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THE EFFECT OF MANAGED CARE ON HEALTH CARE PROVIDERS

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ABSTRACT

We investigate the effect of managed care on the health care system, focusing on the effects managed care could have on the number and types of health care providers and their efficiency. By influencing providers, managed care may change the structure and performance of the entire health care system in ways that influence care provided to all patients. We begin by discussing the mechanisms by which managed care influences health care providers, concentrating on shifts in market demand and increases in the amount of attention paid to price in provider choices. We develop a theoretical framework that illustrates these effects. We then empirically examine the relationship between managed care activity and mammography providers. We find evidence that increases in HMO activity are associated with changes in the number of providers, the volume of services produced by each provider, and the prices they charge. This evidence is consistent with the view that HMOs can have broad effects on health care providers.

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1. INTRODUCTION

The role played by managed care organizations in the U.S. health care system grew rapidly during the 1980s as health care costs began to rise and HMOs were perceived as a way to contain them. In 1980, there were 236 HMOs operating in the U.S., with approximately 9.1 million members. By 1994, there were 556 HMOs in operation, with 50 million members. Nationwide, approximately 19% of people with health insurance were enrolled in an HMO in 1994 (GHAA, 1994). In addition to HMOs, many other types of managed care organizations, such as preferred provider organizations and point-of-service plans, have come to play increasingly important roles as alternatives to traditional indemnity health insurance.

Increases in the size and power of managed care organizations are commonly identified as a key cause of widespread changes in the health care marketplace. In addition to influencing the care provided to their own enrollees, managed care organizations may change the entire health care system in ways that affect the health care provided to all patients. One way in which managed care could bring about such system-wide changes is by altering the characteristics of health care providers. Since most providers serve a wide variety of patients, managed-care-induced changes in providers could influence health care delivery and costs throughout the health care system. For example, managed care induced changes in the number of hospitals and the efficiency with which they operate may have important implications for general health care delivery.

While managed care is commonly linked with changes in health care providers, little attention has been devoted to examining this relationship in detail. Our main goal here is to examine the mechanisms by which managed care could influence the characteristics of providers and provide empirical evidence on this question. For purposes of discussion, we define providers broadly as producers of health care services. Some providers produce a wide range of services (e.g. physicians, hospitals), and other providers produce a narrow range (e.g. MRI centers). Many providers serve patients with different kinds of health insurance coverage. Most hospitals, for example, admit patients with many different types of health insurance.

Managed care may influence providers through a number of mechanisms. This paper focuses on two key issues. First, changes in managed care activity could lead to shifts in demand for health care services. For example, relative to the traditional indemnity insurance plans and fee-for-service providers, managed care organizations may encourage their enrollees to use preventive health care services, but discourage the use of high-cost diagnostic tests. Moving patients from traditional coverage to managed care would then lead to shifts in market demand for these services. A second mechanism is enhanced search. When making purchases, managed care organizations and their patients may search more diligently for low-priced providers than non-managed care patients, whose choices of providers are generally thought to be relatively price-insensitive.

Through these, and perhaps other, mechanisms, increases in managed care activity may prompt a variety of changes in health care markets. We consider two possible effects. First, increases in managed care activity that shift demand for services or increase search for low-priced providers may alter the profitability of providing services and lead to changes in the number and type of providers operating. Increases in demand for preventive care may, for example, prompt expansion in the number of primary care physicians and facilities offering preventive care services. Effects of this type are generally thought to be widespread in today's health care marketplace. For example, as managed care plans have reduced demand for inpatient hospital days and searched for low-price hospitals, the hospital industry has become increasingly burdened with excess capacity and has seen an accelerating number of closures and mergers (Cerne and Montague, 1994).

Second, managed care may influence the efficiency with which services are provided. Efficiency in the production of health care is a complicated topic, and various notions of efficiency are often thrown about carelessly in health care policy debates. In this paper, we adopt a relatively simple characterization of efficiency, focusing on the number of units of services produced per provider. Much of the health care equipment and infrastructure in the U.S. requires substantial fixed costs and is generally thought to be underutilized from the perspective of minimizing social costs. If managed care increases the volume of services produced per provider or per unit of equipment by changing demand or the number of providers, it could lead to reductions in costs, or vice versa. A possible implication of a change in costs is a change in the prices of health care services, which could influence system-wide health care costs.[1]

In the next section, we discuss the effects of managed care on demand and search in more detail, illustrating the effects of managed care using a model of monopolistically competitive health care providers who serve both HMO and traditionally-insured patients and are able to price discriminate between them. We then empirically investigate the relationship between managed care activity and providers who produce mammography services. Mammography is a well defined, relatively homogeneous service produced by identifiable providers about whom good data is available, making it a good candidate for investigating the effects of managed care on providers.[2] We estimate a series of reduced form equations to see whether HMO activity is associated with changes in the number or size of mammography facilities, the volume of services produced per mammography machine per month, and charges. We find that increases in HMO activity are associated with

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[1]Note that our goal is not to be exhaustive in considering the effects of managed care. Managed care may influence health care markets in a number of ways and produce a number of potentially interacting effects. By focusing on the implications of changes in demand and search on the number of providers and their costs, we abstract from the considerable complexity in this area in the hope of better understanding a subset of issues in detail.

[2]Mammography is also of independent interest because screening mammography is widely thought to be an important preventive health care measure for women in some age groups (Kerlikowske et al., 1995; Fletcher et al., 1993), but a large number of women who may benefit do not receive mammography (Breen and Kessler, 1994), in part due to high charges (Urban et al, 1994). This suggests that a better understanding of the ways that managed care affects mammography provision may suggest ways to improve screening rates.

decreases in the number of mammography facilities, and with increases in volume per machine. We also find some evidence that HMO activity influences mammography prices. In general, we interpret this as evidence that system-wide managed care activity does influence the characteristics of health care providers in ways that have implications for system-wide health care delivery.

While some previous research has investigated system-wide effects of managed care, much of this work consists of broadly-based empirical studies focused inpatient hospital care (Feldman *et al.*, 1986, Luft *et al.*, 1986, McLaughlin, 1987, McLaughlin, 1988, Noether, 1988, Robinson, 1991), and Medicare (Baker, 1996, Clement *et al.*, 1992, Welch, 1994), or on conventional insurance premiums (Baker and Corts, 1995, Baker and Corts, 1996, Feldman *et al.*, 1993, Goldberg and Greenberg, 1979, Wickizer and Feldstein, 1995). Although results are mixed, this literature tends to find that managed care can influence hospital costs, Medicare costs, and conventional insurance premiums. But, existing work has generally failed to examine the possibility that managed care may lead to structural changes and has not presented detailed hypotheses about the mechanisms by which managed care may influence the health care system. Moreover, most existing empirical work has focused on broad measures of performance (e.g. aggregate costs), making it difficult to draw conclusions about the manner in which managed care affects the providers. One recent paper empirically examined the relationship between HMO activity and hospital size, finding that increases in HMO market share are associated with decreases in hospital size (Chernew, 1995).

Some investigators have examined mammography provision. Breen and Brown (1994) examined data from the 1992 National Survey of Mammography Facilities, to investigate the effects of facility characteristics on prices. Others have examined the effects of volume on costs of provision (e.g., PPRC, 1989; FDA, 1996). Phillips *et al.* (1996) examined the determinants of adherence to screening mammography guidelines, including a variable to control for HMO activity, and found that increases in HMO activity were associated with increases in adherence. No existing work explicitly investigates the economic effects of managed care on mammography providers.

2. MANAGED CARE ACTIVITY AND HEALTH CARE PROVIDERS

2.A. Mechanisms

This section begins by discussing mechanisms by which managed care may influence health care providers, and then develops a model that illustrates the main mechanisms. First, managed care may shift market demand curves. Managed care organizations may encourage their enrollees to consume a different bundle of services than that consumed by traditionally insured patients. For example, managed care organizations may be more likely to refer their patients for preventive care than other providers or, for a patients requiring surgical procedures, managed care organizations may prefer outpatient treatments to inpatient treatments more strongly than other providers. Even when similar services are demanded, managed care organizations may prefer that their enrollees receive services from providers that offer a different set of amenities (e.g. longer or shorter waiting times, higher or lower staffing levels) than non-managed-care providers. Some of the differences in demand may result from differences in philosophy between managed care organizations and other providers. Other differences may result from the fact that some managed care organizations assume both insurance and health care provision roles. Since the organizations directly incur costs for the services provided, they have stronger incentives to seek out services that are perceived as providing comparable health outcomes at lower costs.

Managed care activity may also affect demand for services by encouraging the spread of practice patterns that are favored by managed care organizations. By imposing financial incentives, practice guidelines, and perhaps by other mechanisms, managed care organizations encourage physicians working for them to practice in accordance with their preferences. If, as some models of physician learning suggest (e.g. Phelps, 1992), physicians tend to adopt the practice patterns of those around them, then an increase in managed care activity that leads to an increase in the number of managed care physicians may contribute to changes in the practice patterns of other physicians in the market, leading to changes in demand even from non-managed-care patients. In an analogous way, managed care organizations may also contribute to changes in preferences among patients.

A final way in which managed care may influence market demand incorporates the competitive effect of managed care on non-managed-care insurers. As managed care activity increases, the competitive pressure felt by traditional insurers may increase. Some studies, and considerable anecdotal evidence, indicate that traditional insurers by respond to competition by imitating managed care organizations. For example, some studies have shown that conventional insurers react to competition by increasing the level of utilization review and/or employing other oversight mechanisms, thereby reducing hospital utilization and the use of other high-cost services among conventional insurance patients (Feldman and Dowd, 1986, Frank and Welch, 1985, Goldberg and Greenberg, 1979). If this occurs, then expanded competition from managed care organizations could lead to changes in demand from traditionally insured patients.

A second mechanism by which managed care may influence providers is by expanding the extent of search for low-price providers. Traditional indemnity insurers often exercise little oversight of patients' choices of providers, providers' choices of services, and provider referrals, but pay submitted bills. Patients and physicians, therefore, give little attention to price in selecting providers, perhaps placing more weight on perceived quality or convenience. In contrast, because of their joint insurance and purchasing roles, managed care organizations may place more weight on price in their purchase decisions and less on other attributes of services. Since managed care organizations directly incur costs for patient care, they have a greater incentive to search for low priced providers among the many service providers operating in the market. Increases in managed care activity may then increase the amount of attention paid to price in decisions about which providers to use once services are selected. Note that price sensitivity may operate independently of the demand effects discussed above. While managed care organizations that wish to contain costs may adjust the set of services they demand for their enrollees toward lower-cost services that are thought to produce similar outcomes, they may also search more diligently among the providers of the services they choose to find the least expensive providers.

There are other mechanisms by which managed care could influence providers. One possibility is that consolidation of purchasing power in managed care organizations will prompt providers to change so that they can better offset the power of managed care organizations. Also, the selective contracting strategies used by managed care organizations may lead to changes in provider characteristics.

2.B. A MODEL

In this section, we build a simple model designed to illustrate the effects of differences in demand and differences in search on the characteristics of health care providers. We expect that focusing on these mechanisms will allow us to capture the most important aspects of managed care's influence on providers. We use the model to investigate the effects of changing managed care activity on the number of providers in the market, the number of units of the service produced by providers, and prices.

Building on previous work by Katz (1984) and Salop and Stiglitz (1977), the model we adopt incorporates monopolistically competitive service providers who serve both managed care and traditionally insured patients and are able to price-discriminate between them. For simplicity, we take as our object of study a market for one homogeneous health care service. Patient demand for only the single service is considered, and providers are assumed to supply only the single service. This abstracts from interactions between the myriad different services that may be demanded by patients and supplied by the same providers, and allows us to illustrate the effects of HMOs more clearly.

We begin with the demand side of the model. Consider a market that contains Y patients. Patients are assumed to be homogeneous, so that informational asymmetries and biased selection do not play a role in the results of the model. All patients obtain health insurance either from a managed care organization or from a traditional indemnity insurer. Let ϕ denote the market share of managed care, so that ϕY patients have managed care coverage and $(1-\phi)Y$ patients have traditional coverage. Of eligible patients, some fraction choose to consume the service or are referred by a provider to obtain it. Let $\gamma_M \geq 0$ and $\gamma_T \geq 0$ denote the fractions of eligible patients with managed care and traditional insurance, respectively, who seek the service. The number of managed care patients seeking the service is then $M = \phi\gamma_M Y$, and the number of traditionally-insured patients seeking the service is $T = (1-\phi)\gamma_T Y$.

We assume that the decision to seek the service is not dependent on price (i.e. γ_M and γ_T are not functions of price). Patients will be price-sensitive when choosing a facility from which to obtain the service, as described below, but the choice of whether or not to obtain it is taken to be independent of price. While this is undoubtedly an oversimplification, it allows us to clearly illustrate the potential effects of managed care without undue notation. γ_M and γ_T, then, capture differences in treatment patterns and preferences concerning the service in the two sectors of the market. By allowing γ_M and γ_T to differ, we incorporate differences in demand patterns between managed care and traditional insurers. We let $\gamma_T = \gamma_T(\phi)$ to allow for the possibility the managed care activity may influence demand among non-managed-care patients through the spread of conservative practice patterns and/or competitive responses of traditional insurers.

To incorporate differences in search for low-priced providers, managed care patients who obtain the service are assumed to be knowledgeable about the prices charged by all providers in the market and to choose randomly from the set of providers with the minimum price. One unit is consumed from the chosen facility. Since decisions about referrals for many services generally incorporate the preferences of the managed care organization and physician, this price sensitivity need not arise solely through action on the part of the patient. For example, in many staff model HMOs, the set of facilities to which patients will be referred for most services is entirely determined by the HMO. Traditionally-insured patients do not search based on price; they choose randomly from the set of all providers, and consume one unit of the service from the chosen provider. All patients have a reservation price p^r.

We now turn to the supply side of the market. We assume that the market for the service can be modeled as monopolistically competitive. Other frameworks, which incorporate further interaction between firms in the market, would produce similar results.[3] The providers are assumed to be homogeneous, with (identical) total cost functions $C(x_i)$, where x_i is the number of units of the service produced by provider i. We assume that $C' > 0$ and $C'' > 0$.[4] For convenience, we denote the average cost curve as A(x): $A(x) = C(x)/x$. We distinguish x^c, the point at which average costs are a minimum, and p^c, the corresponding price: $p^c = A(x^c) = C'(x^c)$. Note that p^r is the monopoly price in this market.

Providers are able to distinguish traditionally-insured and managed care patients and charge them separate prices. Providers make pricing decisions taking the decisions of other providers as given, and play pure strategies.[5] We examine the Nash-Bertrand equilibrium in which free entry

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[3]For example, it is possible to obtain qualitatively similar results from a model in which providers compete in a Cournot fashion for managed care patients and treat the traditionally-insured patients as a price-insensitive fringe.

[4]The assumption that the marginal cost curve is upward sloping is necessary to guarantee the existence of a symmetric equilibrium (in which all providers choose to see both traditionally-insured and managed care patients). See Katz (1984).

[5] Katz (1984) argues that the equilibria that obtain when providers play only pure strategies would also obtain if providers played mixed strategies, choosing a price distribution with knowledge of the price distributions chosen by other providers, but consumers chose among providers based on the actual realized

drives profits to zero, so that the number of providers, n (treated as a continuous variable), is determined in the context of the model.

This structure is sufficient to generate the prices charged to managed care and traditionally-insured patients. Each provider i sets two prices, p_i^M and p_i^T, for managed care and traditional patients, respectively. Competition between providers for the business of managed care patients, who seek the lowest price, will force all providers serving managed care patients to set $p_i^M = C'(x_i)$.[6] All providers serving traditionally-insured patients will set $p_i^T = p^r$ since they face perfectly inelastic demand from traditionally-insured patients and thus charge them the monopoly price.

In this setting, Katz (1984) shows that there exists a unique symmetric equilibrium in which there are n* providers, each of which serves both the managed care and traditional markets. Each provider produces

$$x^* = (T + M) / n^* \tag{1}$$

units of the service at prices $p^M = C'(x^*)$ for managed care patients and $p^T = p^r$ for traditionally insured patients, and n* satisfies the zero-profit condition

$$\Pi(n) = p^r \frac{T}{n} + C'\left(\frac{T+M}{n}\right)\frac{M}{n} - C\left(\frac{T+M}{n}\right) = 0. \tag{2}$$

This equilibrium has at least two noteworthy characteristics. First, as is typical in monopolistic competition models, providers operate at inefficient scale on the downward sloping portion of the average cost curve: $x^* < x^c$.[7] This is consistent with some studies and conventional

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prices.

[6]This follows from standard competition arguments. If $p_i^H > (<) C'(x_i)$, for some facility i, then the facility could increase profits by expanding (reducing) output.

[7]This maybe shown by contradiction. If $x^* \geq x^c$, price would be set at or above average cost for managed care patients and above average cost for traditionally-insured patients. More formally, $x^* \geq x^c$

wisdom that suggest that the resources used to produce health care are, in many cases, underutilized with respect to minimizing average costs. In the case of mammography, studies by the Physician Payment Review Commission (PPRC, 1989) and the FDA (1995) argue that many mammography facilities operate well below efficient scale. Second, the equilibrium exhibits some "cross-subsidization" of managed care patients by traditionally-insured patients. In equilibrium, managed care patients are charged prices below average cost, and providers are able to stay in business because they can charge traditionally-insured patients prices above average cost.[8] Cross subsidization of this type is generally thought to occur in markets for many health care services. Figure 1 illustrates equilibrium conditions.

Managed care and the number of providers

We now investigate the comparative-static effects of managed care market share on the characteristics of the equilibrium, beginning with the effect of changes in ϕ on the equilibrium number of providers n*. Implicitly differentiating equation (2) gives an expression for $\partial n^*/\partial\phi$:

$$\partial n^*/\partial\phi = \frac{-(p^r - C')\gamma_T + (p^r - C')(1-\phi)\gamma_T' + C''\phi\gamma_M y(\gamma_M - \gamma_T + (1-\phi)\gamma_T')}{(1/n^*)[(p^r - C')(1-\phi)\gamma_T + C''\phi\gamma_M y(\phi\gamma_M + (1-\phi)\gamma_T)]}, \qquad \textbf{(3)}$$

where y = Y/n. The denominator in equation (3) is unambiguously positive so that the sign of $\partial n^*/\partial\phi$ depends on the relative importance of the three effects in the numerator. First, increases in ϕ directly reduce the profitability of the market. The first term in the numerator captures the loss in profits that

implies that $p^r \geq p^M = C'(x^*) \geq A(x^*)$ where at least one of the inequalities holds strictly. This implies that providers earn positive profits, which violates the zero-profit condition. See Katz (1984).

[8]This follows from the fact that $x^* < x^c$, which implies that $p^M = C'(x^*) < C'(x^c) = p^c$ and, since $C'(x)$ is monotonically increasing and intersects the average cost curve at its minimum, that $p^M < p^c < A(x^*)$.

occurs when a patient moves from traditional coverage, where providers earn (p^r - C') profit, to managed care coverage, where providers earn no profit on the marginal patient. Second, increases in ϕ influence the size, and hence the profitability, of the market by changing the value of γ_T. If $\gamma'_T >$ (<) 0, this effect will increase (decrease) demand among traditionally insured patients and increase (decrease) the profitability of the market. Third, changes in the number of units demanded move providers along the marginal cost curve, which affects the price charged to managed care patients and influences the profits earned on the inframarginal managed care patients. If the net change in demand is positive (i.e., $\gamma_M - \gamma_T + (1-\phi)\gamma'_T > 0$), then increases in ϕ will increase marginal cost and thus increase profitability and induce entry, and vice versa.

To facilitate discussion, consider two types of services. Services of the first type are preferred by managed care relative to traditional insurance, so that they have $\gamma_M > \gamma_T$ and $\gamma'_T > 0$. Services of the second type are preferred relatively less by managed care and have $\gamma_M < \gamma_T$ and $\gamma'_T < 0$. For the first type, the sign of $\partial n^*/\partial\phi$ is ambiguous and depends on the parameters of the model. Specifically, $\partial n^*/\partial\phi > 0$ if the loss in profits from moving a patient into managed care is smaller than the gain in profitability induced by knowledge spillovers and expansion in market size, that is, if

$$(p^r - C')\gamma_T \;<\; (p^r - C')\,(1-\phi)\gamma_T' + C''\,\phi\gamma_M\, y\,(\gamma_M - \gamma_T + (1-\phi)\gamma_T')\;. \qquad \textbf{(4)}$$

The equilibrium number of providers is more likely to be increasing in managed care market share where γ_T' is large, γ_M is large, and γ_T is small.

The outcome is unambiguous for the second type of services. Here, increases in ϕ reduce γ_T and move providers to the left on the marginal cost curve, reducing demand from traditionally-insured patients and the price charged to managed care patients. In turn, these lead to reduced profitability of the market and induce exit.

Managed care and volume per provider

We next consider the effects of a change in ϕ on the equilibrium number of units produced by each provider. Differentiating equation (1) with respect to ϕ gives:

$$\partial x^*/\partial\phi = y\,[\gamma_M - \gamma_T + (1-\phi)\gamma_T'\,] - (\partial n^*/\partial\phi)\,(1/n^*)\,y\,[\phi\gamma_M + (1-\phi)\gamma_T\,]\,. \tag{5}$$

The first term on the right hand side of equation (5) captures the direct effect of changes in ϕ on demand. If $\gamma_M > \gamma_T$ and $\gamma_T' > 0$, increasing ϕ will increase demand and tend to increase x^*. But, to the extent that this increases market profitability, the effects of increasing market size will be mitigated by the entry of new providers. The second term on the right hand side of equation (5) captures this effect. Similarly, for services where $\gamma_M < \gamma_T$ and $\gamma_T' < 0$, increases in ϕ reduce demand but also induce exit.

In the end, the sign of $\partial x^*/\partial\phi$ depends on the sign and magnitude of $\partial n^*/\partial\phi$. Specifically, if

$$\frac{1}{n^*}\,\frac{\partial n^*}{\partial\phi} < \frac{\gamma_M - \gamma_T + (1-\phi)\gamma_T'}{\phi\gamma_M + (1-\phi)\gamma_T}\,, \tag{6}$$

then $\partial x^*/\partial\phi > 0$. Intuitively, if the proportional change in the equilibrium number of providers is smaller than the proportional change in demand, then the number of units produced per provider will increase. Substituting equation (3) into equation (6) and simplifying yields that $\partial x^*/\partial\phi > 0$ where

$$\phi(1-\phi)\gamma_T' < \gamma_T\,. \tag{7}$$

For positive values of γ_T', the smaller γ_T', the smaller the related increases in profits, and the smaller the amount of induced entry, which tends to lead to increases in x^*. Larger values of γ_T lead to larger losses from moving patients into managed care, which induces more exit and tends to increase x^*. Note that, if $\gamma_T' < 0$, then condition (7) is always satisfied, and $\partial x^*/\partial\phi$ is unambiguously positive.

In light of the common claim of managed care organizations that competition induced by managed care will generally lead to improvements in the "efficiency" with which health care services are delivered, it is interesting to note that, even in this relatively simple model, increases in ϕ need not lead to reductions in average cost, and could lead to increases in average cost. Only in cases where $\partial x^{*}/\partial\phi > 0$ will the average cost of producing the service fall in response to increases in managed care activity.

Managed care and prices

While this model greatly simplifies pricing behavior, it is sufficient to illustrate the potential for price effects to occur. By changing x*, increases in ϕ may either increase or decrease marginal cost. In the model considered here, p^M is set at marginal cost, so that changes in ϕ that affect x* have a direct effect on prices charged to managed care patients. Similar effects are likely to be present in more complex models. For example, in models where providers have market power with respect to managed care organizations, the price charged to managed care patients could reflect marginal cost plus a markup, and changes in x* that affect costs could also influence prices.

It is also useful to note that, in a general model incorporating markups, the size of the markup could depend on the parameters of the model, including the number of providers and the quantity produced so that changes in ϕ that affect the number of providers or the quantity of services consumed could affect prices by altering markups. Similar effects could occur for traditionally-insured patients.

Finally, in markets for some health care services, particularly those with high fixed costs that must be recovered by providers, some observers suggest that providers may be responsive to average cost in price setting. For example, in the case of mammography, facilities seem to be sensitive to fixed cost recovery when setting prices (PPRC, 1989). This implies that changes in volume per provider that influenced average costs could also lead to changes in prices.

3. AN EMPIRICAL EXAMINATION OF MAMMOGRAPHY PROVIDERS

3.A. FRAMEWORK

The previous section illustrates ways that managed care may influence health care providers. In the rest of the paper, we empirically investigate the existence of these effects by studying mammography providers. We examine the relationship between managed care activity and the number of providers, the volume of services they perform, and their charges.

Nationwide, the market for mammography consists of about 9,500 independent mammography facilities. Some, but not nearly all, of these facilities are located in hospitals. Other facilities operate as freestanding imaging centers. Mammography facilities generally provide routine x-ray screening exams for early detection of breast cancer as well as more detailed diagnostic exams for women who have some preliminary indication of cancer. Although these centers may also provide other imaging services (e.g. MRI scans), mammography is a distinct and identifiable service. In part because there are guidelines specifying the services that should be included in exams, it is also a relatively homogeneous service across different facilities. These characteristics make mammography a good candidate for a study of this kind. Because it is relatively homogeneous, difficulties associated with defining services, examining services that vary in quality (or other characteristics) across providers, and product differentiation by providers are alleviated. It is provided by many small centers and the equipment for mammography is often devoted to that service, so entry and exit may be observed. Screening mammography is a classic example of a preventive health care service, so that mammography demand is likely to be affected by managed care activity (although the effects of managed care on diagnostic mammography use are less clear a priori). In the context of the model, we expect mammography to have $\gamma_M > \gamma_T$ and $\gamma'_T > 0$, so that the implications of increases in managed care market share for the number of providers and volume per provider are ambiguous.

We estimate a series of reduced form equations in which the dependent variables measure the number of mammography sites, the number of mammograms performed per site, and charges for mammography. In general, these equations take the form:

$$M_i = f(\phi_i, Z_i) \quad \textbf{(8)}$$

where M is the characteristic of the mammography market under study, ϕ is represents HMO market share, and Z is a vector of additional characteristics. Subscript i denotes market i.

To estimate versions of equation (8), we define market areas using Health Care Service Areas (HCSAs), which are groups of counties thought to approximate markets for health care services (Makuc *et al.*, 1991). As indicators of market area, we expect HCSAs to be superior to both counties, which may be too small to reliably identify markets for mammography, and Metropolitan Statistical Areas, which would exclude non-urban areas from analysis. We did experiment with the use of both of these alternate definitions and found that results were consistent with those reported.

We estimate a version of equation (8) that is linear in ϕ. We also experimented with the use of quadratic and cubic models, but found that they produced similar results. We initially use OLS estimation. However, it is possible that OLS will be biased by the presence of unobserved variables that are correlated with both demand for mammography and with HMO market share or by simultaneity. To investigate the extent of any bias, and control for it if necessary, we use instrumental variables (IV) estimation. If instrumental variables can be found that influence HMO market share but are not directly associated with the mammography market and are orthogonal to the omitted variables, this method will produce unbiased estimates. An additional advantage of the IV methods is the removal of errors-in-variables bias that may result from imprecise estimates of HMO market share. If the instrumental variables are uncorrelated with the measurement error, then the IV method will purge the model of this bias as well (Greene, 1993).

We use three instrumental variables: the average number of employees per firm in each HCSA, the presence of a state HMO enabling law, and the presence of a state law authorizing HMOs to be offered to state employees. Areas with large firms may be particularly attractive to HMOs since large firms are more likely than smaller firms to offer their employees a choice of health insurance policies, that may include HMOs. In part, this occurs because federal law mandates that employers with more than 25 employees offer an HMO if they offer health insurance and there is an HMO that wishes to be offered. HMOs may also face lower costs associated with marketing in areas with larger firms. The presence of state HMO enabling laws is expected to indicate favorable legislative climates that may attract HMOs.

These are valid instruments if they are not correlated with characteristics of the mammography providers, conditional on the other exogenous variables. We expect the main potential source of omitted variable bias to be unobservable patient and/or provider preferences for preventive health care, and we expect that firm size and state HMO laws are independent of preferences for health care. One possible difficulty is that the presence larger firms may be correlated with the demographics of workers in an area. To attempt to minimize any resulting bias, we include in our models a number of controls for demographics of the area population, including measures of education and income. We would also note that estimation using only the state HMO law variables as instruments produced similar results.

We also expect that the instruments will remove simultaneity bias since firm size and state HMO laws are not likely to themselves influence or be influenced by the characteristics of mammography providers, conditional on the exogenous variables. One difficulty is that large firms may have leverage in health care purchasing markets and may influence provider behavior independently of the effect of HMOs. We do not expect this to be a significant source of bias since, as noted above, estimation using only state HMO laws produced estimates consistent with those shown.

3.B. DATA

We analyze data at two levels. First, we study the number of mammography sites in markets using market-level data. Data on the number of licensed mammography facilities in each county in the Unites States in 1992 was obtained from the Food and Drug Administration (FDA), which maintains a database of all licensed mammography facilities in the United States. Using this data, we constructed measures of the number of sites and the number of sites per population in each HCSA.

In the analyses reported below we do not use data on HCSAs with populations under 20,000 since markets for mammography services may not be well-developed in sparsely populated areas. Further, areas with low populations may have a mammography facility for access reasons, and the economic incentives that would affect the mammography market in more highly populated areas may not influence behavior in these markets. We also exclude Alaska and Hawaii. This left data from 726 of the original 803 HCSAs.

Second, we study the characteristics of individual sites using facility-level data. Detailed data on the characteristics of mammography facilities are drawn from the 1992 National Survey of Mammography Facilities (NSMF), conducted by Westat for the National Cancer Institute. The NSMF is the only nationally representative survey of mammography facilities in the United States. It was conducted using telephone and mail surveys between March and July of 1992 and obtained responses from 1,057 of the 1,162 facilities selected for the survey from a national sample frame of about 9,500 facilities (response rate=91%). At each facility, the self-identified person "most knowledgeable about facility services" was asked to provide information about facility size, the number of mammograms performed, charges for mammography, and a range of additional facility characteristics. Further information about the survey contents and design may be found in Hurwitz (1993) and Houn and Brown (1994).

From the 1,057 facilities included in the survey, we eliminated 31 facilities that identified their primary affiliation as an HMO, so that results would reflect the behavior of facilities serving the entire market. We also exclude 10 facilities located in HCSAs with populations under 20,000. Seventeen facilities that failed to report size information or affiliation were also excluded, leaving a base sample of 999 facilities for analysis.

Data on a variety of area characteristics were added to the market and facility files. First, we added estimates of HMO market share in each HCSA. Data on other types of managed care organizations were not available. County-level estimates of HMO market share for 1992 were developed based on existing data on enrollment and market area for all HMOs operating in the U.S. as of December 31, 1992. The county-level estimates were aggregated to the HCSA level for analysis. Conceptually, construction took place in three steps. First, the total enrollment and service area, specified by county, were obtained for each HMO in the United States. Second, the enrollment of each HMO was distributed among the counties in its service area using information on county population and distance from HMO headquarters. Finally, the total number of enrollees in each county was computed by summing county enrollments over all of the HMOs serving the county. Using the total number of HMO enrollees in each county, HMO market share was computed as the ratio of enrollees to total population. The process by which the estimates were constructed is described more fully in Appendix A.

Since the county service areas reported by the HMOs, on which these estimates are based, are expected to be quite accurate, it is likely that the estimates themselves are also accurate. While geographically detailed independent data on HMO market share in 1992 are difficult to obtain, we were able to compare these estimates to data available from the Group Health Association of America (GHAA) for 1991. The estimates performed well in these comparisons (Baker, 1995). Nonetheless, allocating enrollment to individual counties will almost certainly lead to measurement error in some cases. Aggregating market shares to the HCSA level is likely to dampen the effects of any misestimation of market shares at the county level. IV estimation will also mitigate bias from this source.

Additional area data came from a variety of sources. Data on the number of physicians and hospital beds per capita, population demographics, education rates, and area per capita incomes were obtained from the Area Resource file. Data on the characteristics of employers in each county were drawn from the annual County Business Patterns surveys done by the Bureau of Labor Statistics. Data on county 1990 AAPCC rates was obtained from HCFA. Data on state HMO regulation is drawn from previous literature (Aspen Systems Corp., 1992). Characteristics of the market-level and facility-level data sets are shown in Table 1.

3.C. HMOS AND THE NUMBER OF MAMMOGRAPHY FACILITIES

We begin by examining the relationship between HMO market share and the number of mammography facilities in markets. On average, there were 13.3 mammography facilities per HCSA in 1992, or 4.3 facilities per 100,000 population. 16 HCSAs had no mammography facilities, while 42 HCSAs had more than 10 facilities per 100,000 population.

We estimated equations of the form:

$$F_i = \beta_0 + \beta_1 \phi_i + \beta_2 D_i + \beta_3 H_i + \epsilon_i \qquad \textbf{(9)}$$

where F represents the number of facilities per 100,000 population in each HCSA, D represents a vector of demographic variables, H represents a vector of health system variables, and ϵ is an error term.[9]

Variables in D include the proportion of the population that is female, the proportion of

[9]We also experimented with using the total number of facilities in the HCSA as the dependent variable, but including HCSA population among the independent variables on the RHS, and with using the natural logarithm of facilities per population as the dependent variable since the distribution is somewhat skewed. These specifications produced results consistent with those shown.

women who are between ages 45 and 64, the proportion of women over age 65, per capita income, and the proportion of the population (men and women) that graduated from high school and from college. These variables are expected to capture variations in demand for mammography.

Variables in H include the number of hospital beds per 1000 population, the number of radiologists per 100,000 population, and the number of obstetricians and gynecologists per 100,000 population. The population weighted average of the 1990 Medicare AAPCC is also included as a measure of health care costs and utilization patterns in the HCSA.[10] These variables may capture variations in demand for medical services, and they may also capture market characteristics that may affect the ease with which new mammography facilities could enter the market. In addition, we include a variable indicating metropolitan areas and dummies for census regions to capture persistent variation across geographic areas.

Table 2 reports results from estimation of equation (9). Both OLS and IV estimates suggest that increases in HMO market share are associated with decreases in the number of facilities (columns 1 and 3). Note that throughout this paper the coefficients on HMO market share have been scaled to represent the effect of a 10 percentage point change in market share (e.g. moving from 5% to 15% market share). The IV estimate suggests that a 10 percentage point increase in HMO market share would reduce the number of facilities per 100,000 population by 1.1. Evaluated at the mean, this would represent a decrease of 25%.[11] The IV estimate is somewhat larger than the OLS estimate,

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[10]The Medicare AAPCC is an estimate of the average per person expenditures of Medicare beneficiaries not enrolled in HMOs. Separate AAPCCs are computed for each county in the country each year. The values are adjusted for differences in population age, sex, and Medicaid status.

[11]Looking only at changes in the number of sites could mask entry or exit that occurs through expansion or contraction of existing facilities. To examine this possibility, we investigated the relationship between HMO market share and the number of x-ray machines being used for mammography at facilities using the facility level file. We estimated OLS and IV regressions in which the dependent variable was the number of machines per site, and the independent variables included HMO market share, the total number of mammography facilities in the HCSA, and the additional area and facility-level control variables described in the next section. We also estimated negative binomial models since the number of machines

suggesting that unobserved market characteristics may have biased the OLS estimate upward.[12]

A difficulty with this specification is that HMOs may have broad influences on the health care system and thus that the inclusion of the health system variables may bias the estimate of the effect of HMO market share. With the health system variables excluded, the results were similar (columns 2 and 4 of Table 2).

These results imply that managed care activity has influenced mammography providers, decreasing the supply of mammography resources. The results are consistent with the implication of the model in the case where decreases in profitability from enhanced search for low priced providers dominate any increases in demand for mammography that HMOs may produce.

3.D. VOLUME

By influencing the number of facilities in a market, or by directly influencing the demand for mammography, HMOs may affect the volume of mammography done at each facility. Facilities were asked how many mammograms had been performed at the facility in the most recent typical 30 days of normal operation. The mean number of mammograms reported was 236. Facilities were also asked "How many of the x-ray machines at this facility are currently being used for mammography?" On average, facilities reported having 1.25 machines per facility. For each facility, the number of mammograms performed was divided by the number of x-ray machines being used for mammography

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per site is a count variable. None of these models indicated that changes in HMO activity were associated with changes in the number of machines per site.

[12]Results from the first-stage equations are presented in columns 5 and 6 of Table 2. In the first stage regression, the instrumental variables were highly significant, and had the expected signs. As a further check on the validity of the instruments, we performed overidentifying restriction tests (Newey, 1985) that examine whether all possible combinations of the instruments would produce the same results. This hypothesis was rejected. IV regressions using each instrument separately indicated that firm size and the presence of a state law permitting HMOs to be offered to state employees both produced negative estimates of β_1 while the variable indicating the presence of a state HMO enabling law showed no evidence of an effect.

to produce the number of mammograms per machine. The average number of mammograms per month per machine in the sample was 171. 172 facilities (17.2%) performed fewer than 50 mammograms per month per machine, while 145 (14.5%) performed more than 300.

We examined the relationship between HMO market share and mammography volume using facility-level data to estimate equations of the form:

$$\log V_{ij} = \beta_0 + \beta_1 \phi_i + \beta_2 F_i + \beta_3 D_i + \beta_4 H_i + \beta_5 X_j + \eta_{ij} \qquad \textbf{(10)}$$

where V represents the number of mammograms per month per machine at facility j located in market i.[13]

The variables included in the vectors of area demographics and health care market characteristics are the same as those used above. Variables in X include a set of dummy variables indicating whether the center is affiliated with a hospital, a radiology practice, a primary care practice, or has a different affiliation;[14] dummy variables indicating whether the facility participates in an American Cancer Society screening program or in another program designed to encourage screening among low income women; and a dummy variable distinguishing facilities accredited by the American College of Radiology. These variables are designed to capture differences in the characteristics of facilities that may be associated with their size.

Results from estimation of equation (10) suggest that increases in HMO activity are associated with increases in mammography volume (Table 3). In the full model, OLS estimation produced a positive and significant coefficient (column 1). IV estimation produced an estimate of similar

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[13]This specification uses the log of volume as the dependent variable. This was done since visual inspection and Box-Cox analysis indicated that the log model was superior to a linear model. (ML estimate of λ=0.198). We also estimated models in which we controlled for the total number of sites and the total population of the HCSA separately, rather than using a single variable measuring the number of sites per capita and found that these models produced results very similar to those shown.

[14]Facilities were allowed to indicate multiple affiliations. In our data, 60 facilities indicated more than one affiliation.

magnitude, but the move to IV more than tripled the standard error (column 3). The IV estimate implies that 10 percentage point increases in HMO market share are associated with 9.2% increases in volume. Evaluated at the mean, a 9.2% increase would result in an additional 15.7 mammograms per month per machine.

The models in columns 1 and 3 controlled for the number of facilities per 100,000 population. These results should be interpreted as capturing the effect of HMOs on volume that occurs independently of the effect of HMOs on entry or exit. Since increases in HMO activity may also reduce the number of facilities, these results may fail to capture the full effect of changes in HMO market share. Columns 2 and 4 presents results from a model that excludes per capita facilities. Here, IV estimation suggests that 10 percentage point increases in HMO market share are associated with 18.3% increases in volume per machine.[15] At the mean, an 18.3% increase would raise volume by 31.3 mammograms per month per machine.

As above, we experimented with some dropping the area health system variables. Also, since including the facility characteristics in the specification could over-control for the effects of HMOs if increases in HMO activity affect the characteristics of facilities, we estimated a model excluding them. In both cases the results were consistent with our previous findings, generally producing larger significant estimates of the effect of HMOs (Table 4).

These results suggest that increases in HMO activity are associated with increases in the number of mammograms performed per machine, both because HMOs change the number of mammography facilities in markets and because HMOs are associated with increases in demand for mammography.

Changes in the number of mammograms performed per facility should affect average cost.

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[15]Results from the first-stage equations are presented in columns 5 and 6. In both of the first stage regressions, the instrumental variables were highly significant and had the expected signs. In addition, validity of the overidentifying restrictions was not rejected at conventional significance levels.

Previous studies have argued that most mammography facilities operate on the downward sloping portion of the average cost curve, so that increases in facility volume should be associated with decreases in average cost (FDA, 1996; PPRC, 1989). To get a feel for the magnitude of the effect implied by our estimates, we used data from a recent FDA report (FDA, 1996) to construct a sample average cost curve for a medium sized facility assumed to provide 170 mammograms per machine per month (the 50th percentile of volume observed in our data). As an example, the IV estimate in column 3 of Table 4 indicated that a 10 percentage point increase in HMO market share would be associated with an increase of 15.7 mammograms per month per machine. For the sample facility, an increase of 15.7 mammograms per month per machine would reduce average cost by $2.36, from $52.18 to $49.82. Construction of the average cost curves is described in more detail in Appendix B.

3.E. HMOS AND MAMMOGRAPHY CHARGES

By affecting costs or margins, changes in HMO activity could influence prices. In this section, we examine the relationship between HMO market share and mammography charges. The survey asked facilities to report their "average total charge for mammography."[16] Facilities that distinguished screening from diagnostic mammography on the survey (N=620) were asked to report information separately for each type of mammography. Facilities that did not distinguish screening from diagnostic mammography were asked to provide only a single charge figure (encompassing both screening and diagnostic procedures). Separate charge information for patients with different forms of health care coverage was not obtained on the survey.

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[16]This may or may not include the charge for radiologist interpretation. Facilities were separately asked to indicate their average charge for radiologist interpretation and whether or not it was included in the average total charge. We adjusted the data so that radiologist charges were always included in the average total charge figures used. Some facilities provided total charge information, but did not provide information about charges for interpretation. In these cases, the mean charge for interpretation across all facilities was used in the computation of the analysis variables. Results from analyses of only facility charges, excluding the fee for radiologist interpretation, produced results similar to those reported.

We focus on charges for screening mammography using data on the 509 facilities that reported separate screening charges. Screening mammography is relatively homogeneous across facilities and is likely to be affected by HMO activity. Using data on average charges across both screening and diagnostic mammography is complicated by the fact that screening and diagnostic mammography prices are generally quite different and may respond to HMO activity to different degrees. We did experiment with using the average charge across both types of mammography and including facilities that did not distinguish screening from diagnostic mammography on the survey, and found that this produced qualitatively similar, if less interpretable, results.

In the analysis, we included facilities that reported separate screening information, reported charges of $10 or more, and responded to the full set of analysis questions, leaving 470 facilities. These facilities had a mean screening charge of $90.59. We examined the relationship between HMO market share and mammography charges using equations of the form:

$$\log C_{ij} = \beta_0 + \beta_1 \phi_i + \beta_2 D_i + \beta_3 H_i + \beta_4 X_j + \eta_{ij} \qquad \textbf{(11)}$$

where C represents the average charge at facility j located in market i. Variables included in D and H are the same as those used above except that the variable controlling for the number of facilities in the market is not included in the base specification here (we do include it in one specification below). The vector of facility characteristics, X, includes all of the variables used above, and adds two variables that may be directly related to costs: a dummy variable for facilities that include more than 2 views in an average screening exam and a variable that measures the average annual wages that the facility pays its technologists that perform mammography. As a group, these variables are expected to capture variability in costs related to variation in facility characteristics.[17]

Results are presented in Table 5. OLS estimates show no evidence of a relationship between

[17]Equation (11) uses the natural logarithm of charges as the dependent variable. This was done since the distribution of charges is skewed and since Box-Cox analyses suggested that a log specification is superior to a linear specification (ML estimate of λ=-0.229).

HMO market share and fees. IV estimates, on the other hand, suggest that increases in HMO market share are associated with declines in prices.[18] The fall in the estimate of β_1 between the OLS and IV specifications is consistent with the presence of endogeneity bias in the OLS estimates. We are particularly concerned about endogeneity here. Not only may unobserved variables bias the results, but the potential for simultaneity is also significant--areas with high health care costs may be particularly likely to attract the entry or expansion of HMOs.

The models in columns 1 and 3 do not control for facility volume, and hence capture any effect of HMOs on charges that occurs through changes in facility volume. The IV estimate in column 3 suggests that 10 percentage point increases in HMO market share are associated with 11.9% decreases in average screening charges At the mean, this would corresponds to a \$10.78 decrease. To control for any effect HMOs may have on prices through changes in volume, columns 2 and 4 include volume. With this variable included, the IV estimate of the HMO market share effect falls slightly. In both the OLS and IV models, the coefficient on the volume variable is negative, but, perhaps due to the small sample size, imprecisely estimated.

We also experimented with additional specifications to test the robustness of these findings (Table 6). Specifically, we experimented with: (1) dropping the health system characteristics since they may be endogenous; (2) dropping the variables controlling for facility characteristics since they may be endogenous, (3) including a variable controlling for the number of facilities per person in the market; and (4) including additional variables to control for additional characteristics of facilities that may be associated with costs. Results were consistent with those reported above.

We wish to be cautious in drawing conclusions from these data. There were substantial

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[18]Results from the first-stage equations are presented in columns 5 and 6. In both of the first stage regressions, the instrumental variables were highly significant and had the expected signs. In overidentifying restriction tests the hypothesis that all subsets of the instruments would produce the same result was rejected. Analysis using the instruments separately indicated that each of the three instruments produced negative coefficients, but that the magnitude of the estimates varied.

differences between the IV and OLS estimates (although there are good reasons to believe that the OLS estimates are biased). In addition, the data reported are charge data and may not fully reflect the discounts some insurers impose when paying bills. Nonetheless, we interpret the results as providing limited evidence that HMO activity can affect prices in health care markets. These estimates suggest that increases in HMO activity are associated with decreases in average screening charges. Since the data reflect average charges across HMO and non-HMO patients, the most likely interpretation of this overall finding is that it is consistent with a situation in which HMOs are willing to pay lower prices for screening mammography on average than non-HMO plans (and facilities then charge them less on average). If this is the case, increases in HMO market share that move patients from non-HMO to HMO coverage would lead straightforwardly to reductions in average charges. It is also possible that some of the decline observed reflects changes in pricing policy. For example, increases in search for low-priced providers may lead some facilities to reduce margins and hence average charges could fall.

The relationship between the HMO market share and volume variables in these models is more easily interpreted in light of the model. Increases in volume are loosely associated with reductions in price. More importantly, the addition of the volume variable to the model led to a small reduction in the estimated effect of HMO market share. We interpret this as consistent with the hypothesis that increases in volume prompted by increases in HMO market share are associated, to at least some degree, with lower average charges. We are not able to determine the effects on charges for different insurers.

4. CONCLUSIONS

This paper investigates the role of managed care in the transformation of health care providers, arguing that changes in the characteristics of health care providers are an important effect of managed care on the health care system. In particular, managed-care-induced shifts in demand and increases in attention to price in purchase decisions may lead to changes in the number of providers in markets, and the costs of producing services. These changes could then lead to changes in charges for health care services. Through these mechanisms, managed care may influence the performance of the entire health care system, including health care delivery and costs for patients who are not enrolled in managed care organizations.

We investigated the existence of these types of effects by examining the relationship between HMO activity and mammography providers. Our results suggest that increases in HMO market share are associated with declines in the number of mammography facilities in markets. This is consistent with the view that managed care can alter the number of providers in markets. In the context of our model, it is consistent with a situation in which the profit-decreasing effects of increasing HMO market share are larger than the profit increasing effects.

Next, we examined the relationship between HMO market share and the number of mammograms performed per month per machine. Increases in HMO market share are associated with increases in volume. Our results also suggest that the effects of HMOs on volume occur both because of declines in the number of facilities and because of increases in demand. Increases in demand could occur if HMOs are more likely to promote the use of mammography among their enrollees and if increases in HMO activity prompt spillover effects among non-HMO patients.

Increases in the number of mammograms performed per month per machine are expected to reduce the costs of producing mammograms. Since most mammography facilities are thought to be operating on the downward sloping portion of their average cost curve, increases in volume should be associated with decreases in average costs. Depending on the structure of the markets, changes in costs may result in changes in prices. When we examined charges for screening mammography, we found some evidence that HMO activity can influence charges through changes in volume.

Overall, these results suggest that managed care does influence the health care delivery system in ways that could affect system-wide health care delivery. The existence of these effects in the mammography market suggests that providers of other services may also be influenced. While extrapolation to the large scale is speculative, it is likely that effects of these types are important in determining shifts in the hospital market and in physician markets. Increases in managed care activity have been associated with declines in demand for inpatient hospital days and with increased search for low-priced hospitals, exacerbating the amount of excess capacity in hospital markets and perhaps contributing to hospital mergers or closures. Similarly, managed care organizations that increase demand for a range of services provided by generalist physicians and reduce demand for specialist services may contribute to shifts in the number and types of physicians in different areas. By changing the number of hospitals or physicians, it is possible that managed care may also, then contribute to changes in their costs and prices.

It is important to note that, while the evidence suggests that mammography facilities became more efficient in response to managed care, this need not be the case for all services. Services that saw reductions in demand that were not offset by reductions in the number of providers could see rising costs with increases in managed care.

Figure 1

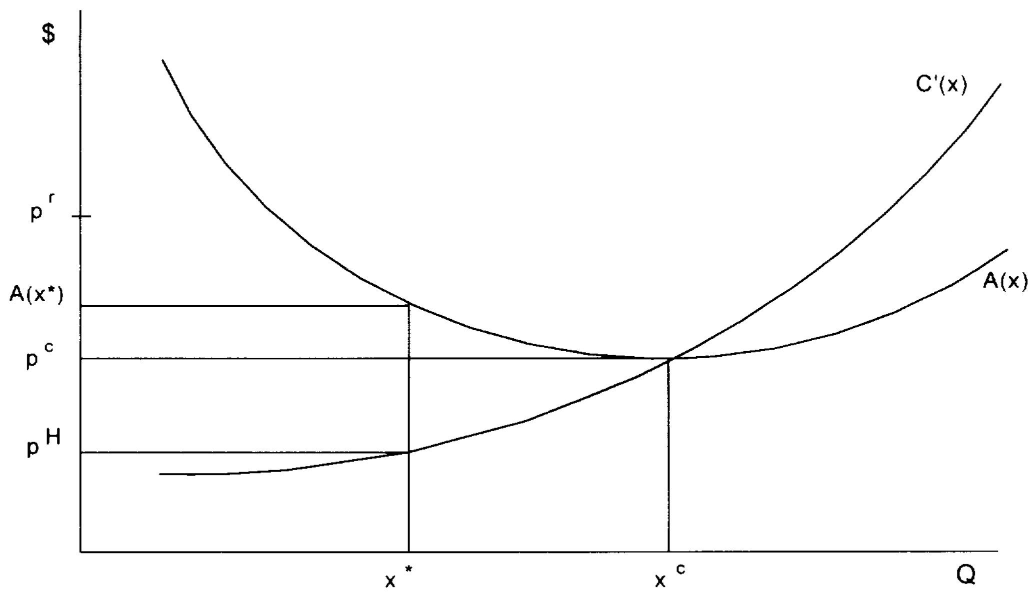

Table 1: Sample Characteristics

	Market-level file		Facility-level file	
	Mean	Standard Dev	Mean	Standard Dev
Facilities per 100,000 pop	4.28	1.88	---	---
Exams per month per machine	---	---	171.43	152.73
Screening charge	---	---	90.73	33.40
HMO market share	7.26	8.95	14.61	11.73
Per capita income/1000	16.96	3.16	19.86	4.22
% pop high school graduate	0.56	0.06	0.55	0.05
% pop college graduate	0.16	0.06	0.19	0.06
% pop female	0.51	0.01	0.51	0.01
% women age 45-64	0.19	0.02	0.19	0.02
% women over 64	0.16	0.04	0.15	0.03
Hospital beds per 1000	5.21	2.94	5.05	1.84
Radiologists per 100,000	6.40	4.16	9.15	4.28
Ob/gyns per 100,000	7.33	4.35	11.23	5.06
1990 AAPCC/100	2.53	0.43	2.96	0.63
Metropolitan area	0.11	0.32	0.40	0.49
Midwest region	0.33	0.47	0.27	0.44
Northeast region	0.10	0.30	0.21	0.41
West region	0.15	0.36	0.18	0.39
South region	0.42	0.49	0.34	0.47
Hospital affiliation	---	---	0.53	0.50
Radiology Practice affiliation	---	---	0.28	0.45
Primary care Practice affiliation	---	---	0.13	0.34

continued

Table 1: Sample Characteristics, continued

	Market-level file		Facility-level file	
	Mean	Standard Dev	Mean	Standard Dev
Other affiliation	---	---	0.12	0.33
ACS program participant	---	---	0.53	0.50
Low income program	---	---	0.44	0.50
ACR accredited	---	---	0.48	0.50
Avg. no. of workers per firm	12.78	2.99	14.45	2.73
State has HMO enabling law	0.25	0.42	0.32	0.47
State employees may be offered HMO	0.45	0.48	0.45	0.50
N	726	726	999	999

Note: Sample size for screening charge is 470. Facility affiliation variables are not mutually exclusive and therefore sum to more than 100%.

Table 2: HMO Market Share and the Number of Mammography Sites

	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) First Stage	(6) First Stage
HMO market share /10	-0.298	-0.359	-1.070	-1.082	---	---
	(0.090)	(0.090)	(0.311)	(0.303)		
Per capita income /1000	0.047	0.048	0.095	0.107	0.031	0.045
	(0.037)	(0.036)	(0.043)	(0.045)	(0.015)	(0.015)
% pop high school graduate	-2.451	-2.599	-2.648	-2.792	-0.099	-0.072
	(1.501)	(1.532)	(1.579)	(1.601)	(0.601)	(0.608)
% pop college graduate	-1.513	-2.086	-0.642	-1.377	2.915	2.273
	(1.975)	(1.935)	(2.101)	(2.040)	(0.819)	(0.779)
% pop female	-15.916	-19.943	-16.257	-19.483	-1.133	-0.676
	(7.593)	(7.584)	(7.979)	(7.919)	(3.138)	(3.138)
% women age 45-64	-7.679	-10.978	-10.906	-13.126	-3.162	-2.269
	(5.256)	(5.310)	(5.659)	(5.609)	(2.143)	(2.145)
% women over age 64	14.573	18.837	13.156	15.959	0.089	-1.686
	(2.741)	(2.589)	(2.930)	(2.936)	(1.205)	(1.144)
Hospital beds per 1,000 pop	0.133	---	0.116	---	-0.017	---
	(0.022)		(0.024)		(0.009)	
Radiologists per 100,000 pop	0.011	---	-0.002	---	-0.017	---
	(0.021)		(0.023)		(0.008)	
Ob/gyns per 100,000 pop.	-0.043	---	-0.023	---	0.005	---
	(0.025)		(0.027)		(0.010)	
1990 AAPCC /100	0.028	---	0.245	---	0.311	---
	(0.191)		(0.217)		(0.077)	
Metropolitan area	0.215	0.160	0.599	0.623	0.435	0.566
	(0.261)	(0.258)	(0.312)	(0.327)	(0.103)	(0.100)
Midwest region	0.874	0.980	1.166	1.221	0.360	0.356
	(0.207)	(0.209)	(0.245)	(0.238)	(0.084)	(0.084)
Northeast region	0.468	0.482	0.647	0.643	0.330	0.350
	(0.254)	(0.260)	(0.276)	(0.279)	(0.108)	(0.109)
West region	1.161	1.131	1.452	1.424	0.570	0.611
	(0.241)	(0.245)	(0.277)	(0.281)	(0.099)	(0.100)

continued

Table 2, continued

	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) First Stage	(6) First Stage
Avg. no. of workers per firm	---	---	---	---	0.069	0.061
					(0.011)	(0.011)
State has HMO enabling law	---	---	---	---	0.351	0.388
					(0.073)	(0.073)
State emps may be offered HMO	---	---	---	---	0.320	0.369
					(0.065)	(0.065)
Constant	11.524	14.224	11.549	14.201	-1.055	-0.651
	(4.216)	(4.175)	(4.430)	(4.358)	(1.716)	(1.697)
N	726	726	726	726	726	726
R^2	0.224	0.182	0.144	0.109	0.460	0.441
F[df] (excluded instruments)	---	---	---	---	23.98	25.37
	---	---	---	---	[3,708]	[3, 712]
$\chi^2[2]$ (overid test)	---	---	---	---	14.175	14.112

Note: Data are from the market-level file. Standard errors in parentheses. The dependent variable is the number of mammography sites per 100,000 population in each HCSA (mean=4.282, standard deviation=1.878). The F-statistic tests the hypothesis that the coefficients on the excluded instruments in the first stage regression are jointly zero. The χ^2 statistic tests the validity of the overidentifying restrictions.

Table 3: HMO Market Share and the Number of Mammograms per Machine

	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) First Stage	(6) First Stage
HMO market share /10	0.081	0.100	0.092	0.183	---	---
	(0.035)	(0.035)	(0.115)	(0.110)		
Facilities per 100,000 pop	-0.107	---	-0.106	---	-0.049	---
	(0.025)		(0.027)		(0.022)	
Per capita income /1000	-0.003	-0.001	-0.003	-0.001	-0.038	-0.038
	(0.016)	(0.016)	(0.016)	(0.016)	(0.015)	(0.015)
% pop female	9.611	10.063	9.602	9.958	-2.687	-2.747
	(4.293)	(4.331)	(4.294)	(4.346)	(3.908)	(3.915)
% women age 45-64	-2.427	-1.792	-2.328	-1.101	-6.134	-5.854
	(2.678)	(2.699)	(2.844)	(2.841)	(2.399)	(2.401)
% women over age 64	1.906	1.015	1.884	0.913	4.901	4.704
	(1.267)	(1.262)	(1.285)	(1.272)	(1.252)	(1.251)
% pop high school graduate	-0.276	0.115	-0.273	0.106	0.107	0.287
	(0.702)	(0.702)	(0.702)	(0.704)	(0.621)	(0.616)
% pop college graduate	0.655	0.530	0.592	0.065	7.249	7.323
	(0.961)	(0.970)	(1.142)	(1.134)	(0.866)	(0.867)
Hospital affiliation	0.005	0.004	0.005	0.002	0.001	0.0003
	(0.113)	(0.114)	(0.113)	(0.115)	(0.100)	(0.1002)
Radiology office affiliation	0.119	0.113	0.118	0.107	0.037	0.034
	(0.113)	(0.114)	(0.113)	(0.114)	(0.099)	(0.099)
Primary care practice affiliation	-0.269	-0.283	-0.270	-0.290	0.026	0.017
	(0.105)	(0.106)	(0.105)	(0.106)	(0.093)	(0.093)
Other affiliation	0.098	0.100	0.097	0.095	0.002	0.001
	(0.121)	(0.122)	(0.121)	(0.122)	(0.107)	(0.107)
ACS program participant	0.005	0.021	0.005	0.022	-0.055	-0.049
	(0.060)	(0.061)	(0.060)	(0.061)	(0.053)	(0.053)
Low income program	0.064	0.056	0.065	0.059	-0.010	-0.013
	(0.060)	(0.060)	(0.060)	(0.061)	(0.053)	(0.053)
ACR accredited	0.666	0.682	0.665	0.675	0.022	0.028
	(0.055)	(0.056)	(0.056)	(0.056)	(0.049)	(0.049)

continued

Table 3, continued

	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) First Stage	(6) First Stage
Hospital beds per 1,000 pop.	-0.023	-0.039	-0.023	-0.035	-0.028	-0.036
	(0.017)	(0.017)	(0.017)	(0.017)	(0.015)	(0.015)
Radiologists per 100,000 pop.	0.011	0.008	0.011	0.007	0.002	0.0001
	(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.0096)
Ob/gyns per 100,000 pop.	-0.003	0.001	-0.003	0.001	-0.009	-0.008
	(0.013)	(0.013)	(0.013)	(0.013)	(0.011)	(0.011)
1990 AAPCC /100	-0.027	-0.017	-0.033	-0.061	0.566	0.578
	(0.070)	(0.070)	(0.090)	(0.089)	(0.061)	(0.060)
Metropolitan area	-0.041	-0.061	-0.046	-0.092	0.274	0.264
	(0.083)	(0.084)	(0.093)	(0.093)	(0.074)	(0.074)
Midwest region	0.008	-0.081	0.003	-0.115	0.396	0.356
	(0.093)	(0.092)	(0.107)	(0.101)	(0.085)	(0.084)
Northeast region	-0.069	-0.127	-0.072	-0.147	0.443	0.424
	(0.095)	(0.095)	(0.100)	(0.098)	(0.089)	(0.088)
West region	0.007	-0.068	-0.005	-0.150	1.133	1.113
	(0.108)	(0.107)	(0.156)	(0.149)	(0.090)	(0.090)
Avg. no. of workers per firm	---	---	---	---	0.105	0.111
					(0.012)	(0.012)
State has HMO enabling law	---	---	---	---	0.119	0.121
					(0.069)	(0.069)
State emps may be offered HMO	---	---	---	---	0.295	0.300
					(0.065)	(0.066)
Constant	0.203	-0.617	0.205	-0.548	-0.915	-1.259
	(2.285)	(2.298)	(2.285)	(2.306)	(2.060)	(2.058)
N	999	999	999	999	999	999
R^2	0.226	0.211	0.226	0.206	0.622	0.620
F[df] (excluded instruments)	---	---	---	---	32.39	36.51
	---	---	---	---	[3, 973]	[3, 974]
χ^2[2] (overid test)	---	---	---	---	1.022	0.846

Note: Data are from the facility-level file. Standard errors in parentheses. The dependent variable is log(exams per month per machine) (mean=4.773, standard deviation=0.932). The F-statistic tests the hypothesis that the coefficients on the excluded instruments in the first stage regression are jointly zero. The χ^2 statistic tests the validity of the overidentifying restrictions.

Table 4: HMOs and Volume per Machine, Alternate Specifications

	OLS		IV	
	Drop Health System Chars	Drop Facility Chars	Drop Health System Chars	Drop Facility Chars
HMO market share /10	0.082	0.119	0.207	0.310
	(0.033)	(0.038)	(0.110)	(0.119)
N	999	999	999	999
R^2	0.224	0.051	0.199	0.026

Note: Data are from the facility-level file. Standard errors in parentheses. The dependent variable is log(exams per month per machine). Models also contain additional variables shown in Table 4, columns 2 and 4.

Table 5: HMO Market Share and Screening Mammography Charges

	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) First Stage	(6) First Stage
HMO market share /10	-0.003	-0.002	-0.119	-0.113	---	---
	(0.020)	(0.020)	(0.060)	(0.060)		
Exams/month/machine /1000	---	-0.139	---	-0.116	---	0.014
		(0.111)		(0.115)		(0.246)
Per capita income	0.003	0.003	0.004	0.004	-0.033	-0.033
	(0.009)	(0.009)	(0.010)	(0.010)	(0.021)	(0.021)
% population female	1.139	1.386	1.928	2.095	0.115	0.096
	(2.432)	(2.439)	(2.549)	(2.545)	(5.532)	(5.547)
% women age 45-64	0.287	0.215	-0.345	-0.374	-4.615	-4.607
	(1.544)	(1.544)	(1.629)	(1.623)	(3.424)	(3.431)
% women over age 64	-0.770	-0.740	-0.739	-0.715	4.874	4.867
	(0.691)	(0.691)	(0.716)	(0.714)	(1.739)	(1.745)
% pop high school graduate	-0.433	-0.417	-0.496	-0.479	0.059	0.057
	(0.421)	(0.421)	(0.437)	(0.436)	(0.925)	(0.927)
% pop college graduate	-0.127	-0.143	0.639	0.588	8.711	8.711
	(0.544)	(0.544)	(0.677)	(0.676)	(1.205)	(1.206)
Hospital affiliation	0.020	0.020	0.023	0.023	-0.002	-0.002
	(0.058)	(0.058)	(0.060)	(0.060)	(0.127)	(0.127)
Radiology office affiliation	-0.027	-0.024	-0.025	-0.023	-0.051	-0.051
	(0.058)	(0.058)	(0.060)	(0.059)	(0.126)	(0.127)
Primary care practice affiliation	0.078	0.073	0.108	0.102	0.149	0.149
	(0.056)	(0.056)	(0.059)	(0.059)	(0.122)	(0.123)
Other affiliation	-0.061	-0.056	-0.045	-0.041	0.060	0.060
	(0.064)	(0.064)	(0.067)	(0.067)	(0.141)	(0.141)
ACS program participant	-0.069	-0.070	-0.079	-0.079	-0.129	-0.128
	(0.034)	(0.034)	(0.036)	(0.036)	(0.076)	(0.076)
Low income program	-0.082	-0.080	-0.080	-0.078	0.065	0.065
	(0.033)	(0.033)	(0.034)	(0.034)	(0.073)	(0.073)
ACR accredited	-0.061	-0.049	-0.045	-0.036	0.047	0.046
	(0.032)	(0.033)	(0.034)	(0.035)	(0.070)	(0.073)
Technologist wages	-0.004	-0.004	-0.002	-0.002	0.031	0.031
	(0.007)	(0.007)	(0.007)	(0.007)	(0.016)	(0.016)

continued

Table 5, continued

	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) First Stage	(6) First Stage
>2 views in screening exam	0.022	0.022	-0.003	-0.001	-0.183	-0.183
	(0.054)	(0.054)	(0.057)	(0.057)	(0.118)	(0.118)
Hospital beds per 1,000 pop.	-0.00004	-0.0005	-0.005	-0.005	-0.049	-0.049
	(0.00872)	(0.0087)	(0.009)	(0.009)	(0.019)	(0.019)
Radiologists per 100,000 pop.	0.0002	0.001	0.002	0.002	-0.005	-0.005
	(0.0059)	(0.006)	(0.006)	(0.006)	(0.013)	(0.013)
Ob/gyns per 100,000 pop.	-0.012	-0.012	-0.016	-0.016	-0.035	-0.035
	(0.007)	(0.007)	(0.008)	(0.008)	(0.016)	(0.016)
1990 AAPCC /100	0.119	0.117	0.197	0.192	0.698	0.699
	(0.041)	(0.041)	(0.057)	(0.057)	(0.085)	(0.085)
Metropolitan area	-0.023	-0.022	0.004	0.004	0.130	0.130
	(0.046)	(0.046)	(0.049)	(0.049)	(0.101)	(0.101)
Midwest region	0.106	0.106	0.162	0.160	0.397	0.397
	(0.051)	(0.051)	(0.060)	(0.060)	(0.115)	(0.115)
Northeast region	0.395	0.391	0.418	0.414	0.354	0.354
	(0.054)	(0.054)	(0.057)	(0.057)	(0.125)	(0.126)
West region	0.038	0.038	0.151	0.145	1.030	1.030
	(0.062)	(0.062)	(0.084)	(0.084)	(0.129)	(0.129)
Avg. no. of workers per firm	---	---	---	---	0.122	0.122
					(0.017)	(0.017)
State has HMO enabling law	---	---	---	---	0.254	0.254
					(0.091)	(0.091)
State emps may be offered HMO	---	---	---	---	0.153	0.153
					(0.098)	(0.099)
Constant	3.967	3.857	3.459	3.391	-3.674	-3.664
	(1.287)	(1.289)	(1.356)	(1.352)	(2.881)	(2.890)
N	470	470	470	470	470	470
R^2	0.231	0.234	0.175	0.183	0.686	0.686
F[df] (excluded instruments)	---	---	---	---	20.46	20.17
	---	---	---	---	[3, 443]	[3, 442]
χ^2[2] (overid test)	---	---	---	---	15.352	14.626

Note: Data are from the facility level file. Standard errors in parentheses. The dependent variable is log(total screening mammography charge) (mean=4.444, standard deviation=0.349). The sample includes only facilities that distinguish screening from diagnostic mammography. The F-statistic tests the hypothesis that the coefficients on the excluded instruments in the first stage regression are jointly zero. The χ^2 statistic tests the validity of the overidentifying restrictions.

Table 6: HMOs and Screening Mammography Charges, Alternate Specifications

	Drop Health System Characteristics	Drop Facility Characteristics	Add Facilities per Population Control	Add Other Facility Chars
HMO market share /10	-0.127 (0.065)	-0.105 (0.059)	-0.098 (0.062)	-0.123 (0.061)
Facilities per 100,000 pop	---	---	0.023 (0.015)	---
Waiting time for appt (days) /10	---	---	---	-0.012 (0.028)
Facility uses batch interp.	---	---	---	-0.015 (0.040)
Exam includes physical exam	---	---	---	0.030 (0.035)
Exam includes radiologist consult	---	---	---	-0.058 (0.094)
Facility has evening hours	---	---	---	0.037 (0.037)
Facility has weekend hours	---	---	---	-0.028 (0.038)
N	470	470	470	470
R2	0.116	0.121	0.199	0.177

Note: Data are from the facility level file. Standard errors in parentheses. The dependent variable is log(total screening mammography charge). All models are estimated using instrumental variables. Models also include variables shown in Table 5, column 3.

Appendix A: HMO Market Share Estimates

This appendix describes the development of the HMO market share estimates. Additional details of the estimation process can be found in Baker (1995).

The primary source of information on HMO enrollments and service areas is the *National Directory of HMOs*, published annually by the Group Health Association of America (GHAA, 1992). Each year the GHAA conducts a mail survey, with telephone follow up, of all known HMOs in the country and, among other things, asks their total enrollment and their service area. The results of the survey are published in the annual *Directories*. To construct estimates of 1992 county market share, the 1993 *Directory*, which lists enrollment and service area for each of the 545 HMOs in the mainland U.S., Alaska, and Hawaii as of December 31, 1992, was used.

All but one of the HMOs in the directory indicated their enrollment. In the missing case, data from the 1992 *Directory* was used. Most HMOs (531 of 545) also indicated the counties that they served. However, 14 HMOs (3 percent), did not provide a clear definition of their market area in terms of counties. For these HMOs, market areas were determined by reference to subsequent *Directories* and/or telephone contact.

The next step was to distribute the enrollment of each HMO among the counties in its service area. Initially, this was done by simply distributing enrollment proportionally to county population. In addition, since HMO enrollment may be concentrated near HMO headquarters or since HMOs may locate their headquarters in areas where their enrollment is concentrated, estimates that incorporate both county population and distance from HMO headquarters were constructed. The correlation between estimates produced by the two methods is approximately 0.97. Estimates that incorporate both population and distance are used here.

Once enrollments had been distributed over service areas, the total number of enrollees in each county was computed by summing over the set of HMOs serving that county. Using the set of county enrollment estimates, market share estimates were computed as the proportion of the population enrolled in HMOs. These estimates were then aggregated to the HCSA level.

Appendix B: Mammography Facility Average Cost Curves

To illustrate the effects of changes in mammography volume on average costs, we used data from a recent FDA study of mammography costs (FDA, 1996) to construct a sample average cost curve for a medium sized facility. The facility was assumed to produce 170 mammograms per month (2040 per year), which corresponds to the median facility found in our data. Based on FDA (1996), we assume that this facility has one mammography machine and a clinical director and requires 3 radiologic technicians and 2 radiologists to operate.

Mammography facilities have a number of fixed costs. We also assume that the facility provides a range of services, 20% of which are mammography-related. This allows the fixed costs for the clinical director's salary, film processor and film processor maintenance, office equipment, malpractice insurance, facility insurance, advertising, and bookkeeping to be spread over other non-mammography activities. Specific fixed cost amounts incorporated into the model, drawn from FDA (1996) and expressed on an annual basis are: clinical director compensation ($8,996.00), annualized capital cost of mammography machine equipment ($9,753.11), annualized capital cost of film processor ($169.63), annualized capital cost of office equipment ($1,965.28), quality assurance testing ($2,086.50), quality assurance test film ($150.00), annual medical physicist inspection ($550.00), mammography machine maintenance ($6,500.00), film processor maintenance ($200.00), professional fees and dues ($1,793.00), inspection fees ($1,178.00), malpractice insurance ($2,000.00), office space rent ($13,488.00), utilities ($1,272.00), facility insurance ($1,460.00), advertising and marketing ($291.79), and bookkeeping and accounting services ($5,100.00). The total annual fixed costs for the facility are $56,953.31.

Variable costs of mammography include labor and materials costs and some office expenses. The variable costs included in the model, drawn from FDA (1996) and expressed on a per-mammogram basis, are: radiologic technician ($8.35), radiologist ($6.57), office staff ($3.71), film ($2.00), processing materials ($1.00), telephone expenses ($1.39), cleaning and laundry ($0.67), and office supplies ($0.57). The total variable cost per mammogram is $24.26. We assume variable costs are constant with respect to the number of mammograms performed.

Note that some items have both fixed and variable components, but have been fully assigned to either the fixed or variable category (e.g. facility insurance costs or telephone costs). This was done to simplify the analysis and because the data required to separate out the fixed vs. variable components were not available. We do not expect the results to be sensitive to these assumptions.

The average cost curve for our example facility is: $A(x) = (1/x)(56953.31 + 24.26x)$ where x is the number of mammograms. The change in average cost associated with moving from x_1 to x_2 is $A(x_2)$ -

$A(x_1)$. Let x_1= 2040 (the assumed base level), and let x_2 reflect an increase of 15.7 mammograms per month per machine, or 188.4 mammograms per machine per year. Then $A(x_1)$=52.18 and $A(x_2)$=49.82, and the reduction in average costs is $2.36.

The implied effect of a change in volume varies with facility size. To compare facilities of different sizes, we also computed average cost curves for a small facility assumed to produce 780 mammograms per year (corresponding to the 25th percentile of our data), to operate without a clinical director. Fixed costs for this facility are $47,957.31 per year. Evaluated starting at the base level of 780 mammograms per year, an increase of 15.7 mammograms per machine per month would reduce average cost by $11.96.

We also considered the case of a large facility, performing 5520 mammograms per year (corresponding with the 75th percentile of observed volumes in our data). This facility requires 2 mammography machines and a clinical director. Total fixed costs for this facility are $91,272.92. (Note that there are some economies of scale so that the second mammography machine does require as many fixed costs as the first. See FDA 1996). Evaluated starting at the base level of 5520 mammograms per year (2760 per machine per year), an increase of 15.7 mammograms per machine per month would reduce average cost by $1.06.

References

Aspen Systems Corp., *HMO Law Manual*. 1992, Rockville, MD: Aspen Systems Corp.

Baker, Laurence C., "The effect of HMOs on fee-for-service health care expenditures: Evidence from Medicare." *Journal of Health Economics*, forthcoming (1996).

Baker, Laurence C. and Kenneth S. Corts, "The effect of HMOs on conventional insurance premiums: theory and evidence," NBER Working Paper No. 5356, November, 1995.

Baker, Laurence C. and Kenneth S. Corts, "HMO penetration and the cost of health care: market discipline or market segmentation?" *American Economic Review*, 86:2 (May, 1996) 389-394.

Breen, Nancy and Martin L. Brown, "The price of mammography in the United States: Data from the National Survey of Mammography Facilities." *The Milbank Quarterly*, 72:3 (1994) 431-450.

Breen, Nancy and Larry G. Kessler, "Changes in the use of screening mammography: Evidence from the 1987 and 1990 National Health Interview Surveys." *American Journal of Public Health*, 84:1 (January, 1994) 62-67.

Cerne, Frank and Jim Montague, "Capacity crisis." *Hospitals & Health Networks*, 68:19 (October 5, 1994) 30-32, ff.

Chernew, Michael, "The impact of non-IPA HMOs on the number of hospitals and hospital capacity." *Inquiry*, 32:2 (Summer, 1995) 143-154.

Clement, Dolores Gurnick, Phillip M. Gleason, and Randall S. Brown, *The Effects of Risk Contract HMO Market Penetration on Medicare Fee-For-Service Costs: Final Report*,, Mathematica Policy Research: Princeton, NJ, December 18, 1992.

Feldman, Roger and Bryan Dowd, "Is there a competitive market for hospital services?" *Journal of Health Economics*, 5 (1986) 277-292.

Feldman, Roger, Bryan Dowd, and Gregory Gifford, "The effect of HMOs on premiums in employment-based health plans." *Health Services Research*, 27:6 (February, 1993) 779-811.

Feldman, Roger, Bryan Dowd, Don McCann, and Allan Johnson, "The competitive impact of health maintenance organizations on hospital finances: An exploratory study." *Journal of Health Politics, Policy, and Law*, 10:4 (Winter, 1986) 675-698.

Fletcher, S.W., W. Black, R. Harris, B.K. Rimer, and S. Shapiro, "Report of the international workshop on screening for breast cancer." *Journal of the National Cancer Institute*, 85:20 (October 20, 1993) 1644-1656.

Food and Drug Administration, Eastern Research Group and Office of Planning and Evaluation, *Costs and Benefits of MQSA*, Office of Management and Systems, Food and Drug Administration: Washington, D.C., 1996.

Frank, Richard G. and W. Pete Welch, "The competitive effects of HMOs: A review of the evidence." *Inquiry*, 22 (Summer, 1985) 148-161.

GHAA, *1991 National Directory of HMOs*. 1991, Washington, D.C.: The Group Health Association of America.

Goldberg, Lawrence G. and Warren Greenberg, "The competitive response of blue cross and blue shield to the growth of health maintenance organizations in northern California and Hawaii." *Medical Care*, 17:10 (October, 1979) 1019-1028.

Greene, William H., *Econometric Analysis*. 1993, New York, NY: MacMillan.

Houn, Florence and Martin L. Brown, "Current practice of screening mammography in the United States: Data from the National Survey of Mammography Facilities." *Radiology*, 190:1 (January, 1994) 209-215.

Hurwitz, Paul E., *National Survey of Mammography Facilities: Phase 1 Final Report*,, Westat: Washington, D.C., January 28, 1993.

Katz, Michael L., "Price discrimination and monopolistic competition." *Econometrica*, 52:6 (November, 1984) 1453-1471.

Kerlikowske, Karla, Deborah Grady, Susan M. Rubin, Christian Sandrock, and Virginia L. Ernster, "Efficacy of screening mammography." *Journal of the American Medical Association*, 273:2 (January 11, 1995) 149-154.

Luft, Harold S., S.C. Maerki, J.B. Trauner, "The competitive effects of health maintenance organizations: another look at the evidence from Hawaii, Rochester, and Minneapolis/St. Paul." *Journal of Health Politics, Policy, and Law,* 10 (1986) 625-658.

Makuc, DM, B Haglund, DD Ingram, JC Kleinman, and Feldman JJ, *Vital and Health Statistics--Health Care Service Areas for the United States*, National Center for Health Statistics: Washington DC, November, 1991.

McLaughlin, Catherine G., "HMO growth and hospital expenses and use: A simultaneous-equation approach." *HSR: Health Services Research*, 22:2 (June, 1987) 183-205.

McLaughlin, Catherine G., "The effect of HMOs on overall hospital expenses: Is anything left after correcting for simultaneity and selectivity?" *HSR: Health Services Research*, 23:3 (August, 1988) 421-441.

Newey, Whitney, "Generalized method of moments specification testing." *Journal of Econometrics*, 29 (1985) 229-256.

Noether, Monica, "Competition among hospitals." *Journal of Health Economics*, 7:3 (September, 1988) 259-284.

Phelps, Charles E., "Diffusion of information in medical care." *Journal of Economic Perspectives*, 6:3 (Summer, 1992) 23-42.

Phillips, Kathryn A., Karla Kerlikowske, Sophia W. Chang, Laurence C. Baker, and Martin L. Brown, "Individual, practitioner, and environmental factors associated with adherence to screening mammography guidelines," manuscript, University of California-San Francisco, April, 1996.

Physician Payment Review Commission, *The Cost of Providing Screening Mammography*, Report to Congress: Washington, D.C., 1989.

Robinson, James C., "HMO market penetration and hospital cost inflation in California." *Journal of the American Medical Association*, 266:19 (November 20, 1991) 2719-2723.

Salop, Steven and Joseph Stiglitz, "Bargains and ripoffs: A model of monopolistically competitive price dispersion." *Review of Economic Studies*, 44:3 (October, 1977) 493-510.

Urban, N., G.L. Anderson, and S. Peacock, "Mammography screening: How important is cost as a barrier to use?" *American Journal of Public Health*, 84:1 (January, 1994) 50-55.

Welch, W. Pete, HMO market share and its effect on local Medicare costs, in *HMOs and the Elderly*, Harold S. Luft, Editor. 1994, Health Administration Press: Ann Arbor, MI. p. 231-249.

Wickizer, Thomas M. and Paul J. Feldstein, "The impact of HMO competition on private health insurance premiums, 1985-1992." *Inquiry*, 32:3 (Fall, 1995) 241-251.