MANAGED HEALTH CARE AND TECHNICAL EFFICIENCY IN THE USA

by

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ABSTRACT

By focusing exclusively on consumer benefit, previous studies of the effects of managed care have ignored important hospital efficiency gains. This study uses data from the 1992-1996 US Health Care Cost and Utilization Project, National Inpatient Sample to estimate a stochastic frontier model of hospital technical efficiency. After controlling for hospital and market area variables, the study finds strong evidence that increased managed care insurance in any given market is associated with improved technical efficiency in area hospitals. Using a one-stage estimation technique (Battese and Coelli 1995), the estimates are more efficient than for two-stage methods found in most of the literature.

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Managed Health Care and Technical Efficiency in the USA

1 Introduction

The effect of managed care insurance contracts, such as health maintenance organizations (HMOs) and preferred provider organizations (PPOs), on health costs is unclear (see Miller and Luft (1994) for a review). Most studies focus on the costs that consumers pay (insurance premiums or provider fees) for health services whenever managed care becomes prevalent in a market (see, *e.g.*, Hadley and Gaskins 1997). The inconclusiveness may arise because the effects of managed care on consumers depend, amongst other things, upon the local competitiveness of the insurance industry. By focusing exclusively on *direct* consumer benefits, these studies may have overlooked other important managed care effects.

Although there are numerous variations, managed care insurance commonly works by steering its customers towards health care providers which are "non-blacklisted" because they have agreed to price cuts. It is possible that pressure from managed care firms has forced hospitals to produce output more efficiently, regardless of whether consumers directly benefit. In this study, data from the 1992-1996 US Health Care Cost and Utilization Project, National Inpatient Sample (HCUP) are combined with MedStat Pulse data on managed care penetration in various markets to test whether managed care improves hospital technical efficiency. The study tests the hypothesis using a stochastic frontier model.

The assumption of optimal taxation ensures the possibility of efficient redistribution (see, *e.g.*, Atkinson and Stiglitz 1980). From this perspective, whether firms or consumers benefit more from managed care is irrelevant. Suppose managed care improves hospital efficiency, but consumers do not directly benefit. In this case, the effects of improved hospital efficiency on welfare may depend on hospital ownership type. In the case of for-profit hospitals, profit-maximization implies that production is already technically efficient, although not necessarily at the most efficient scale nor at a socially desirable level of quality. Therefore, holding scale economies and quality constant, transfers of profits from for-profit hospitals to managed care firms are welfare neutral. Whether this is welfare-improving or not depends on the magnitudes of profits for-profit hospitals lose (gain) in comparison to what managed care firms gain (lose). In the case of nonprofit hospitals, managed care pressure could improve efficiency and/or reduce "profits", which again would be transferred to managed care firms (see Hoerger (1994) for empirical evidence of "nonprofit profits"). The welfare implications are ambiguous, depending on the benefits of nonprofit hospitals. However, note that one could view transfers from nonprofit hospitals to managed care firms as transfers from the untaxed to the taxed. Finally, managed care pressure could force improvements in efficiency at public hospitals in the same way that government budget cuts could force efficiency gains (see *e.g.*, Gerdtham *et al.* 1999).

The Battese and Coelli (1995) stochastic frontier model used in this paper allows one to estimate not only the hospital's efficiency, it allows one to estimate coefficients related to the *reasons* for a hospital's efficiency or inefficiency. The Battese and Coelli model estimates the coefficients for the standard stochastic frontier and the coefficients for the reasons for (in)efficiency in a one-stage process, which is *statistically* more efficient than the two-stage process normally used.

This paper is the first the author knows of that tests the effects of managed care on hospital efficiency. If managed care can improve the technical efficiency of area hospitals, aggregate welfare could improve in many instances. In these cases, public policy makers can use the power of taxation to redistribute the benefits to consumers if they so choose. The results show that managed care insurance significantly affects hospital efficiency.

Section 2 provides a brief literature review. Section 3 presents the model and describes the data. Section 4 gives results while Section 5 provides discussion.

2 Brief Literature Review

Table 1 summarizes Miller and Luft's literature review of the effect of managed care's effects on health costs (1994).

Table 1: Number of papers examining managed care by type of health cost

	Affect:*		
Cost Type	Lower	Higher	Uncertain
Physician/outpatient cost per enrollee	2	1	2
Total cost per enrollee	1	1	1
Hospital Costs	2	0	0
Premium levels	0	1	0
Growth of premiums	0	0	0
*In comparison to fee-for-service insurance			

Clearly the effects of managed care penetration on costs is mixed.

Most studies of health service utilization confirm the results from the Rand experiment, where utilization declines for holders of managed care insurance (Manning, Leibowitz, Goldberg *et al.* 1985). Feldman, Dowd, and Gifford (1993) show that firms which offer HMO coverage face increases in average premium costs in comparison to firms where only fee-for-service is offered. Gaskin and Hadley (1997) show that hospital costs decline with managed care penetration.

Baker and Corts (1996) show that consumer benefits depend on competitiveness in insurance markets. They find that fee-for-service insurance premiums fall by 13.8 when HMOs have 0-10 percent of the market share; fall by 1.8 when HMOs have 10-20 percent of the market share; and *increase* by 20.3 percent when HMOs have 20-30 percent of the market share.

Recently, Gerdtham *et al.* (1999) use the Battese and Coelli (1995) model employed in this paper to show that a recent budget reform improved hospital efficiency by 10 percent. A dummy variable for budget reform is significantly related to improved efficiency. More typically, a two-stage estimation technique is used, whereby technical efficiency is estimated in the first stage; technical efficiency is explain in the second stage. Kooreman (1994) uses data envelope analysis to show that 50 percent of Dutch nursing homes are efficient. The reasons for technical efficiency are then explained in a second stage.

Vitaliano and Toren (1994) and Zuckerman, Hadley, and Iezzoni (1994) also estimate stochastic frontier cost functions.

3 The model of technical efficiency

The model that we estimate is from Battese and Coelli (1995). Specifically

$$\text{Output}=f(\text{labor, capital, other inputs})+TE,$$

where TE is the term which captures technical efficiency. In turn,

$$TE=f(\text{firm characteristics, market characteristics}).$$

Following Coelli (1996), the model specification is

$$\ln y_{it} = x_{it}'\beta + (v_{it} - u_{it}), \tag{1}$$

where y_{it} are hospital outputs, x_{it} is a vector of hospital inputs, transformed to natural logs, and β are parameters corresponding to those inputs. Subscripts i and t index firm number and time period. The error is composed of $\epsilon_{it} = v_{it} - u_{it}$. Note that $v_{it} \sim N(0, \sigma_V^2)$ and v_{it} is assumed to be iid and is independent of u_{it}, which is the non-negative random variable accounting for technical *inefficiency.*

Note that the non-negativity of u_{it} means its distribution is truncated. By assumption, $u_{it} \sim N(m_{it}, \sigma_U^2)$ at the zero truncation. Note further that $m_{it} = z_{it}\delta$, where z_{it} is a vector of variables influencing firm efficiency and δ is a vector of corresponding parameters. In our model, market, firm, and time variables influence hospital technical efficiency.

3.1 The Data

The study primarily uses data from the 1992-1996 US Health Care Cost and Utilization Project, National Inpatient Sample (HCUP, as defined earlier). This data base compiled by the Agency for Health Care Policy and Research (AHCPR) provides discharge data from a 20 percent stratified random sample of hospitals from 17 US states. The sampling probabilities were proportional to the number of US community hospitals in each stratum. For each hospital, HCUP provides discharge data on 100 percent of the patients. This source provided information on diagnosis related group (DRG), patient age, and Metropolitan Statistical Area (MSA). The data are an unbalanced panel.

The study links these data with the American Hospital Association (AHA), Annual Survey of Hospitals to identify hospital characteristics. Finally, managed care penetration, which is the proportion of the population enrolled in HMOs and PPOs, were obtained from the 1992, 1994, 1995, and 1996 MedStat Pulse survey of households. The data for 1993 are imputed. While the MedStat HMO enrollment data correlate highly with other sources, it is one of the few sources of PPO enrollment. These data have previously been used in analysis of the provision of health insurance by small employers (Morrisey and Jensen 1997). There were 1,837 cases available for study. A list of variables, means and standard deviations, along with their respective sources, is found in Table 2. Appendix tables A-1 and A-2 list the cities and states included in this sample.

In order to account for case mix, the HCUP data are split into classes by DRG. The DRG weights developed by the Health Care Financing Administration reflect average resource use. Higher weights reflect greater resource use and more complex cases. Because there are relatively more routine cases, the distribution of admissions by DRG weight is right-skewed. Therefore, the data are split into classes for cases with DRG ≤ 1, those with $1 <$ DRG ≤ 2, and those with DRG > 2. Separate estimates were obtained for each category, plus a category for all cases. If a particular hospital did not have a positive number of admissions in one of those categories, it was not included in that estimate.[1] A log transformation, to base e, was applied to the dependent variables in each regression.

Let us now consider the hospital inputs, x_{it}, as computed from the AHA data. In all cases, the hospital inputs are logged to base e. This means that the functional form of the production function is Cobb-Douglas. Labor variables include total employee payments

[1] This happened quite infrequently.

and benefits (labor expenses). Total beds and total expenses, less labor expenses, are proxies for capital equipment. All costs are in 1996 dollars.

Let us now consider the hospital factors related to hospital efficiency, z_{it}. There is one dummy variable which measures hospital teaching responsibility, COTH, the acronym for Council of Teaching Hospitals. Even though hospitals receive Federal subsidies which in part offset the costs of teaching, one would expect that these responsibilities would lower efficiency. Additionally, we include the number of full and part time residents combined. Dummy variables for for-profit hospitals and public hospitals measure the effect of ownership type on efficiency, relative to nonprofit hospitals. As noted in the introduction, accepted theorems of public and nonprofit hospital efficiency do not exist. Therefore, the relative efficiency of public hospitals relative to nonprofit hospitals as well as for-profit hospitals relative to nonprofit hospitals is not clear.

In addition to managed care variables PPO and HMO, market characteristics explaining inefficiency include the Herfindahl Index, defined as the sum of the squared admission shares of hospitals within the MSA. As the Index increases, other things equal, there is less structural competition in the local hospital market, perhaps leading to lower technical efficiency. Of course, our hypothesis is that higher levels of managed care lead to greater efficiency.

Finally, dummy variables for year are included to control for trends in efficiency over the sample period. The HMO and PPO variables are each squared and interacted to account for curvi-linearities in the relationship between managed care and technical efficiency.

The model is estimated using *Frontier 4.1* software (Battese and Coelli 1994). The method of estimation is maximum likelihood, using Davidson-Fletcher-Powell Quasi-Newton.

4 Results

The results are presented in Tables 3 and 4. The coefficients in Table 3 are in natural log form.

As one might expect, the coefficient for total beds are all positively and significantly related to output in each regression. Surprisingly, the other capital variable, non-labor expenses, is negative. However, it is only significant at the 10 percent level in the all cases regression and the <1 DRG cases regression.

The coefficients for pay and benefits are of the right sign in every case. However, they are only significant in the all cases regression.

Consider the estimate for $\gamma = \sigma_U^2/(\sigma_V^2 + \sigma_U^2)$. The fact that γ is close to one indicates the importance of inefficiency in these hospitals relative to the the x_{it} variables. Table 5 reports the LR test of the truncated error, u_{it}. In each regression, the null hypothesis of $\gamma = 0$ is rejected.

Now let us consider the independent variables explaining inefficiency, z_{it}, given in Table 4. Surprisingly, more residents are associated with increased efficiency in each of the 4 regressions. Similarly, COTH, or Council of Teaching Hospitals member, significantly increases efficiency in each of the 4 regressions.

Relative to nonprofit hospitals, both for-profits and publics reduce efficiency. In the case of for-profits, the relative inefficiency may indicate an attempt to lower congestion

Table 2: Means, Standard Deviations, and Sources

Hospital Output Variables
(dependent variables)

Variable	N	Mean	Standard Dev	Source
All Cases (ln)	1837	8.896	0.977	A
<1 DRG Cases (ln)	1837	8.407	0.974	A,D
>2 DRG Cases (ln)	1826	6.517	1.354	A,D
1 to 2 DRG Cases (ln)	1831	7.553	1.032	A,D

Hospital Input Variables
(independent variables)

Variable	N	Mean	Standard Dev	Source
ln Pay and Benefits	1837	16.669	1.112	C
ln Other Expenses	1837	16.186	1.146	C
ln Total Beds	1837	5.295	0.778	C

Firm, Market Variables
(independent variables)

Variable	N	Mean	Standard Dev	Source
Residents	1837	24.345	81.321	C
COTH	1837	0.133	0.339	C
Public	1837	0.107	0.310	C
For-Profit	1837	0.175	0.380	C
MSA Herfindahl	1837	0.062	0.060	C
Year 1993	1837	0.212	0.409	A
Year 1994	1837	0.209	0.407	A
Year 1995	1837	0.167	0.373	A
Year 1996	1837	0.193	0.395	A
HMO	1837	0.310	0.091	B
HMO square	1837	0.104	0.060	B
PPO	1837	0.270	0.074	B
PPO square	1837	0.078	0.041	B
HMOxPPO	1837	0.085	0.034	B

A. AHCPR, HCUP Nationwide Inpatient Sample.
B. MedStat, MarketScan Survey.
C. AHA, Annual Survey of Hospitals.
D. HCFA, Listing of DRG Weights.

Table 3: Regression Results

Coefficients Explaining Output, (β), standard errors underneath

Variables	All Cases (ln)		<1 DRG Cases (ln)		1<DRG<2 Cases (ln)		Over 2 DRG Cases (ln)	
Intercept	4.145	***	3.992	***	2.940	***	-0.122	
	0.133		0.161		0.132		0.239	
ln Pay and Benefits	0.031	*	0.028		0.012		0.031	
	0.019		0.020		0.017		0.025	
ln Other Expenses	-0.034	*	-0.031	*	-0.019		-0.022	
	0.018		0.017		0.018		0.022	
ln Total Beds	0.979	***	0.926	***	0.974	***	1.334	***
	0.012		0.014		0.015		0.022	

*Significant at the ten percent level, two tailed test.
**Significant at the five percent level, two tailed test.
***Significant at the one percent level, two tailed test.

and increase patient service (see Newhouse 1994). In terms of high tertiary cases (> 2 DRG), for-profits tend to be smaller than nonprofits so that scale economies may not be realized. The relative inefficiency of public hospitals may reflect, among other things, a higher level of bureaucracy or a more expensive clientele relative to nonprofits.

High concentration in the hospital market, indicated by a Herfindahl approaching one, is positively related to efficiency in all 4 regressions. This may indicate that scale economies exist in these markets.

Relative to 1992, efficiency is lower in every period. Inefficiency is also highest in 1996 in 3 of 4 regressions.

Now let us consider the variables related to our original hypothesis. In 3 of the 4 regressions, increased HMO and PPO insurance led to greater efficiency. The effect is especially strong in the over 1 DRG regression. This confirms the thesis that managed care insurance increases efficiency for most DRG cases. However, it also may indicate that managed care insurance firms are most concerned with increasing efficiency when

Table 4: Regression Results

Coefficients Explaining *Inefficiency*, (δ), standard errors underneath

Variables	All Cases (ln)	<1 DRG Cases (ln)	1<DRG<2 Cases (ln)	Over 2 DRG Cases (ln)
Intercept	-1.230 *	-3.124 ***	-0.510	-0.123
	0.633	0.892	0.413	0.711
Residents	-0.002 ***	-0.000	-0.005 ***	-0.006 ***
	0.001	0.001	0.000	0.001
COTH	-4.765 ***	-4.693 ***	-4.347 ***	-6.239 ***
	1.209	0.751	0.320	0.358
Public	1.881 ***	1.440 ***	2.904 ***	5.787 ***
	0.382	0.297	0.186	0.598
For-Profit	1.515 ***	2.028 ***	1.531 ***	1.606 ***
	0.296	0.385	0.151	0.256
MSA Herfindahl	-3.641 ***	-2.460 **	-5.871 ***	-17.746 ***
	1.099	1.093	1.116	2.077
Year 1993	0.159	0.094	0.151	1.335 ***
	0.112	0.120	0.133	0.236
Year 1994	0.719 ***	0.746 ***	0.889 ***	2.733 ***
	0.203	0.232	0.161	0.350
Year 1995	0.464 **	0.552 **	0.538 ***	2.915 ***
	0.187	0.232	0.196	0.299
Year 1996	0.830 ***	1.182 ***	0.414 **	3.802 ***
	0.250	0.382	0.209	0.454
HMO	-2.487 ***	2.171 *	-2.143 ***	-14.519 ***
	0.641	1.183	0.723	2.648
HMO square	-10.024 ***	-22.221 ***	-9.095 ***	-6.076 ***
	3.120	7.425	1.328	1.376
PPO	-1.548 *	3.894 **	-10.464 ***	-11.266 ***
	0.820	1.864	0.987	1.456
PPO square	-11.037 ***	-21.928 **	-5.462 ***	-4.756 ***
	3.793	9.512	0.992	1.002
HMOxPPO	4.924 **	12.747 *	-2.390 **	-7.344 ***
	2.412	6.759	0.978	1.042
σ^2	1.744 ***	2.099 ***	2.693 ***	5.271 ***
	0.348	0.368	0.212	0.511
γ	0.967 ***	0.963 ***	0.976 ***	0.969 ***
	0.007	0.007	0.002	0.004
Log-likelihood	-973.57	-1210.66	-1776.74	-1144.45

*Significant at the ten percent level, two tailed test.

**Significant at the five percent level, two tailed test.

***Significant at the one percent level, two tailed test.

Table 5: LR Truncated Error Test

Model:	Overall	Routine	Over 2 DRG	1 to 2 DRG
LR Test of U_{it}	524.391*	386.991*	670.29*	677.68*

*Significant at the one percent level, critical value at 16 *d.f.* is 31.353 (Kodde and Palm 1986).

scale economies exist. It is likely that scale economies exist most strongly in the over 2 DRG category where capital inputs are highest.

It appears that routine cases (<1 DRG) and managed care have a "U-shaped" relationship in terms of efficiency. If the proportion using managed care is low, hospitals are relatively inefficient in the production of routine services. Efficiency increases greatly at higher levels of managed care penetration.

In order to test the effects of joint HMO and PPO pressure, an interaction term is included. In the 2 tertiary regressions (1 to 2 and > 2 DRG), increased joint managed care penetration increases efficiency. In the overall regression as well as the routine regression (<1 DRG), increased joint penetration increases inefficiency, although the effects are not as strong as in the two tertiary cases.

5 Conclusion

By focusing exclusively on consumer benefit, previous studies of the effects of managed care may not have uncovered important hospital efficiency gains which may occur when managed care increases in a market. This study uses a 1992-1996 sample of hospitals from markets with various levels of managed care penetration in order to estimate a stochastic frontier model of technical efficiency. After controlling for hospital and market area variables, the study finds strong evidence that managed care insurance causes increases in hospital technical efficiency.

Technical efficiency has been overlooked in the managed care literature. Given efficient tax instruments are available, consumers can benefit indirectly if managed care firms increase their profits.

In addition to strong findings that managed care increases hospital technical efficiency, the study highlights a relative efficiency of nonprofit hospitals. In comparison to for-profits, this is not surprising. For-profits may trade-off efficiency, in terms of output, for less congestion and possibly higher quality.

The effect of managed care on tertiary cases is stronger than in routine cases.

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APPENDIX

Table A-1: Cities included

Allentown et al, PA	Omaha, NE-IA
Baltimore, MD	Orange County, CA
Bergen et al, NJ	Orlando, FL
Boston, MA-NH	Philadelphia, PA-NJ
Buffalo et al, NY	Phoenix et al, AZ
Chicago, IL	Pittsburgh, PA
Denver, CO	Portland et al, OR-WA
Des Moines, IA	Providence et al, RI-MA
Fort Lauderdale, FL	Reading, PA
Fresno, CA	Riverside et al, CA
Harrisburg et al, PA	Rochester, NY
Hartford, CT	Sacramento, CA
Jacksonville, FL	St. Louis, MO-IL
Kansas City, MO-KS	San Diego, CA
Lakeland et al, FL	San Francisco, CA
Lancaster, PA	San Jose, CA
Las Vegas, NV-AZ	Sarasota et al, FL
Los Angeles et al, CA	Scranton et al, PA
Miami, FL	Seattle et al, WA
Milwaukee et al, WI	Spokane, WA
Minneapolis et al, MN-WI	Springfield, MA
Monmouth et al, NJ	Syracuse, NY
Nassau et al, NY	Tacoma, WA
New Haven et al, CT	Tampa et al, FL
New York, NY	Tucson, AZ
Newark, NJ	Washington, DC-MD-VA-WV
Oakland, CA	West Plm Beach et al, FL

Table A-2: States included in *HCUP*

Arizona
California
Colorado
Connecticut*
Florida
Illinois
Iowa
Kansas*
Maryland*
Massachusetts
New Jersey
New York*
Oregon*
Pennsylvania
South Carolina*
Washington
Wisconsin
*No *HCUP* data for 1990 or 1992.

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