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ENTER AT YOUR OWN RISK:
HMO PARTICIPATION AND ENROLLMENT
IN THE MEDICARE RISK MARKET

Jean Abraham
Ashish Arora
Martin Gaynor
Douglas Wholey

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Jean Abraham, Ashish Arora, Martin Gaynor,
and Douglas Wholey
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ABSTRACT

We examine HMO participation and enrollment in the Medicare risk market for the years 1990 to 1995. We develop a profit-maximization model of HMO behavior, which explicitly considers potential linkages between an HMO's production decision in the commercial enrollee market and its participation and production decisions in the Medicare risk market. Our results suggest that the payment rate is a primary determinant of HMO participation, while the price of a supplemental Medicare insurance policy positively affects HMO Medicare enrollment. We also find empirical support for the existence of complementarities in the joint production of an HMO's commercial and Medicare products.

Jean Abraham
H. John Heinz III School of Public
Policy and Management
Carnegie Mellon University
Pittsburgh, PA 15213-3890
abraham@andrew.cmu.edu

Ashish Arora
H. John Heinz III School of Public
Policy and Management
Carnegie Mellon University
Pittsburgh, PA 15213-3890
ashish@andrew.cmu.edu

Martin Gaynor
H. John Heinz III School of Public
Policy and Management
Carnegie Mellon University
Pittsburgh, PA 15213-3890
and NBER
mgaynor@andrew.cmu.edu

Douglas Wholey
University of Minnesota
Division of Health Services Research
School of Public Health
15-223 Phillips-Wangensteen Building
Box 729, 420 Delaware Street SE
Minneapolis, MN 55455-0392
whole001@tc.umn.edu

I. **Introduction**

Medicare is the federal entitlement program that provides comprehensive health insurance coverage to individuals age 65 and older and certain disabled people. In 1995, total Medicare expenditures reached $187 billion dollars, with expected annual growth of ten percent (Statistical Abstract of the United States, 1997; Wilensky, 1995). With passage of the Balanced Budget Act of 1997, reforms are being implemented to address the program's financial condition and to expand beneficiary coverage options with the creation of Medicare Part C, otherwise known as Medicare+Choice.

Under Medicare+Choice, several types of coordinated care plans are eligible to contract with the Health Care Financing Administration (HCFA) to provide coverage to Medicare beneficiaries.[1] This expands and modifies the Medicare HMO risk-contracting program begun in 1985. Under this program, an HMO entering into a "risk contract" receives a fixed monthly payment equal to 95% of an actuarial measure of the average cost of providing care to a beneficiary in the traditional Medicare program adjusted for geographic and demographic differences. This is called the Adjusted Average Per Capita Cost, or AAPCC. In return, the HMO is responsible for providing all covered services and takes full financial responsibility for the actual costs generated.[2]

In addition to expanding the types of organizations eligible to enter contracts, Medicare+Choice also differs from the preceding system with respect to the payment methodology. Though organizations participating in Medicare+Choice still receive a

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[1] Medicare+Choice also permits fee-for-service insurers and religious fraternal benefit society plans to contract with HCFA.

[2] Additional regulations capped net revenues for risk-contracting HMOs. If an HMO exceeded the limit, then the firm would be required to take a lower payment rate or pass the savings onto the beneficiaries in the form of supplementary benefits or lower out-of-pocket costs. Premium rebates were prohibited. See (Zarabozo and LeMasurier, 1996) for discussion of TEFRA guidelines.

fixed monthly payment to provide coverage for Medicare beneficiaries and bear the financial risk associated with the costs of providing care, a different methodology has been adopted for calculating this payment. Under Medicare+Choice, an organization's payment is based on the largest of three rates, which include the following: a minimum payment amount (which for 1998 is $367 per month); a blended rate, which consists of the area-specific rate and an input-price adjusted national rate; and a minimum percentage increase which uses the AAPCC rate in 1997 as the base (www.hcfa.gov, 1998).

There has been considerable growth in recent years in both the number of HMOs offering Medicare products and HMO Medicare beneficiary enrollment. Table 1 summarizes HMO participation in the Medicare risk market for the years 1990 to 1995.[3] During this period, the number of HMOs participating in Medicare risk contracting nearly doubled, from 66 to 114. As HCFA makes the transition into Medicare+Choice, effective implementation of this program depends on participation by coordinated care organizations, enrollment by beneficiaries, and a payment methodology that yields savings to Medicare that would not be realized under the traditional program.

The purpose of this paper is to directly examine two of these implementation issues: the decision by organizations to participate in the Medicare market and the factors that influence the number of beneficiaries who enroll in these institutions. Given the infancy of the Medicare+Choice program, we focus our analysis on HMO participation and enrollment decision-making as a way to identify insights that may apply more broadly to contracting organizations under this new program.

Two studies have examined HMO entry into the Medicare market. Adamache and Rossiter (1986) examine the determinants of HMO participation in the National Medicare Competition demonstration, modeling this decision as a function of an HMO's organizational, market, and performance characteristics, and then estimating a binary probit model.[4] Their results suggest that the AAPCC rate, federal qualification by an HMO, and prior experience with Medicare beneficiaries positively affect an HMO's probability of participation. Porell and Wallack (1990) model the problem similarly, using a different market definition and data set. The authors' findings confirm previous results, with additional results suggesting that stronger utilization controls and favorable financial performance by an HMO also increase the probability of entry into the Medicare market. However, both of these studies fail to directly address HMO production in the commercial enrollee market and how this may affect a firm's decision regarding Medicare, given the potential for important cost or demand linkages between these products. Furthermore, they also fail to consider the impact of what has become an important part of conventional Medicare – the price of supplemental Medicare insurance.

In this paper, we develop a model of HMO behavior that explicitly considers the linkage between an HMO's production in the commercial enrollee market and its decision to participate and produce in the Medicare market. We estimate the model using data from 1990 to 1995, which reflects a time period of significant growth and change in the HMO industry. The remainder of this paper is divided into the following sections. Section II presents the model. A discussion of the data and measures are

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[3] Table 1 was constructed using data from a national sample of HMOs in the United States. Therefore, the number of risk-contracting HMOs reported in Table 1 is smaller than the number reported by HCFA for this time period.

contained in Section III. Section IV outlines a set econometric estimation issues. Section V reports the results and provides a discussion of the findings. Section VI identifies potential policy implications and contains concluding remarks.

II. Model

In this section, we develop a profit-maximization model of HMO behavior. The primary objective for doing so is to examine how the Medicare price (the AAPCC payment rate), the price of substitutes for an HMO Medicare product (specifically the price of a supplemental Medicare insurance policy), and a firm's production in its private (commercial enrollee) market, influence its decision-making with respect to the Medicare market.

We employ the following set of assumptions. First, we consider the populations demanding each of these products to be separate, since only Medicare beneficiaries are eligible to enroll in a Medicare product, while most commercial enrollees are labor force participants and their families. Second, we assume that the products are distinguishable from one another by the fact that coverage under the traditional Medicare program and hence, Medicare products, is typically broader than that required for private products produced by federally qualified HMOs (Zarabozo and LeMasurier, 1996). Third, we assume that all HMOs produce a positive quantity of the private product. Finally, we allow for the possibility of demand complementarities for a firm's private and Medicare products.

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[4] The National Medicare Competition demonstration occurred in 1982, and included 52 risk-contracting plans. See Langwell and Hadley (1982) and Langwell and Hadley (1986) for discussion.

Private demand

Let an HMO face a separate demand function for each of its products, and let an HMO's demand function for its private product be specified as the following:

$$Q_p = \theta_0 - \theta_1 P_p + \theta_2 X_p + \theta_3 Q_m, \ \theta_i \geq 0 \ \forall i \tag{1}$$

where the private quantity (Q_p) depends on the price charged for the private product (P_p), X_p, which represents a set of exogenous factors that shift demand for the private product, and the firm's Medicare enrollment (Q_m).[5]

Medicare demand

We specify the "potential" market demand for an HMO's Medicare product to be some function of the demographic composition of the Medicare population, a set of exogenous factors that shift HMO Medicare market demand (X_m), and commercial enrollment. Individual firm demand is some proportion of this "potential" or residual market demand (Q_{mR}), such that:

$$Q_m \leq Q_{mR}. \tag{2}$$

We specify individual firm demand as the following:

$$Q_m = m_1 z + m_2 X_m + m_3 Q_p \tag{3}$$

where z represents the quality level of the Medicare product chosen by the firm, X_m is a vector of exogenous factors that shift HMO Medicare market demand (such as the price of supplemental Medicare insurance), and Q_p is a firm's private quantity.[6] We assume

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[5] This specification does not explicitly model strategic interaction by firms in the private market. Assume this represents a reduced form residual demand curve with γ capturing factors that shift rivals' demands as well as the firm's own demand.

[6] This specification also does not explicitly model strategic interaction among firms in the Medicare market. It subsumes rivals' actions and should be considered a reduced form specification. We assume

that Q_m is not directly under the control of the firm, but rather is influenced by the quality of the product (z), which is set by the firm.

Medicare price

In contrast to the private market, the Medicare price is set administratively by the Health Care Financing Administration, rather than being determined as a function of quantity. Under federal guidelines, the price of the Medicare product (P_m) is set equal to 95% of the AAPCC, which is an actuarial measure of the average cost of providing care to a beneficiary enrolled in the traditional Medicare program, adjusted for age, sex, geographic, Medicaid eligibility, and institutional status differences.

Costs

The firm faces the following cost function associated with its production of the private and Medicare products::

$$C = C_1 Q_m + C_2 Q_p + C_3 Q_p Q_m + C_4 Q_m^2 + C_5 Q_p^2 + C_6 z Q_m + C_7 z + C_8 z^2. \tag{4}$$

Total cost is a function of the private and Medicare quantities and the quality level chosen by the firm. The third cost parameter, C_3, captures those costs associated with the joint production of the private and Medicare products.

The last two terms in the cost function specification capture the fixed cost associated with production of a Medicare product, where this cost is strictly increasing with the level of quality chosen by the firm. HMOs may incur fixed costs for such things as new equipment purchases, facility renovation for easier accessibility by the

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that HMOs only seek to enroll beneficiaries from the traditional Medicare population and not those beneficiaries who are already enrolled in other HMOs.

elderly, development of geriatric programs, marketing, or administrative services related to the risk contract application process and compliance with government regulation.

Entry Decision

Based on the above assumptions, the decision for an HMO to enter the Medicare market is a function of the variable profit and fixed cost associated with production of a Medicare product. Entry by the firm will occur when, for a given level of quality, the following condition holds:

$$(P_m - C_1 - C_3 Q_p - 2C_4 Q_m - C_6 z) Q_m - (C_7 z + C_8 z^2) \geq 0 . \tag{5}$$

Using this condition, we can assess how changes in the price, costs, or private enrollment affect a firm's probability of entry into the Medicare market. For example, if the Medicare price increases, this increases a firm's variable profit, and will increase its likelihood of participation. Second, if variable or fixed costs increase, this will decrease the probability of entry by the firm, ceteris paribus. Finally, the probability of participation depends on the presence of complementarities. If there are demand or cost complementarities, then an increase in a firm's private enrollment (Q_p), will serve to increase its probability of participation in the Medicare market.

To examine how these factors affect a firm's probability of entry into the Medicare market, we construct a binary dependent variable, OFFER, defined as the following:

$$\text{OFFER} \begin{cases} = 1 \ if \ Q_m > 0 \\ = 0 \ if \ Q_m = 0 \end{cases}$$

and designate the model as the following:

$$\text{Prob}(OFFER = 1) = \beta_1 + \beta_2 P_m + X_m \beta_3 + X_p \beta_4 + (COST) \beta_5 \tag{6}$$

where the decision to offer a Medicare product is a function of a constant, the Medicare

price, Medicare demand shifters, private demand shifters, and factors that shift an

HMO's costs (COST). This equation is a reduced form specification derived

from the preceding entry condition.

Profit-Maximization Problem

We assume that HMOs seek to maximize profits.[7] The firm's problem is then:

$$Max\ \pi = P_p Q_p + P_m Q_m - C_1 Q_m - C_2 Q_p - C_3 Q_p Q_m - C_4 Q_m^2 - C_5 Q_p^2 - C_6 z Q_m - C_7 z - C_8 z^2 \qquad (7)$$

$$Q_p, z$$

subject to:
(1) $Q_m \geq 0$
(2) $Q_p - Q_m \geq 0$
(3) $Q_{mR} - Q_m \geq 0$

where an HMO chooses its private quantity and level of quality to maximize profit

subject to the three constraints. Constraint (1) reflects an HMO's choice to participate in

the Medicare market. Constraint (2) reflects federal guidelines that require HMOs not to

have more than 50% of their total enrollment from Medicare enrollees. Constraint (3)

requires that no individual firm's demand for its Medicare product exceed its residual

market demand.[8]

Table 2 outlines four possible cases of HMO behavior under various

combinations of slack and binding constraints. Case I includes all HMOs that have

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[7] Profit-maximization is the appropriate assumption, even for non-profit HMOs, provided that the HMO seeks to maximize the income of a decisive set of agents, or that the residual claimants can agree on maximizing their joint gain (Pauly, 1987; Danzon, 1982). A separate model for non-profit HMOs is required only if something which affects demand (e.g., output) also appears in the HMO's objective function. Since this is uncertain, we do not believe there is a need for a special model of non-profit HMOs (Wholey et al, 1995). In our data set, approximately 70% of HMOs have for-profit status.

[8] See Appendix 1 for the first-order and second-order conditions of the profit-maximization problem.

chosen to operate in the private market only. HMOs that fall into Case II participate in both the private and Medicare markets, and are constrained by the 50/50 rule. Case III includes HMOs that participate in both markets and that are constrained by demand in the Medicare market. This suggests that an individual firm's demand equals its residual market demand, and therefore, no further increases in quality can increase firm demand. Finally, Case IV includes those HMOs that operate in both markets and are neither constrained by the 50/50 rule, nor constrained by demand. Cases I, III, and IV appear to be the most empirically plausible. Descriptive statistics from the data reveal that less than two percent of all operational HMOs are constrained by the 50/50 rule, and therefore, fall into Case II.

To examine the determinants of an HMO's private and Medicare enrollment, we use the first order conditions of the profit-maximization problem to specify the enrollment equations below. Specifically, we solve for Q_p and Q_m individually from first order conditions (1) and (2), and impose an assumption of linearity. These single equation, implicit solutions are expressed as the following:

$$Q_m = \alpha_1 + \alpha_2 P_m + X_m \alpha_3 + (COST)\alpha_4 + \alpha_5 Q_p \qquad (8)$$

$$Q_p = \omega_1 + \omega_2 P_m + X_p \omega_3 + (COST)\omega_4 + \omega_5 Q_m. \qquad (9)$$

Here, an HMO's Medicare quantity is a function of the Medicare price, Medicare demand shifters, factors that shift cost, and private quantity, while a firm's private quantity is a function of the Medicare price, private demand shifters, factors that shift cost, and a firm's Medicare quantity.

Appendix 2 outlines a set of comparative static predictions that are used to assess how changes in the Medicare price and factors that shift private and Medicare demand

affect an HMO's behavior regarding private and Medicare enrollment. Using our predictions, we can distinguish between Case III (firms are demand constrained) and Case IV (firms are unconstrained), and utilize this information in relating our empirical results back to theory. Furthermore, we use combinations of predictions to test for the presence of complementarities in production.

Table 3 reports these predictions, where the parameters identified are those specified in equations (8) and (9). We can distinguish between the demand constrained and unconstrained cases using the parameter on the Medicare price in the Medicare quantity equation. Finding a zero effect suggests that the firm is demand constrained, while finding a positive effect, suggests that the firm responds to an increase in price and is therefore, unconstrained by demand. To test for complementarities, we use the signs on the parameter estimates for Qp, Qm, and Pm in the Medicare and private enrollment regressions, respectively. Finding a positive effect suggests the presence of complementarities.

III.   Empirical Specification

Data

We used the InterStudy HMO Census to identify the population of HMOs in the United States from 1990 to 1995. The InterStudy Census describes the organizational structure of HMOs in terms of model type, profit status, headquarters location, and federal qualification. In addition, the Census indicates changes in ownership (organizational name changes, mergers) and plan terminations.

We matched the InterStudy data with information obtained from forms that HMOs file with state regulators. The state filings include financial information,

enrollment figures, and utilization statistics. We obtained these from Health Care

Investment Analysts (HCIA) , who code the data, and sell them in machine readable

format. We matched 2564 (80.2%) of the 3197 HMOs identified in the InterStudy

Census with HMOs in the HCIA data. Matches did not occur for a variety of reasons:

financial forms were not available from some states (ie: Hawaii); some national firms

filed the same statement in all states in which they operated; and some forms were

missing for unknown reasons.   We were more likely to have data for independent

practice association (IPA) HMOs than non-IPA HMOs, for federally-qualified HMOs,

and for firms affiliated with a national HMO. We were less likely to have data for HMOs

affiliated with a non-HMO based national firm (ie: insurer) and for firms associated with

Blue Cross Blue Shield. Fifty-two observations for which private enrollment was

identified as being zero were excluded from the final empirical analysis.

County-level data from the Area Resource File were used to construct

demographic and economic market measures. The Health Care Financing Administration

was the source for data on the Adjusted Average Per Capita Cost, and data on

supplemental Medicare insurance policy premiums were obtained from a report issued by

the Families USA Foundation and supplemented through direct correspondence with the

American Association of Retired Persons.

Unit of Analysis

The HMO is the unit of analysis for this study. HMOs frequently operate in

multiple geographic markets and so HMO market measures were developed through a

process consisting of several steps. In the first step, the counties in which the HMO

operates were obtained from InterStudy Censuses (1990 to 1995). Second, in a recent InterStudy survey, HMOs were asked to list enrollment by Metropolitan Statistical Area (MSA). We were able to allocate enrollments to MSAs and use county population weights to allocate enrollment within MSAs that span over more than one county. Residual enrollment not included in these MSAs was allocated over the counties served by the HMO that are not in MSA counties where the HMO allocated enrollment. In the third step, market characteristics (e.g., input prices) were created for each HMO, using a weighted average of the county-level variables over all counties where the HMO operates. Weights were calculated as the HMO's estimated enrollment in a county divided by its total enrollment over all counties it serves. For example, if an HMO operates in two counties with enrollments of 10,000 and 30,000, and the average nurse wage rate is $12 and $16 respectively, then the nurse wage rate for the HMO market is [(1/4)*12+(3/4)*16] = $15 (Wholey et al, 1995).

Variables

As stated in the theoretical section, firms choose the quantity of the private product and level of quality for the Medicare product in order to maximize profits. While we do not have any empirical measures for quality, a firm's quantity of Medicare enrollees is a function of quality, and is observable. The product that an HMO produces is defined as a member month of health care coverage, with the private and Medicare quantities denoted as Q_p and Q_m, respectively. We use the AAPCC county base rate for the aged as our measure of the Medicare price.

Factors affecting Medicare demand (δ):

We control for differences in the demographic composition of markets by including the proportion of the population 65 to 74 years of age and the proportion 75 years of age and older.   Approximately 70% of beneficiaries purchase supplemental Medicare (Medigap) insurance to cover services not included in the traditional Medicare benefits package, as well as out-of-pocket costs, such as co-insurance and deductibles (Zarabozo and LeMasurier, 1995).   An HMO Medicare product frequently includes a set of benefits that are comparable to a combination of traditional Medicare and a supplemental Medicare policy. In markets where Medigap premiums are high, an HMO Medicare product may be perceived as an attractive substitute.   In 1992, supplemental Medicare insurers were required by federal law to limit their selection of policies to ten standardized packages (National Association of Insurance Commissioners, 1996). We use annual premiums for AARP/Prudential supplemental Medicare insurance (Package A) to proxy for the price of a supplemental Medicare policy (Dallek, 1996; Smolka, 1996).[9,10]   To deal with missing premium data, we construct an indicator variable that takes on a value of one if the premium data is missing and sets the Medigap premium to zero.[11]

Factors affecting private demand (γ):

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[9]   Package A includes coverage for the Medicare Part A coinsurance amount for the 61st-90th day of hospitalization; coverage for the Part A coinsurance amount for each of the 60 non-renewable lifetime hospital inpatient reserve days; coverage for 100% of the Medicare Part A eligible hospital expenses; coverage for three pints of blood; and coverage for the coinsurance amount for Part B services after the $100 deductible has been met (National Association of Insurance Commissioners, 1996).

[10] AARP/Prudential uses a community rating method to calculate premiums, which means that it does not charge differentiated prices based on age, health status, or geographic location within a state. We acknowledge that endogeneity issues may be present if HMOs in the market experience favorable selection, leading to a costlier traditional Medicare population on which supplemental Medicare insurance premiums are calculated.

[11] See Greene (1993) for a discussion of this technique.   Most of the missing premium data come from Massachusetts, Minnesota, and Wisconsin, which all received waivers for alternative simplification plans prior to 1990.

To capture the effect of income on private demand, we use the percentage of families below the poverty level. If the freedom to choose one's physician in the fee-for-service sector is a normal good, then there should be a positive relationship between poverty and demand for an HMO's private product. Second, we include the annual rate of change in the population under 65 years of age to proxy for the migration of younger persons into market areas served by HMOs. Third, we include the proportion of the population, 25 years of age and older, that has obtained at least a four-year college degree. Fourth, we include the proportion of active physicians in the market who are pediatricians, which should proxy for the prevalence of pediatric services provided in a market. Here, we assume that pediatricians' services are an input to the production of coverage for the private population only. [12] Finally, we include a set of indicator variables pertaining to the state regulatory environment for HMOs. These measures cover such issues as whether subscribers have a policy-making role, whether employers are required to offer an HMO option for their employees' health coverage, whether HMO rates must have state approval, and whether HMOs are required to have an open enrollment period.[13]

Factors affecting HMO cost structure (COST):

While we do not observe empirical measures to differentiate among the cost parameters, we do employ a set of measures to capture various input prices. Nurse and administrative wage rates from the fee-for-service sector will be used to measure labor costs, based on the assumption that these measures are highly correlated with an HMO's

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[12] Note that while we considered including measures of HMO competition and market penetration for the private enrollee population, we chose not to because of endogeneity issues.
[13] To deal with missing regulations data, we again adopt the indicator variable technique discussed in Greene (1993).

corresponding labor costs. Hospital inpatient price per diem and the price of an office

visit of intermediate complexity are both measures from the fee-for-service sector which

should also be highly correlated with input prices faced by HMOs. To control for

differences in health status across markets, we use an average infant mortality measure.

We expect that in markets where the population is less healthy, there will be higher

utilization of services, resulting in higher costs to an HMO. Finally, federal qualification

may be considered to lower an HMO's fixed cost of offering a Medicare product, since

those HMOs that are federally qualified have already incurred some of the administrative

costs associated with entering a risk contract.

HMO characteristics affecting both demand and costs:

An HMO's age may be an indicator of the acceptance of the HMO concept in a

market. Also, over time, HMOs may gain experience and organizational knowledge in

the provision of care, leading to more efficient production. Ownership (for-profit or non-

profit status) may also affect both demand and cost. Debate continues regarding the role

of for-profit organizations in health care, with some considering profit-seeking behavior

as inappropriate for this industry (Hansmann, 1987). With regard to costs, it is plausible

that the profit motivation may lead managers of for-profit institutions to place greater

emphasis on cost minimization in production. However, an alternative demand-side

argument suggests that individuals frequently associate not-for-profit HMOs with higher

quality of care, and thus may be more likely to enroll in a not-for-profit, than a for-profit

HMO (Wholey et al, 1995). Additionally, HMO model type may suggest differing

production technologies, leading to differing abilities to contain costs. The relationship

between model type and an HMO's physician panel may also influence demand. A set of

dummy variables are included to control for HMO model type (staff, group, network, and mixed, with IPA as the excluded variable) (Wholey et al, 1996).   We also include indicator variables for whether a firm is affiliated with a national HMO, a national insurer that is not an HMO, or Blue Cross Blue Shield. Affiliations with these institutions may affect a firm's access to capital and organizing expertise, which may in turn, affect its production decision. Finally, we include a set of dummy variables for each year in our sample (1990 as the excluded variable) to capture time trends.

IV. Econometric Specification

We estimate a two-part econometric model for this analysis. In the first part, we focus on an HMO's decision regarding its participation in the Medicare risk market. As discussed in Section II, the decision to offer a Medicare product is modeled as the following:

$$\text{Prob}(OFFER = 1) = \beta_1 + \beta_2 P_m + X_m \beta_3 + X_p \beta_4 + (COST)\beta_5 + \varepsilon_1. \tag{10}$$

With repeated observations on the same set of cross-section units, we are concerned about the presence of unobserved HMO-specific effects. We estimate the participation regression as a probit within a generalized estimating equations framework, additionally using a Huber/White/sandwich estimator of variance that allows for within HMO group correlation and heteroscedasticity across HMOs.[14]   Table 6 reports the results for this regression.

The second part of the model focuses on the factors that determine HMO enrollment in both the Medicare and private products. The enrollment equations to be estimated are specified as:

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[14] See Appendix 3 for additional discussion of econometric estimation methods.

$$Q_m = \alpha_1 + \alpha_2 P_m + X_m \alpha_3 + (COST)\alpha_4 + \alpha_5 Q_p + \varepsilon_2 \tag{11}$$

$$Q_p = \omega_1 + \omega_2 P_m + X_p \omega_3 + (COST)\omega_4 + \omega_5 Q_m + \omega_6 (OFFER) + \varepsilon_3. \tag{12}$$

Equation (11) is estimated only for firms that participate in the Medicare market, while equation (12) is estimated for all firms in the sample.[15, 16]

We encounter two estimation issues, which include the simultaneity of Q_p and Q_m, and the presence of unobserved HMO-specific effects. Instrumental variables estimation is used to deal with the simultaneity of our enrollment measures. To instrument for an HMO's private enrollment, we use our private demand shifters. The rate of change in the population under 65 years of age reflects the potential growth of the market for an HMO's commercial product and should be exogenous with respect to a firm's Medicare enrollment. Second, we use the percentage of poor families, asserting that this measure reflects the income of the non-Medicare beneficiary population. The ratio of pediatricians to active medical doctors is also used, since this measure should reflect the potential market demand for pediatric services, which should be used predominantly by an HMO's commercial enrollees. Finally, indicator variables capturing an HMO's regulatory environment as well as the proportion of the population who have four or more years of college are also used as private enrollment instruments.

To instrument for an HMO's Medicare quantity, we use the AAPCC rate, supplemental Medicare insurance premiums, and our two demographic measures which capture the proportion of the population ages 65 to 74 and the proportion 75 years and

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[15] We include both OFFER and the Medicare quantity in the private quantity equation because we consider the decision whether to offer and how much to offer to capture a joint outcome. In estimating the Medicare enrollment regression, we use the predicted value for OFFER.

older.[17,18] These factors should all serve to influence HMO Medicare enrollment, but not directly affect an HMO's commercial enrollment. To obtain consistent estimates of our standard errors, we again use the Huber/White/sandwich estimator of variance.[19]

By estimating this model as two separate parts, we have not considered the issue of selection, whereby HMOs choose whether or not to offer a Medicare product. In taking this approach, our inferences may be applicable to only those HMOs in the sample. Given the possibility of selection issues, we also adopt the conventional approach in the literature and estimate the Medicare enrollment regression with an inverse Mill's ratio measure (lambda), constructed using predicted values from the participation regression.[20]   Both specifications are reported in Table 7.

V. Results and Discussion

Tables 4 and 5 provide definitions and descriptive statistics of the measures used in this analysis. Missing values for 75 observations reduce the sample size to 2437. We use all observations to estimate equations (1) and (3). For equation (2), we use only those observations which have positive Medicare enrollment (N=490).

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[16] We also estimate the model using various transformations of the enrollment measures, including the natural log and the square-root of private and Medicare quantities. The results are qualitatively similar and the linear model was chosen based on fit.

[17] One issue regarding the use of the AAPCC and Medigap variables as instruments is that that they reflect general health care costs and health status of the population in a market. It is unclear if expenditure growth patterns for the Medicare and private populations are the same. In fact, for the time period of the study, Medicare expenditures were growing significantly faster than private personal health care expenditures (HCFA Statistical Supplement, 1996). Nor is it clear that health status for the under 65 and Medicare eligible populations are highly correlated in a given market.

[18]   To examine the "quality" of our instruments, we separately ran regressions of our enrollment quantities on all predetermined variables in the system and then performed joint F-tests on the instruments.   In both regressions, the instruments were jointly significant at the 1% level. See Staiger and Stock, 1997.

[19] See Appendix 3 for an explanation of the Huber/White/sandwich variance estimator.

[20] We specify federal qualification of an HMO to affect the decision to offer a Medicare product, but not to affect enrollment. This specification enables identification to be based on something in addition to functional form assumptions.

Table 6 reports our results from the participation regression, which are generally consistent with theoretical predictions. Most notably, we obtain a positive and significant coefficient on the AAPCC measure. In our sample, the average AAPCC payment rate is $349. Using our estimates, we calculate the average impact of a $35 increase in the AAPCC increases the probability that an HMO offers a Medicare product by .028.[21] Additionally, the elasticity of the probability of entry with respect to the AAPCC payment rate (evaluated at the mean) is equal to 1.39, suggesting a large behavioral response by HMOs.

Finding this response suggests that the payment rate, which is set to reflect the predicted costs of providing coverage to beneficiaries, does a poor job of adjusting for differences in risk between beneficiaries in traditional Medicare and those who enroll in HMOs. Since the AAPCC rate is constructed to correspond to HMOs earning zero economic profits in the Medicare market, cross-sectional differences in its value should not be associated with differential entry. However, finding this effect indicates that areas with higher AAPCC rates are more profitable, and thus cost differences have not been accurately adjusted.

Second, the proportion of the population 65 to 74 years of age and 75 years and older, are statistically significant with positive and negative coefficient signs, respectively. This suggests that the demographic composition of the Medicare population affects an HMO's participation decision in a way that is consistent with favorable

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[21] The average predicted probability for our sample is .198. We find the effect of the AAPCC on an HMO's probability of entry to be smaller in magnitude as compared with the findings of Adamache and Rossiter (1986) and Porell and Wallack (1990).

selection.[22]   We also find that as the rate of change in the under 65 population increases, which shifts demand for an HMO's private product, this decreases the probability of an HMO offering a Medicare product. Finally, HMOs that have federal qualification, affiliation with a national HMO organization, and are older are associated with an increased probability of Medicare market participation.

Table 7 reports our results from estimation of the enrollment regressions.[23] We find that the results for the Medicare enrollment regression do not change substantially when the selection correction is included, and that the estimate on the inverse Mill's ratio is statistically insignificant. In both the private and Medicare enrollment regressions the coefficients on the instrumented enrollment measures are positive and statistically significant, suggesting complementarities in the joint production of a firm's private and Medicare products. Given the particular model specification, we are unable to empirically distinguish between demand and cost complementarities. [24]

With respect to the AAPCC payment rate, we find that it has no significant effect on Medicare enrollment. Two possible interpretations suggest that either the coefficient estimate is so imprecisely estimated that we simply can't discern an effect or that the coefficient is truly zero, which is consistent with the demand constrained case. In contrast, we find a positive and significant effect of the price of a supplemental Medicare insurance policy on Medicare enrollment. This is consistent with the argument that as supplemental Medicare premiums increase, beneficiaries are likely to consider enrollment

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[22] We are cautious in this assertion since this result may be partially due to the fact that the AAPCC payment measure used in this analysis is not specifically adjusted to reflect the actual demographic composition of enrollees that an HMO would face.

[23] The standard errors for the Medicare enrollment regression estimated with the selection correction term will not be exactly correct, since we are using a predicted value of lambda in the specification.

in an HMO as a substitute for the combination of traditional Medicare and a supplemental policy.

Relating our empirical results back to our theory, we refer back to the predictions outlined in Table 3. First, we cautiously conclude that HMO behavior is consistent with the demand constrained case, given our insignificant effect on a change in the Medicare price on Medicare enrollment ($\alpha_2=0$). Second, we find support for the presence of complementarities in production. We find positive and significant relationship between a firm's private and Medicare quantities in the enrollment regressions, which suggests either demand or cost complementarities ($\alpha_5>0$, $\omega_5=0$). Additionally, we find a positive effect of the Medicare price on private quantity, however, because of the imprecision with which the coefficient is estimated, it provides only marginal support.

Policy Implications

Participation by coordinated care organizations, beneficiary enrollment, and a payment methodology that yields savings to Medicare, are three key implementation objectives for Medicare+Choice. Under this new program, the methodology used to calculate payments to contracting organizations has changed. In an effort to induce entry into the Medicare market, one modification in payment policy includes the establishment of a minimum payment level to organizations located in markets which historically have experienced low AAPCC payment rates.

To assess the effect of implementing such a policy, we compute a set of predicted probabilities of entry into the Medicare market for a subset of HMOs that reflect the characteristics of the target group affected by the minimum payment policy.

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[24] The studies of Wholey et al (1996) and Given (1996), find the presence of diseconomies of scope in the joint production of private and Medicare products. This suggests our results may be due to demand

Specifically, our subset consists of HMOs that do not offer a Medicare product and that have AAPCC payments less than the Medicare+Choice minimum payment level.[25] Using our probit results, we compute a set of predicted probabilities of entry into the Medicare market for the minimum, median, and maximum payment rates associated with this group, with all other regressors held at the sample mean. These results are found in Table 8. While the predicted probabilities for this set of HMOs are low, ranging from .0785 to .1373, increasing the payment rate from the minimum in the sample to the designated Medicare+Choice minimum payment rate increases the predicted probability of entry by almost 75%.

Using the payment rate for the purpose of inducing entry raises two additional issues. First, adopting such a policy may lead to the payment of rents to incumbent HMOs who are already operating in markets for which the minimum payment rate applies. Second, there may be factors other than the payment rate which deter entry by firms. Such issues may include a scarcity of potential enrollees or lack of negotiating power with providers (Serrato et al, 1995). Given the low probability of entry, these results further suggest that some of the new alternatives under Medicare+Choice (e.g., medical savings accounts) may be more successful in these areas relative to HMOs, perhaps due to lower fixed costs of entry.

Rather than using the payment rate to induce entry, an alternative policy tool would be for the government to individually subsidize the sunk costs of entry for organizations operating in markets with little or no program participation. Without having estimated the parameters of the cost function, we are unable to directly calculate

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complementarities.

firms' sunk costs using the entry condition identified in Section II. However, using data

from 1995, we calculate an approximation of the upper bound on sunk costs for entry into

the Medicare market under three hypothesized profit rates. Since variable profits must

exceed sunk costs for a firm to enter, an estimate of variable profits serves as an upper

bound on sunk costs. We calculate variable profits as $P_m \cdot Q_m \cdot \phi$, where ϕ is equal to the

profit per dollar of revenue. We simulate this for various values of ϕ.

For this exercise, we subdivide the group of new entrants into three geographic

regions (West, Central, and East), and select the firm with the largest Medicare

enrollment in its first year of participation. Choosing the largest new entrant allows us to

get an upper bound on the sunk costs in each of the regions, presuming that sunk costs are

not decreasing in size. Table 9 reports the estimated sunk costs of entry for each firm

under values of ϕ equal to .05, .1, and .2 and a calculation of the sunk cost per member

month. With direct information on ϕ, one could then compare the actual cost of using the

payment rate per beneficiary as a method for inducing plan participation versus direct

subsidization of sunk costs.

A final, broader policy implication stems from the complementarities result.

Finding empirical support for the presence of demand and/or cost linkages across a firm's

private and Medicare markets has important ramifications for policy design and

evaluation. First, it suggests that federal policies for this program should take account of

firms' private market activities when designing Medicare policy related to participation

and enrollment. For example, in locations where there is significant growth in

commercial enrollment, Medicare could decrease payment rates to contracting firms,

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[25] We first deflated the 1998 minimum payment level of $367 to 1995 dollars before selecting our subset of

without inducing exit, if indeed there are complementarities which serve to partially offset the shock. Second, with respect to policy evaluation, if there are linkages between these markets, then it becomes increasingly difficult to isolate the effect of a policy intervention on Medicare market activity (e.g., growth in HMO Medicare enrollment) from changes that result simply due to a firm's commercial market activities.

Concluding Remarks

In this paper we have developed a model of HMO behavior to examine both participation in the Medicare market and HMO Medicare enrollment.   We estimate a two part model using data from HMOs in the United States over the time period of 1990 to 1995, and obtain results that are generally consistent with our theoretical predictions. Three primary conclusions can be drawn from this research. First, we find evidence to support the assertion that changes in the payment rate may have direct implications for participation by firms in the Medicare market. While the specific payment methodology has been revised with the institution of Medicare+Choice, we believe that the effect of changes in payment will continue to have a significant effect on participation by coordinated care plans.   Second, while enrollment by Medicare beneficiaries is dependent on plan participation, it is also a function of the set of insurance alternatives available to beneficiaries, such as the combination of traditional Medicare and supplemental insurance policies. By broadening the set of coverage choices available to beneficiaries, this may subsequently introduce additional issues for regulators with respect to competitive behavior by contracting plans. Third, we find empirical evidence in support of a linkage between a firm's private and Medicare products, giving rise to additional concerns regarding policy design and evaluation. As HCFA makes the

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HMOs. In 1995 dollars, this value equals $341.

transition and expands from its risk-contracting program to Medicare+Choice, it is

worthwhile to recognize and integrate lessons learned under TEFRA, specifically

regarding how payment rates and beneficiary options impact implementation strategies

and design of future Medicare policy.

Table 1: HMO Medicare market activity

Year	*Entry*	*Exit*	**Continuing**	**Total Offer**
1990	Not available	Not available	Not available	66
1991	15	20	46	61
1992	32	10	51	83
1993	12	18	65	77
1994	34	14	63	97
1995	25	8	89	114

Table 2: Cases

Case	*Regime*	*HMO behavior*
I	$\lambda>0, \rho=0, \sigma=0$	HMO does not participate in Medicare market
II	$\lambda=0, \rho>0, \sigma=0$	HMO participates in both markets and 50/50 constraint binds
III	$\lambda=0, \rho=0, \sigma>0$	HMO participates in both markets and is constrained by demand
IV	$\lambda=0, \rho=0, \sigma=0$	HMO participates in both markets and is unconstrained

Note: λ, ρ, σ are Lagrange multipliers on constraints (1), (2), and (3), respectively, from the optimization problem.

Table 3: Predicted effects

	Demand constrained (Case III)	**Unconstrained (Case IV)**	**Complementarities in production**	**No complementarities in production**
Predicted parameter estimates	$\alpha_2=0$	$\alpha_2>0$	$\alpha_5>0$ $\omega_2>0$ $\omega_5>0$	$\alpha_5=0$ $\omega_2=0$ $\omega_5=0$

Table 4: Variable Definitions

Variable	Definition
Offer Medicare	Indicator variable =1 if HMO offers a Medicare risk product, 0 otherwise
Medicare member months	Member month of health insurance coverage for a Medicare enrollee (in 10000s)
Private member months	Member month of health insurance coverage for a private, commercial enrollee (in 10000s)
AAPCC	Adjusted average per capita cost base rate (in hundreds of dollars)
Medigap	Annual premium for AARP/Prudential Medigap policy Package A (in hundreds of dollars)
Gapmiss	Indicator variable for missing Medigap premium data
Proportion 65-74	Proportion of population 65 to 74 years of age
Proportion 75 and older	Proportion of population 75 to 84 years of age
% of families in poverty	Percentage of families below the poverty level
Young population change	Estimated rate of change in population under 65 years of age
College	Percentage of persons age 25 and older with four or more years of college
Pediatrician to active MD ratio	Proportion of active physicians who are pediatricians
Subscriber policy-making	Subscribers maintain policy-making role
HMO required option	Employers must offer an HMO option in their employees' health benefits package
Rate approval	State approval for HMO premium rates
Open enrollment	HMOs required to have an open enrollment period
Missing regulation measures	Indicator variable for missing regulatory data
Physician charges	Average fee for office visit of intermediate complexity (in hundreds of dollars)
Nurse wage rate	Average nurse wage rate
Supervisor wage rate	Average supervisor wage rate
Per diem hospital rate	Average hospital per diem rate (in hundreds of dollars)
Infant mortality	5 year average (1988-92) infant mortality rate

Table 4: Variable Definitions (continued)

Variable	Definition
Federal qualification	Indicator variable=1 if HMO is federally qualified, 0 otherwise
Age	Average age of HMOs in market
Staff HMO	Indicator variable =1 if HMO is a staff model, 0 otherwise
Network HMO	Indicator variable = 1 if HMO is a network model, 0 otherwise
Group HMO	Indicator variable = 1 if HMO is a group model, 0 otherwise
Mixed HMO	Indicator variable =1 if HMO is a mixed model, 0 otherwise
National affiliation – HMO	Indicator variable =1 if HMO is affiliated with a national HMO firm, 0 otherwise
National affiliation - Other	Indicator variable =1 if HMO is affiliated with a national non-HMO firm (ie: insurer), 0 otherwise
Blue Cross affiliation	Indicator variable = 1 if HMO is affiliated with Blue Cross Blue Shield, 0 otherwise
Profit status	Indicator variable = 1 if HMO is has for-profit status, 0 otherwise
1990 Indicator	Indicator variable =1 if year is 1990, 0 otherwise
1991 Indicator	Indicator variable = 1 if year is 1991, 0 otherwise
1992 Indicator	Indicator variable = 1 if year is 1992, 0 otherwise
1993 Indicator	Indicator variable = 1 if year is 1993, 0 otherwise
1994 Indicator	Indicator variable = 1 if year is 1994, 0 otherwise
1995 Indicator	Indicator variable = 1 if year is 1995, 0 otherwise

Table 5: Descriptive Statistics

Variable	Mean	Standard Deviation
Offer Medicare	.197	.398
Medicare member months (10000s)	5.477	34.199
Private member months (10000s)	98.215	294.45
AAPCC (100s)	3.49	.754
Medigap (100s)	3.07	2.099
Gapmiss	.273	.445
Proportion 65-74	.069	.012
Proportion 75 and older	.05	.011
% of families in poverty	8.98	3.005
Young population change	-.015	.023
College	22.19	4.54
Pediatrician to active MD ratio	.068	.011
Subscriber policy-making	.616	.486
HMO required option	.23	.421
Rate approval	.783	.412
Open enrollment	.298	.457
Missing regulations	.086	.28
Physician charges (100s)	.474	.103
Nurse wage rate	16.28	1.66
Supervisor wage rate	11.63	1.92
Per diem hospital rate (100s)	7.31	1.58
Infant mortality	9.218	1.46
Federal qualification	.541	.498
Age	9.91	7.53
Staff HMO	.062	.241
Network HMO	.1	.3
Group HMO	.087	.282
Mixed HMO	.129	.336
IPA HMO	.62	.485
National affiliation - HMO	.16	.366
National affiliation - Other	.304	.46
Blue Cross affiliation	.151	.358
Profit status	.683	.465
1990 Indicator	.192	.394
1991 Indicator	.164	.371
1992 Indicator	.165	.372
1993 Indicator	.16	.366
1994 Indicator	.152	.359
1995 Indicator	.166	.372
N = 2512		

Table 6: Participation regression

Dependent variable: Offer Medicare	Parameter estimate	Standard error	Standard error with clustering
Constant	-1.61	1.011	1.07
AAPCC	.358***	.101	.112
Medigap	.0405	.045	.050
Gapmiss	-.336	.272	.272
Proportion 65-74	37.417***	10.87	11.74
Proportion 75 and older	-32.42*** (**)	12.04	12.83
Percentage of families in poverty	-.0102	.0223	.025
Young population change	-3.843* (insig.)	2.019	2.64
College	.0213	.0167	.018
Pediatrician to active MD ratio	-.062	5.32	5.21
Subscriber policy-making	.168	.123	.127
HMO required option	-.188	.151	.169
Open enrollment	-.02	.132	.147
Rate approval	-.057	.175	.215
Missing regulatory observations	-.1969	.196	.271
Physician charges	.294	.947	.957
Nurse wage rate	-.091**	.0369	.041
Supervisor wage rate	-.0137	.0181	.019
Per diem hospital rate	-.015	.0327	.034
Infant mortality	-.1207***	.044	.045
Federal qualification	.4734***	.0969	.105
Age	.0395***	.0073	.008
Staff HMO	.306* (insig)	.173	.192
Network HMO	.247*	.135	.144
Group HMO	.326**	.162	.149
Mixed HMO	.3949***	.106	.121
National affiliation – HMO	.431***	.129	.130
National affiliation – Other	.1	.116	.135
Blue Cross Blue Shield affiliation	-.047	.149	.148
Profit status	.051	.124	.139
1991 indicator	-.409*	.241	.214
1992 indicator	-.258	.272	.259
1993 indicator	-.428* (insig)	.281	.274
1994 indicator	-.314	.292	.290
1995 indicator	-.341	.3101	.316
N=2437			

*   Significant at the 10% level   **   Significant at the 5% level   *** Significant at the 1% level
Notation in parentheses indicates significance using the standard error with clustering

Table 7: Quantity regressions

	Dependent variable: Medicare quantity (no selection correction)		Dependent variable: Medicare quantity		Dependent variable: Private quantity	
	Parameter Estimate	Robust Standard Error	Parameter Estimate	Robust Standard error	Parameter Estimate	Robust Standard error
Offer Medicare	…..	…..	.....	.....	-93.112	319.502
Medicare member months	…..	…..	.....	.....	6.524*	3.968
Private member months	.117***	.033	.1239***	.0398	…..	…..
AAPCC	-2.39	6.64	.714	8.69	3.463	19.792
Medigap	6.67**	2.81	7.278**	3.395	…..	…..
Gapmiss	24.19	17.17	21.02	17.497	…..	…..
Proportion 65-74	897.18	771.62	1317.67	994.8	…..	…..
Proportion 75 and older	-478.22	625.47	-885.65	1014.66	…..	…..
% Families in poverty	…..	…..	.....	.....	-.466	4.065
Young population change	…..	…..	.....	......	650.03**	327.427
College	…..	…..	.....	......	2.497	2.477
Pediatrician to active MD ratio	…..	…..	.....	......	847.24	611.14
Subscriber policy-making	…..	…..	.....	......	25.208	30.116
Required HMO option	…..	…..	......	......	2.168	13.207
Rate approval	…..	…..	......	......	-43.563	35.225
Open enrollment	…..	…..	......	......	1.164	19.804
Missing regulations	…..	…..	......	......	-51.751	36.099
Physician charges	69.77	71.97	80.55	83.62	-70.678	104.389
Nurse wage rate	-5.59*	3.19	-7.18	4.79	5.013	4.751
Supervisor wage rate	.044	1.15	.2945	1.37	1.363	3.333
Per diem hospital rate	-.138	2.30	.219	2.24	-2.657	5.111
Infant mortality	-2.60	2.43	-4.203	3.478	-4.969	7.875
Age	-.034	.704	.18	.786	5.443*	3.301
Staff HMO	.648	10.81	5.773	16.943	-51.139	37.242
Network HMO	18.63	13.75	22.855	16.616	-37.349**	16.809
Group HMO	-24.99*	14.06	-21.616*	13.747	58.338*	33.677
Mixed HMO	13.20	13.60	18.01	18.78	9.838	49.793
National affiliation - HMO	18.37	12.37	21.046	14.24	17.587	37.005
National affiliation - Other	2.01	8.32	1.845	8.65	13.372	19.001
Blue Cross Blue Shield affiliation	-14.94	14.12	-16.21	14.22	27.454	25.531
Profit status	1.823	5.154	2.526	5.99	-13.202	14.151
1991 indicator	-4.43	13.55	-9.003	17.73	2.467	5.725
1992 indicator	-2.09	17.59	-4.943	19.95	1.775	14.949
1993 indicator	-7.024	16.67	-11.33	20.786	20.456	14.382
1994 indicator	-6.07	16.90	-8.947	19.461	19.912	18.022
1995 indicator	-12.81	17.84	-15.606	20.44	43.313	25.05*
Lambda	…..	…..	14.41	28.48	…..	…..
Constant	20.47	52.96	6.56	59.24	-75.525	79.208
Number of observations	490		490		2437	
F-statistic	F(25,168)=2.92 Prob > F = .0000		F(26, 168) = 2.28 Prob > F = .0009		F(31, 562) = 3.39 Prob > F = .00000	

* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Table 8: Predicted Probabilities for HMO subsample (N=84)

AAPCC Payment Rate	*Designation*	*Predicted Probability*
$251	Minimum	.0785
$300	Median	.1075
$341*	Maximum	.1373

*1998 Medicare+Choice minimum payment level deflated to 1995 dollars.

Table 9: Sunk Costs of Entry Estimates

Geographic Region	Medicare member months	Medicare price	Profit per dollar of revenue	Estimated sunk costs of entry	Sunk cost per member month
West	46578	$381	.05	$ 887,387	$19.05
			.10	1,774,621	38.10
			.20	3,549,243	76.20
Central	115213	$409	.05	$2,356,105	$20.45
			.10	4,712,211	40.90
			.20	9,424,423	81.80
East	83825	$481	.05	$2,015,991	$24.05
			.10	4,031,982	48.10
			.20	8,063,965	96.20

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Appendix

Maximization Problem and Comparative Statics

Profit-maximization problem

$$Max\ \pi = P_pQ_p + P_mQ_m - C_1Q_m - C_2Q_p - C_3Q_mQ_p - C_4Q_m{}^2 - C_5Q_p{}^2 - C_6zQ_m - C_7z - C_8z^2$$

Qp, z

subject to:

$(1) Q_m \geq 0$

$(2) Q_p - Q_m \geq 0$

$(3) Q_{mR} - Q_m \geq 0$

To solve this constrained optimization problem, we set up a Lagrangian expression:

$$L = P_pQ_p + P_mQ_m - C_1Q_m - C_2Q_p - C_3Q_pQ_m - C_4Q_m{}^2 - C_5Q_p{}^2 - C_6zQ_m - C_7z - C_8z^2 + \lambda Q_m$$
$$+ \rho(Q_p - Q_m) + \sigma(Q_{mR} - Q_m) = 0$$

Taking the first order conditions:

(1)

$$\frac{\partial L}{\partial Q_p} = P_p + Q_p\left[\frac{\partial P_p}{\partial Q_p} + \frac{\partial P_p}{\partial Q_m} \cdot \frac{\partial Q_m}{\partial Q_p}\right] + P_m\frac{\partial Q_m}{\partial Q_p} - C_1\frac{\partial Q_m}{\partial Q_p} - C_2 - C_3\left[Q_m + Q_p\frac{\partial Q_m}{\partial Q_p}\right] - 2C_4\frac{\partial Q_m}{\partial Q_p} - 2C_5Q_p$$

$$- C_6z\frac{\partial Q_m}{\partial Q_p} + \lambda\frac{\partial Q_m}{\partial Q_p} + \rho\left(1 - \frac{\partial Q_m}{\partial Q_p}\right) + \sigma\left(\frac{\partial Q_{mR}}{\partial Q_p} - \frac{\partial Q_m}{\partial Q_p}\right) = 0$$

(2)

$$\frac{\partial L}{\partial z} = Q_p\left[\frac{\partial P_p}{\partial Q_m} \cdot \frac{\partial Q_m}{\partial z}\right] + P_m\frac{\partial Q_m}{\partial z} - C_1\frac{\partial Q_m}{\partial z} - C_3Q_p\frac{\partial Q_m}{\partial z} - 2C_4Q_m\frac{\partial Q_m}{\partial z} - C_6\left[z\frac{\partial Q_m}{\partial z} + Q_m\right]$$

$$- C_7 - 2C_8z + \lambda\frac{\partial Q_m}{\partial z} - \rho\frac{\partial Q_m}{\partial z} - \sigma\frac{\partial Q_m}{\partial z} = 0$$

(3) $\frac{\partial L}{\partial \lambda} = Q_m \geq 0$

(4) $\frac{\partial L}{\partial \rho} = Q_p - Q_m \geq 0$

(5) $\quad \dfrac{\partial L}{\partial \sigma} = Q_{mR} - Q_m \geq 0$

(6) $\quad \lambda Q_m = 0$

(7) $\quad \rho(Q_p - Q_m) = 0$

(8) $\quad \sigma(Q_R - Q_m) = 0$

$$\dfrac{\partial^2 L}{\partial Q_p^{\,2}} = 2\dfrac{\partial P_p}{\partial Q_p} + \dfrac{\partial P_p}{\partial Q_m} \cdot \dfrac{\partial Q_m}{\partial Q_p} - 2C_5 < 0$$

The second order conditions can be expressed as the following:

$$\dfrac{\partial^2 L}{\partial z^2} = -2C_4\left(\dfrac{\partial Q_m}{\partial z}\right)^2 - 2C_6\dfrac{\partial Q_m}{\partial z} - 2C_8 \quad < 0$$

$$\dfrac{\partial^2 L}{\partial Q_p \partial z} = \dfrac{\partial^2 L}{\partial z \partial Q_p} = \dfrac{\partial P_p}{\partial Q_m} \cdot \dfrac{\partial Q_m}{\partial z} - C_3\dfrac{\partial Q_m}{\partial z} - C_6\dfrac{\partial Q_m}{\partial Q_p} > 0$$

To ensure a maximum, the following criteria must hold:

$$\left(\dfrac{\partial^2 L}{\partial Q_p^{\,2}}\right)\left(\dfrac{\partial^2 L}{\partial z^2}\right) - \left(\dfrac{\partial^2 L}{\partial Q_p \partial z}\right)^2 > 0 \; and \left|\dfrac{\partial^2 L}{\partial Q_p^{\,2}}\right| < 0.$$

Predicted Effects:

Firms are demand-constrained (Case III):

When firms are demand-constrained, an individual firm's Medicare quantity is determined by the constraint. Firms choose the level of quality (z), that corresponds to $Q_m(z, X_m, Q_p) = Q_{mR}(X_m, Q_p)$, such that z is a function of residual market demand, Medicare demand shifters, and private quantity. We proceed by substituting residual market demand for individual firm demand in the profit-maximization problem, taking the first order condition with respect to private quantity, and then determining the predicted effects of the Medicare price and demand shifters on a firm's private and Medicare quantities. Note, here we make the assumption that there are no diseconomies of scope in production.

$$\underset{Q_p}{Max}\; \pi = P_p Q_p + P_m Q_{mR} - C_1 Q_{mR} - C_2 Q_p - C_3 Q_{mR} Q_p - C_4 Q_{mR}^2 - C_5 Q_p^2 - C_6 z Q_{mR} - C_7 z - C_8 z^2$$

First-Order Condition:

$$
\frac{\partial \pi}{\partial Q_p} = P_p + Q_p \left[\frac{\partial P_p}{\partial Q_p} + \frac{\partial P_p}{\partial Q_{mR}} \cdot \frac{\partial Q_{mR}}{\partial Q_p} \right] + P_m \frac{\partial Q_{mR}}{\partial Q_p} - C_1 \frac{\partial Q_{mR}}{\partial Q_p} - C_2 - C_3 \left[Q_{mR} + Q_p \frac{\partial Q_{mR}}{\partial Q_p} \right]
$$

$$
- 2C_4 Q_{mR} \frac{\partial Q_{mR}}{\partial Q_p} - 2C_5 Q_p - C_6 \left[z \frac{\partial Q_{mR}}{\partial Q_p} + Q_{mR} \frac{\partial z}{\partial Q_{mR}} \cdot \frac{\partial Q_{mR}}{\partial Q_p} \right] - C_7 \frac{\partial z}{\partial Q_{mR}} \cdot \frac{\partial Q_{mR}}{\partial Q_p} - 2C_8 z \frac{\partial z}{\partial Q_{mR}} \cdot \frac{\partial Q_{mR}}{\partial Q_p} = 0
$$

Case III (assuming no complementarities):

$$
\frac{\partial Q_p}{\partial P_m} = 0 \quad \frac{\partial Q_m}{\partial P_m} = 0
$$

$$
\frac{\partial Q_p}{\partial X_p} > 0 \quad \frac{\partial Q_m}{\partial X_p} = 0
$$

$$
\frac{\partial Q_p}{\partial X_m} = 0 \quad \frac{\partial Q_m}{\partial X_m} < 0
$$

Firms are unconstrained (Case IV):

Using first-order conditions (1) and (2) from Appendix 1, we form the total differentials and derive the predicted effects below.

Recall:

$$
P_P = \frac{-1}{\theta_1} Q_p + \frac{\theta_0}{\theta_1} + \frac{\theta_2}{\theta_1} X_p + \frac{\theta_3}{\theta_1} Q_m
$$

$$
Q_m = m_1 z + m_2 X_m + m_3 Q_p
$$

(1)

$$d\left[\frac{\partial \pi}{\partial Q_p}\right] = \left(\frac{-2}{\theta_1} + \frac{\theta_2}{\theta_1}m_3 - C_3m_3 - 2C_5\right)dQ_p + \left(\frac{\theta_3}{\theta_1}m_1 - C_3m_1 - C_6m_3\right)dz + m_3dP_m +$$

$$\left(\frac{\theta_3}{\theta_1}m_2 - C_3m_2\right)dX_m + \left(\frac{\theta_2}{\theta_1}\right)dX_p + (1-m_3)d\rho - m_3dC_1 - 1dC_2 - (Q_m + Q_pm_3)dC_3$$

$$-2m_3dC_4 - 2Q_pdC_5 - zm_3dC_6 + 0dC_7 + 0dC_8 + \left(\frac{\partial Q_{mR}}{\partial Q_p} - m_3\right)d\sigma + m_3d\lambda = 0$$

(2)

$$d\left[\frac{\partial \pi}{\partial z}\right] = \left(\frac{\theta_3}{\theta_1}m_1 - C_3m_1 - C_6m_3\right)dQ_p - \left(2(C_4m_1^2 + C_6m_1 + C_8)\right)dz + m_1dP_m + 0dX_p$$

$$\left(-2C_4m_1m_2 - C_6m_2\right)dX_m - m_1dC_1 - 0dC_2 - m_1Q_pdC_3 - 2m_1Q_mdC_4 + 0dC_5$$

$$-\left(m_1z - Q_m\right)dC_6 - 1dC_7 - 2zdC_8 - m_1d\rho - m_1d\sigma = 0$$

Case IV (assuming no demand or cost complementarities):

$$\frac{dQ_p}{dP_m} = 0 \qquad \frac{dQ_m}{dP_m} > 0$$

$$\frac{dQ_p}{dX_m} = 0 \qquad \frac{dQ_m}{dX_m} = ?$$

$$\frac{dQ_p}{dX_p} > 0 \qquad \frac{dQ_m}{dX_p} = 0$$

Econometric Estimation

When one cannot assume that the error terms of observations are independent and identically distributed, then specifying the appropriate probability density function to do maximum likelihood estimation may be very complex. One alternative approach is to specify a quasi-likelihood function, which requires the following two things to occur. First, one needs to be able to specify the relationship between the mean and the variance of the dependent variable. And second, the unknown distribution of the dependent variable must be of the linear exponential family, which includes such distributions as binomial, normal, and Poisson (Gourieroux, Monfort, and Trognon, 1984; McCullagh and Nelder, 1983). Once the quasi-likelihood is specified, then the parameter estimates can be found by solving the corresponding quasi-score functions simultaneously.

For estimation of the participation regression, we use generalized estimating equations (GEE), which is the multivariate analogue of quasi-likelihood estimation. We specify the distribution of the dependent variable as binomial. Furthermore, to address the issue of unobserved firm-specific effects, we specify an exchangeable correlation structure (corresponding to the presence of random effects), and this "working correlation matrix" is also incorporated into the maximization problem. Using this method, we are able to obtain consistent parameter estimates. See Liang and Zeger (1986) and Zeger and Liang (1992) for additional discussion of GEE. For the enrollment equations, parameter estimates are calculated using traditional instrumental variables estimation.

The standard errors for both the participation and enrollment regressions are computed using the method described below, which permits within HMO-cluster correlation and allows for the possibility that residuals across HMO clusters are not identically distributed. Here, a cluster includes all observations over the time period of our sample that correspond to a single HMO.

The Huber/White/sandwich estimator of variance is defined as the following:

$$\upsilon = q_c \hat{V} (\sum_{k=1}^{M} u_k^{(G)}{}' u_k^{(G)}) \hat{V}$$

$$u_k^{(G)} = \sum_{j \in G_k} u_j$$

where:

$G_k \ \ denotes \ \ each \ \ cluster, k = 1,...M$

$\hat{V} = (X'X)^{-1}$

$u_j = (y_j - x_j b)\hat{x}_j \ and \ is \ a \ row \ vector \ of \ scores, where \ j \ denotes \ individual \ observations \ in \ cluster \ \ G_k$

$q_c = \dfrac{N-1}{N-k} \cdot \dfrac{M}{M-1}, N = number \ of \ observations, M = number \ of \ clusters, k = number \ of \ regressors$

Computation of the term in parentheses can be summarized in the following manner. First, the score (u_j) is calculated for each observation within a cluster. Scores are then summed up over the j observations in a cluster, producing a row vector. The outer product is then calculated, which results in a matrix of dimension equal to the number of regressors. One matrix is constructed for each cluster and then these matrices are summed over the clusters in the sample, giving rise to the matrix in parentheses.

By using this method, we have addressed the problem of obtaining consistent standard error estimates given the presence of within-cluster correlation, since we rely only on "between" cluster variation in the computation of this estimator of variance. Additional discussion may be found in the Stata Reference Manual, 1997.

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