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Abstract

Current debates in the insurance and public policy literatures over health care financing and cost control measures continue to focus on managed care and HMOs. The lower utilization rates found in HMOs (compared to traditional fee-for-service indemnity plans) have generally been attributed to the organization's incentive to eliminate all unnecessary medical services. As a consequence HMOs are often considered to be a more efficient arrangement for delivering health care. However, it is important to make a distinction between utilization and efficiency (the ratio of outcomes to resources). Few studies have investigated the effect that HMO arrangements would have on the actual efficiency of health care delivery. Because greater control over provider autonomy appears to be a recurrent theme in the literature on reform, it is important to investigate the effects these restrictions have already had within the HMO market. In this article, the efficiencies of two major classes of HMO arrangements are compared using "game-theoretic" data envelopment analysis (DEA) models. While other studies confirm that absolute costs to insurance firms and sponsoring companies are lowered using HMOs, our empirical findings suggest that, within this framework, efficiency generally becomes worse when provider autonomy is restricted. This should give new fuel to the insurance companies providing fee-for-service (FFS) indemnification plans in their marketplace contentions.

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INTRODUCTION

Approximately three decades have passed since Robert Finch, then Secretary of Health, Education and Welfare, launched the U.S. Government's Health Maintenance Organization (HMO) strategy to combat what was perceived to be a financial crisis in health care. The HMO Act of 1973 gave HMOs several strategic advantages over traditional indemnity health insurance providers and was justified on the grounds that there were public policy benefits associated with the "more cost efficient" HMOs. The subsequent escalation in health care expenditures from 7.4 percent of U.S. GDP in 1970 to 12.4 percent in 1990 has only intensified public concern and turned health care financing into one of the most pressing problems facing U.S. domestic policy-makers. It has also provided impetus for the significantly increased market share of HMOs in the health insurance/health care financing marketplace.

Because the HMO is both the contractor and the medical provider, it directly bears financial risk like the traditional indemnity insurer; however, unlike the indemnity insurer, the HMO also has the opportunity and incentive to control costs by eliminating unnecessary utilization. This arrangement has produced the desired effect. Luft's 1981 review of earlier studies showed that HMO enrollees had lower total costs (premium and out-of-pocket expenses) than enrollees in the familiar Blue Cross Blue Shield plan. Miller and Luft (1997, 2002) showed that, overall, HMOs appeared to use fewer resources. Moreover, Luft (1981) presented a variety of evidence to suggest that hospital utilization—the most cost intensive aspect of medical care—was lower in HMOs than in comparable indemnity (fee-for-service or FFS) plans. This finding has been confirmed by other studies, e.g., Hornbrook and Berki (1985), Langwell et al. (1987), and Miller and Luft (2002). As health care costs now account for approximately 26 percent of the typical firm's payroll, more corporations are turning toward HMOs and away from traditional insurance. However, there have been some rumblings of discontent.

Lower utilization and its concomitant reduction in overall expenditures are generally attributed to the HMOs incentive to eliminate all unnecessary medical services. Previously, this potential for streamlining has been regarded as indicating that the HMO is a more efficient arrangement for delivering health care. It is important, however, to point out the distinction between studies of utilization and our current study of efficiency; utilization refers to the frequency with which services are used, whereas efficiency refers to the outputs produced for given levels of resources consumed. Although both play important roles when evaluating the performance of health care delivery systems, low utilization (or even low costs) is not synonymous with efficiency. Efficiency is only improved if unnecessary utilization is eliminated together with an appropriate reduction in expenditures.

To rigorously determine the health care delivery and financing system which appears to be most efficient overall, strict attention must be paid to quantifying the multiple inputs consumed for the multiple outputs produced. As noted by Saward and Greenlick (1981, p. 27) "counting the pieces of the [medical care] process" fails to produce a coherent measure of system performance. Data Envelopment Analysis (DEA), an efficiency measurement tool introduced by Charnes, Cooper, and Rhodes (1978), is one of the appropriate approaches for this situation. In the recent literature, Rosenman Siddharthan, and Ahern (1997) used DEA to measure the relative technical efficiencies of 28 HMOs licensed to practice in the state of Florida in the autumn of 1994. Bryce, Engberg, and Wholey (2000) used a nationwide sample of 585 HMOs to compare the effectiveness of DEA, stochastic production frontiers (SFR), and fixed-effects regression (FER) in evaluating HMO efficiency.

In this article, the authors contrast two arrangements within the HMO health insurance framework: the tightly controlled, highly centralized Staff/Group HMO arrangement; and the loosely controlled, highly autonomous Independent Practice Association (IPA) arrangement. Our situation is additionally complicated by the need to compare and contrast two different systems while incorporating the above multiplicities. The model used in the present study overcomes these difficulties by combining features of two well-established methodologies: Data Envelopment Analysis (DEA), and two-person zero-sum games, a theory for analyzing behavior between rational competing economic agents as introduced by von Neumann (1928) and later refined in von Neumann and Morgenstern (1944) (for a recent reference, see Fudenberg and Tirole, 2000). Because organizations in DEA are evaluated against one another to determine their relative efficiencies, it is both natural and appropriate to adopt a model that formally reflects this competitive element (see also Banker, 1980; Banker et al., 1989).

From the origins of Staff/Group HMO arrangement and the IPA arrangement, we would expect that IPAs are a more efficient delivery system than the Staff/Group arrangements. IPA physicians typically come from private practice and thus are matured in an environment that encouraged patient–doctor contact. These physicians still have greater discretion over the provision of care and thus may elect to see patients they might otherwise be discouraged from seeing in a more regulated, obtrusive, cost conscious system. These two systems are compared to determine which, if any, in the aggregate exhibits greater overall efficiency.

BACKGROUND

The U.S. Government initiated its Health Maintenance Organization (HMO) strategy in the early 1970s under the belief that the efficiency of health care delivery would be improved through competition. The national goal was to have 1,700 competing HMOs by 1977 and to cover 90 percent of Americans by 1980 (U.S. Department of Health, Education and Welfare, 1971). Although this goal was never reached, the emergence of HMOs as a market force has dramatically impacted the health care sector and changed the character of the health insurance marketplace. The HMO has gone from virtually no market share in 1970 to a current share of 31.7 percent in 2001 (HMO-PPO/Medicare-Medicaid Digest, 2002).

Health care plans can be classified into two broad categories: managed care and nonmanaged care. The managed care category includes various models of HMOs, Preferred Provider Organizations (PPOs) and their variants, and managed indemnity plans (MIP). The nonmanaged category is synonymous with fee-for-service (FFS) indemnity insurance plans. Although plans under the managed care category differ widely in organization, financial risk, accessibility, enrollment, and care provision, the common feature is that some form of utilization review is adopted to control the costs of the provider's practice (Weiner and Lissovoy, 1993).

Types of HMO Arrangements

While consensus on the definition of *managed care* is elusive,[1] the Health Maintenance Organization Act of 1973 defines an HMO (in part) as an organization that provides basic health services for a fixed periodic payment under a community rating system.[2] There are, however, several important characteristics (cf., Luft, 1981, p. 2) which differentiate HMOs from more traditional health insurance systems:

- The HMO assumes a contractual responsibility to provide or ensure the delivery of a stated range of health services. This includes at least ambulatory care and inpatient hospital services.
- The consumer makes a fixed annual or monthly payment that is independent of the use of services. (This does not exclude the possibility for some minor additional charges related to utilization.)
- The HMO assumes at least part of the financial risk or gain in the provision of services.

The most commonly referenced taxonomy for HMOs consists of the following four basic arrangements: a *Staff* model; a *Group* model; a *Network* model; and an *Independent Practice Association* (IPA) model.

The Staff and Group models are the most restrictive since physician behavior is closely monitored and health care delivery is highly centralized.[3] In contrast, the IPA model affords the provider a higher degree of autonomy since physician behavior is only loosely controlled. It is thus considered a more decentralized health care delivery system because physicians remain primarily in independent practice. In 2001, over 90 million people were enrolled in 542 HMOs, with IPAs accounting for 65 percent and Staff/Group models accounting for 13 percent (HMO-PPO/Medicare-Medicaid Digest, 2002).

DEA Model Development

To begin with, a general description of Data Envelopment Analysis (DEA) is followed by a more detailed description of the specific model that will be proposed for contrasting Staff/Group and IPA HMOs.

Data Envelopment Analysis (DEA)

Data Envelopment Analysis (Charnes, Cooper, and Rhodes, 1978) is a multi-input, multi-output efficiency measurement technique that generalizes the classical single input, single output approach used in engineering. Given are n "decision-making

[1] For example, the Health Insurance Association of America (HIAA) no longer considers managed indemnity plans as managed care. The requirement for a plan to be considered as managed care is its obligation to arrange care provision.

[2] The 1988 Amendments to the HMO Act changed "community rating" to "adjusted community rating" which is a prospective experience rating.

[3] Indeed, many studies combine these two groups into a single category (Group/Staff or Staff/Group).

units" (DMUs), where each unit j ($j \in \{1, 2, \ldots, n\}$) has m observed inputs whose levels are denoted by the vector $x_j^T = (x_{j1}, x_{j2}, \ldots, x_{jm})$ and s observed outputs whose levels are denoted by the vector $y_j^T = (y_{j1}, y_{j2}, \ldots, y_{js})$. DMUs are assumed to be *homogenous* in the sense that each consumes a similar set of inputs to produce a similar set of outputs. Each unit's observed input–output levels are then "tested" against those exhibited in the entire sample. When constant-returns-to-scale are assumed, this test is conducted by solving the fractional mathematical program

$$\begin{aligned} &\operatorname*{Max}_{u,v} \frac{y_0^T v}{x_0^T u} \\ &\text{s.t.} \quad \frac{y_j^T v}{x_j^T u} \leq 1 \quad j = 1, 2, \ldots, n \\ &u, v > 0. \end{aligned} \tag{1}$$

Here, the subscript "0" is used to denote any one of the n DMUs (the "test" unit) whose efficiency is being examined and $u, v > 0$ are vectors ($u^T = (u_1, u_2, \ldots, u_m)$ $v^T = (v_1, v_2, \ldots, v_s)$) of input and output weights to be determined by the optimization in Equation (1). In practice, the condition $u, v > 0$ is typically relaxed to $u, v \geq 0$ for computational simplicity; where absolutely necessary, strict positivity can be achieved using algorithms based on implicit infinitesimals (Charnes, Rousseau, and Semple, 1993).

In other words, the DMU being tested in Equation (1) seeks to maximize its ratio of weighted output to weighted input, subject to the conditions that no DMU (including the test unit) attains a ratio >1 for the same set of weights (u, $v \geq 0$). As stated in Charnes, Cooper, and Rhodes (1978, p. 430), this "maximization then accords the most favorable weighting that the constraints allow" to the test unit. Units that achieve an optimal ratio of 1 are termed *ratio efficient*; those with optimal ratios <1 are *ratio inefficient*. It is important to note that each unit's evaluation involves a separate optimization, and therefore distinct weights are computed for each unit.

Game-Theoretic DEA

When DMUs can additionally be categorized into one or more groups (e.g., IPA vs. Staff/Group), it has been customary to pool the units together for the purpose of performing a joint DEA analysis (see, e.g., Charnes, Cooper, and Rhodes, 1981; Grosskopf and Valdmanis, 1987). This poses significant difficulties for any study attempting to compare the performances of distinct groups. First, pooling means that each unit is compared against members of its own group in addition to members of other groups. Consequently, a characterization of "inefficient" may result from "within group" effects instead of the desired "between group" effects. This situation can be repaired by comparing the test unit exclusively against members outside its own group. In the current study, this means that when the test unit is an IPA organization, it will be compared exclusively against Staff/Group organizations. Similarly, when the test unit is a Staff/Group organization, it will be tested exclusively against IPA organizations. This element of competition is evident in the following mathematical program: for each DMU $k \in G$, solve

$$
\begin{aligned}
&\max_{u,v} \frac{y_k^T v}{x_k^T u} \\
&\text{s.t.} \quad \frac{y_j^T v}{x_j^T u} \leq 1 \quad j \in G^C \\
&u, v \geq 0,
\end{aligned}
\tag{2}
$$

where G and G^C (the complement of G) are disjoint index sets describing the competing groups. This formulation can additionally be shown to solve a two-person, zero-sum "ratio" game (Rousseau and Semple, 1995), thus Equation (2) is reffered to as a *game theoretic* DEA model.[4] Note that the input–output data for DMU_k do not appear in the constraints of Equation (2). Consequently, the efficiency score for DMU_k can exceed 1. Values ≥ 1 indicate the test unit is *ratio efficient with respect to the competing group,* while values < 1 indicate it is *ratio inefficient with respect to the competing group.*

DEA Efficiency Perspectives

In general, different parties to an efficiency analysis have different perspectives of what constitutes the best performance (i.e., different goals). Moreover, trying to accommodate different perspectives in a single model can make it impossible to determine whether an item should be an input or an output. Therefore, an efficiency evaluation begins by selecting a perspective. Since the purpose of this article is to examine public policy issues in the health insurance arena, two separate perspectives are investigated, that of consumers and that of society.

Inputs and Outputs

All input and output dimensions selected for a policy level DEA analysis should satisfy the property that each output-to-input ratio is a meaningful indicator of some aspect of efficiency (see Cooper, Seiford, and Tone, 1999). The inputs and outputs selected for our perspectives meet this standard and are outlined below.

Consumers' Perspective

Consumers are the beneficiaries and purchasers of health care plans and are concerned with services received and expenses incurred. Accordingly, from the perspective of consumers, the only relevant input is out-of-pocket expense. Relevant outputs include at least outpatient and inpatient services received. The specific measures selected are detailed in the following.

Out-of-pocket expense for an HMO enrollee consists of both premiums and co-payments; however, data on co-payments are not available in most instances.[5] In our analysis, we took total premiums as the sole input.

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[4] Cummins, Weiss, and Zi (1999) use this method to analyze the efficiency of the stock and mutual property-liability insurers.

[5] Additionally, co-payments are made directly to physicians or other health care providers, and hence most organizations keep no record of them. It is not mandatory for HMOs to report co-payment information to their regulators. Co-payments for outpatient visits, normally charged at US$5 or US$10 per visit, represent a minute portion of the consumers' out-of-pocket expenses. No co-payments are made for inpatient services.

Ambulatory encounters are defined as the total number of outpatient visits made by the membership of an HMO. This number is a summary measure for all outpatient services received and becomes our first output. Visits include all patient contacts with physicians, physician's assistants and other medical personnel. Inpatient services are measured using the number of hospital days (i.e., total number of patient days for which enrollees are hospitalized). This becomes our second output.

Societal Perspective

From a societal perspective, what the policy-makers care about is the total resources consumed, the aggregate cost incurred by the consumers and the HMOs considered as a whole. However, in HMOs, as in other types of insurance, premiums are significantly determined by expected expenses, which are highly correlated with the actual expenses experienced. This is verified in our samples, where the total premiums and the total expenses are almost the same. Therefore, either the total premiums or the total expenses might be appropriate as an input from the societal perspective; however, as profits (a part of premiums) are dispersed back into the economy (society),[6] and as companies can occasionally (intentionally or inadvertently) misprice their health care insurance products, premiums are arguably less indicative of the costs to society than are HMO expenses incurred. Accordingly, in the present analyses, the total HMO expenses are used as the sole input.[7]

Ambulatory and inpatient services improve the health status of the population and hence are employed as our first and second outputs respectively. In addition, expanding health care coverage to a larger proportion of the population is a societal benefit, thus total enrollment is taken as a third output in the societal model.[8] Enrollees in HMOs include group subscribers, Medicare and Medicaid beneficiaries, and individual subscribers. Enrollment is measured here as the total member-months (TMM) during 1995.

DATA AND SAMPLE SELECTION

The data used in this study came from the 1995 Series of HCIA's HMO Database. The database includes financial, enrollment, and utilization figures as well as general company information. Items were gathered at the company level from information that HMOs supply annually to their state regulators. In 1995, the data included 538 HMOs from 46 states. For the purposes of this study, there were 36 Staff, 41 Group, and 344 IPA HMOs.[9] These HMOs ranged in size from a few hundred members to over 10 million members. Some HMOs failed to report one or more of the inputs or outputs selected in the previous section and were deleted. All the remaining HMOs

[6] Another potential component of total resources consumed, tax subsities, will also be redistributed to society and hence are not included (being a redistribution rather than a cost at the agregrate societial level).

[7] We have also run the model with both premiums and expenses included as inputs (co-linearity is not a problem with DEA) and the same three outputs described. The results are essentially the same and are not reported.

[8] In fact universal coverage was the main objective of President Clinton's nationalized health care plan and was the rallying point for proponents.

[9] The 117 remaining organizations were Network HMOs.

TABLE 1
Sample Statistics (Noncost-Adjusted)

	Member Months	Ambulatory Encounters	Hospital Days	Total Premium	Total Expenses
IPA HMOs					
Sample mean ($\bar{x}$)	1748500	5.89	0.33	$1628.64	$1555.09
Sample SD (s)	1922743	8.99	0.15	$309.18	$299.68
Staff/Group HMOs					
Sample mean ($\bar{x}$)	1700656	6.23	0.34	$1937.62	$1884.92
Sample SD (s)	1562806	3.83	0.17	$915.83	$883.05

were then studied to ensure that the HMOs in our sample were financially viable and HMOs whose total premiums do not meet or exceed (to the nearest 1 percent) their expenditures were deleted.

For the population outlined above, the database provided observations on 19 Staff/Group HMO and 85 IPA plans. Although the Staff/Group sample, as well as the IPA subsamples which include 19 IPAs randomly selected from the 85 IPAs, would be too small for most statistical tests based on normality, it is quite adequate for the nonparametric methods[10] employed in this article.

We adjusted all payments (premium dollars, total expenses) for regional cost differences among HMOs by a "cost differential" index. This index is constructed as a population weighted combination of city and county level hospice[11] wage indices used by Medicare for Hospice care.[12] This care represents a basket of like services—including ambulatory care and hospital care—adjusted to reflect different regional costs. The counties in which each HMO operates are reported in our database so we are able to construct a unique regional cost index for each HMO. The cost differential indices for all the HMOs in our sample and the raw data are given in the Appendix.

The summary statistics for the sample are given in Table 1 (noncost-adjusted) and Table 2 (cost-adjusted) below. Premiums, ambulatory visits, hospital days, *total expenses* were all calculated on a per member per year basis.

RESULTS AND IMPLICATIONS

The 85 IPA observations are temporarily pooled with the 19 Staff/Group HMOs for the purpose of scaling. Each input and output is divided by its average in the

[10] Indeed, small sample sizes and departures from normality are the primary reasons for using nonparametric techniques (see, e.g., p. 35 of Sigel and Castellan, 1988).

[11] Hospice is a special way of caring for people who are terminally ill, and for their family. This care includes physical care and counseling. Hospice care is covered under Medicare Part A (Hospital Insurance).

[12] The hospice wage indices are from HCFA Medicare payment systems: http://www.hcfa.gov/medicare/hospiceps.htm (based on 1996 hospital cost report data). And the population data are from U.S. Census Bureau county population estimates http://eire.census.gov/popest/archives/county/co_99_8.php (1996).

TABLE 2
Sample Statistics (Cost-Adjusted)

	Member Months	Ambulatory Encounters	Hospital Days	Total Premium	Total Expenses
IPA HMOs					
Sample mean ($\bar{x}$)	1748500	5.89	0.33	$1471.17	$1404.36
Sample SD (s)	1922743	8.99	0.15	$306.85	$292.60
Staff/Group HMOs					
Sample mean ($\bar{x}$)	1700656	6.23	0.34	$1830.61	$1780.17
Sample SD (s)	1562806	3.83	0.17	$792.41	$762.36

108 unit pooled sample. This scaling is necessary to ensure that the results are units invariant.

Equal sample sizes for the IPA vs. G/S DEA comparison in this article were used. Smaller samples intensify the upward bias on DEA scores, and when using grouped data, equal sample sizes should be used to ensure equal bias. Because the IPA sample is much larger, it was randomly sampled with replacement 19 IPAs to run against the 19 G/S units. The process was repeated a total of 20 times to check the robustness of results to different IPA samples, so 20 different IPA samples (each of size 19) were run against the 19 (fixed) G/S HMOs.

Both the regular "collective frontier" DEA model, where all units (IPA and G/S units) are included in the reference set, and the cross-frontier DEA model, where the units of one group are run exclusively against the efficient frontier of the alternative group, were run. The results are presented below. Analysis to detect efficiency differences between two groups was performed by the rank statistical method outlined in Brockett and Golany (1996).[13]

For both the consumers' and societal perspectives, the null hypothesis is: IPA HMOs and G/S HMOs are equally efficient. For each run, we rank the efficiency scores of the 38 HMOs, compute the rank sum for the IPAs and G/Ss, respectively, and the corresponding p-values of Mann–Whitney tests. We reject the null hypothesis if the p-value is <1 percent.

Societal Perspective

Recall that the input is total expenses, and the three outputs are total member months, ambulatory encounters, and hospital days. As before, the input and outputs are scaled by their respective (pooled sample) averages prior to implementing Equation (2). The results are given in Tables 3 and 4 below.

[13] Cummins, Rubio-Misas, and Zi (2002) measured the difference between the stock and mutual frontiers for each operating point to determine which technology is dominant. Our measure combines both technical dominance and efficiency, and uses a rank statistical test to enhance robustness and because of the intrinsically nonmetric nature of efficiency scores.

TABLE 3
Tests of the Null Hypothesis of Equal Efficiency Between IPA and G/S HMOs: Societal Perspective, Collective Frontier Method

Run No.	IPA Rank Sum	G/S Rank Sum	p-Value
1	329	412	0.11284
2	324	417	0.08730
3	307	434	0.03188
4	308	433	0.03403
5	298	443	0.01715
6	315	426	0.05258
7	342	399	0.20269
8	295	446	0.01375
9	283	458	0.00532
10	304	437	0.02610
11	301	440	0.02123
12	293	448	0.01183
13	318	423	0.06267
14	295	446	0.01375
15	290	451	0.00938
16	303	438	0.02438
17	323	418	0.08276
18	310	431	0.03867
19	301	440	0.02123
20	293	448	0.01183

Note: Mann–Whitney test is used to test the hypotheses. The alternative hypothesis is: the IPA (Independent Practice Association) HMOs are more efficient than the G/S (Group/Staff) HMOs. The significance level is 1 percent.

For the collective frontier DEA model, the Mann–Whitney Rank test ($n_{IPA} = 19$, $n_{G/S} = 19$) for "equally efficient" *versus* the one-sided alternative "the IPA HMOs are more efficient than the G/S HMOs" supported the alternative hypothesis for 18 of the 20 runs at the 10 percent or less significance levels. Only two of the runs did not support the alternative hypothesis at these significance levels. The p-values of these two runs are 0.20269 and 0.11284, respectively. These empirical findings suggest that from a societal perspective the decentralized IPAs are relatively more efficient, in an overall sense, than the more regulated Staff/Group arrangements.

More dramatic results were obtained using the cross-frontier DEA model. The Mann–Whitney Rank Test ($n_{IPA} = 19$, $n_{G/S} = 19$) for "equally efficient" *versus* the one-sided alternative "the IPA HMOs are more efficient than the G/S HMOs" supported the alternative hypothesis for all the 20 runs at the 5 percent or less significance levels. And 19 of them had p-values <1 percent.

Consumers' Perspective

In the consumer model, the input is the total premium, and the outputs are ambulatory encounters and hospital days. In the societal model, it is found that IPAs

TABLE 4
Tests of the Null Hypothesis of Equal Efficiency Between IPA and G/S HMOs: Societal Perspective, Cross-Frontier Method

Run No.	IPA Rank Sum	G/S Rank Sum	*p*-Value
1	252	489	0.000271
2	286	455	0.006813
3	259	482	0.000567
4	263	478	0.000849
5	214	527	0.000002
6	252	489	0.000271
7	311	430	0.041186
8	242	499	0.000088
9	236	505	0.000043
10	241	500	0.000078
11	220	521	0.000006
12	217	524	0.000004
13	238	503	0.000055
14	224	517	0.000009
15	202	539	0.000000
16	222	519	0.000007
17	250	491	0.000217
18	259	482	0.000567
19	244	497	0.000111
20	222	519	0.000007

Note: Mann–Whitney test is used to test the hypotheses. The alternative hypothesis is: the IPA (Independent Practice Association) HMOs are more efficient than the G/S (Group/Staff) HMOs. The significance level is 1 percent.

are more efficient than G/Ss. In this section, it is first checked to see if this conclusion remains true for the consumer model. The alternative hypothesis of the test is that IPAs are more efficient than G/Ss, and test results of the consumer model using both the collective frontier and cross-frontier methods are presented in Tables 5 and 6.

For the collective frontier DEA model, the Mann–Whitney Rank Test ($n_{IPA} = 19$, $n_{G/S} = 19$) for "equally efficient" *versus* the one-sided alternative "the IPA HMOs are more efficient than the G/S HMOs" did not support the alternative hypothesis for 16 of the 20 runs at the 10 percent or less significance levels. But four of the runs supported this alternative hypothesis at 10 percent significance levels. The *p*-values of these four runs were 0.074209, 0.078396, 0.082759, and 0.092030, respectively.

For the cross-frontier DEA model, the Mann–Whitney Rank Test ($n_{IPA} = 19$, $n_{G/S} = 19$) for "equally efficient" *versus* the one-sided alternative "the IPA HMOs are more efficient than the G/S HMOs" did not support the alternative hypothesis for 18 of the 20 runs at the 10 percent or less significance levels. Only two runs supported the

TABLE 5
Tests of the Null Hypothesis of Equal Efficiency Between IPA and G/S HMOs: Consumers' Perspective, Collective Frontier Method

Run No.	IPA Rank Sum	G/S Rank Sum	p-Value (1)	p-Value (2)
1	325	416	0.092030	0.907970
2	338	403	0.171354	0.828646
3	340	401	0.186615	0.813385
4	346	395	0.237221	0.762779
5	364	377	0.424746	0.575254
6	331	410	0.124416	0.875584
7	341	400	0.194552	0.805448
8	349	392	0.265104	0.734896
9	352	389	0.294563	0.705437
10	323	418	0.082759	0.917241
11	370	371	0.494177	0.505823
12	348	393	0.255628	0.744372
13	358	383	0.357580	0.642420
14	331	410	0.124416	0.875584
15	321	420	0.074209	0.925791
16	369	372	0.482535	0.517465
17	351	390	0.284577	0.715423
18	322	419	0.078396	0.921604
19	346	395	0.237221	0.762779
20	334	407	0.143300	0.856700

Note: Mann–Whitney test is used to test the hypotheses. p-value (1) corresponds to the alternative hypothesis: IPA (Independent Practice Association) HMOs are more efficient than the G/S (Group/Staff) HMOs, while p-value (2) corresponds to the alternative hypothesis: the G/S HMOs are more efficient than the IPA HMOs. The significance level is 1 percent.

alternative hypothesis. And the p-values for these two runs are 0.001141 and 0.082759, respectively (note that one would expect two significant results at the 10 percent level of significance in twenty repetitions).

These results alone cannot tell us whether the converse is true, i.e., whether the IPAs are significantly more efficient than the G/Ss or not. We need to conduct another test with the alternative hypothesis that G/Ss are more efficient than IPAs to do this. However, due to the symmetry of the Mann–Whitney test statistic, the p-values for this alternative hypothesis can be derived from the p-values for the previous alternative hypothesis by taking 1 minus the previous p-value. The final column in Tables 5 and 6 show this result.

For the collective frontier DEA model, the Mann–Whitney Rank Test ($n_{IPA} = 19, n_{G/S} = 19$) for "equally efficient" *versus* the one-sided alternative "the G/S HMOs are more efficient than the IPA HMOs" did not support the alternative hypothesis for all the 20 runs at the 10 percent or less significance levels. Actually, the p-values are all over 0.5. These empirical findings suggest that the G/Ss are not more efficient than the

TABLE 6
Tests of the Null Hypothesis of Equal Efficiency Between IPA and G/S HMOs: Consumers' Perspective, Cross-Frontier Method

Run No.	IPA Rank Sum	G/S Rank Sum	*p*-Value (1)	*p*-Value (2)
1	452	289	0.991329	0.008671
2	464	277	0.996830	0.003170
3	437	304	0.973898	0.026102
4	453	288	0.991992	0.008008
5	350	391	0.274756	0.725244
6	353	388	0.304708	0.695292
7	476	265	0.998965	0.001035
8	463	278	0.996538	0.003462
9	389	352	0.705437	0.294563
10	361	380	0.390756	0.609244
11	388	353	0.695292	0.304708
12	331	410	0.124416	0.875584
13	399	342	0.797310	0.202690
14	394	347	0.753668	0.246332
15	266	475	0.001141	0.998859
16	323	418	0.082759	0.917241
17	410	331	0.875584	0.124416
18	394	347	0.753668	0.246332
19	430	311	0.958814	0.041186
20	405	336	0.843085	0.156915

Note: Mann–Whitney test is used to test the hypotheses. *p*-value (1) corresponds to the alternative hypothesis: IPA (Independent Practice Association) HMOs are more efficient than the G/S (Group/Staff) HMOs, while *p*-value (2) corresponds to the alternative hypothesis: the G/S HMOs are more efficient than the IPA HMOs. The significance level is 1 percent.

IPAs. Combined with the corresponding results from the previous test that IPAs are more efficient than G/Ss, we can say that the IPAs are still a little more efficient than G/Ss using the collective frontier DEA model from the consumers' perspective, even though it had only two significant runs.

For the cross-frontier DEA model, the Mann–Whitney Rank Test ($n_{IPA} = 19, n_{G/S} = 19$) for "equally efficient" *versus* the one-sided alternative "the G/S HMOs are more efficient than the IPA HMOs" supported the alternative hypothesis for 7 of the 20 runs at the 10 percent or less significance levels. The *p*-values of these seven runs were 0.001035, 0.003170, 0.003462, 0.008008, 0.008671, 0.026102, and 0.041186. Compared with the corresponding results (only 2 runs were significant) from the test that IPAs are more efficient than G/Ss, this result suggests that the G/Ss are more efficient than the IPAs.

These results for the cross-frontier model different from the results found for the societal models, where the IPAs are shown to be more efficient than G/Ss. The reason for this disparity seems to be because of the inclusion of a single G/S unit from Iowa that is truly "superefficient."[14] No other G/S unit comes close, but this single unit can dominate any sample of IPAs and dictates the results in cross-frontier analysis. Moreover, while a few IPAs are most likely overachievers, the fact that we subsampled the IPAs mitigates the effects of a few IPA overachievers (not in all of our random samples); however, we do not subsample the G/S units so the one dominant G/S unit prevails. Rerunning the analysis with this unit removed yields the result that the IPAs dominate the G/Ss from both the consumer and the societal perspectives. In addition, the entire analysis was also run using 1992 data, and the results with the 1992 data also are also consistent with the IPA units being more efficient than the G/S units.

CONCLUDING REMARKS

The current study applied a new game-theoretic DEA model to evaluate the relative overall efficiencies of two principle HMO categories, viz., the less autonomous Staff/Group arrangement and the more autonomous IPA arrangement. The models used here focus on intergroup comparisons of efficiency. Since one's view of what constitutes best performance is conditioned on one's perspective, it is necessary to address the question from two perspectives: that of consumers and that of society.

From a societal perspective, the results from both the collective and cross-frontier models suggest that the IPAs are more efficient than the G/Ss. This does not seem surprising given the origins of these plans. IPA physicians typically come from private practice and thus matured in an environment that encouraged patient–doctor contact. These physicians still have greater discretion over the provision of care and thus may elect to see patients they might otherwise be discouraged from seeing in a more regulated, obtrusive, cost-conscious system.

From the consumers' perspective, the results from the collective frontier model also suggest that the IPAs are a more efficient delivery system than Group/Staff arrangements. But the results from the cross-frontier model suggest the opposite. However, closer examination of the data indicates that the result of a single G/S unit from Iowa whose data indicates that it is "superefficient." No other G/S unit comes close to performance of this unit, and in cross-frontier analysis this unit outperforms all the IPAs. Reanalyzing using the 1992 data, and analysis with this single G/S unit removed does not show this anomaly.

The results of the study should be viewed as a preamble to the debate concerning the actual efficiency of HMOs *versus* traditional insurers since it distinguishes between "efficiency" and "utilization," and focuses the analysis on efficiency. Our initial findings suggest that provider autonomy played a significant role in securing greater efficiency within the HMO sector in 1995. This conclusion is especially evident from a societal public-policy perspective and therefore should be of immediate interest to those designing new health care delivery systems in the future.

[14] We wonder if the data for this one unit is actually correct (we have serious doubts). This problem does not occur with the 1992 data set.

APPENDIX

Regional Cost Indices and Raw Data

Regional Cost Index	Type	Total Premiums	Total Expenses	Member Months	Ambulatory Encounters	Hospital Days
1.0753	GRP	542224342	520493660	3695207	1698474	81386
1.2825	GRP	80997607	80878189	543591	227473	12918
1.1360	GRP	564582438	546503171	1220684	585501	22824
1.0326	GRP	295386651	266538066	2170309	932380	34847
1.0676	GRP	166461910	161068028	1185929	519418	22410
0.9264	GRP	43047386	40393487	315960	197766	15706
0.8770	GRP	45517996	44171589	304932	509048	21943
0.9932	GRP	69806175	69423166	551341	218736	9885
1.1456	GRP	73031279	71952106	495513	148497	11314
1.1176	GRP	831198526	818563205	5715505	4269267	180466
1.2196	GRP	325881667	325439868	2065932	882942	82723
1.0281	GRP	362887460	363668832	2248381	924167	59320
1.0323	GRP	36890270	36342439	302184	51169	10756
1.1565	GRP	721268445	717922749	4618276	1969138	98866
0.9131	GRP	216185913	217258608	1851643	990175	50427
1.0744	STA	550172960	511079208	2644351	961780	109055
1.0799	STA	37208483	35159501	351540	114058	5497
0.9348	STA	272502581	266917542	1562497	600729	29859
0.9974	STA	58955058	58591315	468706	405540	11037
0.9921	IPA	82419459	76876777	646967	267934	10826
1.0084	IPA	36285155	36083289	332378	145261	3983
1.3325	IPA	820248609	782298708	6975097	2590169	161056
1.3598	IPA	138496629	138596252	1024274	494028	30536
1.3266	IPA	786976380	760630155	3657970	1250529	342386
1.2877	IPA	172874136	156635118	1560666	561845	26363
1.3245	IPA	85290738	85649238	850173	108506	12062
1.0996	IPA	159115910	158901307	1523343	469859	28482
1.0547	IPA	520310979	490260935	3645014	1362633	107614
1.0193	IPA	66407813	64635672	450215	202736	19281
1.2905	IPA	205168499	201847187	1641589	771229	37678
1.3109	IPA	279892583	259254837	2211590	432169	72335
1.2905	IPA	149690254	147665617	1096168	446198	22903
1.0300	IPA	809520412	780750982	5721186	2451984	157925
1.0797	IPA	209132099	191104397	799287	361033	54849
0.9824	IPA	62805423	59161702	527304	96035	15076
1.1434	IPA	33459506	30543590	265425	55899	4979
1.0376	IPA	204674721	189172150	1476886	628954	36354
0.9762	IPA	41174759	37838203	276013	111933	7179
0.8861	IPA	97053991	87141923	735801	395756	17292
0.9100	IPA	52640437	52339358	489797	225184	9517
0.9685	IPA	48396594	43967557	387995	177102	7654
1.0334	IPA	381591362	353472233	3463483	306789	69172
1.0490	IPA	329105938	297215235	2628712	1248639	64683
1.1091	IPA	522873542	515264758	4387837	2084223	121226

(continued)

APPENDIX
(Continued)

Regional Cost Index	Type	Total Premiums	Total Expenses	Member Months	Ambulatory Encounters	Hospital Days
1.2042	IPA	704244651	694649303	4581339	1799209	117196
1.2044	IPA	609242386	605831383	3777521	1426271	89131
1.1178	IPA	291819219	277656373	2354885	917980	66811
1.1166	IPA	94434978	87032442	658514	96468	22318
1.1040	IPA	238111707	236726746	1802707	528264	43983
0.9476	IPA	269602153	268657030	2187704	640703	40886
1.1103	IPA	166749980	163510877	1135159	846804	42858
0.9591	IPA	54563360	45982060	375027	132647	9891
0.9841	IPA	37108648	32649703	258666	111550	5409
0.9645	IPA	62754189	62137057	560336	3974822	12853
1.0246	IPA	30579543	30182727	289583	147527	5458
1.0660	IPA	46415874	46314213	316301	121963	3719
1.2013	IPA	171768565	150773557	1228105	654136	24208
1.2164	IPA	234525886	224023226	1251510	1300878	72657
1.2164	IPA	867034277	741948450	6134615	2779471	208217
1.2640	IPA	283115543	273370484	1914824	812371	56306
1.2668	IPA	233341677	234512561	1469007	593710	42623
1.2265	IPA	34448153	29975168	271777	78844	5156
1.2355	IPA	124572182	121783692	816057	210704	20839
0.9350	IPA	38357040	35603717	323257	251535	12149
1.5198	IPA	137075894	135114436	967204	1073847	26100
1.4437	IPA	139313348	135095894	1171843	602428	23592
0.9533	IPA	335025601	334955788	2831232	943365	87558
1.5357	IPA	1081232555	1060166883	7257103	2350076	222057
1.1244	IPA	37797371	34724144	278066	93510	7547
1.5254	IPA	841994204	687551699	6076018	2229833	178441
1.5082	IPA	75426103	70209576	604261	191967	14342
1.4887	IPA	48032972	45209143	334665	131991	7472
1.4667	IPA	59090089	58995348	410880	89255	9561
1.5469	IPA	82122908	74305616	479506	86932	22061
0.9552	IPA	198214069	183731197	1507870	545541	30265
0.9725	IPA	34733607	34214678	284386	121936	7701
1.0184	IPA	75602951	74717610	550701	247144	10745
1.0446	IPA	50433473	49494368	425759	60916	11034
0.9851	IPA	38396792	36791082	290637	89036	10301
1.0236	IPA	87591934	84794530	690411	428080	18360
1.1386	IPA	634315760	630567917	5640548	5623967	176902
1.1252	IPA	73419527	73053093	661898	364101	28057
1.1536	IPA	50792809	50904640	466847	125207	7092
0.8955	IPA	142615992	138953101	1222093	485752	28067
1.0984	IPA	1312067811	1282695758	8904087	4637545	378304
1.1891	IPA	1045082645	1010702012	6825434	2155896	320656
1.1241	IPA	114363354	111610565	848336	378617	26996

(continued)

Appendix
(Continued)

Regional Cost Index	Type	Total Premiums	Total Expenses	Member Months	Ambulatory Encounters	Hospital Days
1.0140	IPA	173171138	153411241	1464384	607888	32339
1.1891	IPA	207422231	208040780	1037876	252797	64216
1.1959	IPA	337437604	334428972	2615698	698614	85482
0.9410	IPA	122245729	114847179	1096512	423777	27642
0.8977	IPA	49698304	44539525	407803	213653	7378
0.9870	IPA	46941749	46819683	406787	27652	8915
0.9336	IPA	70771934	68785867	617510	601321	11257
0.9758	IPA	509443995	479990805	3506553	1145084	97127
0.9736	IPA	298641016	294558071	1423248	442367	54715
1.0226	IPA	259761776	247006540	1761341	598855	49490
1.0105	IPA	58718058	55678252	471598	152181	7933
0.9496	IPA	339937843	330304960	2582494	1559055	62591
1.0002	IPA	41340075	37807347	308445	98056	5336
0.9857	IPA	74644403	73107758	636859	276524	11211
1.1352	IPA	162607731	157896873	1490136	469637	24998
1.1900	IPA	72118272	71878276	440580	147829	14851
1.0222	IPA	160367923	160118263	1142840	847381	29784

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