Enter at your own risk:
HMO participation and enrollment in the Medicare risk market

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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 AAPCC 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.

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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 outlays reached $180.1 billion dollars, with expected annual growth of ten percent (O'Sullivan and Price, 1996; Wilensky, 1995). To address growing concerns regarding the program's financial condition, a series of market-based reforms have been proposed in Congress, designed to increase beneficiary choice, while controlling costs and encouraging efficient and competitive behavior among health providers and insurers (Oberlander, 1997; Brown et al, 1993).

With the private sector's transition from predominantly fee-for-service health insurance to managed care, the federal government has renewed interest in approaching Medicare cost containment efforts in a similar fashion. In 1985, under the Tax Equity and Fiscal Responsibility Act (TEFRA), formal guidelines were implemented for health maintenance organizations (HMOs) to provide coverage to Medicare beneficiaries by entering into risk contracts with the government.[1] Under the terms of a risk contract, an HMO receives a fixed monthly payment equal to 95% of the Adjusted Average Per Capita Cost (AAPCC), which is an actuarial measure of the average cost of providing care to a beneficiary in the traditional Medicare program. In

[1] HMOs are also permitted to serve Medicare beneficiaries by entering cost contracts, which provide an HMO with a fixed monthly payment to cover the cost of services with the balance adjusted at the end of the contract period to reflect actual costs. Since 1990, there has been a decline in cost contracting activity. We have chosen not to consider cost-contracting in this paper.

return, the HMO is responsible for providing all covered services and takes full financial risk for the actual costs generated.[2]

From an HMO's perspective, there are several factors to be considered when making the decision to offer a Medicare product. Expansion into the Medicare market may require an HMO to incur costs for such things as renovation of its facilities to provide easier access to the elderly population, hiring of additional personnel, expansion of its physician panel, and compliance with federal regulations. Furthermore, the marketing strategy employed by HMOs for a Medicare product is different than for its commercial product, in that the former is marketed at the individual level, while the latter is typically employer-based. In contrast to these additional costs, firms may also consider the potential benefits of expansion into the market, such as production efficiencies.

Also considered is the AAPCC payment rate designated for the counties located in an HMO's service area. Capturing both the price and utilization components of expenditure, higher AAPCC rates reflect either higher input prices, greater utilization of services by the beneficiary population, or both. Therefore, an HMO should also evaluate its ability to influence input prices (e.g., provider contracts) in the market. Furthermore, as reported by the Health Care Financing Administration, high variance exists in the distribution of program payments for traditional Medicare enrollees, with approximately 11% of the beneficiary population responsible for generating 72% of all payments (U.S. Department of Health and Human Services, 1996). Thus,

[2] Additional regulations cap net revenues for risk-contracting HMOs. If an HMO exceeds the limit, then the firm is 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 are prohibited. See (Zarabozo and LeMasurier, 1996) for discussion of TEFRA guidelines.

an HMO should be concerned about the characteristics of those Medicare beneficiaries who seek to enroll in its Medicare plan, as well as what forms of utilization review will be implemented. Finally, firms may also consider such things as the total number of Medicare beneficiaries in the market to ensure that it can enroll a population large enough to spread risk sufficiently, anticipated growth of this population, alternatives that exist relative to its Medicare product, and how well the concept of managed care is understood by the Medicare population in the market (U.S. General Accounting Office, 1997).

In recent years, there has been considerable growth 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, which represents the time period of this study.[3] Effective implementation of the Medicare risk program depends on HMO participation, enrollment by beneficiaries into HMOs, 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 HMOs to participate in the Medicare market and the factors that influence the number of beneficiaries who enroll in these institutions.

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,

[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.

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.

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 theoretical model. A discussion of the data and measures are contained in Section III. Section IV outlines the econometric specification and identifies 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. Theoretical Model

[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.

In this section, we develop a profit-maximization model of HMO behavior. This model examines the relationship between an HMO's production in the commercial enrollee, or private market, and its participation and production in the Medicare market. We define the "private product" to be a comprehensive set of medical benefits offered by an HMO to its commercial enrollee population. If an HMO chooses to enter into a risk contract to offer a "Medicare product," by law this product must consist of a set of medical benefits that are equivalent to, or exceed the level of coverage provided under the traditional Medicare program.

We lay out 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). Finally, we assume that all HMOs produce a positive quantity of the private product and maintain the option to produce in the Medicare market once they have satisfied the eligibility requirements specified by the TEFRA guidelines.

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:

$$Q_p = q_0 - q_1 P_p + q_2 g \qquad (1)$$

where the private quantity demanded is inversely related to the price charged for the private product ($\underline{P_p}$) and positively related to γ, which represents a set of exogenous factors that shift demand for the private product.[5] Assume that an HMO possesses some market power in the private market, maximizing profits by producing at a quantity that equates marginal revenue with marginal cost.

Medicare demand

We consider a Medicare beneficiary's decision regarding his or her health care coverage to be based on a comparison of the expected utility that would be derived under the traditional Medicare program and each HMO Medicare option. We assert that expected utility is a function of the perceived quality of each Medicare product, where quality is broadly defined to include both the "richness" of the benefits package, such as coverage for eyeglasses, hearing aids, routine physical exams, wellness education, and pharmaceuticals (items not covered under traditional Medicare but frequently included in HMO products), and the quality of medical care received, such as the amount of time a physician spends with a Medicare enrollee and the breadth of provider choice.[6]

We specify the "potential" market demand for an HMO's Medicare product to be some function of the demographic composition of the Medicare population in the market, a set of

[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' prices and demands as well as the firm's own demand.

[6] For those HMOs who charge Medicare beneficiaries an additional out-of-pocket premium, one can think of quality (z) as the benefit net of premium. Here, we invoke the envelope theorem and assume that the firm has solved the optimal combination of supplementary benefits and level of premium to be charged.

exogenous factors that shift HMO Medicare market demand (δ). Individual firm demand is some proportion of this "potential" or residual market demand (Q_{mR}) and is therefore constrained to be no greater than it. We specify individual firm demand as the following:

$$Q_m = m_1 z + m_2 d \quad (2)$$

where z represents the quality level of the Medicare product chosen by the firm and δ are exogenous factors shifting HMO Medicare market demand.[7, 8]

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. Federal regulations set the price of the Medicare product (P_m) 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.

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

[8] We also expect that there may be complementarities in demand between the private and Medicare products (e.g., if consumers view private demand as a signal of quality), although we do not model this explicitly.

Cost function

Let the firm face a cost function associated with its production of the private and Medicare products. It is specified as the following:

$$C = C_1 Q_p + C_2 Q_m + C_3 Q_p Q_m + C_4 Q_m^2 + C_5 Q_p^2 + C_6 z Q_m + C_7 z + C_8 z^2$$

The total cost is a function of the private and Medicare quantities, a vector of cost parameters associated with production, 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 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:

$$(P_m - C_2 - C_3 Q_p - 2C_4 Q_m - C_6 z)Q_m - (C_7 z + C_8 z^2) \geq 0 .$$

(4)

Profit-Maximization Problem

For an HMO that participates in both markets, its profit is defined as total revenue generated in both markets, less the cost of producing both products.[9] We assume that HMOs seek to maximize profits.[10] Let the firm's objective function be specified as the following:

$$Max\ p = P_p Q_p + P_m Q_m - C_1 Q_p - C_2 Q_m - C_3 Q_p Q_m - C_4 Q_m^{\ 2} - C_5 Q_p^{\ 2} - C_6 z Q_m - C_7 z - C_8 z^2 \quad \text{Qp, z}$$

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.

[9] For HMOs operating in the private market only, this reverts back to the standard profit-maximization problem for a firm exhibiting some market power.

[10] 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 (output or quality) 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.

Constraint (2) reflects federal guidelines established under TEFRA that require HMOs not to have more than 50% of their total enrollment from Medicare enrollees.[11] Constraint (3) requires that no individual firm's demand for its Medicare product exceed its residual market demand.[12]

Table 2 outlines four possible cases of HMO behavior under various combinations of slack and binding constraints. Case I includes all HMOs that have 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 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

Comparative Statics and Testable Hypotheses

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. As with previous studies, we are interested in evaluating how changes in the Medicare price, demand shifters, and cost shifters affect the probability that an HMO chooses to offer a Medicare risk product. To examine an HMO's decision to offer a

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[11] By law, the 50% constraint, frequently referred to as the 50/50 rule, includes all public enrollees, not just Medicare enrollees. However, for the time period of the sample, the majority of public enrollees are Medicare enrollees. We do acknowledge that for a very small percentage of HMOs in our sample, this constraint binds once we consider all public enrollees.

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

Medicare product, we use information on firms operating under all of the specified cases. Additionally, a set of comparative statics is worked out for Cases III and IV to assess how changes in the Medicare price and factors that shift private and Medicare demand affect an HMO's behavior regarding private enrollment and choice of quality (z), which in turn, determines Medicare enrollment.[13] These predictions are reported in Table 3. The parameter C_3 influences the predicted sign of many comparative statics, and so Table 3 includes predictions under the assumption of economies of scope ($C_3 < 0$) and diseconomies of scope ($C_3 > 0$).[14]

In our empirical analysis, we concentrate on how the AAPCC payment level affects both HMO participation and quality choice, which in turn, determines Medicare enrollment. A second issue examines how the price of a beneficiary's comparable alternative to HMO coverage, specifically the combination of traditional Medicare and a supplemental Medicare insurance policy, affect HMO participation and enrollment. Third, we consider how demand for an HMO's private product influences its activity in the Medicare market. Finally, we address the issue of complementarities in the joint production of private and Medicare products.

For those HMOs that offer a Medicare product, we can use a subset of our comparative statics to distinguish between Cases III and IV. Specifically, we use the combination of predictions about an HMO's choice of quality and hence, its Medicare quantity, given shifts in the Medicare price and in an HMO's private quantity. A graphical representation can be found in Figures 1 and 2. In both sets of graphs, the quantity of the Medicare product is on the horizontal axis and the Medicare price is on the vertical axis. Individual firm demand [Q_m], residual market

[13] Comparative static analysis was not done for Case I, since HMOs in this case do not offer a Medicare product.

[14] See Appendix 2 for a derivation of the comparative statics.

demand [Q_{mR}], and the marginal cost curve for a Medicare product, given an HMO's choice of its private quantity [$MC_m(Qp)$], are also labeled.

The graphs in Figure 1 show the predicted effect of an increase in the Medicare price on an HMO's Medicare quantity. For Case III, this effect is depicted as a movement from point A to point B on the first graph. Notice that for a demand-constrained HMO, an increase in the Medicare price increases marginal revenue, but should not have any corresponding effect on Medicare quantity, since the HMO is already operating on the residual demand curve. For Case IV, the effect is depicted as a movement from point A to point C on the second graph, whereby an increase in the Medicare price should increase both marginal revenue and Medicare quantity.

Figure 2 contains two graphs showing the effect of a change in an HMO's private quantity on its Medicare quantity. Here, the predictions rely heavily on assumptions made about the existence of complementarities in demand. For Case III, an increase in an HMO's private quantity should lead to an increase in its Medicare quantity if there are demand complementarities, or a combination of demand and cost complementarities. This is depicted in the first graph as a movement from point D to point E. In Case IV, increasing an HMO's private quantity should correspond to an increase in the Medicare quantity if there are cost complementarities. This is depicted in the second graph as a movement from point D to point F, where the marginal cost curve for the Medicare product shifts downward when private quantity increases. However, since the residual market demand constraint does not bind in this case, any outward shift in this curve due to complementarities in demand should not directly affect an HMO's Medicare quantity. In what follows, we will revisit these differences in predictions in the discussion section to empirically distinguish between Cases III and IV.

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 codes the data, and sells 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 to construct our measure of the Medicare price.

Factors affecting Medicare demand (d):

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. Empirical evidence suggests that HMOs generally experience favorable selection in enrollment, extending to the Medicare population (Hellinger, 1995; Porell and Turner, 1990). If a positive correlation between age and propensity for illness exists, then HMOs may seek to enroll younger Medicare beneficiaries.

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 (Health Care Financing Administration, 1996). We use annual premiums for AARP/Prudential supplemental Medicare insurance (Package A) to proxy for the price of a supplemental Medicare policy.[15,16] To deal with missing premium data, we use a spline

[15] 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

technique by constructing an indicator variable that takes on a value of one if the premium data is missing and sets the Medigap premium to zero.[17]

Factors affecting private demand (g):

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

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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).

[16] 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.

[17] 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.

provided in a market.[18] 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.[19]

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 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.

[18] 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.

[19] To deal with missing regulations data, we again adopt the spline technique discussed in Greene (1993).

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 impact 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

A three equation selection model is estimated for this analysis. The first equation examines an HMO's decision regarding its participation in the Medicare risk 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 to be estimated:

$$\text{Prob}(OFFER = 1) = b_1 + b_2 P_m + db_3 + gb_4 + (COST)b_5 + e_1 \qquad (5)$$

where the decision by an HMO to offer a Medicare product is a function of a constant, the Medicare price, Medicare demand shifters, private demand shifters, HMO cost shifters (COST), and an error term. The second and third equations of the model examine the factors that determine HMO enrollment in both the Medicare and private markets. We solve for Q_p and Q_m from the first-order conditions (1) and (2) of our constrained maximization problem, and express them as the following:

$$Q_m = a_1 + a_2 P_m + da_3 + (COST)a_4 + a_5 Q_p + e_2$$

(6)

$$Q_p = w_1 + gw_2 + (COST)w_3 + w_4 Q_m + w_5 (OFFER) + e_3.$$

(7)

An HMO's Medicare quantity is a function of the Medicare price, Medicare demand shifters, factors that shift cost, private quantity, and an error term (e_2). A firm's private quantity is a function of private demand shifters, factors that shift cost, Medicare quantity, whether an HMO

offers a Medicare product, and an error term (e_3).[20] Here we have made the assumption that the relationship between HMO enrollment and our exogenous factors is linear.[21]

We identify three econometric issues associated with estimating our model. First, HMOs choose whether or not to offer a Medicare product and we do not observe positive quantities of Medicare enrollment for many HMOs in our sample. Second, Q_p and Q_m are simultaneously determined and endogenous. Including these terms directly in our specification would introduce simultaneity bias and produce inconsistent parameter estimates. The panel structure of the data gives rise to a third estimation issue. With repeated observations on the same set of cross-section units, unobserved HMO-specific effects may affect both the probability that an HMO offers a Medicare product as well as Medicare enrollment.

To address these issues, we proceed with the following estimation strategy. First, we estimate the OFFER equation as a binary probit with random effects, within a generalized estimating equations framework.[22] Since we believe that there may exist unobserved characteristics of an HMO that affect both its participation decision and Medicare enrollment, such that the cov (e_1, e_2) $\neq 0$, we construct the inverse Mill's ratio using predicted values from the OFFER equation, and include this selection correction term as a variable in the estimation of the Medicare quantity equation.

[20] 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.

[21] 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.

We use instrumental variables estimation to deal with the endogeneity of our enrollment measures. We instrument for an HMO's private enrollment by using the following measures: the percentage of poor families, the rate of change in the population under 65 years of age, the proportion of the population who have four or more years of college, the ratio of pediatricians to active medical doctors, and the set of HMO regulatory measures. We also instrument for an HMO's Medicare quantity using the AAPCC rate, supplemental Medicare insurance premiums, the indicator variable for missing Medigap premium data, and our two demographic measures which capture the proportion of the population ages 65 to 74 and the proportion 75 years and older. We have selected these instruments based on the assumption that they are highly correlated with their respective enrollment measures, but uncorrelated with the error term in the other equation.[23]

Finally, all three issues identified above have implications for obtaining consistent estimates of our standard errors. With heteroscedasticity arising from the incidental truncation and panel data, we use White's heteroscedasticity consistent estimator of variance, which permits relaxation of the assumption that the observations are independent.[24] However, while this method produces consistent estimates of our standard errors, they are not efficient.

V. Results and Discussion

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[22] See Liang and Zeger (1986) for discussion of generalized estimating equations.

[23] 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.

[24] See Greene (1997) for 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).

Table 6 reports our results from the OFFER equation, 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 that the average impact of a $35 increase in the AAPCC is to increase the probability that an HMO offers a Medicare product by .028.[25] 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 selection. 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 equations. In the private quantity regression, the coefficient on the rate of change in the under 65 population is positive and statistically significant, which corresponds to a shift in demand for the private product resulting in

[25] 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). From our results, we calculate the elasticity of entry probability with respect to the AAPCC to be equal to 1.39.

an increase in private enrollment. In the Medicare quantity regression, the price of a supplemental Medicare insurance premium (Medigap) is positively associated with Medicare enrollment, which is consistent with the argument that as supplemental Medicare premiums increase, beneficiaries are likely to consider enrollment in an HMO as a substitute for the combination of traditional Medicare and a supplemental policy. Note that while the price of a supplemental Medicare insurance policy directly affects HMO Medicare enrollment, the AAPCC payment does not. In both enrollment regressions the coefficients on the quantity measures in each are positive and statistically significant. We interpret these results to suggest the presence of a linkage between an HMO's production of its private product and its Medicare product.

In relating our empirical results back to theory, we use the combination of comparative static predictions described in Section II to determine which theoretical case most closely corresponds to our empirical findings. As stated above, we find no significant effect of the AAPCC on the Medicare quantity. This result provides support for Case III and the assertion that HMOs are constrained by demand. Second, we find a positive and significant relationship between an HMO's private and Medicare quantities, which is consistent with the presence of complementarities in demand. In the theoretical section we argue that in Case III, any positive relationship between an HMO's private and Medicare quantities must be due to either the presence of demand complementarities or the combination of demand and cost complementarities. While cost complementarities may exist in combination with demand complementarities, we are unable to empirically distinguish between these two types, given our model specification.[26]

[26] 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 complementarities.

VI. Policy Implications

This section identifies potential policy implications regarding the implementation objectives to increase HMO participation and beneficiary enrollment in the Medicare risk program. Specifically, we examine the potential costs of using the AAPCC as the means to achieve these policy goals and propose a set of alternative policy options that are consistent with the empirical findings reported in this paper.

Using the probit results and data from 1995, we find that in order to induce entry of one more HMO in probability, the AAPCC would need to be raised by $4.60 on average. To approximate the increase in expenditure associated with this, we used the following calculation strategy. First, we multiplied $4.60 by the total number of Medicare member months in the United States for 1995. This provides us with the increase in payments to existing Medicare HMOs due to raising the AAPCC. Second, we multiplied $4.60 by the average number of Medicare member months for risk-contracting HMOs to approximate the new entrant's enrollment in terms of member months.[27] Finally, we added these two values together to arrive at a cost of $136.3 million. Dividing this number by the new entrant's anticipated member months yields an increased expenditure per new member month equal to $52.87. Although the actual expense associated with changing the AAPCC depends on the particular geographic level at which the adjustment is made, the point to be recognized is that using a pricing policy by itself to induce entry and thereby increase enrollment may be a costly solution. Specifically, in markets where there are already risk-contracting HMOs, increasing the AAPCC to induce additional firms to

[27] Note, in this calculation we have only considered the incremental increase in the cost for the new member months, rather than the total cost of these new member months.

enter would result in increasing the payment rate to all risk-contracting firms including the new entrants, thereby giving rents to incumbents in the market.

We acknowledge that in markets without any risk-contracting firms using the AAPCC as the policy tool may be an appropriate strategy. However, based on our empirical findings, we argue that a more effective strategy would be to use the AAPCC in geographic markets that exhibit specific characteristics. First, we found evidence to suggest a positive relationship between Medicare enrollment and the price of supplemental Medicare premiums. Using this information, the government could target markets with little or no HMO participation and high supplemental Medicare premiums, and adjust the AAPPC upward in order to encourage entry. Second, our results suggest that the demographic composition of the Medicare population in a market also affects participation. Again, in markets with little or no HMO participation and a high proportion of older beneficiaries (ages 75 and older), one could argue that the AAPCC should also be increased further to encourage entry. Third, in finding support to suggest complementarities in the joint production of an HMO's private and Medicare products, this leads us to recommend that the government target markets with HMOs that have large private enrollment.

Rather than using the AAPCC to induce entry, an alternative policy tool would be for the government to individually subsidize the sunk costs of entry for HMOs operating in markets with little or no Medicare risk program participation. Furthermore, the same criteria described above could be applied to identify such markets. Without having estimated the parameters of the cost function, we are unable to directly calculate 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.

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 8 reports the estimated sunk costs of entry for each firm under values of ϕ equal to .05, .1, and .2. We also calculate the sunk cost per member month. This allows for a direct comparison of the anticipated increase in expenditures under each type of policy strategy that would be required to increase HMO participation and enrollment by one member month. Using these results, we find that it is only when an HMO's profit per dollar of revenue exceeds 10% that the AAPCC-based policy is more cost-effective then a direct subsidy approach. While direct information on ϕ is not available to us, it is obtainable by HCFA, and thus a targeted subsidy is a feasible policy.

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 three equation selection 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, linkages exist between the criteria required for effective implementation of the Medicare risk program, whereby legislative changes to the AAPCC payment may have direct implications for HMO participation and indirect effects on enrollment. Second, while enrollment by Medicare beneficiaries is dependent on HMO

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. Finally, we find empirical support for the existence of complementarities in production of an HMO's private and Medicare products and identify the applicability of these results to the design of future 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: Comparative Statics for Cases III and IV

Comparative Static	**Behavior**	**Predicted sign under economies of scope**		**Predicted sign under diseconomies of scope**	
		Case III	Case IV	Case III	Case IV
$\frac{dQ_p}{dP_m}$	effect of a change in the Medicare price on private quantity	0	+	0	-
$\frac{dz}{dP_m}$	effect of a change in the Medicare price on Medicare quantity	0	+	0	+
$\frac{dQ_p}{dd}$	effect of a change in Medicare market demand on private quantity	+	+	-	-
$\frac{dz}{dd}$	effect of a change in Medicare market demand on Medicare quantity	+	?	+	?
$\frac{dQ_p}{dg}$	effect of a change in private market demand on private quantity	+	+	+	+
$\frac{dz}{dg}$	effect of a change in private market demand on Medicare quantity	0	+	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: Probit with random effects

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

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

Table 7: Quantity regressions

	Dependent variable: Medicare quantity		**Dependent variable: Private quantity**	
	Parameter Estimate	Robust Standard error	Parameter Estimate	Robust standard error
Offer Medicare	.....	.....	-62.79	192.73
Medicare member months	.....	.....	6.341*	3.45
Private member months	.1239***	.0398	.....	.....
AAPCC	.714	8.69	.....	.....
Medigap	7.278**	3.395	.....	.....
Gapmiss	21.02	17.497	.....	.....
Proportion 65-74	1317.67	994.8	.....	.....
Proportion 75 and older	-885.65	1014.66	.....	.....
% Families in poverty	.....	.....	-.615	3.448
Young population change	.....	.....	695.19***	246.88
College	.....	.....	2.398	2.091
Pediatrician to active MD ratio	.....	.....	889.926*	483.76
Subscriber policy-making	.....	.....	22.98	25.149
Required HMO option	.....	.....	2.646	13.221
Rate approval	.....	.....	-46.33	31.806
Open enrollment	.....	.....	2.622	15.917
Missing regulations	.....	.....	-53.84*	30.864
Physician charges	80.55	83.62	-59.472	87.558
Nurse wage rate	-7.18	4.79	5.197	4.145
Supervisor wage rate	.2945	1.37	1.158	2.549
Per diem hospital rate	.219	2.24	-2.804	4.703
Infant mortality	-4.203	3.478	-3.999	4.155
Age	.18	.786	5.326	3.353
Staff HMO	5.773	16.943	-52.663*	33.548
Network HMO	22.855	16.616	-37.095**	16.576
Group HMO	-21.616*	13.747	57.707	34.49
Mixed HMO	18.01	18.78	5.888	42.962
National affiliation - HMO	21.046	14.24	14.647	28.196
National affiliation - Other	1.845	8.65	13.504	18.135
Blue Cross Blue Shield affiliation	-16.21	14.22	27.744	25.416
Profit status	2.526	5.99	-13.05	13.967
1991 indicator	-9.003	17.73	2.366	5.538
1992 indicator	-4.943	19.95	.658	11.222
1993 indicator	-11.33	20.786	21.268	15.645
1994 indicator	-8.947	19.461	20.405	18.978
1995 indicator	-15.606	20.44	43.746*	25.81
Lambda	14.41	28.48	.....	.....
Constant	6.56	59.24	-76.397	77.675
Number of observations	490		2437	
F-statistic	F(26, 168) = 2.28 Prob > F = .0009		F(30, 562) = 3.53 Prob > F = .00000	

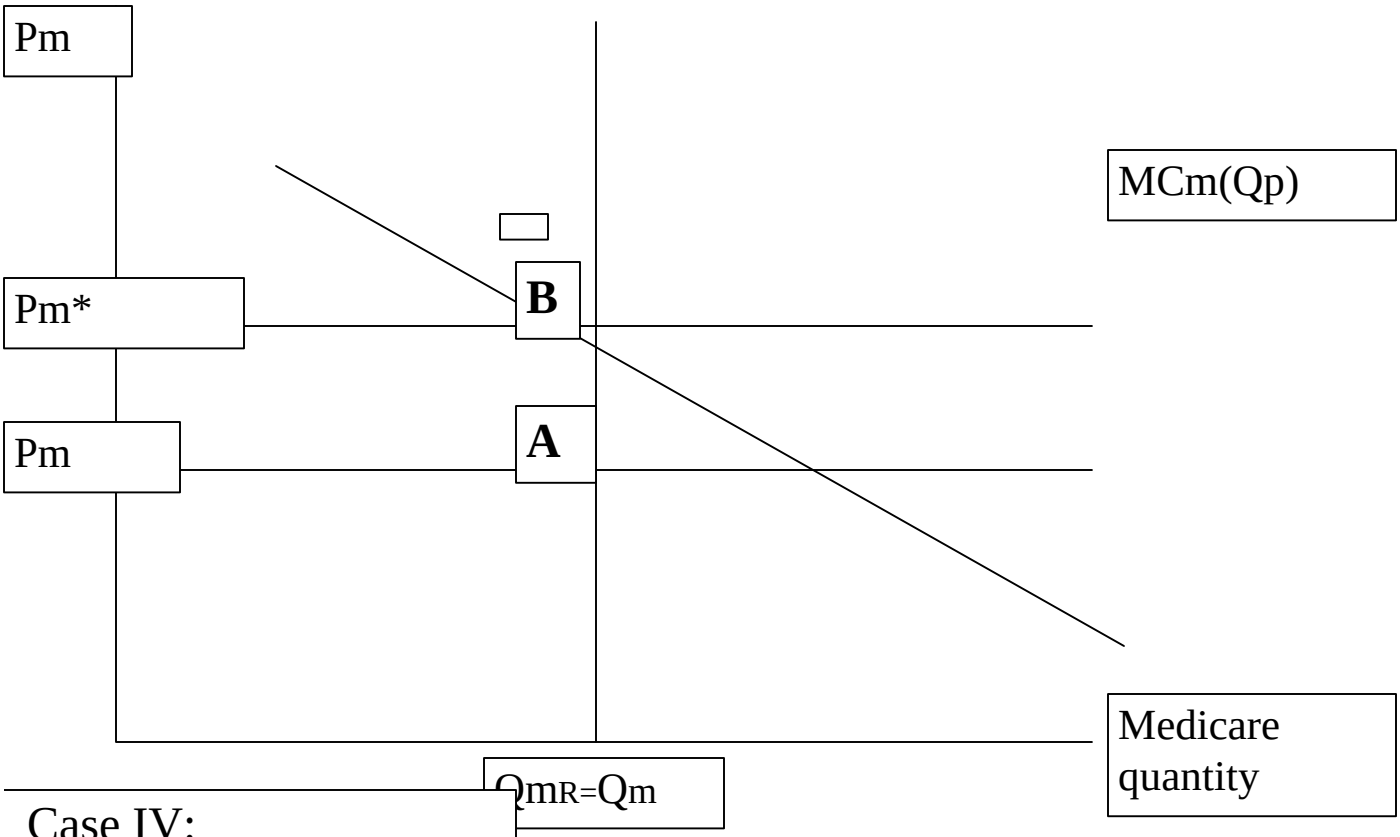
* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

Table 8: Sunk Costs of Entry Estimates

Geographic Region	**Medicare member months**	**Medicare price**	**Profit per dollar of revenue**	**Estimated sunk costs of entry (millions)**	**Sunk cost per member month**
West	46578	$381	.05	$ .887387	$19.05
			.10	1.774621	38.10
			.20	3.549243	76.20
Central	115213	$409	.05	$2.356105	$20.45
			.10	4.712211	40.90
			.20	9.424423	81.80
East	83825	$481	.05	$2.015991	$24.05
			.10	4.031982	48.10
			.20	8.063965	96.20

Figure 1:

Case III:



Case IV:

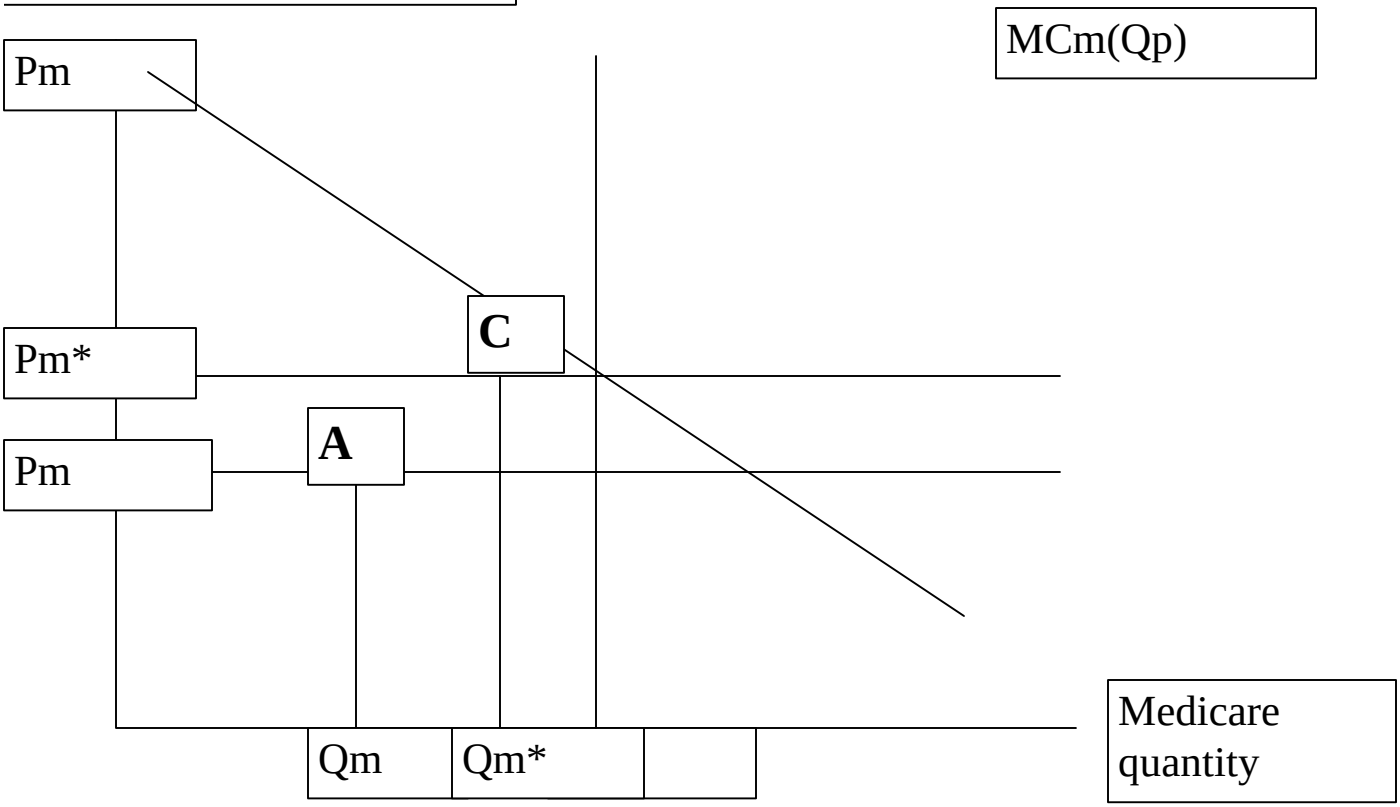
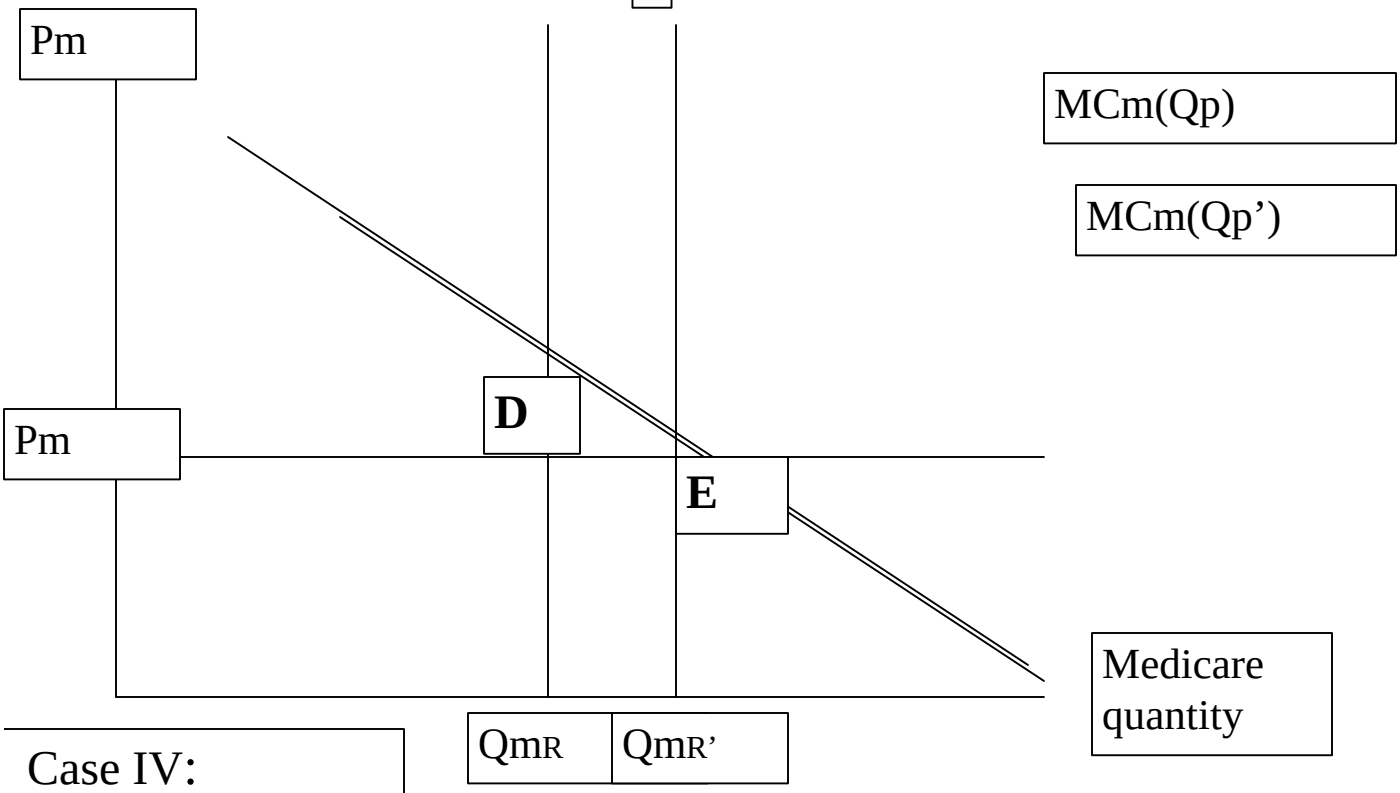
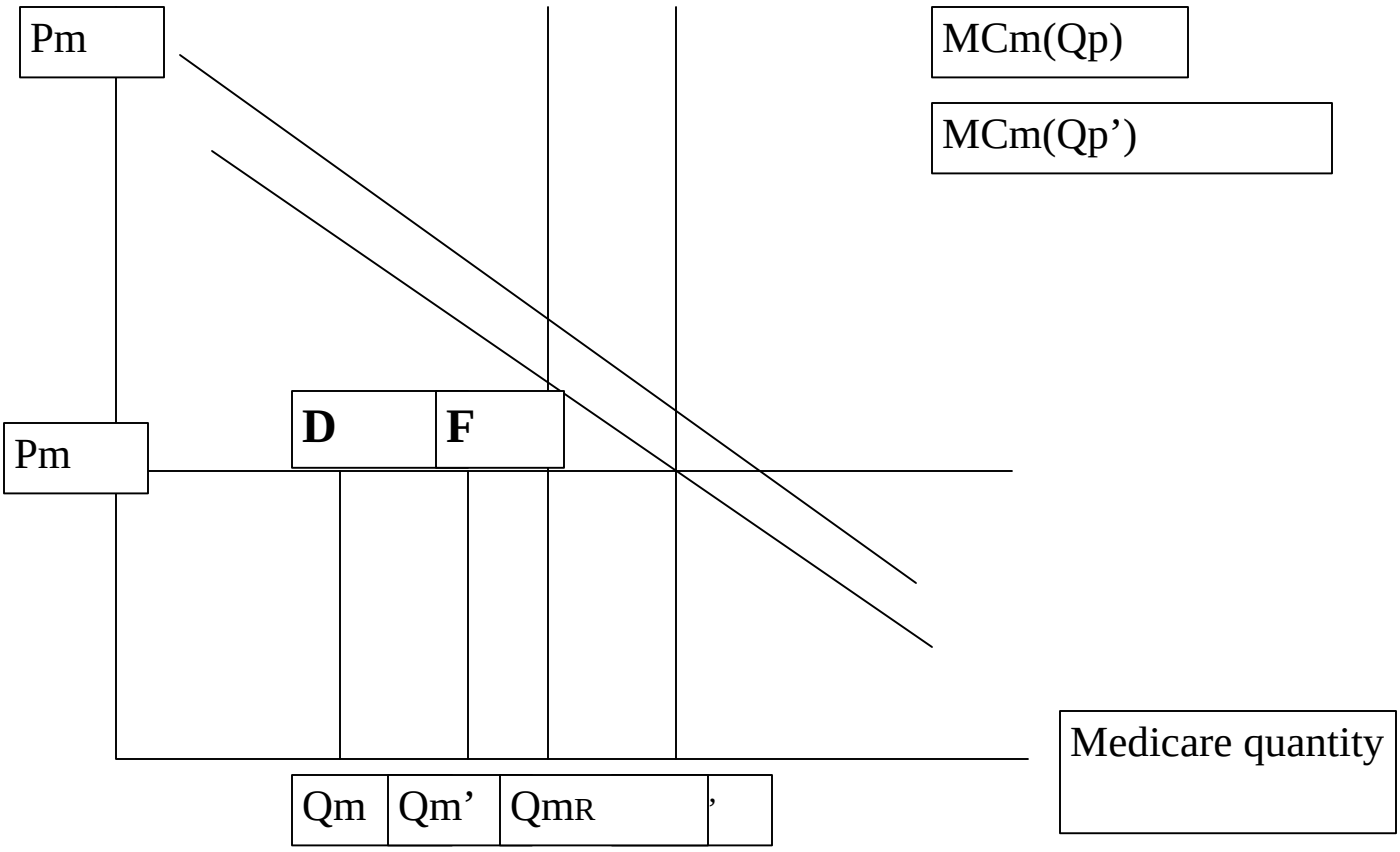


Figure 2:

Case III:



Case IV:



Appendix 1: Profit-maximization problem

$$\underset{Qp,\, z}{Max} p_j = P_p Q_p + P_m Q_m - C_1 Q_m - C_2 Q_p - C_3 Q_m Q_p - C_4 Q_m^{\,2} - C_5 Q_p^{\,2} - C_6 z Q_m - C_7 z - C_8 z^2$$

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:

$$L = P_p Q_p + P_m Q_m - C_1 Q_m - C_2 Q_p - C_3 Q_p Q_m - C_4 Q_m^{\,2} - C_5 Q_p^{\,2} - C_6 z Q_m - C_7 z - C_8 z^2 + l Q_m + r(Q_p - Q_m) + s(Q_{mR} - Q_m) = 0$$

Taking the first order conditions:

(1) $\dfrac{\partial L}{\partial Q_p} = P_p - C_2 - C_3 Q_m - 2C_5 Q_p + r = 0$

(2) $\dfrac{\partial L}{\partial z} = (P_m - C_1 - C_3 Q_p - 2C_4 Q_m - C_6 z + l - r - s)\left(\dfrac{\partial Q_m}{\partial z}\right) - C_6 Q_m - C_7 - 2C_8 z = 0$

(3) $\dfrac{\partial L}{\partial l} = Q_m \geq 0$

(4) $\dfrac{\partial L}{\partial r} = Q_p - Q_m \geq 0$

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

(6) $l Q_m = 0$

(7) $r(Q_p - Q_m) = 0$

(8) $s(Q_R - Q_m) = 0$

The second order conditions can be expressed as the following:

$$\frac{\partial^2 L}{\partial Q_p^{\,2}} = -2C_5 < 0$$

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

$$\frac{\partial^2 L}{\partial Q_p \partial z} = \frac{\partial^2 L}{\partial z \partial Q_p} = -C_3\frac{\partial Q_m}{\partial z}$$

To ensure a maximum, the following criteria must hold:

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

Appendix 2: Comparative statics for Cases III and IV

Using first-order conditions (1), (2), and (5) from Appendix 1, we form the total differentials. Substitutions for the private and Medicare demand function parameters have been made.

Recall:

$$Q_p = J_0 - q_1 P_p + q_2 g$$

$$Q_m = m_1 z + m_2 d$$

(1)

$$d\left[\frac{\partial p}{\partial Q_p}\right] = \left(\frac{-2}{q_1} - 2C_5\right)dQ_p - (C_3 m_1)dz + 0dP_m - (C_3 m_2)dd + \left(\frac{q_2}{q_1}\right)dg + 1dr + 0dC_1$$

$$-1dC_2 - Q_m dC_3 + 0dC_4 - 2Q_p dC_5 + 0dC_6 + 0dC_7 + 0dC_8 + 0ds + 0dl = 0$$

(2)

$$d\left[\frac{\partial p}{\partial z}\right] = -(C_3 m_1)dQ_p - \left(2(C_4 m_1^2 + C_6 m_1 + C_8)\right)dz + m_1 dP_m - (C_3 m_1 q_2)dg$$

$$-(2C_4 m_1 m_2 + C_6 m_2)dd - m_1 dC_1 - 0dC_2 - m_1 Q_p dC_3 - 2m_1 Q_m dC_4 + 0dC_5$$

$$-(m_1 z - Q_m)dC_6 - 1dC_7 - 2zdC_8 + m_1 dl - m_1 dr - m_1 ds = 0$$

(5)

$$d\left[\frac{\partial p}{\partial s}\right] = 0dQ_p - m_1 dz + 0dP_m + \left(\frac{\partial Q_{mR}}{\partial d} - m_1\right)dd + 0dg + 0dl + 0dr + 0ds$$

$$+0dC_1 + 0dC_2 + 0dC_3 + 0dC_4 + 0dC_5 + 0dC_6 + 0dC_7 + 0dC_8 = 0$$

Using the total differentials and applying Cramer's rule, we form the following comparative statics. For each expression, the denominator is equal to the determinant of the matrix of second-order partial derivatives and is assumed to be positive in both Cases III and IV. We shall denote

this denominator as Δ in each expression. Note that the sign of the numerator will determine the predicted sign of the comparative static.

Case III: Firm is constrained by residual market demand (λ, $\rho = 0$; $\sigma > 0$).

For all expressions in Case III, the following is true:

$$\Delta_3 = \begin{bmatrix} (-C_3 m_1)(-m_1)(0) + (0)(-C_3 m_1)(-m_1) + \left(-\frac{2}{q_1} - 2C_5\right)(-2(C_4 m_1^2 + C_6 m_1 + C_8))(0) - \\ \left(-\frac{2}{q_1} - 2C_5\right)(-m_1)(-m_1) - (-C_3 m_1)(-C_3 m_1)(0) - (0(-2(C_4 m_1^2 + C_6 m_1 + C_8))(0) \end{bmatrix} > 0$$

$$\frac{\partial Q_p}{\partial P_m} = \frac{\left[\begin{pmatrix} (-C_3 m_1)(-m_1)(0) + (0)(-m_1)(-m_1) + (0)(-2(C_4 m_1^2 + C_6 m_1 + C_8))(0) - \\ (0)(-m_1)(-m_1) - (-C_3 m_1)(-m_1)(0) - (0)(-2(C_4 m_1^2 + C_6 m_1 + C_8))(0) \end{pmatrix}\right]}{\Delta_3}$$

This expression is equal to zero under the assumption of economies of scope and diseconomies of scope.

$$\frac{\partial Q_p}{\partial g} = \frac{\left[\begin{pmatrix} (-C_3 m_1)(-m_1)(0) + (0)(C_3 m_1 q_2)(-m_1) + \left(-\frac{q_2}{q_1}\right)(-2(C_4 m_1^2 + C_6 m_1 + C_8))(0) - \\ \left(-\frac{q_2}{q_1}\right)(-m_1)(-m_1) - (-C_3 m_1)(C_3 m_1 q_2)(0) - (0)(-2(C_4 m_1^2 + C_6 m_1 + C_8))(0) \end{pmatrix}\right]}{\Delta_3}$$

This expression is positive under the assumption of economies of scope and diseconomies of scope.

$$\frac{\partial Q_p}{\partial d} = \frac{\left[\begin{array}{l} (-C_3 m_1)(-m_1)\left(-\left(\frac{\partial Q_{mR}}{\partial d} - m_1\right)\right) + (0)(2(C_4 m_1 m_2 + C_6 m_2)(-m_1) \\ + (C_3 m_2)(-2(C_4 m_1^2 + C_6 m_1 + C_8)(0) - (C_3 m_2)(-m_1)^2 - (-C_3 m_1)(2(C_4 m_1 m_2 + C_6 m_2))(0) \\ - (0)(-2(C_4 m_1^2 + C_6 m_1 + C_8))\left(-\frac{\partial Q_{mR}}{\partial d} - m_1\right) \end{array}\right]}{\Delta_3}$$

This expression is positive under the assumption of economies of scope and negative under diseconomies of scope.

$$\frac{\partial z}{\partial P_m} = \frac{\left[\begin{array}{l}(0)(-m_1)(0)+(0)(-C_3 m_1)(0)+\left(-\frac{2}{q_1}-2C_5\right)(-m_1)(0)- \\ \left(-\frac{2}{q_1}-2C_5\right)(-m_1)(0)+(0)(-C_3 m_1)(0)-(0)(-m_1)(0)\end{array}\right]}{\Delta_3}$$

$$\frac{\partial Q_m}{\partial P_m} = m_1 \frac{\partial z}{\partial P_m}$$

These expressions are equal to zero under the assumptions of economies of scope and diseconomies of scope.

$$\frac{\partial z}{\partial g} = \frac{\left[\begin{array}{l}\left(-\frac{q_2}{q_1}\right)(-m_1)(0)+(0)(-C_3 m_1)(0)+\left(-\frac{2}{q_1}-2C_5\right)(C_3 m_1 q_2)(0)- \\ \left(-\frac{2}{q_1}-2C_5\right)(m_1)(0)-\left(-\frac{q_2}{q_1}\right)(-C_3 m_1)(0)-(0)(C_3 m_1 q_2)(0)\end{array}\right]}{\Delta_3}$$

$$\frac{\partial Q_m}{\partial g} = m_1 \frac{\partial z}{\partial g}$$

These expressions are equal to zero under the assumptions of economies of scope and diseconomies of scope.

$$\frac{\partial z}{\partial d} = \frac{\left[\begin{array}{l}(C_3 m_2)(-m_1)(0) + (0)(-C_3 m_1)\left(-\frac{\partial Q_{mR}}{\partial d} - m_1\right) + \left(-\frac{2}{q_1} - 2C_5\right)(2(C_4 m_1 m_2 + C_6 m_2)(0) - \\ \left(-\frac{2}{q_1} - 2C_5\right)(-m_1)\left(-\frac{\partial Q_{mR}}{\partial d} - m_1\right) - (C_3 m_2)(-C_3 m_1)(0) - (0)(2(C_4 m_1 m_2 + C_6 m_2)(0)\end{array}\right]}{\Delta_3}$$

$$\frac{\partial Q_m}{\partial d} = m_1 \frac{\partial z}{\partial d} + m_2$$

These expressions are positive under the assumptions of economies of scope and diseconomies of scope.

Case IV: Firms are unconstrained by demand ($\lambda, \rho, \sigma = 0$).

For all expressions in Case IV, the following is true (by assumption):

$$\Delta_4 = \left[\left(-\frac{2}{q_1} - 2C_5\right)\left(-2(C_4 m_1^2 + C_6 m_1 + C_8\right) - \left(-C_3 m_1\right)^2\right] > 0.$$

$$\frac{\partial Q_p}{\partial P_m} = \frac{\left[(0)\left(-2(C_4 m_1^2 + C_6 m_1 + C_8\right) - \left(-C_3 m_1\right)\left(-m_1\right)\right]}{\Delta_4}$$

This expression is positive under the assumption of economies of scope and negative under the assumption of diseconomies of scope.

$$\frac{\partial Q_p}{\partial g} = \frac{\left[\left(-\frac{q_2}{q_1}\right)\left(-2(C_4 m_1^2 + C_6 m_1 + C_8)\right) - \left(-C_3 m_1\right)\left(C_3 m_1 q_2\right)\right]}{\Delta_4}$$

This expression is positive under the assumptions of economies of scope and diseconomies of scope.

$$\frac{\partial Q_p}{\partial d} = \frac{\left[\left(C_3 m_2\right)\left(-2(C_4 m_1^2 + C_6 m_1 + C_8\right) - \left(-C_3 m_1\right)\left(2(C_4 m_1 m_2 + C_6 m_1 + C_8\right)\right]}{\Delta_4}$$

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diseconomies of scope.

$$\frac{\partial z}{\partial P_m} = \frac{\left[\left(-\frac{2}{q_1} - 2C_5\right)(-m_1) - (0)(-C_3 m_1)\right]}{\Delta_4}$$

$$\frac{\partial Q_m}{\partial P_m} = m_1 \frac{\partial z}{\partial P_m}$$

These expressions are positive under the assumption of economies of scope and diseconomies of scope.

$$\frac{\partial z}{\partial g} = \frac{\left[\left(-\frac{2}{q_1} - 2C_5\right)(C_3 m_1 q_2) - \left(-\frac{q_2}{q_1}\right)(-C_3 m_1)\right]}{\Delta_4}$$

$$\frac{dQ_m}{dg} = m_1 \frac{\partial z}{\partial g}$$

These expressions are positive under the assumption of economies of scope and negative under the assumption of diseconomies of scope.

$$\frac{\partial z}{\partial d} = \frac{\left[\left(-\frac{2}{q_1} - 2C_5\right)(2(C_4 m_1 m_2 + C_6 m_2) - (C_3 m_2)(-C_3 m_1)\right]}{\Delta_4}$$

$$\frac{\partial Q_m}{\partial d} = m_1 \frac{\partial z}{\partial d} + m_2$$

The predicted sign of this comparative static is not clear. Rather, it depends on the magnitude of the terms. If we assume that $\partial z/\partial \delta$ is negative, then $\partial Q_m/\partial \delta$ will also be negative unless $-m_1/m_2 > \partial z/\partial \delta$.

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