' case mix. Other candidate control variables were identified from previous studies of hospital costs. A complete variables list is provided below.

To study the relationship over time between hospital costs and the degree

[6]The assumption that output levels are exogenous is clearly incorrect. Hospitals do have some degree of control over the level of outputs they provide. To minimize the biasing effects of assuming exogeneity, we will use the number of inpatient discharges, rather than patient days, as the primary measure of hospital output. Hospitals' response to the Medicare PPS, with admissions and average length of stay falling, suggests that hospitals have much greater control over the length of stay than over the number of admissions.

of competition, the cost function must, at a minimum, include variables to distinguish the pre- from the post-selective contracting period and a measure of the intensity of competition of a hospital's market. If our hypothesis is correct, the results should show that hospitals in more competitive markets had higher costs for the time variables before the enactment of selective contracting legislation and an adjustment towards lower costs afterward.

The data used in the analysis consist of observations for California general acute care hospitals over the 1980–1985 period. An important concern with cross-sectional-time-series data is the possibility of hospital-specific variation in the dependent variable that is not captured by the variables in the model. A variance components (VC) model was used to test for the presence of residual hospital-specific effects. More then 70 percent of the residual variance was found to be hospital-specific, confirming the high degree of intra-hospital correlations. The importance of these correlations confirmed the need to use a variance components model in the analysis.[7]

4. Data description

The California Office of Statewide Health Planning and Development (OSHPD) requires hospitals to file quarterly reports on selected aspects of their operations. This data set is intended to provide a timely, if necessarily aggregate, view of the California hospital industry. It is the basic data set used for this study.

The data that hospitals are required to report to OSHPD include:

- inpatient discharges and patient days,
- outpatient visits,
- total operating expenses,
- total operating revenue, inpatient and outpatient,
- beds – licensed, available, and staffed.

Quarterly data from the first quarter 1980 to the third quarter 1985 were used in this study.

Two other OSHPD data sets were used: the 1983 Discharge Abstract Data Set, and the 1983–84 Annual Disclosure (Cost Report) Data Set. The Discharge Data Set contains approximately 3.2 million records, one record for each inpatient discharged from a California hospital during 1983. Three data elements were drawn from this file: patient zip code, the DRG of the discharge, and the hospital facility number. The Annual Disclosure Report provided information on the characteristics of each hospital including such variables as ownership, teaching status, and an urban/rural indicator.

[7]Since only a single value of the HHI was available for each hospital, it would be completely absorbed by the hospital dummy were we to use a fixed effects model.

Table 1
Model variables.

Variable	Specific measure[a]
Dependent variable	total hospital expense in each quarter
Output variables	(all marked per quarter)
	logarithm of
	inpatient discharges
	average length of stay
	deflated outpatient revenue
Input price variables	input cost index (see text)
	hospital labor cost index
Control variables	(all marked per quarter)
Ownership	dummy variables for ownership status
	(proprietary, not-for-profit, public, church)
Specialty	children's hospital dummy
Case mix	DRG case mix index (see text)
	number of distinct DRGs treated by the hospital
Payer mix	proportion of discharges by major payer category: Medicare, Medi-Cal, Private Insurer, HMO
Medical education	number of residents and fellows
Measure of scale	available beds
Location	urban dummy variable
Market competitiveness	Hirschman–Herfindahl Index (HHI)
Time variable	
Time	Annual dummy variables

[a]The logarithm of all continuous variables.

Data pertaining to hospital costs and reimbursement under the Medicare program were drawn from a file containing a 20 percent sample of hospital bills for the first year of PPS.

Other data, such as price and cost indices, were also merged into this primary data set. The process of their development will be described as part of the construction of the specific variables involved.

A total of 8,126 observations were used in estimating the hospital cost functions.

5. Variable construction

Model variables are listed in table 1. Most of the variables used in the cost function will not be discussed because they are based on previous studies. Variables presenting unusual aspects and/or those that are integral to this study are discussed in detail below.

Dependent variable. The value for total expenses was taken directly from the quarterly data. The nominal value for total expenses was used since an input price index is one of the independent variables in the cost function.

The distribution of this variable is highly skewed, with a small number of hospitals having very large expenses. The distribution of expenses is approximately lognormal, so that log(expenses) was that dependent variable used in the cost function.

Outpatient revenue. Ideally, one would want to use physical measures of output, preferably visits for outpatient services. An alternative had to be found since the quality of the data for outpatient visits was too poor to be used. The only available alternative was total outpatient revenue. In order to make revenue a better measure of the volume of outpatient services, the effect of price variations on revenue had to be corrected for. This was accomplished using a price deflator for outpatient services.[8]

The price deflator was created from the Bureau of Labor Statistics (BLS) price indices. Three series were used:

(a) The change in prices for 'Total Medical Services', U.S. city average.
(b) The change in prices for 'Total Medical Services', Los Angeles area.
(c) The change in prices for 'Other Hospital Services', U.S. city average.

First, the ratio of the Los Angeles area to the U.S. city average was found, enabling a comparison between changes in overall health care prices in Los Angeles – a proxy for California – relative to the urban average. Next, the rate of change in 'Other Hospital Services', the closest index available to an outpatient services index, was multiplied by this ratio to get a relative year-over-year percent change in the price index. Quarterly values were then found by geometric interpolation from these annual changes. Quarterly outpatient revenue was divided by the corresponding value of the price index.

Input price variables. Total cost will depend on input prices. In the context of estimating cost functions, it is relative input prices that are relevant. The California Health Facilities Commission produces a cost index for hospital inputs, the California Weighted Hospital Input Price Index (CWHIPI) [CHFC (1982)]. CWHIPI is a composite, state-wide average index formed from disaggregate price indices for the inputs used by California hospitals. These indices are weighted by the state-wide average proportion of total hospital expenditures that occurs in each input category.

The CWHIPI controls for the portion of input price variation that takes place over time, but ignores spatial variations of input prices. To account for

[8]The logarithmic transformation may reduce the error associated with the poor measure of output for outpatient services. For each hospital the error associated with this measure is equivalent to constant multiple, or an additive constant if the logarithm is taken. This error is then absorbed in the hospital specific error term in the variance components model to estimate the cost function.

spatial variation, the total index was split into components: one that is likely to vary regionally from hospital to hospital – primarily the labor-related component – and one that is not – purchased supplies, fuel and utilities, capital costs, and miscellaneous. The labor-related component was multiplied by the hospital–specific labor wage rate index developed by the Health Care Financing Administration for the determination of payment rates for hospitals under the Medicare PPS. The log transform of these prices was used.

Medicare PPS pressure index. In order to control for the introduction of the Medicare PPS program in October of 1983, we constructed an index to measure the financial pressure felt by each hospital at the introduction of the PPS program. The index is defined as the product of two terms. The first is the ratio of the hospital's base year costs divided by the PPS regional rate, a measure of the severity of the financial pressure that the Medicare PPS program exerted on the hospital. The greater the ratio the more the hospital would be expected to lose under PPS (assuming it does not change its costs). The second term is the proportion of the hospital's discharges that were paid for by Medicare, a rough measure of the importance of Medicare to the hospital.

Payer mix. Expected source of payment information was taken from the 1982 and 1983 discharge data sets. For each hospital, the percent of total discharges accounted for by the following payer categories was calculated: Medicare, MediCal, Private Insurer, and HMO. The values calculated from the 1982 discharge data set were used for all observations up to and including the fourth quarter of 1982, those from the 1983 data set were used for all later observations. The log transform of these variables was used.

Case mix. Two case mix measures are used: the number of distinct DRGs included in the hospital's 1983 discharge data and the hospital's DRG case mix index based on the same data set. The former measure is intended to reflect the fixed 'availability' cost borne by the hospital for the ability to perform a given set of services. Almost all hospitals provide a 'basic' set of commonly provided services. The additional costs associated with the provision of more rarely provided services are not fully reflected in the hospital's case mix index, but may substantially influence its total costs. The number of DRGs is used as an approximate measure of additional fixed costs.[9]

[9]It is clearly an oversimplification to assume that the logarithm of 'additional' fixed costs is proportional to the logarithm of the number of DRGs. This formulation was chosen nevertheless because it captures an important phenomenon: it is generally possible to rank hospitals monotonically on the basis of the complexity of the services they provide. As hospitals add services of increasing complexity their fixed costs will also tend to increase monotonically with the number of DRGs they provide.

The DRG case mix index is intended to capture the direct cost consequences of the hospital's case mix. To get a general population-based weight for each DRG for this study (as opposed to Medicare's weights which are based on the over 65 population), a random sample of 88,676 discharges was drawn from New Jersey hospital data from which outliers had been excluded. The average cost for each DRG was then calculated and relative weights assigned.

Market variables. We chose as our basic measure of competition the HHI, a measure that is widely used both in studies of industrial organization and by the Department of Justice to assess market competitiveness in antitrust cases.

Three basic steps were required to calculate each hospital's HHI. First, we defined service-specific market areas for each short term general hospital in California. Next each hospital's competitors were identified and their share of that market was calculated. Finally, the service-specific HHIs derived from the market share values were averaged, resulting in an overall measure of the competitiveness for each hospital. The primary data source for this task was the Discharge Data Set for 1983.

The basic steps are described in more detail below:

Defining service-specific market areas for individual hospitals. Hospital services categories were developed by combining all the DRGs that would generally be provided by the same type of physician [Zwanziger (1987)]. All of the discharges from a given hospital that fall within a single service category are combined and used to calculate service-specific market areas.

Hospitals typically draw their patients from a large number of five-digit zip code areas (ZCAs), but, for most hospitals, only a small number of these ZCAs contribute to the vast majority of the hospital's patients. These significant ZCAs were identified by selecting all the ZCAs contributing at least three percent of a hospital's total discharges for each service category.

This rule, while effective for defining the market areas of community hospitals, where patients originate locally, would unduly truncate the diffuse market area of a hospital with a regional draw. For example, if only ZCAs contributing at least three percent of admissions were included, this market area would account for less than 20 percent of UCLA Medical Center's total admissions. To provide a fuller picture of the market area of regional hospitals, a further requirement was imposed: the hospital market must contain the ZCAs that provide the hospital with the largest number of discharges and that contain at least 40 percent of its discharges for each service.

Identifying competing hospitals. For each hospital, another hospital was identified as a competitor if it drew significantly – at least 3 percent of a

Table 2
Calculation of the HHI for a ZIP code area.

	Hospitals					
	A	B	C	D	E	F
Proportion of the ZIP code area's patients	0.35	0.25	0.20	0.15	0.03	0.02

$$\begin{aligned} HHI &= 0.35\times 0.35+0.25\times 0.25+0.20\times 0.20+0.15\times 0.15+0.03\times 0.03+0.02\times 0.02 \\ &= 0.1225 \quad +0.0625 \quad +0.04 \quad +0.0225 \quad +0.0009 \quad +0.0004 \\ &= 0.2488 \end{aligned}$$

HHI (truncated at greater than 3 percent) = 0.2475

ZCA's total discharges – from at least one of the ZCAs in one of the first hospital's market areas.

Calculation of the HHI. The service-specific HHI for each ZCA was calculated using all of the hospitals in the ZCA that accounted for at least 3 percent of the discharges from the ZCA for that service category. Since the HHI is the sum of the square of the market shares of the hospitals in the ZCA, hospitals with small market shares contribute insignificantly. For example, each hospital at the minimum, accounting for 3 percent of a ZCA's discharges, will only add 0.0009 to the value of the ZCA's HHI [see table 2 for a more detailed example). The degree of competition facing each hospital is measured by a double weighted average of the HHIs of the ZCAs in its service-specific markets, with the proportion of patients from that ZCA in each case used as the weight. First, a hospital's weighted average HHI is calculated for each service by summing the average HHI for the ZCAs in the relevant service market weighted by the proportion of the hospital's discharges for that service that originate in the ZCA. Then the overall HHI for the hospital is the weighted average service HHI, weighted by the proportion of the hospital's discharges accounted for by the service.

The model was constructed to test the hypothesis that the policy changes that took place in California have changed the nature of hospital competition; specifically, we will examine the coefficients of the first order interaction terms between the market measures and yearly dummy variables[10] for changes in trends before and after the introduction of selective contracting.

Table 3 provides some basic descriptive statistics for the variables included in the model.

[10]Three forms of time variable could have been used to test the hypothesis: before and after (bf) dummy variables (two time variables), yearly dummy variables (six time variables), quarterly dummy variables (twenty three time variables). Yearly dummy variables were chosen both because they provided better explanatory power than bf variables, and because they would enable us to identify a gradual response whereas the bf form would only show an abrupt change. Quarterly dummy variables were rejected because the addition of so many variables to the model would have made the computation impossible.

Table 3
Descriptive statistics.

Variable	Mean	Std. dev.
Total expenses	6,250,000	7,690,000
Outpatient revenue	1,260,000	1,580,000
Available beds	165	143
Total patient days	9,532	1,005
Total discharges	1,521	1,530
Labor cost index	1.6169	0.2555
Non-labor cost index	1.2716	0.13520
Case mix index	1.0704	0.16785
Total DRGS provided	337	92.5
Number of fellows	1.13	8.12
Number of residents	11.1	51.1
Short-term childrens' hospital	0.015	0.12
Church owned	0.079	0.027
District	0.14	0.35
Investor owned	0.30	0.46
County	0.056	0.22
Proportion HMO discharges	0.041	0.051
Proportion Medicare discharges	0.32	0.14
Proportion Medi-Cal discharges	0.17	0.13
Proportion private insurer discharges	0.38	0.14
Outpatient price deflator	1.55	2.63
HHI	0.27	0.16
Market HMO total discharges	10,800	11,500
Market Medi-Cal total discharges	14,500	14,300
Market total discharges	102,000	97,700

Interaction terms. First order interaction between input prices and outputs were also included as suggested by standard trans-log cost functions, although in keeping with the 'behavioral' cost function orientation no constraints were placed on the values of the coefficients.

6. Empirical results

The empirical results are presented in table 4. To conserve space, only the estimated coefficients for the Medicare Program and competition variables are presented below. The estimated coefficients for the full model are included in the appendix.[11] In general the model performs quite well. Many of the estimated coefficients are statistically significant and signs are generally in the expected direction.

The Medicare PPS Pressure Index (MPI) is highly significant and is in the expected direction. In 1983, the first year of PPS, the estimated coefficient is −0.013. In the next two years, 1984 and 1985, hospitals continued to reduce

[11] A model containing the interaction between the private payer share and time variables was also estimated. The additional variables were found to contribute insignificantly.

Table 4
Estimated regression coefficients for Medicare and competition variables (t-statistic in parentheses).
Dependent variable is logarithm (total hospital expense).

Year	Log Medicare pressure index	Log HHI	Log proporion Medi-Cal
1980		−0.0596 (2.81)	0.0149 (3.46)
1981		−0.0614 (2.90)	0.0153 (3.56)
1982		−0.0673 (3.19)	0.0157 (2.77)
1983	−0.0132 (2.20)	−0.0612 (2.88)	−0.0002 (0.09)
1984	−0.0457 (7.90)	−0.0331 (1.56)	−0.0031 (1.05)
1985	−0.0612 (9.17)	−0.0166 (0.77)	−0.0053 (1.67)

their costs at increasing rates – 0.046 and 0.061 percent, respectively. These findings are consistent with previous findings by Feder et al. (1987), that high cost hospitals differentially lowered their costs as a result of the revenue constraints imposed by the PPS Program.

The estimated coefficients for the HHI variables over time reveal a significant cost reducing trend for hospitals operating in competitive markets. From 1980 until 1982, the coefficients of the HHI variables are approximately equal and are significantly negative, consistent with previous literature. Hospitals with higher values of the HHI, those in less competitive markets, had significantly lower costs. For the years following 1982, the estimated coefficients for HHI variables increase continuously in value from a significant −0.061 in 1983 to a non-significant −0.017 in 1985. This trend suggests that the initial differential in hospital costs due to differences in hospital market competitiveness declined substantially after the introduction of hospital price competition legislation.

The estimated coefficients for the Medi-Cal variables over time suggest that the selective contracting program has led to lower hospital costs. The values of the estimated coefficients for the Medi-Cal variables covering the period 1980 to 1982 are approximately equal, are positive, and are statistically significant, suggesting that all else being equal an increase in the proportion of Medi-Cal patients was associated with higher costs. This relationship changed significantly after 1983. The estimated coefficients for the Medi-Cal variables in the years 1983 and after are negative but are not significantly different from zero.

To test whether the change in behavior suggested by the values of the coefficients of HHI interacted with time were significant, we performed a simple regression analysis using the following model:

$$Ct = a + bT83,$$

where

Ct = value of coefficient of HHI in year t,

$T83 = T - 1983$ if $T > 1983$ and

$= 0$ otherwise.

The results of this regression on the six values of the coefficients are:

$$\underset{(31.41)}{Ct = -0.0671} + \underset{(11.02)}{0.02373} \quad T83.$$

The statistical results confirmed that the change in the slope of the coefficients after the introduction of selective contracting legislation was highly significant and positive.

To evaluate whether the observed cost reduction trend in the estimated coefficients of the Medi-Cal variables over time was significant, we performed a similar regression analysis on the estimated coefficients. The results of this regression on the six values of the coefficints are:

$$\underset{(16.81)}{Ct = 0.0139} - \underset{(11.91)}{0.0140}T83.$$

These results confirm that there was a significant reduction in the costs of hospitals serving a greater number of Medi-Cal patients after the introduction of the selective contracting law.

Table 5 presents the percentage difference in the predicted total costs for three pairs of hypothetical hospitals that differ only in their values of the MPI, the proportion of Medi-Cal patients, and the HHI respectively. The table is constructed to isolate the separate effects of the PPS program, Medi-Cal contracting, and competition on hospital costs. For each pair, one hospital has a high value – the mean plus one standard deviation – and the other has a low value – the mean minus one standard deviation. The

Table 5
Percentage difference in total hospital expenses.

	Competition effect (high vs. low)	PPS effect (high vs. low)	Medi-Cal effect (high vs. low)
1980	+8	N/A	+3
1981	+8	N/A	+3
1982	+9	N/A	+2
1983	+8	−1	0
1984	+4	−4	−1
1985	+2	−6	−1

percentage differences in total hospital expenses presented in the table provide an estimate of the separate effect of each policy on high and low value hospitals. For example, the difference between the hospitals subject to high and low financial pressure from the Medicare PPS program is the 'PPS effect'.

The percentage differences presented in table 5 allows one to compare the effects of each policy with one another over time. (The patterns traced out over time are identical to those described previously from the coefficients in the cost function.) The difference in total hospital expenses between the hospital in the highly competitive market and the one in the low competition market was 8 percent in 1980, peaked in 1982 at 9 percent and then, in 1982, following the introduction of selective contracting, declined steadily. The total reduction in the percentage difference between the two hospitals between 1982 and 1985 is 7 percentage points. The estimated effect of the PPS program through 1985 is a decrease of 6 percent. A comparison of the effects of the three programs shows that through 1985, the adjustments to competition and the Medicare PPS were roughly the same in magnitude. MediCal's selective contracting program appears to have had a much smaller effect that stabilized by 1984.

7. Discussion and conclusions

The results of our analysis strongly support the hypothesis that the nature of hospital competition underwent a structural change as a result of the implementation of California's 'pro-competition' legislation. As expected, hospitals competed on a non-price basis before 1983, and, increasingly, on a price basis after 1983. Testing this hypothesis was made more difficult by the introduction of the Medicare PPS program.

The two programs were implemented in close proximity. California's novel pro-competition legislation passed in June 1982 and was implemented in January 1983. In April 1983 Congress passed legislation to implement the

DRG-based Prospective Payment System (PPS) for Medicare inpatients and the program went into effect the following October. Both of these programs were designed to reduce the rate of increase in hospital costs.

Selective contracting should be most effective in competitive markets – those with many alternative providers. Similarly, recent evidence indicates that Medicare PPS has induced more stringent cost-cutting on the part of hospitals facing tighter revenue constraints under PPS – hospitals with high relative costs and a high share of Medicare patients [Feder et al. (1987)]. Since previous studies have suggested that hospitals in more competitive markets have higher costs, it is essential to separate the effects of selective contracting and the Medicare PPS.

After controlling for the effects of the Medicare PPS Program and other important determinants of hospital costs, our results indicate that a structural change in the nature of hospital competition has taken place in California following the implementation of selective contracting. It will be important to examine in future research whether these cost-reducing effects will persist in the long run and whether selective contracting affects other dimensions of hospital behavior.

See Appendix on next page

Appendix: Full regression results

Table A.1
Estimated regression coefficients – Full model.

Variable	Coefficient	T
Intercept	$9.3395E+00$	25.0740
Log(discharges)	$5.7946E-01$	8.8733
Log(deflated outpatient revenue)	$-4.8861E-01$	-8.0212
Log(case mix index)	$3.6156E-01$	1.6603
Rural dummy (rural = 0)	$4.3653E-02$	1.2614
Log(local labor price index)	$1.2825E+00$	2.4744
Log(state-wide non-labor price index)	$7.7110E-01$	1.1369
Log(proportion private insurers)	$4.5337E-03$	0.7485
Log(proportion HMO)	$-4.2266E-03$	-3.3985
Investor owned	$-3.5666E-02$	-1.4891
Children's hospital	$1.3374E-01$	0.7785
Church owned hospital	$1.1686E-01$	3.2083
District hospital	$-2.9734E-02$	-1.0646
County hospital	$7.4470E-02$	1.6610
Fellows dummy	$1.1742E-01$	2.4893
Resident's dummy	$1.1205E-01$	3.2435
Log(available beds)	$2.8391E-01$	23.2125
Log(number of distinct DRGs)	$3.5365E-01$	11.9328
1981 dummy	$1.5734E-02$	1.2117
1982 dummy	$1.9423E-02$	1.3215
1983 dummy	$-1.5030E-02$	-0.7734
1984 dummy	$-2.5964E-02$	-1.2260
1985 dummy	$-1.1020E-02$	-0.4414
Log(outpat rev) squared	$4.7290E-02$	12.0482
Log (outpat rev) * log(disch)	$-7.1643E-02$	-8.5358
Log(disch) squared	$5.0409E-02$	9.4367
Log(local PI) squared	$-6.3621E-01$	-1.5286
Log(state-wide PI) squared	$-1.8718E+00$	-2.6312
Log(local PI) * log(state-wide PI)	$1.3006E+00$	1.2388
Log(case mix) * log(disch)	$4.2328E-02$	1.4084
Log(outpat rev) * log(state-wide PI)	$7.0469E-02$	1.0311
Log(outpat rev) * log(local PI)	$-1.3731E-01$	-2.7501
Log(disch) * log(state-wide PI)	$-1.9249E-01$	-2.3665
Log(disch) * log(local PI)	$2.4633E-01$	4.1428
Log(pressure variable) * 1983 dummy	$-1.3207E-02$	-2.2000
Log(pressure variable) * 1984 dummy	$-4.5703E-02$	-7.9013
Log(pressure variable) * 1985 dummy	$-6.1251E-02$	-9.1735
Log(Herfindahl index) * 1980 dummy	$-5.9601E-02$	-2.8123
Log(Herfindahl index) * 1981 dummy	$-6.1419E-02$	-2.9022
Log(Herfindahl index) * 1982 dummy	$-6.7283E-02$	-3.1874
Log(Herfindahl index) * 1983 dummy	$-6.1167E-02$	-2.8833
Log(Herfindahl index) * 1984 dummy	$-3.3091E-02$	-1.5649
Log(Herfindahl index) * 1985 dummy	$-1.6667E-02$	-0.7797
Log(proportion Medi-Cal) * 1980 dummy	$1.4918E-02$	3.4616
Log(proportion Medi-Cal) * 1981 dummy	$1.5348E-02$	3.5637
Log(proportion Medi-Cal) * 1982 dummy	$1.1578E-02$	2.7711
Log(proportion Medi-Cal) * 1983 dummy	$-2.7495E-04$	-0.0897
Log(proportion Medi-Cal) * 1984 dummy	$-3.1203E-03$	-1.0532
Log(proportion Medi-Cal) * 1985 dummy	$-5.3570E-03$	-1.6745

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