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ALTERNATIVE COMPENSATION ARRANGEMENTS AND PRODUCTIVE EFFICIENCY IN PARTNERSHIPS: EVIDENCE FROM MEDICAL GROUP PRACTICE

Martin Gaynor

Mark Pauly

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ABSTRACT

Although the role of the services sector in the economy has grown increasingly large, and partnerships are a prevalent form of organization in this sector, relatively little is known about the behavior and performance of these firms. In this paper an attempt is made to fill that gap by developing and testing a model of the effect of alternative compensation arrangements on productive efficiency in medical group practices. The technique employed is two-stage production frontier estimation. This technique provides direct estimates of productive efficiency and allows for differences across agents in ability or responsiveness to financial incentives. In the frontier literature productive efficiency is assumed to be exogenously given. In this paper it is determined endogenously, thus a simple econometric technique correcting for this endogeneity in estimating the production frontier is employed. In addition, the measures of efficiency themselves can be made dependent variables for explicit econometric analysis of the determinants of efficiency.

Overall, the empirical results are consistent with theoretical work on internal theory of the firm, which predicts that productivity compensation schemes will work well for firms with non-joint production and observable output. These two criteria are met by medical group practices. The treatment of measured efficiency as an endogenous variable is unique and allows some interesting insights into the determinants of productive efficiency. We find that relating compensation to productivity does increase the quantity and efficiency of production, as theory has hypothesized. The number of members in a group decreases both the quantity produced and the efficiency with which that output is produced. Experience does lead to greater productivity and efficiency. Medical groups in general are measured as being no less efficient than an average manufacturing firm, but Health Maintenance Organizations are less efficient than average.

Martin Gaynor
Center for Health Economics Research
72 2nd Avenue, Suite 100
Needham, MA 02194

Mark Pauly
University of Pennsylvania
Leonard Davis Institute
of Health Economics
3641 Locust Walk/CE
Philadelphia, PA 19104-3872

1.0 INTRODUCTION

Although the role of the services sector in the economy has grown increasingly large, and partnerships are a prevalent form of organization in this sector, relatively little is known about the behavior and performance of these firms. In this paper an attempt is made to fill that gap by developing and testing a model of the effect of alternative compensation arrangements on productive efficiency in medical group practices. In addition, some comparisons of efficiency with manufacturing sectors are made.

There is a vast theoretical literature on compensation, organizational form and efficiency in firms, but the empirical literature is comparatively sparse. The basic theoretical results are that productivity based compensation arrangements are best when production is non-joint across agents. Jointness in production calls for some kind of sharing of revenues, costs, or profits, plus monitoring where observability is possible. If observability is impossible, bonus-penalty schemes work best.

Some empirical evidence on this matter has been provided by the literature on the economics of medical group practices and legal group practices. For medical practice Newhouse (1973) provided solid evidence of "behavioral diseconomies of scale", or shirking under equal sharing arrangements as size increases. Held, Pauly, and Reinhardt (1978), using a more comprehensive data set, estimated a production function which examined the effect of compensation arrangements. They found evidence that productivity-based compensation arrangements do lead to greater productivity. Similar evidence on legal practice is represented by Leibowitz and Tollison (1980). Both of these studies do show "shirking" present under equal-sharing, non-productivity based compensation arrangements.

The work in this paper differs from these prior studies in both focus and technique. The intent of this research is to uncover the determinants of productive efficiency in medical partnerships. The technique employed is two-stage production frontier estimation. This technique allows for differences across agents in ability or responsiveness to financial incentives. In the frontier literature productive efficiency is assumed to be exogenously given. In this paper efficiency is determined endogenously, and a simple econometric technique to take this endogeneity into account in estimating the production frontier. In addition, the measures of efficiency themselves can be made dependent variables for explicit econometric analysis of the determinants of efficiency. The paper is organized as follows: Section 2.0 contains the theoretical model, in 3.0 the econometric methodology is presented, there is a discussion of the data in section 4.0, 5.0 contains estimation results, and 6.0 has the summary and conclusions.

2.0 THE MODEL

In this model the partners are utility maximizing agents who make decisions over "effort" in response to the incentives present in the firm's compensation method.[1] The compensation structure is treated as fixed by any partner, although it is endogenous as far as the group as a whole is concerned. Effort is defined as a variable input supplied by a partner which determines his efficiency of production. In order to highlight the efficiency aspects of production, all other inputs are assumed to be chosen at the firm level.[2]

Production is described by the production function:

$$q_i = f(h_i, t_i, k_i, e_i, \underline{\theta}_i), \tag{1}$$

where q_i = quantity produced by partner,[3]

h_i = partner i's hours at work in the given period,

[1]This model draws on that contained in Gaynor (1986).

[2]Some empirical support for this assumption is provided by the fact that in the data sample employed in this study, less than 35% of physicians indicated that they set their own hours.

[3]Output is assumed homogeneous. Although output may truly be heterogeneous, and compensation structure will affect the quality of service (as shown in Gaynor; 1986), the incentives for efficiency in production are unchanged by heterogeneity of the product.

h_i = $H_i - l_i$, where H_i represents the maximum number of hours available to i in the period and l_i represents i's leisure time,

t_i = non-partner labor hours used by i,

k_i = capital service hours used by i,

e_i = i's effort,

and $\underline{\theta}_i$ = a vector of i's characteristics which affect productive efficiency.

f is assumed to be strictly concave in all inputs. Effort increases the marginal productivity of all factors of production, but the elements of $\underline{\theta}_i$ only affect the marginal productivity of h_i.

Given h_i, t_i, k_i chosen by the firm and $\underline{\theta}_i$ is exogenous, the partner's choice of effort determines the quantity produced. This choice maximizes his or her utility, and utility in turn depends directly on the net income the physician receives and inversely on the level of effort and hours applied. The utility function is assumed to be linear in money and additively separable in effort,

$$u_i = y_i - v_i(e_i, h_i), \tag{2}$$

where u_i = i's utility,

y_i = i's net income,

and v_i = the private non-monetary cost of effort and hours. v_i is assumed to be strictly convex in e_i and h_i.

The compensation structure determines y_i for each partner, and is described by:

$$y_i = \alpha(P - C)q_i + \frac{1}{n}(1 - \alpha)(P - C)\sum_{i=1}^{n} q_i \tag{3}$$

where α = the proportion of net income generated by i that he "keeps." $\alpha \in [0,1]$

P = the output price set by the firm,

C = the average cost of non-physician inputs, assumed constant over output,

and n = the number of partners in the firm.

Thus, the first term in (3) is the portion of net income generated by i which he "keeps," and the second term is his share from the firm's net-income sharing pool.[4]

Maximization of utility yields the first order condition,

$$[\alpha + \frac{1}{n}(1-\alpha)](P-C)\frac{\partial f(\ )}{\partial e_i} - \frac{\partial v_i(\ )}{\partial e_i} = 0 \qquad (4)$$

The second order condition (not shown) also holds, given the assumptions made about the functions u_i, v_i, and f. Equation (4) can be readily interpreted as indicating that the utility maximizing level of effort is where the marginal net income product of effort (the first term in (4)) is equal to its marginal utility cost (the second term in (4)). Figure 1 illustrates this. In A., utility is maximized at the tangency (point E) between an indifference curve, uu, and the effort-income locus, YY. In B., this is represented by the point (E) where the marginal net income product of effort curve and marginal utility cost of effort curve cross.

Examining the comparative static derivatives for the equilibrium shows the effects of changes in α, P, n or C on the optimal choice of e_i. Table 1 contains the results. These can also be determined by examination of the effects of any of these variables on curve YY in Figure 1.A or curves II and CC in Figure 1.B.

It is clear from these results that a partner will be responsive to changes in the compensation structure and other variables set by the firm. The effect of an increase in α is to increase productivity, or measured efficiency, given measured levels of all inputs, because the increase will call forth higher levels of the unmeasured input effort, e_i.

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[4]This form is highly simplified; real world compensation structures often have different shares for revenue and cost, and non-physician average cost is not necessarily constant.

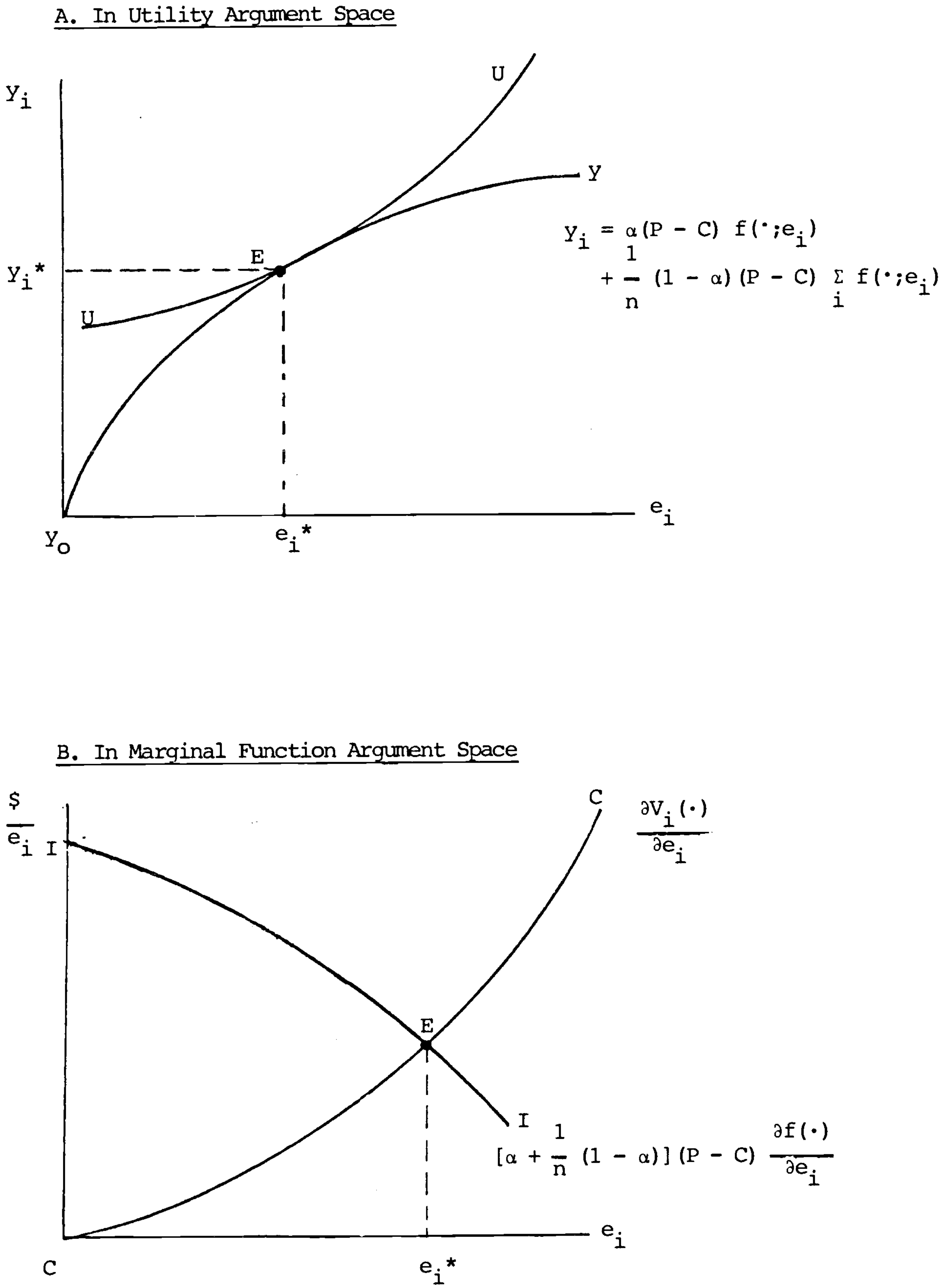
TABLE 1

COMPARATIVE STATIC EFFECTS ON e_i

Variable	Comparative Static Derivative	Sign
α	$\dfrac{(1 - \frac{1}{n})(p - c)f'}{s.o.c.}$	+
p	$\dfrac{[\alpha + \frac{1}{n}(1 - \alpha)]f'}{s.o.c.}$	+
c	$-\dfrac{[\alpha + \frac{1}{n}(1 - \alpha)]f'}{s.o.c.}$	−
p	$\dfrac{\frac{(1 - \alpha)}{n^2}(p - c)f'}{s.o.c.}$	-

FIGURE 1

The Utility Maximizing Level of Effort



Given the impossibility of measuring effort, an estimate of the production function will require attention both to the shape of the frontier and the impact of the compensation structure on the distance between actual output and the frontier.

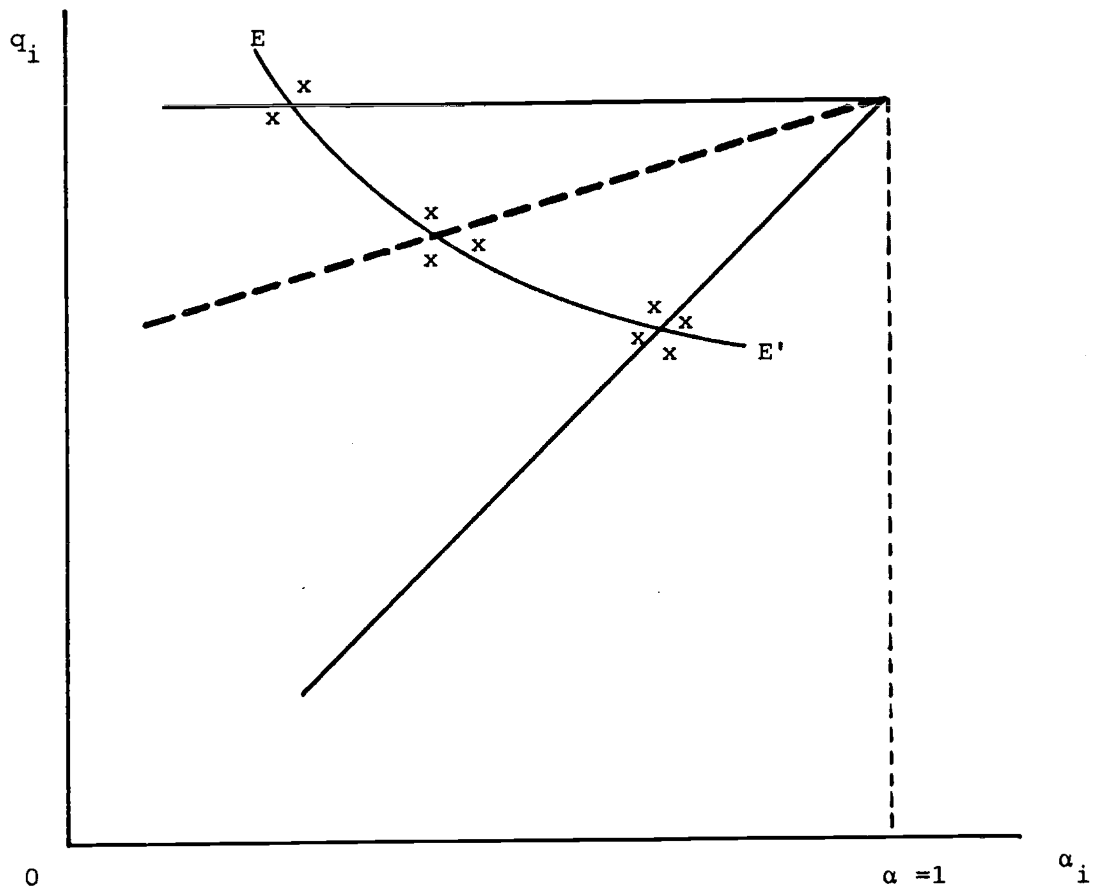
Using the frontier technique for estimating the production function will provide direct evidence of the effect of compensation structure on the measured efficiency of production. Using the frontier technique controls for the possibility that partners have differences in efficiency, ability, and degree of responsiveness to financial incentives. These are unmeasured attributes contained in the $\underline{\theta}_i$ vector.

In this paper we will analyze measured productivity by using both endogenous right side variables and a frontier function technique. Correct treatment of the error term in a regression equation requires that these approaches be combined.

To see why this is so, note that a conventional OLS regression line can suffer from two kinds of problems: there may be simultaneous equations bias, and the line through the central tendency of the data may not describe the experience of the most efficient producers. Simultaneous equations bias will arise if agents differ in their responsiveness to incentives and they can choose their level of incentives. Frontier functions are appropriate if agents differ in their ability to produce, given the incentives they face. Since agents in the real would probably differ in both willingness and ability, we need to take account of both influences.

Suppose initially that all agents have equal ability, in the sense that, with a given level of effort and with given levels of all other inputs, equal outputs will be observed. However, since the level of effort is not directly observable, measured productivity can still differ. Suppose also that agents differ in their responsiveness to financial incentives, that is, in their willingness to trade off effort for financial reward. When faced with payments that fully correspond to the revenue for their services ($\alpha = 1$), all agents are equally productive; as α falls below unity, productivity falls, but at different rates for different agents. Figure 2 shows several possible "incentive-productivity" curves; the dashed line plots the curve for an individual of average responsiveness.

FIGURE 2
Incentive-Productivity Curves for Agents of Differing Responsiveness



Since reducing α below unity reduces productivity, why would any firm choose a value less than one? One may conjecture that, for risk averse individuals facing a situation in which actual productivity is affected by random events, some implicit insurance may be chosen. Having sicker patients come to one's office may reduce productivity, but receiving part of one's office may reduce productivity, but receiving part of one's compensation as a salary guards against this risk.

If individuals have similar attitudes toward risk, one would then expect the level of α chosen to be inversely related to the degree of responsiveness to financial incentives. Actual observations might cluster as the "x's" in Figure 2, and the estimated α would be indicated by the slope of the line EE', which does not even have the same sign as any of the true values of α.

The solution to this problem is to find identifying variables, and treat α as endogenous. Our data set does contain a number of such variables.

The other influence on productivity is the ability of the individual agent. Figure 3 illustrates this point in a situation in which all partners are of equal responsiveness to incentives, but of two levels of ability. (In order to observe variation in α, we will need to assume that some other determinant of the desired level of α, e.g., risk aversion, varies across individuals.) The able partners always produce more output at all levels of α (A_o, A_1). The unable partners produce less (U_o, U_1). Standard regression techniques will result in the estimated function represented by the dotted line SS. Frontier estimation will compare actual output with the best practice frontier, FF. Clearly frontier estimation deals more effectively with the problem of unobserved abilities than does standard regression analysis.

This approach has a further implication for the relationship between deviations of observed, from best practice, output and the level of α. Note that, in Figure 1, the incentive productivity curves are closer together at high α than at lower levels of α. If there are some reasons why α might vary at a given level of incentive responsiveness (e.g., variation in degree of risk aversion), then one might observe people with different levels of responsiveness as indicated by the x's and the z's in Figure 4. But note that the deviation between the best practice frontier and the actual values is much smaller for the x's (high α) than it is for the z's (low α).

FIGURE 3
Comparison of Frontier and Standard Estimation Techniques

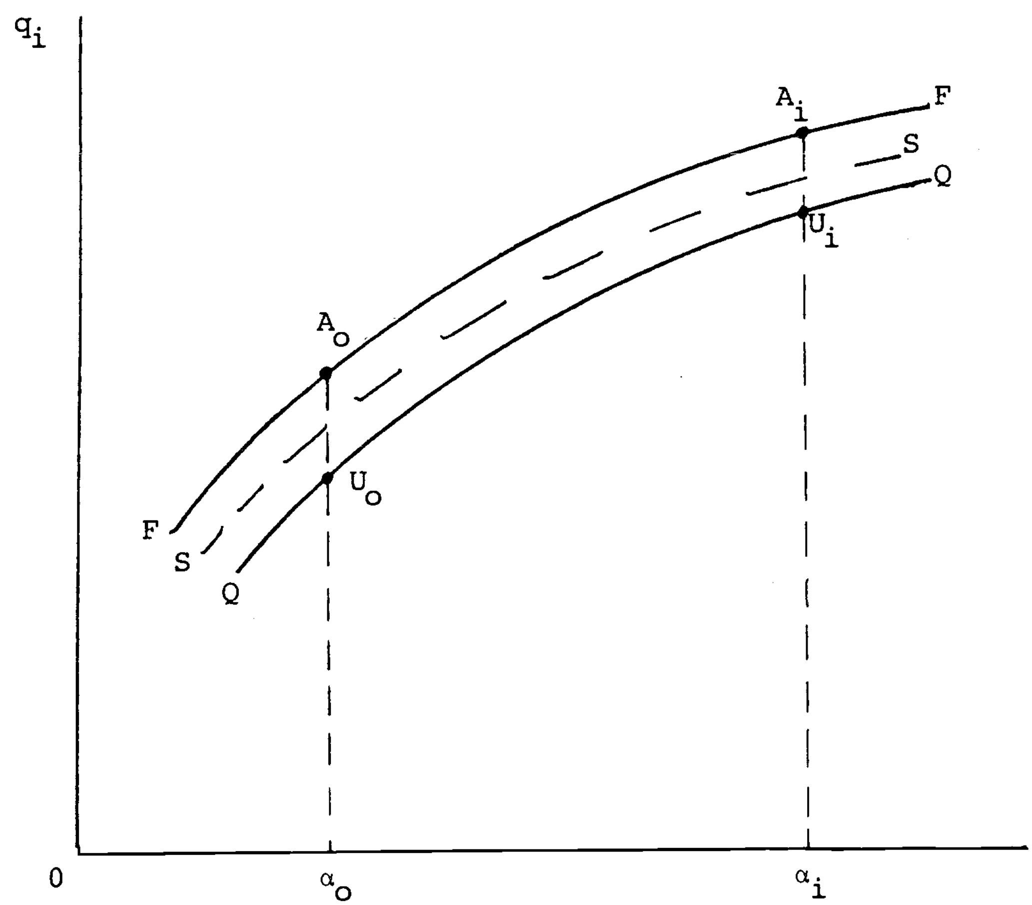
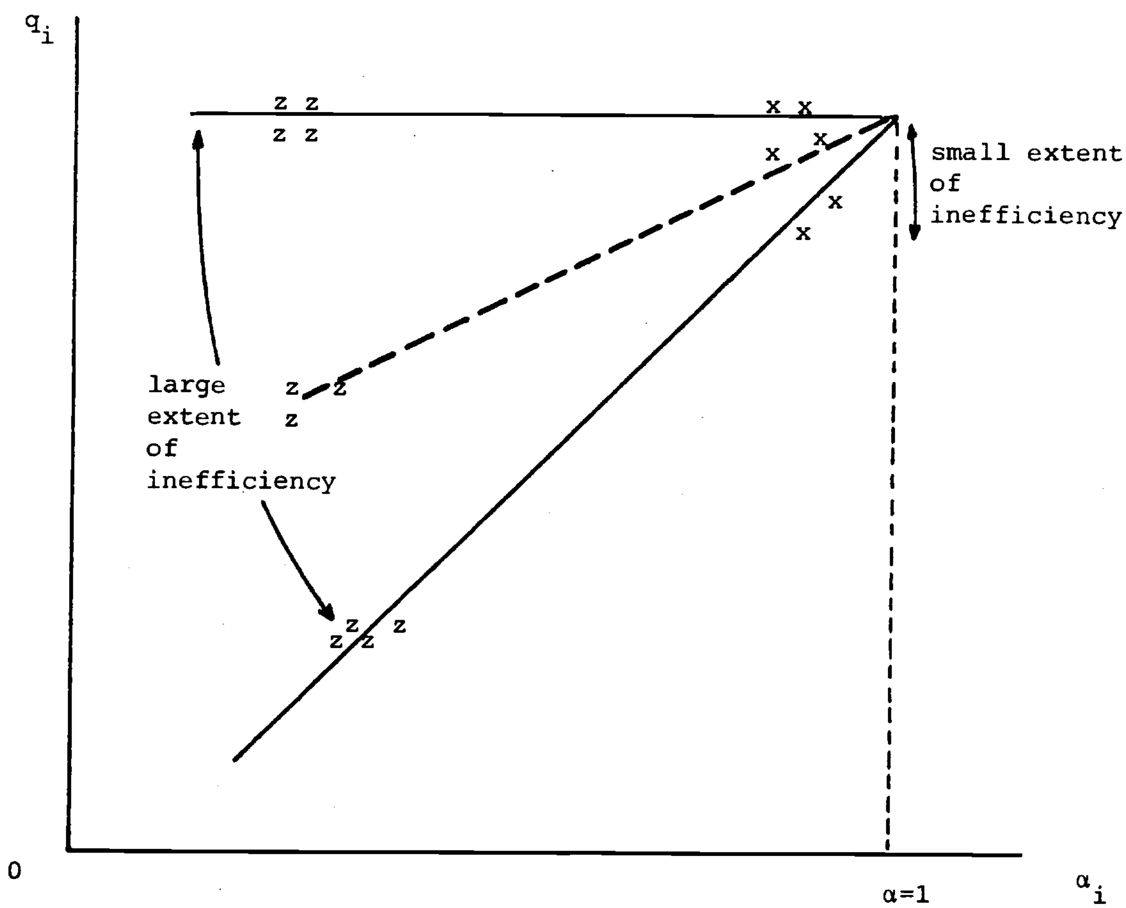


FIGURE 4
Differences in Responsiveness and in Preferences



3.0 METHODOLOGY

The literature on production frontiers and comparative efficiency (see Aigner, Lovell, and Schmidt (1977), Forsund et al., (1980) and Greene (1980)), indicates that technical, or productive efficiency can be estimated via econometric techniques as a means of comparing actual output to that which would result from a "best practice" frontier which corresponds to the most efficient set of observations. This implies:

$$q_i = f(h_i, t_i, k_i)u_i \tag{5}$$

where u_i is a multiplicative error team representing efficiency, i.e.,

$$u_i = \frac{q_i}{f(\ )}$$

Since in the conventional treatment the production function f represents the frontier along which decisions are efficient, the error term must be constrained to be nonnegative. Much of the literature on frontier estimation examines maximum likelihood estimation of functions like (5), perhaps with the addition of a two-sided error term to represent truly random deviations.[5] Greene (1980), Richmond (1970), and Forsund et al., (1980), have shown that a "corrected ordinary least squares" technique, or "COLS" can be used to estimate consistent and unbiased estimates of the frontier. This technique involves estimating the production function by OLS and then changing the constant term until all the regression residuals are non-negative.

The production function to be estimated is of form

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[5]Estimation of productive efficiency without the two-sided error term introduces a downward bias, if any, into efficiency estimates. This is because with only the single, one-sided error, no observations are allowed above the frontier.

$$Q_i = A \prod_j (X_{ji}^{\beta_j}) \exp(\sum_k \gamma_k Y_{ki}) u_i \qquad (6)$$

which is the same form as in Held and Reinhardt (1978), excepting the multiplicative error team.

As in Richmond (1974), it is assumed that the multiplicative error term, $u_i = \exp(-z_i)$, where the z_i's are drawn from a Gamma distribution. Then taking the natural logarithm of equation (6):

$$\log Q_i = a + \sum_j \beta_j \log X_{ji} + \sum_k \gamma_k Y_{ki} - z_i \qquad (7)$$

where $a = \log A$,
and $E(z_i) = \lambda$,
$Var(z_i) = \lambda$,
and $Cov(z_i, z_h) = 0$, $i \neq h$.
Let $\beta_o = a - \lambda$
and $v_i = \lambda - z_i$.

Then

$$\log Q_i = \beta_o + \sum_j \beta_j \log X_{ji} + \sum_k \gamma_k Y_{ki} + v_i \qquad (8)$$

where $E(v_i) = 0$
$E(v_i^2) = \lambda$
and $E(v_i, v_h) = 0$
$i \neq h$

The further assumption is made that $E(V \mid X) = 0$, (where V and X are vectors). Then, denoting the least squares estimator of λ by λ and the least squares estimators of the β_j's and γ_j's by β_j and γ

$$\lambda = \frac{1}{N - K - 1} \sum_{i=1}^{N} (\log Q_i - \beta_o - \sum_j \beta_j \log X_{ji} - \sum_k \gamma_k Y_{ki})^2 \qquad (9)$$

Where N is the total number of observations and K the total number of independent variables. λ is the estimated variance of the regression residuals, or the mean squared error of the regressions. $\beta_o + \lambda$ is an unbiased estimator of a, and $\exp(\beta_o + \lambda)$ is an upward biased but consistent estimator of A.

Now the size of "measured" efficiency in production is given by u, as indicated earlier. Call the average measured efficiency.

$$\varepsilon = E(u) = 2^{-\lambda} \qquad (10)$$

where $u = \exp(-z)$ and z has the density function $G(z;\lambda)$. The estimated measured efficiency thus is $\varepsilon = 2^{-\lambda}$, and this in turn is a consistent, but upward biased estimator of ε. Greene (1980) points out that the bias can be removed from the intercept, and thus the efficiency, estimators by simply changing the value of the intercept until no residuals are positive. This procedure is employed in this study.

In addition to the ε measure of productive efficiency derived from Greene (1980) and Richmond (1974), we employ an efficiency measure suggested by Cavin and Stafford (1985). This is a measure of relative efficiency, indicating the mean difference within each firm beteen actual performance and the best practice point, standardized by the range of the regression residuals, so that the efficiency measure is within the range [0,1][6].

This measure is computed as

$$r_i = \frac{e_{max} - e_i}{e_{max} - e_{min}} \qquad (11)$$

[6]Notice that although in the case of a two error term frontier some manipulation is required to obtain a firm-specific efficiency measure (see Jondrow, Lowell, Materov, and Schmidt (1982)), no such calculation is necessary here, due to the single error term structure.

for the firm, where e_i is the corrected OLS (COLS) error for firm i, e_{max} is the maximum of all COLS errors, and e_{min} is the minimum of all COLS errors. The average relative efficiency for the sample is

$$r = \frac{1}{N} \sum_{i=1}^{N} \frac{e_{max} - e_i}{e_{max} - e_{min}} \tag{12}$$

As noted earlier, the compensation structure of the firm will affect both the shape of the production frontier and the estimated distance between actual output and the frontier. That is, what is relevant is the difference between the best practice output and the actual output, conditional on the level of incentives for efficiency. Thus, OLS estimates of the production function will be both biased and inconsistent. This problem can be remedied by using two-stage least squares estimation techniques. The correct residual to use as a base for measures of efficiency is calculated using the second-stage parameter estimates and the actual variable values for endogenous right side variables, not those calculated using instruments,

$$v_i = \log Q_i - \beta_o - \sum_j \beta_j \log X_{ji} - \sum_k \gamma_k Y_{ki} \tag{13}$$

where the β's and γ's are estimates from the second-stage equation. This residual can then be used to calculate Greene's measure of efficiency, ε, or Cavin and Stafford's measure, r. These are consistent and unbiased.

4.0 DATA

The data utilized for this study were assembled by Mathematica Policy Research, Inc., under contract to the National Center for Health Services Research, Department of Health and Human Services, U.S. Government. The bulk of the data set is composed of surveys conducted by Mathematica, although some secondary data sources have been merged in. During the period March to June of 1978, Mathematica conducted a nationwide survey of medical group practices. The final sample included 957 groups and 6353 physicians practicing in those groups. The sample was stratified by: group size, type of group (multispecialty or single specialty), physician specialty, and prepaid vs. fee-for-service. Large group practices were oversampled in an effort to supply a reasonable number of observations, and a census was taken of pre-paid groups, for the same purpose. Further, only five medical practice specialities were sampled: general practice, internal medicine, pediatrics, general surgery, and obsterics/gynecology. Approximately 60 percent of all office-based physicians practice in these specialities.

Since surveys tend to produce low response rates, Mathematica conducted analysis for nonresponse bias on their data. Examining each of the survey instruments and using statistical techniques (e.g., the Heckman Technique) Mathematica concluded that nonresponse bias was not a problem to be faced in the utilization of the data set for purposes of statistical analysis.

This data set also includes data measuring characterisitcs of the area in which the group practiced and data on the hospital with which the group is affliated. The data on area characteristics were obtained from many sources, including the American Medical Association, The County and City Data Book, and various other sources. For a full listing of all these data sources see Boldin, Carcagno, Held, Jamieson, and Woolridge (1979). The hospital data were obtained from the American Hospital Association Guide for 1978.

This data set is currently the most complete and comprehensive of its kind in the U.S., and as such is appropriate for the empirical analysis conducted in this paper.

5.0 ESTIMATION RESULTS

A number of different empirical procedures are employed to examine the determinants of productive efficiency. The production frontier is estimated using the two-stage procedure described previously. This provides estimates of the parameters of the production function and allows the efficiency measures, ϵ and r, to be calculated. Two methods are used to uncover the determinants of efficiency. One, the sample is split between productivity related and unrelated compensation structures and production frontiers estimated on each subsample. Theory predicts that the estimated efficency of production should be higher for the productivity related compensation structure subsample. Two, the measure of productive efficiency can be made a dependent variable and regressed against its hypothesized determinants. As indicated before, this is possible due to the fact that a single error term frontier model is employed in this study. Finally, a test for efficient employment of labor is presented. Table 2 presents the acronyms and definitions for the variables employed in estimating the production frontier. Table 3 has the means and standard errors of those variables.

Three of the independent variables, INCOPROD, LNGRPSIZ, and HMO, are likely endogenous. The physician will have an effect on which values of these variables he is associated with in two ways: his part in decision-making within the group, and his choice of which group to join. The physician preference variables, e.g., IMPRODY, PREFSIZ, are hypothesized to affect the values of INCOPROD, LNGRPSIZ, and HMO. Thus, the system is estimated via two-stage least squares.

The first-stage estimates are presented in Table 5. Table 4 shows the second stage estimates of the production function. The signs on the second-stage coefficients are generally as expected. One exception is LNEXRM, which is insignificant. It may be that the number of examining rooms per M.D. functions as a poor proxy for the flow of capital services. The other inputs, physician time, (LNOHRSF), aide time (HRSNON), and administrators' time (HRSADM) all have positive and significant coefficients. Experience has a positive but diminishing effect, consistent with greater experience leading to greater productivity, but being counteracted by increasing age. The coefficient for group size is negative and significant. This is consistent with increasing group size leading to diminution of efficiency incentives, as hypothesized.

The compensation structure variable, INCOPROD, is positive and significant, as hypothesized. An increasingly strong link between compensation and productivity does lead to more office visits per week being produced. This is the finding of Held, Pauly, and Reinhardt (1978). This is as hypothesized for a firm with non-joint production, where output can be observed. Whether or not the group is multispecialty or an HMO seems to have little effect on output. It is possible, however, that those two variables are highly collinear.

TABLE 2

VARIABLE ACRONYMS AND DEFINITIONS

Acronym	Definition
LNOVISSF	Natural log of the number of first-time office visits per week
INCOPROD	A scale varying between 1 and 10, increasing with strength of relation between compensation and productivity
LNGRPSIZ	Natural log of the number of FTE Physicians in the group practice
HMO	Dummy variable indicating if the group is 50 percent or more prepaid
LNOHRSF	Natural log of the number of physician hours per week
LNEXRM	Natural log of the number of examining rooms per FTE M.D.
HRSNON	Hours of non-physician medical personnel
HRSADM	Hours of administrative personnel
HRSTOTSQ	Total hours of non-physician personnel, squared
EXPER	Number of years since graduating from medical school
EXPERSQ	EXPER squared
GPS, PDS, OBS	Physician specialty dummies for general practice, pediatrics, and obstetrics/gynecology, respectively - Internal medicine is excluded.
OWNRESP	Whether the physician judges himself responsive to financial incentives
MULTSPEC	Dummy for whether the group is multi- or single-specialty
GPA	Dummy for whether there is more than one graduate physician assistant
IMPREGY	Lack of importance of regular income to physician
SIZREGY	Group size best providing regular income
TYPREGY	Group type best providing regular income

TABLE 2 (continued)

VARIABLE ACRONYMS AND DEFINITIONS

Acronym	Definition
IMPROTEC	Lack of importance of protection from financial risk in practice
SIZPROTEC	Group size best providing financial protection
TYPROTEC	Group type best providing financial protection
IMPRODY	Lack of importance of productivity related to income
SIZPRODY	Group size best relating productivity to income
TYPRODY	Group type best relating productivity to income
IMPCOSTY	Lack of importance of costs related to income
SIZCOSTY	Group size best relating costs to income
TYPCOSTY	Group type best relating costs to income
IMPREGHR	Lack of importance of regular hours
TYPREGHR	Group type best providing regular hours
SIZREGHR	Group size best providing regular hours
PREFSIZ	Preferred group size
BOARD	Dummy for board certification

TABLE 3

VARIABLE MEANS AND VARIANCES

Acronym	Mean	Variance
LNOVISSF	4.46	0.36
INCOPROD	6.24	11.80
LNGRPSIZ	2.93	0.31
HMO	0.04	0.04
LNOHRSF	3.22	0.23
LNEXRM	0.72	0.76
HRSNON	54.55	427.63
HRSADM	63.97	845.57
HRSTOTSQ	15577.45	115771809.31
EXPER	18.67	99.89
EXPERSQ	448.31	136469.62
GPS	0.31	0.22
PDS	0.18	0.15
OBS	0.13	0.11
OWNRESP	0.32	0.22
MULTRESP	0.63	0.23
GPA	0.26	0.19
IMPREGY	2.19	0.64
SIZREGY	3.16	0.68
TYPREGY	0.25	0.19
IMPROTEC	3.03	0.91
SIZPROTEC	3.01	0.94

TABLE 3 (continued)

VARIABLE MEANS AND VARIANCES

Acronym	Mean	Variance
TYPROTEC	0.19	0.15
IMPRODY	1.90	0.76
SIZPRODY	2.32	1.22
TYPRODY	0.02	0.02
IMPCOSTY	2.32	0.71
SIZCOSTY	2.32	1.23
TYPCOSTY	0.15	0.35
IMPREGHR	2.17	0.76
TYPREGHR	0.20	0.40
SIZREGHR	3.15	0.81
PREFSIZ	14.70	20.30
BOARD	0.72	0.45

TABLE 4

ESTIMATED PARAMETERS OF THE PRODUCTION FUNCTION

Variable	Parameter Estimate	t-ratio
Intercept	2.42	7.31
LNOHRSF	0.53	14.91
LNEXRM	-0.01	-0.47
HRSNON	0.0041	1.76
HRSADM	0.0053	2.30
HRSTOTSQ	-0.000013	-1.61
EXPER	0.02	2.50
EXPERSQ	-0.00052	-2.93
GPS	0.48	10.46
PDS	0.53	10.77
OBS	0.41	7.44
OWNRESP	0.06	1.53
MULTSPEC	0.66	1.21
LNGRPSIZ	-0.22	-2.47
GPA	-0.001	-0.03
HMO	-0.20	-0.83
INCOPROD	0.033	2.10

F-Ratio : 36.37

N : 894

TABLE 5

FIRST-STAGE ESTIMATION RESULTS

Independent Variable	INCOPROD Parameter Estimate	INCOPROD t-Ratio	LNGRPSIZ Parameter Estimate	LNGRPSIZ t-Ratio	HMO Parameter Estimate	HMO t-Ratio
INTERCEPT	3.53	2.75	2.65245	12.3729	0.383415	5.3789
LNOHRSF	0.27	1.25	0.02222	0.6025	-0.022626	-1.8448
LNEXRM	0.21	1.75	-0.18177	-8.8617	-0.00662863	-0.9719
HRSNON	0.018	1.44	-0.003481	-1.6444	-0.00433438	-6.1569
HRSADM	0.02	1.75	-0.0024434	-1.1377	-0.00395856	-5.5434
HRSTOTSQ	-.0000278	-0.62	.0000089565	1.1977	.00001615857	6.4987
EXPER	-0.064	-1.59	0.00895135	1.3186	-0.00277584	-1.2297
EXPERSQ	0.00156	1.43	-0.00017963	-0.9828	.00005036676	0.8288
GPS	-0.5238	-1.93	-0.14040	-3.1044	0.023599	1.5693
PDS	-0.0397	-0.127	0.06748	1.3012	0.016046	0.9305
DBS	-0.5058	-1.465	0.08888	1.5448	0.028477	1.4885
OWNRESP	0.1075	0.46	-0.0093382	-0.2401	-0.014681	-1.1350
MULTSPEC	0.9658	3.70	0.15637	3.5990	0.064576	4.4697
GPA	-1.0025	-4.06	0.19775	4.8061	0.030703	2.2441
IMPREGY	0.362	2.518	0.00330990	0.1350	-0.013087	-1.6406
SIZREGY	0.1653	0.78	0.04102	1.1625	-0.014489	-1.2349
TYPREGY	0.273	0.96	-0.06506	-1.3744	0.064265	4.0828
IMPROTEC	-0.044	-0.38	-0.02537	-1.3146	-0.0012855	-0.2003
TYPPROTE	-0.329	-1.1129	0.00303436	0.0615	0.065157	3.9717
SIZPROTE	-0.00215	-0.0167	0.04692	2.1793	-0.00165127	-0.2306
IMPRODY	-1.358	-9.45	-0.04499	-1.8785	0.005832302	0.7323
TYPRODY	-1.4424	-1.77	-0.10913	-0.8035	0.267148	5.9153
SIZPRODY	0.096	0.7798	-0.01732	-0.8379	-0.000165185	-0.0240
IMPCOSTY	0.3898	2.7689	0.01015	0.4325	-0.00748693	-0.9592
TYPCOSTY	0.3917	1.1876	-0.05453	-0.9917	0.041192	2.2527
SIZCOSTY	0.0064	0.0562	-0.02271	-1.1955	0.004192825	0.6636
IMPREGHR	0.136	0.91	0.03770	1.5052	-0.00667734	-0.8017
TYPREGH	-0.386	-1.29	-0.09352	-1.8783	0.002687203	0.1623
SIZREGHR	0.045	0.2199	0.02988	0.8724	-0.00454341	-0.399
PREFSIZ	-0.00098	-0.17	0.00783838	8.2589	0.0005707543	1.8086
BOARD	-0.167	-0.6626	0.05334	1.2637	0.0031601285	0.2252
R^2	0.23		0.30		0.24	
F	8.69		12.20		9.08	

Dependent Variables: INCOPROD, LNGRPSIZ, HMO

The first-stage estimations contain some interesting results. The physician preference variables tended to have the signs intuition would suggest. Physicians with a preference for hard work or productivity-related rewards should locate in groups with high INCOPROD, or lead groups to adopt a high INCOPROD. That is what the empirical results indicate. IMPREGY, the lack of alleged importance of regular income, was positively related to INCOPROD, indicating that the less important is regular income to a physician, the more strongly related to productivity will his group's compensation structure be. When the dependent variable is HMO, the sign of IMPREGY is the opposite, indicating that as importance of regular income declines, it is less likely a doctor will be in an HMO. IMPRODY, the lack of alleged importance of productivity related to income, is negatively related to INCOPROD. (Here "importance" is interpreted as the physician's subjective feelings about the propriety of relating income to productivity.) This indicates that the less important is productivity related to income, the weaker will be the relation between income and productivity. As preferred group size rises (PREFSIZ), so does group size and the probability of being in an HMO. The variable OWNRESP, which increases with the physician's responsiveness to financial incentives, had no statistically significant effect on any of the dependent variables. Board certification status, thought to be a proxy for physician ability, was also uniformly insignificant.

We examine efficiency, given the compensation method, by stratifying the sample by values of INCOPROD and comparing the efficiency estimates across subsamples. The variable INCOPROD contains the response to a survey question asking how closely income is related to productivity in the group. It is specified to take a value of one when there is no relationship, and ten when the relationship is perfect. Due to the nature of the question responses with values in the range two to nine are difficult to interpret. We therefore split the sample by high (6-10) and low (1-5) values of INCOPROD.[7] The estimates of the two measures of efficiency, ε and r, are contained in Table 6. The values of both ε end r are significantly higher for the high INCOPROD subsample than for the low INCOPROD subsample. In both cases the difference in efficiency measures across subsamples is approximately equal to .05.

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[7] A Chow test shows a significant difference at the 5% level between estimates of the production function stratified in this way.

TABLE 6

ESTIMATES OF EFFICIENCY

Subsample	Efficiency Measure		
	ε	r	N
High INCOPROD	0.948	0.914	757
Low INCOPROD	0.899	0.855	454

Table 7 reports the values of ε and r for the sample stratified into 3 groups, [1,3], [4,7], [8, 10]. Both efficiency measures rise with INCOPROD. Overall, efficiency does appear to rise with INCOPROD, supporting the hypothesis of this paper. Not only does a productivity based compensation structure lead to a greater level of production, it leads to more efficient production.

It is interesting to compare these estimates of efficiency against those obtained for manufacturing. Richmond (1974) obtained a mean efficiency measure (ε) for manufacturing of 0.869. Given that the services sector, and particularly medical practice, is often alleged to be grossly inefficient relative to the manufacturing sector, it is interesting that the efficiency estimates obtained here compare favorably with one obtained for manufacturing. This gives reason to doubt whether production of physician services is any less efficient than production in the industrial sector of the economy.

In order to examine the effect of compensation method on productive efficiency in a more systematic way, we regressed one of the efficiency measures, ε, on some hypothesized determinants. These are the exogenous characteristics of the medical groups, such as compensation structure or group size. Table 9 presents the results. ALPHA is a dummy variable taking value one when INCOPROD is greater than 5, and zero otherwise. ALPHA2 is one when INCOPROD equals ten and zero when INCOPROD equals one. The results support the hypotheses that productive efficiency increases as compensation is related to productivity, since both ALPHA and ALPHA2 turn up positive and significant in all the specifications. The coefficient for GRPSIZ is negative and significant, supporting the hypostheses that diminished productivity incentives as group size rises leads to a loss of efficiency. Physician experience, EXPER, is seen to increase measured efficiency. Efficiency is lower in HMO's, as has been alleged in some quarters. This may be due to lack of productivity incentives in the compensation structure, larger group sizes associated with HMO's, or the removal of physicians from the decision-making process in HMO's. Interestingly enough, the coefficient for multispecialty groups is positive and significant. Multispecialty groups may save their member physicians the costs associated with lumpy demand, including slack time

TABLE 7

EFFICIENCY MEASURES - STRATIFIED THREE WAYS

Value of INCOPROD	Efficiency Measures	
	ε	r
[1, 3]	0.89	0.76
[4, 7]	0.94	0.84
[8, 10]	0.95	0.88

TABLE 8

MEANS AND STANDARD DEVIATIONS OF VARIABLES IN EFFICIENCY REGRESSION

Variable	Mean	Standard Error
Eff	0.941	0.116
ALPHA	0.622	0.485
ALPHA2	0.302	0.459
INCOPROD	6.21	3.47
GRPSIZ	22.43	16.11
EXPER	18.40	9.91
HMO	0.038	0.19
MULTSPEC	0.60	0.49
OWNRESP	0.319	0.466

TABLE 9

REGRESSIONS OF EFFICIENCY STATISTIC (ϵ) ON ITS HYPOTHESIZED DETERMINANTS

Independent Variables	Regression 1	Regression 2	Regression 3
INTERCEPT	0.927 (98.42)	0.938 (102.69)	0.913 (88.58)
ALPHA	.042 (6.10)	--- ---	--- ---
ALPHA2	--- ---	.032 (4.43)	--- ---
INCOPROD	--- ---	--- ---	0.0064 (6.62)
GRPSIZ	-.0012 (-5.79)	-.0013 (-5.90)	-0.0012 (-5.49)
EXPER	.0005 (1.60)	.0006 (1.69)	0.00054 (1.64)
HMO	-.017 (-0.99)	-0.032 (-1.81)	-0.02 (-1.17)
MULTSPEC	.01 (1.38)	.02 (2.85)	0.0098 (1.36)
OWNRESP	-.0013 (-0.18)	.0004 (.054)	-0.0019 (-0.26)
$\bar{R}^2$	.061	0.047	0.066
N	1200	1200	1200

and time spent drumming up patients, mainly via referrals. The system of internal referrals in multispecialty groups may decrease physician slack time and the "one-stop shopping" nature of a multispecialty group may make it more attractive to consumers, thus relieving group members of the necessity of finding patients.

Speaking to the issue of the efficient use of inputs, we examine the use of non-physician medical personnel (HRSNON) by calculating the value of the marginal product and comparing it to the wage. Table 10 presents these results. They point to underuse of aide-time for most specialties. These results are consistent with the results from previous studies, expecially that of Reinhardt (1975).

6.0 SUMMARY AND CONCLUSIONS

The goal of this paper was to investigate the determinants of productive efficiency in partnerships. This has been done for the case of medical group practice by using the frontier estimation technique and its associated efficiency measures. We find that relating compensation to productivity does increase the quantity and efficiency of production, as theory has hypothesized. The number of members in a group decreases both the quantity produced and the efficiency with which that output is produced. Experience does lead to greater productivity and efficiency. Medical groups in general are measured as being no less efficient than an average manufacturing firm, but Health Maintenance Organizations are less efficient than average. Non-physician labor is underemployed, although this result could be an artifact of unmeasured quality or defensive medicine.

Overall, the empirical results are consistent with theoretical work on internal theory of the firm, which predicts that productivity compensation schemes will work well for firms with non-joint production and observable output. These two criteria are met by medical group practices. The treatment of measured efficiency as an endogenous variable is unique and allows some interesting insights into the determinants of productive efficiency. Future research examining efficiency and its determinants for other services (e.g., law) and other types of compensation systems (e.g., bonus-penalty) would be illuminating.

TABLE 10

EFFICIENT USE OF NON-PHYSICIAN MEDICAL PERSONNEL

Sample <u>Average</u>	Average Weekly <u>Office Visits*</u>	Average Fee for an <u>Office Visit</u>	Value of Marginal <u>Product**</u>	<u>Wage</u>
Subsamples: <u>by Specialty</u>	86.48	14.02	5.00	4.38
GP	117	12	5.80	4.33
IM	72	16	4.76	4.52
PD	109	14	6.30	4.59
OB	94	16	6.21	4.45
GS	59	14	6.21	4.19
<u>by INCOPROD</u>				
1	87.36	14.02	5.138	4.29
10	85.63	14.04	11.510	4.33

*This equals exp(mean of LNOVISSF)

**This equals the fee x marginal product of HRSNON, where marginal product equals the regression coefficient on HRSNON, multiplied by the mean number of office visits,

$$\text{i.e., } Q = A \prod_i X_i^{a_i} \exp(\Sigma b_j Z_j) + MP_{Z_j} = \frac{\partial Q}{\partial Z_j} = b_j \times Q.$$

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