NBER WORKING PAPERS SERIES

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Working Paper No. 3872

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
October 1991

September 26, 1991. We gratefully acknowledge helpful comments from Richard Frank, Barry Friedman, Mark Pauly, and David Salkever. This research was supported by a grant from the AmHS Institute. This paper is part of NBER's research program in Health Economics. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

NBER Working Paper #3872
October 1991

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ABSTRACT

The cost of excess capacity in the hospital industry has reemerged as an important policy issue. Utilized capacity in the hospital industry, as measured by the inpatient hospital bed occupancy rate, has declined over the past 10 years and now stands at approximately 65 percent. Congress and the Administration are concerned that the costs associated with empty beds represent wasteful expense and have proposed an adjustment to Medicare payment rates which will penalize hospitals with low occupancy rates. Hospitals, on the other hand, have indicated that the costs of empty hospital beds are low and that reimbursement adjustments are unnecessary.

In order to provide more current and representative estimates of the cost of an empty hospital bed we estimate the cost function model of Friedman and Pauly using data from a national sample of 5315 hospitals for the years 1983-1987. We find that empty beds account for approximately 18 percent of total costs, or $546 per admission (1987 dollars). The estimate (in 1987 dollars) of the cost of an empty hospital bed is approximately $38,000.

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I. INTRODUCTION

The cost of excess capacity in the hospital industry has reemerged as an important policy issue. In the 1970s and early 1980s, the cost of empty hospital beds was an important justification for the health planning program. With the elimination of federal funding for health planning, interest in the issue waned. Utilized capacity in the hospital industry, as measured by the inpatient hospital bed occupancy rate, has declined over the past 10 years and now stands at approximately 65 percent.[1] While the costs of excess capacity are borne privately in other industries, in the hospital industry a large portion of these costs are publicly paid, due to the presence of Medicare, Medicaid, and other public programs.[2] The exclusion of capital costs from Medicare's prospective reimbursement for hospitals, combined with the dramatic decline in occupancy rates, has reestablished the cost of empty hospital beds as an important public policy issue. As capital becomes included in the Medicare prospective payment rate over a ten year period Congress and the Administration will continue to be concerned that the costs associated with empty beds represent wasteful expense. An adjustment to Medicare payment policy has been proposed which

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[1]This represents a decrease of approximately 11 percentage points from an average occupancy rate of 76 percent in 1980.

[2]For example, revenues from Medicare constitute 30 percent of a hospital's total revenues, on average. Medicare (and most Medicaid programs) reimburse hospitals for their share of allowable capital costs incurred.

will penalize hospitals with low occupancy rates.[3] Hospitals, on the other hand, have indicated that the costs of empty hospital beds are low and that occupancy adjustments are unnecessary.[4]

The evidence on this topic is mixed. Previous estimates of the cost of an empty bed range from $4,251 (Friedman and Pauly, 1981), $6,439-$10,274 (Friedman and Pauly, 1983), $6,926-$18,855 (Pauly and Wilson, 1986), $6,850-$28,768 (Schwartz and Joskow, 1980), $46,437 (Institute of Medicine, 1976) to $83,564-$98,632 (State of Michigan, 1979).[5] The differences in the estimates may be due to differences in time periods covered, hospital samples, or cost estimation methods.

The previous estimates, however, may not be representative of the current cost of an empty hospital bed. First, structural changes may have occurred since these analyses were done. Medicine has recently been characterized by rapid technological change which could have substantially changed the technology of production. In addition, the introduction of Medicare's Prospective Payment System (PPS) in 1983 was intended to give

[3]For example, Representative Fortney "Pete" Stark has been quoted as saying "Low occupancy is a symptom of the indulgent spending spree the country's hospitals have been on.", and Gail Wilensky, Chief of the Health Care Financing Administration, has indicated that 4 out of every 10 empty staffed hospital beds should be reduced (Healthweek News, July 30, 1990, p. 9).

[4]Healthweek News, op.cit., p.9.

[5]All figures have been converted to 1987 dollars using the implicit GNP deflator unless indicated otherwise. There is little difference if the HCFA hospital input price index (Freeland, Anderson, and Schendler, 1979)is used instead, e.g., the figure in 1987 dollars for Friedman and Pauly (1981) is $4,251.

hospitals incentives to be more efficient, and thus may also have affected the structure of costs. Thus the cost of an empty bed may differ substantially from estimates for earlier time periods. Second, the analyses were based on data which are not necessarily representative of the population of hospitals in the U.S.[6] Last, most of these estimates are derived in a rather ad hoc fashion. The exceptions are Friedman and Pauly (1981, 1983) and Pauly and Wilson (1986), which are based on a cost function derived for a hospital facing uncertain demand.

In order to provide more current and representative estimates of the cost of empty hospital beds we estimate the Friedman and Pauly model using data from a national sample of 5315 hospitals for the years 1983-1987. We also employ specification tests to examine the sensitivity of the model to issues of functional form, heteroskedasticity, and collinearity. Our estimates indicate that the costs due to empty beds are approximately 18 percent of total costs. This is comparable in magnitude to the figures in Pauly and Wilson, who estimate that 11 to 18 percent of costs can be attributed to empty beds. In our sample this amounts to approximately $546 per admission (in 1987 dollars).

Last, the methodology employed here is relevant to the general analysis of questions involving excess capacity. It is

[6]For example, Pauly and Wilson used data for 176 hospitals in the state of Michigan from 1979-1982, and Friedman and Pauly used data for 871 hospitals from 1973-1978.

often alleged that excess capacity is wasteful, but there are few estimates of the effects of excess capacity on the costs of production (Scherer and Ross, 1990). This analysis demonstrates the use of a technique which allows the measurement of the cost of that capacity which exceeds the optimal "excess" capacity required in the face of uncertain demand.

The rest of the paper is as follows: Section II contains a brief description of the Friedman and Pauly model, a description of the data is contained in Section III, Section IV discusses econometric issues, Section V contains the empirical results, and a summary and conclusions are contained in Section VI.

II. THE MODEL

The model of hospital costs employed in this paper is that derived by Friedman and Pauly (1981) for a service firm with variable quality and stochastic demand. The basic notion is that when a firm produces a heterogeneous product (e.g., a service) and is subject to stochastic demand, it may choose to let quality deteriorate in the face of unexpectedly high realizations of demand.[7] There is a penalty to this quality deterioration, through market responses to the reduced quality, and through a reduction in the hospital's utility if quality is an explicit argument in the firm's objective function. Since neither the quality responses of firms faced with unexpectedly high demand

[7] This is analagous to "the repairman problem." For example, see Rothschild and Werden (1979).

nor the associated penalties are observable, this is called the "latent penalty" model.

If the hospital's inputs, such as labor, are fixed over the relevant time period, e.g., due to contracts, then a rational response to demand uncertainty is to hire "extra" inputs, i.e. "excess capacity", as a hedge against the latent penalty associated with unexpectedly high realizations of demand. Thus, inputs are chosen to minimize expected costs, taken over all possible realizations of demand. The "currently fixed" inputs can be referred to as "quasi-fixed inputs", and their associated costs are termed "quasi-fixed costs". Costs are consequently a function of expected demand, actual demand, and other factors such as input prices, fixed capacity, and other hospital characteristics which may effect costs,

$$C = C(\hat{Q}/q,\ w,\ k,\ X), \qquad (1)$$

where $\hat{Q}$ is expected demand, q is actual demand, w represents input prices, k is fixed capacity, and X are other exogenous hospital characteristics. Quasi-fixed costs will be increasing in $\hat{Q}$, expected output. Fixed costs are positively related to k, the level of fixed capacity.

In the case of hospitals, fixed capacity is represented by the number of hospital beds. If a bed is unoccupied, the variable costs associated with output are avoided, but fixed costs which vary with the number of available beds are not. In the context of the Friedman-Pauly model, the cost of an empty bed which was forecasted to be unoccupied will be less than that of an unexpectedly empty bed, since the variable costs associated with the forecasted empty bed can be avoided. Thus, the cost of an (expectedly) empty hospital bed is the fixed cost associated with that bed. This is arguably the relevant cost of an empty bed, since unexpectedly empty beds do not represent permanent excess capacity (assuming rational forecasts).

III. DATA

A. Sources

We used data from the American Hospital Association's (AHA) Annual Survey of Hospitals for each of the years 1983 through 1987. This is an annual survey of the universe of hospitals in the United States. It contains data on costs, payments to inputs, output, hospital characteristics, and other factors. In addition, a Medicare case mix index for each hospital was obtained from the U.S. Health Care Financing Administration.[8] We were able to obtain complete data for 5315 hospitals.[9] Hospitals were deleted if we could not match AHA and Medicare identification numbers, if the hospital did not exist for all five years, or if the hospital did not report information to the AHA for all five years.

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[8] See Anderson and Lave (1986) for more detail.

[9] These represent 93% of short-term community general hospitals in 1985.

B. VARIABLES

Dependent Variable

The dependent variable is average cost, measured in real terms. This variable was constructed by dividing each hospital's total annual expenses by the number of admissions for the year. The implicit GNP deflator was used to convert all money figures to 1983 dollars.

Independent Variables

The independent variables are the ratio of expected to actual output, the inverse of the occupancy rate, the number of hospital beds, the wage rate, the Medicare case mix index, a dummy variable indicating whether the hospital is for-profit, a dummy variable indicating if the hospital is public, and a dummy variable indicating if the hospital is a teaching hospital (if there are any interns or residents). Descriptive statistics for all the variables are displayed in Table 1.

Output is measured as the number of inpatient admissions to the hospital in a year. Expected output is the econometric forecast of output for the hospital, as in Friedman and Pauly (1981).[10] Since we had a relatively short time series for each hospital (eight years), we were unable to forecast expected output for each hospital using pure time series methods as

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[10]AHA data covering the period 1980-1987 were used for the purposes of forecasting expected admissions. The model used three lags, thus there were forecasted values for 1983-1987.

Friedman and Pauly did. Rather we exploited the cross-sectional as well as the time series variation in the data to generate forecasts for expected output for each hospital by grouping the hospitals by geographic area.[11] Hospitals which were in the following categories were pooled together: hospitals in the same Metropolitan Statistical Area (MSA), hospitals in the same urban area, hospitals in rural areas in the same state.[11] There were 365 such areas. The forecasting equation used three lags for admissions, a time trend, and hospital specific dummies. The hospital specific intercepts allowed us to generate forecasts for each hospital even though the forecasting equation was estimated for pooled sets of hospitals. The fits for the forecasting equations were excellent, with R^2s in the range of 0.97 to 0.99. Examples for three MSAs are reported in an appendix.

The inverse of the occupancy rate is a proxy for fixed capacity. Assuming that fixed costs are positively related to capacity, average fixed costs will depend positively on the inverse of the occupancy rate. In addition, the number of inpatient beds is allowed to shift the cost function. This variable may proxy for unmeasured severity of illness associated with large size or perhaps economies of scale or scope (Anderson and Lave, 1986).

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[11]Since hospitals in the same area share common shocks specific to their market, perhaps not too much is violated by pooling hospitals in this manner for the purpose of forecasting.

[11]MSAs or urban areas with only one hospital were combined with rural hospitals in the same state. There were 14 such areas.

There are no reported data on wages (or other input prices) by hospital, therefore we used reported payroll per full time equivalent (FTE) employee as a proxy for hospital wages.[12] An alternative would have been to use a hospital wage index constructed by HCFA for the purpose of Medicare reimbursement, but this index is area, rather than hospital specific. The Medicare case mix index measures the complexity of a hospital's Medicare cases in any given year in terms of their relative costliness. It is constructed by HCFA for the purposes of Medicare reimbursement (see Pettengill and Vertrees (1982) for details). Last, the ownership form of the hospital and teaching status are control variables for hospital characteristics which may affect cost. A hospital is defined as a teaching hospital if it has any interns or residents.

IV. ECONOMETRIC ISSUES

The model was estimated by the method of fixed effects, or least squares with dummy variables. Dummy variables for each hospital represented unobserved hospital specific effects which are constant over time. Dummy variables for each year control for the effect of secular changes over time.

Since the cost function we estimate has not been derived from a specific production technology, there is no particular

[12] Labor is the chief input in the production of hospital services. Expenditures on labor constitute approximately 80% of hospital costs (Freeland, Anderson, and Schendler, 1979).

functional form which is indicated. Friedman and Pauly employed a linear functional form, and Pauly and Wilson explored a logarithmic as well as a linear functional form. Since the logarithmic functional form has been widely used in the literature on hospital cost functions, and since the linear form has been used for estimation of this particular cost function, we felt we should explore the issue of the appropriate functional form. MacKinnon, White, and Davidson (1983) provide a specification test for distinguishing between non-nested models: the "Extended Projection" or P_E test. The linear specification was rejected in favor of the logarithmic specification at the 1% level.[13] Nonetheless, we report the estimates of the linear functional form for the purposes of comparison with earlier work.

There were two other salient issues to consider concerning the econometric specification: heteroskedasticity and multicollinearity. It is often alleged that the errors in hospital cost regressions are heteroskedastic due to the differing sizes of the institutions. For that reason we employed the Breusch-Pagan (1979) test for heteroskedasticity of a particular form. A computationally convenient form of the test consists of regressing the squared residuals from the cost

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[13]The test statistic is the t-statistic on the difference of the log of the predicted values from the linear model and the predicted values from the logarithmic value in an augmented linear regression. Significance of this statistic implies rejection of the null hypothesis. The value of the t-statistic is 24.468, therefore the hypothesis of linearity is rejected at the 1% confidence level.

regression on hospital bed size. The test statistic is equal to the product of the R^2 from this regression multiplied by the number of observations.[14] It is asymptotically distributed χ^2 with degrees of freedom equal to the number of regressors. The R^2 from this regression is zero, therefore the hypothesis of homoskedastic errors cannot be rejected.[15] Last, we were concerned that there might be significant collinearity among regressors such as bed size, occupancy rate, and admissions. We therefore utilized the diagnostics of Belsley, Kuh, and Welsch (1980) to check for multicollinearity. These diagnostics did not detect any significant impact of multicollinearity.

V. RESULTS

Table 2 contains the fixed effects estimates of the cost function. The estimates of the individual hospital and time fixed effects are not reported. Column 1 contains the estimates from the logarithmic functional form and column 2 contains estimates using the linear functional form. Since the signs of the estimates do not differ between the two columns (with one exception), we shall mainly discuss the estimates from column 1.

Most of the parameter estimates are consistent with expectations and with the results of Friedman and Pauly and Pauly

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[14]This test statistic is asymptotically equivalent to the LaGrange multiplier test statistic and is also robust to non-normality (Koenker, 1981).

[15]The regression itself was not significant.

and Wilson. The estimate of the ratio of expected to actual output is positive and significant, as expected. The inverse of the occupancy rate is also positive and significant, consistent with its interpretation as a proxy for fixed capacity costs. The coefficient on bed size is not significant, but the total effect of the number of hospital beds is positive.[16] This result is consistent with the findings in most studies of hospital costs that the total effect of bed size on cost is positive. The effect of bed size is negative and significant in the linear specification, although the total effect of bed size is still positive. The wage rate and case mix index have a positive impact on costs, as expected. Finally, teaching hospitals are not significantly more costly, for-profits cost more, and public hospitals cost less.

VI. WHAT IS THE COST OF AN EMPTY BED?

In this section we report calculations of the costs associated with empty beds based on the estimates reported in Table 2. We report two figures, the proportion of total costs which are fixed costs and the total fixed cost per bed. The proportion of total costs due to empty beds is unitless and hence is useful for the purpose of comparison with previous estimates. As mentioned previously, comparisons of estimates of the cost of an empty bed may be confounded by changes in technology or

[16] Recall that the inverse of the occupancy rate is defined as (365 x Beds)/Days.

changes in regulatory policy.

The proportion of costs which are fixed costs represent the proportion of costs attributable to empty beds. Figure 1 illustrates the basis for this measure. Long run marginal cost (LMC) and average cost (AC) are equal at minimum efficient scale, q* (e.g., at the minimum of the average cost curve). At this point there is no excess capacity and average cost contains no fixed costs. At the observed output, $\hat{q}$, the ratio of long run marginal cost to average cost ($MC(\hat{q})/AC(\hat{q})$) thus provides an indication of how far hospitals are from minimum efficient scale, since at minimum efficient scale this ratio equals one.

Comparing the inverse of this ratio to one ($[AC(\hat{q})/MC(\hat{q})]-1$) provides an estimate of the proportion of costs which are fixed, since there is no excess of average costs over long run marginal costs at efficient capacity. Applying this proportion to average costs yields an estimate of the fixed cost per case.[17]

The cost of an empty bed is the estimate of total fixed costs per bed. Since the inverse of the occupancy rate represents fixed capacity, its marginal impact on average cost can be used to quantify the total fixed cost per bed. Multiplying the marginal impact by the inverse occupancy rate

[17] This is actually an overestimate, or upper bound, since marginal costs are higher at minimum efficient scale than at points below it. The correct measure is $[AC(\hat{q})/MC(q^*)]-1$. Since observed output is less than minimum efficient scale, q*, our estimate of long run marginal cost is less than marginal cost at minimum efficient scale, and the ratio $AC(\hat{q})/MC(\hat{q})$ is thus somewhat too large.

yields the total impact on average cost. Further multiplying by total admissions and dividing by total beds generates the total fixed cost per bed, or the cost of an empty bed.[18]

Table 3 contains estimates for the cost impacts of empty beds from both the logarithmic and linear forms, although we only discuss the estimates from the logarithmic form.[19] The estimate of the ratio of long run marginal cost to average cost is 0.85. This is close to the figures for this ratio reported by Pauly and Wilson of 0.85 to 0.9. Friedman and Pauly (1981) a figure of report 0.98, and Friedman and Pauly (1983) report ratios of 0.92 to 1. This implies that the proportion of total cost attributable to empty beds (i.e., fixed costs) is approximately 18 percent. This amounts to $546 per admission in 1987 dollars.

The estimates of the cost of an empty bed are also reported in Table 3. The cost of an empty bed from the logarithmic form is $32,568 ($37,918 in 1987 dollars). This estimate is in the mid-range of previous estimates, although it is larger than those produced by the same method. This may be due to changes in the hospital production process which may have led to higher fixed costs (e.g., the diffusion of capital intensive new technologies such as magnetic resonance imaging), actual diseconomies

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[18] This impact is equal to $\hat{\beta}$(Inverse Occupancy Rate) x (Admissions)/Beds for the linear form and $\hat{\beta}$(Average Cost) x (Admissions)/Beds for the logarithmic form, where $\hat{\beta}$ is the estimated coefficient of the inverse occupancy rate. Since the inverse of the occupancy rate represents fixed capacity, the estimate of its impact on average cost is marginal fixed cost.

[19] These are evaluated at the sample means of all variables.

associated with lower occupancy rates (i.e., movement "back up" the average cost curve), or changes in incentives under the Prospective Payment System. Thus, it is difficult to discern whether the cost of an empty bed is truly "higher" than previously estimated by this method, or whether the production of hospital services has changed in important but unmeasurable ways.

These estimates, while significant, is not as large as some policymakers have contended. We believe that 18 percent represents an upper bound on actual realizable cost savings due to bed reductions, because actual cost savings depend on the method and volume of bed reductions. In addition, society may value excess capacity in the hospital system.[20]

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[20] The optimal number of beds, of course, depends not just on the cost of an empty bed, but also on the benefit of an empty bed, i.e., the social value placed on having beds available when needed.

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TABLE 1

Variable Descriptive Statistics[a]

Variables	Mean	Standard Error
Cost per Admission	3136.51	2578.16
Ratio of Forecasted to Actual Admissions	1.01	0.313
Forecasted Admissions	6092.41	6585.69
Actual Admissions	6092.62	6611.85
Beds	170.16	177.94
Inverse of the Occupancy Rate	1.89	1.14
Wage Rate	16,838.31	11,550.96
Case Mix Index	1.094	0.14
Teaching Hospital	0.16	0.37
For-Profit Hospital	0.13	0.34
Public Hospital	0.29	0.45

[a]All monetary figures are in 1983 dollars.

TABLE 2

Fixed Effects Estimates of Average Cost Function[a,b,c]

Dependent Variable

Cost per Admission

Independent Variables	Parameter Estimates: Logarithmic	Parameter Estimates: Linear
Ratio of Forecasted to Actual Output	0.89*** (0.03)	1352.07*** (22.13)
Inverse of the Occupancy Rate	0.29*** (0.01)	529.92*** (7.92)
Beds	0.004 (0.007)	-1.55*** (0.33)
Wage Rate	0.36*** (0.01)	0.0013*** (0.0004)
Case Mix Index	0.62*** (0.02)	2220.72*** (138.74)
Teaching Hospital	0.001 (0.01)	-41.17 (37.12)
For-Profit Hospital	0.08*** (0.01)	96.42 (83.63)
Public Hospital	-0.06*** (0.01)	-134.61** (65.77)
R^2	0.55	0.46
F	2725.39***	1858.09***
Number of Observations	26423	26423

[a]The parameter estimates for the hospital specific and time dummies are not reported.

[b]Standard errors are in parentheses below the estimates.

[c]***-Significant at 1% confidence level; **-significant at 5% confidence level.

TABLE 3

The Cost Impact of Empty Beds[a]

	Specification	
Measure	Logarithmic	Linear
Long Run Marginal Cost/ Average Cost	0.85	0.68
Proportion of Costs Which are Fixed[b]	0.176	0.47
Total Fixed Cost per Bed	$32,568.02	$35,860.70

[a]In 1983 dollars.

[b]This is calculated as (Average Cost/Long Run Marginal Cost)-1.

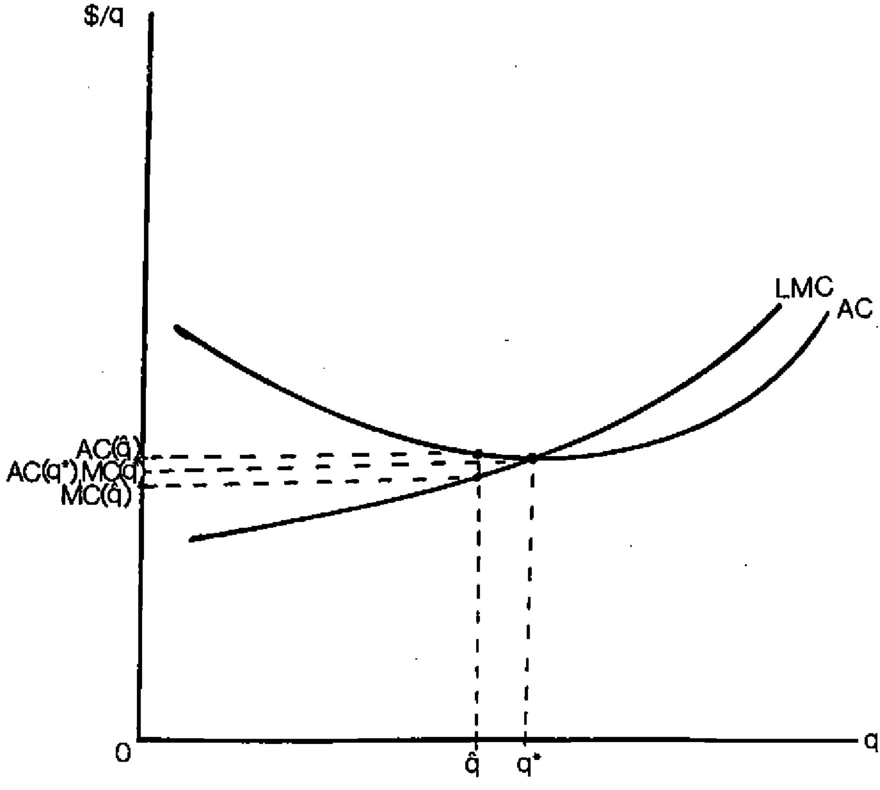

FIGURE 1

APPENDIX

Forecasting Hospital Admissions-Three Examples[a,b,c]

Dependent Variable

Hospital Admissions

Independent Variables	Area: Baltimore MD	Area: Appleton-Oshkosh-Neenah, WI	Area: Amarillo, TX
Intercept	417.83 (365.47)	98.15 (350.13)	-462.70 (797.66)
Admissions Lagged 1 Year	1.21*** (0.09)	0.60*** (0.20)	1.41*** (0.31)
Admissions Lagged 2 Years	-0.52*** (0.13)	0.23 (0.26)	-0.54 (0.47)
Admissions Lagged 3 Years	0.31*** (0.10)	0.11 (0.23)	0.14 (0.31)
Time Trend	-100.63 (64.31)	-37.92 (65.59)	70.87 (149.80)
R^2	0.98	0.99	0.98
F	1632.17***	754.63***	285.45***
Number of Observations	120	35	25

[a]The parameter estimates for the hospital specific and time dummies are not reported.

[b]Standard errors are in parentheses below the estimates.

[c]***-Significant at 1% confidence level.