IS HOSPITAL COMPETITION SOCIALLY WASTEFUL?*

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We study the consequences of hospital competition for Medicare beneficiaries' heart attack care from 1985 to 1994. We examine how relatively exogenous determinants of hospital choice such as travel distances influence the competitiveness of hospital markets, and how hospital competition interacts with the influence of managed-care organizations to affect the key determinants of social welfare—expenditures on treatment and patient health outcomes. In the 1980s the welfare effects of competition were ambiguous; but in the 1990s competition unambiguously improves social welfare. Increasing HMO enrollment over the sample period partially explains the dramatic change in the impact of hospital competition.

INTRODUCTION

The welfare implications of competition in health care, particularly competition among hospitals, have been the subject of considerable theoretical and empirical debate. On one side has been work that finds that competition reduces costs, improves quality, and increases efficiency of production in markets for hospital services (e.g., Pauly [1988], Melnick et al. [1992], Dranove et al. [1992], Vistnes [1995], and Town and Vistnes [1997]). On the other side has been research that argues that differences between hospital markets and stylized markets of simple economic models lead competition to reduce social welfare. Health insurance, which dampens patients' sensitivity to cost and price differences among hospitals, is the most important source of these differences: insensitivity to price may lead hospitals to engage in a "medical arms race" and compete through the provision of medically unnecessary services [Feldstein 1971; Held and Pauly 1983; Robinson and Luft 1985]. Other work focuses on informational imperfections in hospital markets, which may cause increases in the number of providers to lead to higher costs (e.g., Satterthwaite [1979] and Frech [1996]), and on the monopolistically competitive

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nature of hospital markets, which may cause competition to lead to excess capacity and therefore higher costs (e.g., Joskow [1980] and Fisher et al. [1999]) and potentially to increased adverse patient health outcomes [Shortell and Hughes 1988; Volpp and Waldfogel 1998].

These opposing views have been manifested in two distinct policy perspectives. If competition among hospitals improves social welfare, then strict limits on the extent to which hospitals coordinate their activities may lead to greater efficiency in health care production. But if competition among hospitals is socially wasteful, then coordination and mergers should receive more lenient antitrust treatment, or possibly even be encouraged.

Despite the theoretical and policy implications of evidence on the welfare consequences of competition in health care, virtually no previous research has identified these effects on both health care costs and patient health outcomes; and without information on both costs and outcomes, conclusions about patient welfare are necessarily speculative. In addition, previous research has used measures of market competitiveness that may result in biased assessments of the impact of competition. In this paper we develop models of the effects of hospital competition on costs and health outcomes for all nonrural elderly Medicare recipients hospitalized for a treatment of a new heart attack (AMI) in 1985–1994. We identify the effects of hospital market competition with a relatively exogenous source of variation—travel distances between patients and hospitals—that depends neither on unobserved characteristics of patients nor on unobserved determinants of hospital quality. Based on this identifying assumption, we construct geographic hospital markets that have variable size, and continuous rather than discrete boundaries. We also explore how managed care mediates the effects of hospital competition on medical treatment decisions, costs, and outcomes. Finally, because we observe information on hospital markets and HMOs over a long time horizon, we estimate the impact of area competitiveness holding constant other time-varying market characteristics and fixed effects for zip code areas. Thus, we control for all time-invariant heterogeneity across small geographic areas, hospitals, and patient populations.

Section I of the paper discusses the theoretical ambiguity of the impact of competition among providers on efficiency in hospital markets. Section II reviews the previous empirical literature on this topic. Although this literature has helped to shape understanding of markets for medical care, Section II describes its three key limitations: it does not assess directly both the financial implications and the patient health consequences of competition; it uses measures of hospital competition that depend on unobserved hospital and patient heterogeneity, leading to biased estimates of the impact of competition; and it has failed to control for a comprehensive set of other hospital and area characteristics that may be correlated with competition, or that may mediate its effects. Section III presents our econometric models of the exogenous determinants of hospital choice and thus of differences in competition across small areas, and our models of the effects of changes in competition on medical treatment decisions, health care costs, and health outcomes. Section IV discusses our three data sources. Section V presents our empirical results. Section VI concludes and discusses potential implications of our findings for antitrust policy.

I. Theoretical Models of the Impact of Hospital Competition on Social Welfare

Basic microeconomic theory suggests that competition leads to efficient outcomes. Markets for health care in general, and markets for hospital services in particular, deviate substantially from the stylized conditions required by the basic theory, in which multiple buyers and multiple sellers of a product or service are price takers with full information, and bear the full costs of their actions at the margin. Not surprisingly, economic models of hospital competition suggest that it may either improve or reduce social welfare.

Most of the models of how hospital competition may reduce social welfare focus on distorted price signals and a more general absence of price competition. Insurance and tax incentives may make consumers relatively insensitive to price, for example, so that hospitals in more competitive markets engage in a medical arms race (MAR) and supply socially excessive levels of medical care [Salkever 1978; Robinson and Luft 1985].[1] Further, hospitals

1. The original MAR hypothesis was formulated around the idea that hospitals compete for patients through competition for their physicians, by providing a wide range of equipment and service capabilities. Greater availability of equipment may induce physicians to admit their patients to a hospital for several reasons. If physicians are uncertain about the necessity of various intensive treatments at the time the admission decision is made, then additional service capabilities may allow them to provide higher-quality care. Also, to the

were historically reimbursed on a "cost-plus" basis, so that they too did not bear the marginal costs of intensive treatment decisions. In addition, "quality competition" may be socially excessive because of price regulation in the health care industry (see, e.g., Joskow [1983] and McClellan [1994a] for a discussion).[2] If the additional intensity of medical care resulting from competition is excessive, in terms of improvements in patient health outcomes whose value is less than the social costs of production, then competition among hospitals would be socially wasteful.

However, even in MAR-type models, competition may improve welfare. Indeed, if regulated prices are set appropriately and hospital markets are competitive, McClellan [1994a] shows that a first-best outcome can be achieved even with full insurance. Moreover, many of the MAR models are now viewed as theoretically outdated, because of improved price competition among managed-care health plans. If plans have more capacity to negotiate and influence hospital practices than do patients, and consumers pay for the marginal differences in premiums across plans [Enthoven and Singer 1997], then the growth of managed care may have induced hospitals to compete on the basis of price (e.g., Town and Vistnes [1997]) and have led to more cost-effective use of medical technology (e.g., Pauly [1988]). Such price competition is likely to be greatest in areas where managed-care health plans are most widespread.

Other aspects of hospital markets besides the effects of insurance and managed care on price and quality competition also make it difficult to draw definitive theoretical conclusions about the consequences of competition. Informational imperfections in hospital markets may cause competition to reduce social welfare (e.g., Satterthwaite [1979] and Frech [1996]). In addition, if hospital markets are monopolistically competitive and not perfectly competitive, greater competition may lead to less efficient levels of care (e.g., Dranove and Satterthwaite [1992] and Frech [1996]). Although conventional wisdom is that monopolistic competition in hospital markets yields too many providers and excess

extent that high-tech equipment is a complement to compensated physician effort, additional equipment may allow physicians to bill for more services; to the extent that equipment is a substitute for uncompensated physician effort, additional equipment allows physicians to work less for the same level of compensation.

2. Models of the airline industry (e.g., Douglas and Miller [1974], Panzar [1979], and Schmalensee [1977]), for example, showed that regulated pricing induced airlines to engage in nonprice competition, leading airline markets with greater numbers of competitors to have higher service levels.

capacity (with no hospital large enough to exhaust returns to scale), in fact monopolistic competition can lead to either socially excessive or inadequate capacity [Tirole 1988, Section 7.2]. Finally, a substantial fraction of hospitals are nonprofit institutions, which may have different objectives and behave differently than their for-profit counterparts (e.g., Hansmann [1980], Kopit and McCann [1988], and Lynk [1995]). Models of competition based on for-profit objectives may not accurately characterize the welfare implications of interactions in hospital markets.

II. Previous Empirical Literature

A vast empirical literature has examined the consequences of competition in markets for hospital services (see Gaynor and Haas-Wilson [1997] and Dranove and White [1994] for comprehensive reviews). In summary, research based on data from prior to the mid-1980s finds that competition among hospitals leads to increases in excess capacity, costs, and prices [Joskow 1980; Robinson and Luft 1985, 1987; Noether 1988; Robinson 1988; Robinson et al. 1988; Hughes and Luft 1991]; and research based on more recent data generally finds that competition among hospitals leads to reductions in excess capacity, costs, and prices [Zwanziger and Melnick 1988; Wooley 1989; Dranove, Shanley, and Simon 1992; Melnick et al. 1992; Dranove, Shanley, and White 1993; Gruber 1994], with some important exceptions [Robinson and Luft 1988; Mannheim et al. 1994].

The empirical literature has three well-known limitations. First and foremost, virtually none of the literature directly assesses the impact of competition either on resource use or on patient health outcomes; without significant additional assumptions, it is not possible to draw any conclusions about social welfare (see Hoxby [1994] for discussion of this point in the context of competition among public schools). Most research does not measure the impact of competition on the total resources used to treat a given occurrence of illness—that is, the financial social costs or benefits of competition. Some work uses "list" charges rather than transaction prices (e.g., Noether [1988]), although fewer and fewer patients pay undiscounted prices [Dranove, Shanley, and White 1993]. Even those studies that use transaction prices (e.g., Melnick et al. [1992]) or transaction-price/cost margins (e.g., Dranove, Shanley, and White [1993]) analyze the prices for a fixed basket of services, despite the fact that the welfare losses from the absence of hospital competition are likely to be due to the provision of additional services of minimal medical benefit, rather than to increases in prices for a given basket of services. Other studies measure the effects of competition on the profitability of for-profit hospitals [Wooley 1989], on accounting costs per case-mix adjusted admission [Robinson and Luft 1985, 1987, 1988; Zwanziger and Melnick 1988; Mannheim et al. 1994], on employment of specialized personnel [Robinson 1988], on lengths of stay [Robinson et al. 1988], and on patterns of provision of specific hospital services [Hughes and Luft 1991; Dranove, Shanley, and Simon 1992]. We identified two previous economic studies that sought to assess the consequences of competition for patient health outcomes [Shortell and Hughes 1988; Volpp and Waldfogel 1998]. Shortell and Hughes [1988] do not examine the impact of competition on treatment decisions; and both studies investigate the effect of competition on in-hospital mortality only. This is an incomplete measure of health: if longer hospital stays improve patient health but provide more time for deaths to occur, better outcomes might be associated with higher in-hospital mortality. No studies have examined comprehensive or longer-term health effects.

The second well-known problem in the empirical literature is that the commonly used measures of market competitiveness may result in biased estimates of the impact of competition on prices, costs, and outcomes. For example, the "variable radius" method specifies each hospital's relevant geographic market as a circular area around the hospital with radius equal to the minimum necessary to include a fixed percentage of that hospital's patients, often 60 or 75 percent [Elzinga and Hogarty 1978; Garnick et al. 1987; Phibbs and Robinson 1993]. Hospitals inside the circular area are considered to be relevant competitors; hospitals outside the area are considered to be irrelevant. Based on its universe of relevant competitors, each hospital receives an index of competitiveness like the Hirschman-Herfindahl index (HHI), equal to the sum of squared shares of beds or number of patient discharges. For purposes of assessing the effect of competition on individual patients, each patient is assumed to be subject to the competitiveness of the relevant market of her hospital of admission.

Every stage in the process of constructing conventional measures can lead to bias in the estimated effects of competition. First, the specification of geographic market size as a function of actual patient choices leads to market sizes and measures of competitiveness that are increasing in unobservable (to the researcher) hospital quality, if patients are willing to travel farther for higher-quality care (e.g., Luft et al. [1990]). In this case, estimates of the effect of market competitiveness on costs or outcomes are a combination of the true effect and of the effects of unobservable hospital quality (e.g., Werden [1989]). Second, the discrete nature of market boundaries assume that hospitals are either completely in or completely out of any relevant geographic market. This leads to measurement error in geographic markets, which in turn biases the estimated effect of competition toward zero. Third, the measures of output conventionally used to construct indices of competitiveness like the HHI—such as hospital bed capacities and actual patient flows—may themselves be outcomes of the competitive process. Fourth, assigning hospital market competitiveness to patients based on which hospital they actually attended—rather than their area of residence—can induce a correlation between competitiveness and unobservable determinants of patients' costs and outcomes, because patients' hospital of admission may depend on unobserved determinants of their health status.

The third problem is that most previous work has failed to control for a comprehensive set of other hospital and area characteristics that may be correlated with competition, or that may mediate its effects. These additional factors include hospital bed capacity and the influence of managed care. Substantial research, starting with Roemer [1961], has suggested that high levels of bed capacity per patient lead to longer lengths of stay and higher costs; more recent research indicates that hospitals which treat relatively few cases of any particular type may deliver lower-quality care. On the other hand, high levels of capacity per patient may reduce the travel distance and time necessary to obtain treatment, which may lead to improved health outcomes.

Similarly, recent studies have generally shown that higher levels and growth of managed care are associated with lower growth in medical expenditures (e.g., Baker [1999]). However, few studies have examined the consequences of managed care growth for health outcomes, leaving important unresolved questions about the impact of managed care on patient welfare. Moreover, the studies provide little insight about how managed care achieves its effects. Can it substitute for hospital competition in limiting medical spending, or does competition among hospitals enhance its effects? And do the consequences of managed care for health outcomes differ in areas with more or less competition among providers? Surprisingly, even though negotiations with providers are the principal mechanism through which managed care is thought to influence medical practices, essentially no studies have examined how managed care interacts with provider competition.

Thus, although the previous literature has provided a range of insights about variation in hospital competition and the relation of competitiveness to measures of hospitals' behavior, it has not provided direct empirical evidence on how competition affects social welfare. Furthermore, because the literature has analyzed measures of market size and competitiveness that are not based on exogenous determinants of the demand for hospital services, and because these measures may be correlated with other determinants of costs and outcomes like hospital capacity, the resulting estimates of the effects of competition may be biased. Finally, very few studies have assessed the effects of competition in recent health care environments, in which managed care figures prominently.

III. Models

As we describe in more detail in the next section, we analyze patient-level data on the intensity of treatment, all-cause mortality, and cardiac complications rates for all nonrural elderly Medicare beneficiaries hospitalized with cardiac illness over the 1985–1994 period. To avoid the problems of prior studies in obtaining accurate estimates of the effects of market competitiveness on hospital performance, we use a three-stage method. The core idea of our method is to model hospital choice based on exogenous factors, and to use the results as a basis for constructing our competition indices. This approach avoids the major empirical obstacles in previous studies of competition described in Section II, and our data permit a thorough evaluation of the consequences of competition for treatment decisions, expenditures, and health outcomes.

First, we specify and estimate patient-level hospital choice models as a function of exogenous determinants of the hospital admission decision. We do not constrain hospital geographic markets based on a priori assumptions. We allow each individual's potentially relevant geographic hospital market for cardiac-care services to include all nonfederal, general medical/surgical hospitals within 35 miles of the patient's residence with at least five admissions for AMI, and any large, nonfederal, general medical/surgical teaching hospital within 100 miles of the patient's residence with at least five AMI admissions. (We explain the reason for these a priori constraints on potentially relevant geographic markets below; because markets for cardiac care are generally much smaller than the constraints, they are not restrictive.) We model the extent to which hospitals of various types at various distances from each patient's residence affect each patient's hospital choice, and we also allow each patient's demographic characteristics to affect her likelihood of choosing hospitals of one type over another. The results of these models of hospital demand provide predicted probabilities of admission for every patient to every hospital in his or her potentially relevant geographic market. We then estimate the predicted number of patients admitted to each hospital in the United States, *based only on observable, exogenous characteristics of patients and hospitals.*

Second, we calculate measures of hospital market competitiveness that are a function of these predicted patient flows (rather than actual patient flows or capacity), and assign them to patients based on their probabilistic hospital of admission (rather than their actual hospital of admission). Thus, the measure of hospital market structure that we assign to each patient is uncorrelated with unobserved heterogeneity across individual patients, individual hospitals, and geographic hospital markets.

Third, we use these unbiased indices of competitiveness to estimate the impact of hospital competition on treatment intensity and health outcomes. Because managed care organizations are likely to be an important mechanism through which competition affects hospital markets, we investigate the extent to which the rate of HMO enrollment in an area interacts with hospital market competitiveness. We now describe each stage of our estimation process in more detail.

III.1. Modeling Patients' Hospital Choice

Consider an individual i with cardiac illness at time $t = 1, \ldots, T$ who chooses among the J hospitals in her area (J may vary across individuals; in the subsequent choice model, the time subscript is suppressed for notational economy). The jth hospital ($j = 1, \ldots, J$) has H binary characteristics describing its size, ownership status, and teaching status, denoted by $Z_j^1, \ldots, Z_j^H$. Our model hypothesizes that individual i's hospital choice depends on her utility from that choice, and that her utility from choosing hospital j depends on her characteristics, the characteristics of j, and the distance of i to j *relative to* the distance of i to the nearest hospital $j' \neq j$ that is either a good substitute or a poor substitute for j in some dimension.[3] We hypothesize that the utility from choosing one particular hospital over another depends on the relative distance between i's residence and each hospital because travel cost, as measured by distance, is an important determinant of the hospital choice decision for individuals with acute illness.[4] As we discuss below, we seek to avoid the most restrictive assumptions typically associated with modeling of a choice decision. Most importantly, our model does not assume that the choice decision between any two hospitals is independent of so-called irrelevant alternatives. The relative utility for i of choosing hospital j versus hospital j^* depends not only on the characteristics of j and j^*, but also on the characteristics of other hospitals j' that may be good or poor substitutes for j and j^*.

Because hospital j is characterized by H binary characteristics $Z_j^1, \ldots, Z_j^H$, we parameterize the utility of i from choosing j as a function of 2^*H relative distances: H relative distances that depend on the location of hospitals that are good substitutes for j (*same-type* relative distances), and H relative distances that depend on the location of hospitals that are poor substitutes for j (*different-type* relative distances). First, i's utility from choosing j depends on H same-type relative distances, $D_{ij}^{1+}, \ldots, D_{ij}^{H+}$, where D_{ij}^{h+} is the distance from i's residence to hospital j minus the distance from i's residence to the nearest hospital j' with $Z_{j'}^h = Z_j^h$. D_{ij}^{h+} enters i's utility because the availability at low travel cost of good substitutes for j in one or more dimensions (e.g., $D_{ij}^{h+} \gg 0$) may reduce i's utility from choosing j. Second, i's utility from choosing j depends on H different-type relative distances, $D_{ij}^{1-}, \ldots, D_{ij}^{H-}$, where D_{ij}^{h-} is the distance from i's residence to hospital j minus the distance from i's residence to the nearest hospital j' with $Z_{j'}^h \neq Z_j^h$. D_{ij}^{h-} enters i's utility because the availability at low travel cost of poor substitutes for j in one or more dimensions may also affect i's utility from choosing j.

3. We calculate travel distances from patients to hospitals as the distance from the center of the patient's five-digit zip code to the center of the hospital's five-digit zip code.

4. Particularly for acute illnesses such as heart disease, distances from patient residence to different types of hospitals are a strong predictor of hospital of admission [McClellan 1994b].

We model i's indirect expected utility from choosing j, Y^*_{ij}, as the sum of a function V of the $2H$ relative distances and hospital characteristics $Z^1_j, \ldots, Z^H_j$; a function W of i's demographic characteristics X_i and hospital characteristics $Z^1_j, \ldots, Z^H_j$; and a factor ϵ_{ij} that depends on unobservable characteristics of individuals and hospitals, such as individuals' choice of physician (because the admission decision is made jointly with patients and physicians) and health status:

$$Y^*_{ij} = V(D^{1+}_{ij}, \ldots, D^{H+}_{ij}, D^{1-}_{ij}, \ldots, D^{H-}_{ij}; Z^1_j, \ldots, Z^H_j) + W(X_i; Z^1_j, \ldots, Z^H_j) + \epsilon_{ij}.$$

We specify V as a nonparametric function of relative distances and hospital characteristics to avoid assuming a particular functional relationship between travel costs, hospital characteristics, and individuals' hospital choice problem. In particular, we divide each differential distance D^{h+}_{ij} and D^{h-}_{ij} into four categories, with category boundaries at the tenth, twenty-fifth, and fiftieth percentile of the distribution of the respective differential distance. This implies four indicator differential distance variables $(DD1^{h+}_{ij}, \ldots, DD4^{h+}_{ij}) = DD^{h+}_{ij}$ for each D^{h+}_{ij}, and four indicator differential distance variables $(DD1^{h-}_{ij}, \ldots, DD4^{h-}_{ij}) = DD^{h-}_{ij}$ for each D^{h-}_{ij}. Also, we allow the impact on utility of D^{h+}_{ij} and D^{h-}_{ij} to vary, depending on whether $Z^h_j = 0$ or $Z^h_j = 1$. For example, same-type relative distance would be a more important determinant of the utility derived from choosing one nonteaching hospital over another versus than of the utility derived from choosing one teaching hospital over another, if nonteaching hospitals were on average closer substitutes for one another than were teaching hospitals. Thus, for every i–j pair, $V(.)$ can be written as a function of relative distances, hospital characteristics, and $4{*}H$ vectors of parameters $[(\theta^1_1,\theta^1_2,\theta^1_3,\theta^1_4), \ldots, (\theta^H_1,\theta^H_2,\theta^H_3,\theta^H_4)]$:

$$V_{ij} = \sum_{h=1}^{H} \{DD^{h+}_{ij} \cdot [\theta^h_1 Z^h_j + \theta^h_2(1 - Z^h_j)] + DD^{h-}_{ij} \cdot [\theta^h_3 Z^h_j + \theta^h_4(1 - Z^h_j)]\}.$$

We specify W as a nonparametric function of the interaction between individual i's characteristics X_i and hospital characteristics $Z_j^1, \ldots, Z_j^H$, and H vectors of parameters $\lambda^1, \ldots, \lambda^H$:[5]

$$W_{ij} = \sum_{h=1}^{H} X_i Z_j^h \lambda^h.$$

Under the assumption that the individual chooses that hospital that maximizes her expected utility, and that ϵ_{ij} is independently and identically distributed with a type I extreme value distribution, McFadden [1973] shows that the probability of individual i choosing hospital j is equal to

$$\Pi_{ij} = \Pr(Y_{ij} = 1) = \frac{e^{(V_{ij}+W_{ij})}}{\sum_{l=1}^{J} e^{(V_{il}+W_{il})}}.$$

We solve for θ and λ by maximizing the log-likelihood function,

$$\log l = \sum_{i=1}^{N} \sum_{j=1}^{J} \log(\Pi_{ij}).$$

We estimate this model separately for different years and for different regions of the country (e.g., allow θ and λ and the relative-distance category boundaries to vary), to account for differences in the effects of distances and other hospital and patient characteristics across regions and over time.[6]

III.2. Calculating Measures of Hospital Market Structure

With estimates of θ and λ from the choice models, we calculate predicted probabilities of admission for every patient to every hospital in his or her potentially relevant geographic market $\hat{\pi}_{ij}$. Summing over patients, these $\hat{\pi}_{ij}$ translate into a predicted number of patients admitted to each hospital in the United States, *based only on observable, exogenous characteristics of patients and*

5. Because i's individual characteristics can only affect her probability of choosing one type of hospital relative to another, the impact of characteristics X_i necessarily varies by hospital type.

6. We divided the country into the following twenty regions: CT, ME, NH, RI, and VT; MA; Buffalo, NY, Amityville, NY and Pittsburgh, PA MSAs; the NJ portion of CMSA 77 (CMSA 77 is Ancora, NJ, Philadelphia, PA, Vineland, NJ; Wilmington, DE MSAs); the PA portion of CMSA 77; Passaic, NJ, Jersey City, NJ, and Edison, NJ MSAs; Toms River, NJ, Newark, NJ, and Trenton, NJ MSAs; NY PMSA counties other than Queens and Kings; Queens and Kings Counties, NY PMSA; all other NY, NJ, and PA urban counties; DE, DC, FL, GA, MD, NC, SC, VA, and WV; IN and OH; MI and WI; IL; AL, KY, MS, and TN; IA, KS, MN, MO, NE, ND, and SD, AR, LA, OK, and TX; AZ, CO, ID, MT, NV, NM, UT, and WY; AK, HI, OR, WA, and all of CA except the Los Angeles PMSA; and the Los Angeles, CA PMSA. We subdivided standard census regions as needed to enable us to estimate the choice models in regions with very high densities of hospitals.

hospitals. For every zip code of patient residence $k = 1, \ldots, K$, the predicted probabilities translate into a predicted share of patients from zip k going to hospital j, denoted by $\hat{\alpha}_{jk}$:

$$\hat{\alpha}_{jk} = \frac{\sum_{i \text{ living in } k} \hat{\pi}_{ij}}{\sum_{j=1}^{J} \sum_{i \text{ living in } k} \hat{\pi}_{ij}}.$$

For comparability with the previous literature, our measures of competitiveness are in the form of predicted HHIs.[7] If hospitals face separate demand functions for each zip code in their service areas—that is, are able to differentiate among patients based on their zip code of residence—then the predicted HHI for patients in zip k is

$$HHI_k^{\text{pat}} = \sum_{j=1}^{J} \hat{\alpha}_{jk}^2.$$

HHI_k^{pat} differs from the measures used in the previous literature in several ways. First, it uses expected patient shares based on exogenous determinants of patient flows, rather than potentially endogenous measures such as bed capacity or actual patient flows. Second, it assigns patients to hospital markets based on an exogenous variable (zip code of residence), rather than an endogenous one (actual hospital of admission). Third, it defines geographic markets to include all potentially competitive hospitals, but only to the extent that they would be expected to serve a geographic area, rather than defining geographic markets to include arbitrarily all hospitals located within a fixed distance or within the minimum distance necessary to account for a fixed share of admissions.

However, this measure assumes that hospitals differentiate among patients based on the competitiveness of their particular residential area. More realistically, hospital decisions would depend on the total demand for hospital services from all nearby areas. The competitiveness of a *hospital's* market is a function of the weighted average of the competitiveness of all the patient residence areas that it serves. If β_{kj} represents the share of hospital j's predicted demand coming from zip code k (this is a

7. The key properties of competition indices like HHIs are that they decrease in the number of competitors and increase in inequality in size among competitors. As noted in more detail below, we use HHIs in only a categorical way; provided that an index has these properties, our results are likely to be robust to the specific form of the index.

hospital-level share, not a zip-level share like α_{jk}), then the *HHI* for *hospital j* can be written as

$$HHI_j^{\text{hosp}} = \sum_{k=1}^{K} \hat{\beta}_{kj} \cdot \left(\sum_{j=1}^{J} \hat{\alpha}_{jk}^2 \right) = \sum_{k=1}^{K} \hat{\beta}_{kj} \cdot HHI_k^{\text{pat}},$$

where

$$\hat{\beta}_{kj} = \frac{\sum_{i \text{ living in } k} \hat{\pi}_{ij}}{\sum_{i=1}^{N} \hat{\pi}_{ij}}.$$

If we were to follow the approach of the previous literature, we would assign to patients such a measure of the competition faced by the hospital according to each patient's actual hospital of admission. However, as Section II observed, this will lead to biased estimates of the impact of market structure on patient welfare, if unobserved determinants of hospital choice are correlated with patient health status. For this reason, the competitiveness index that we use in analysis, $HHI_k^{\text{pat*}}$, assigns HHI_j^{hosp} to patients based on the vector of average expected probabilities of hospital choice in the patient's zip of residence:

$$HHI_k^{\text{pat*}} = \sum_{j=1}^{J} \hat{\alpha}_{jk} \cdot \left[\sum_{k=1}^{K} \hat{\beta}_{kj} \cdot \left(\sum_{j=1}^{J} \hat{\alpha}_{jk}^2 \right) \right] = \sum_{j=1}^{J} \hat{\alpha}_{jk} \cdot HHI_j^{\text{hosp}}.$$

In words, this index is the weighted average of the competition indices for hospitals expected to treat patients in a given geographic area of residence, weighted by the hospital's expected share of area patients. Thus, variation in $HHI_k^{\text{pat*}}$ over time and across areas comes from three sources: changes over time across areas in hospital markets (e.g., openings, closures, and mergers of hospitals), changes over time in the response of individuals' hospital choice decision to differential distances (which affects competition differently across areas), and changes over time in the distribution across areas of the population of AMI patients.

Other important market factors—including the distance to the nearest hospital of any type (which could affect treatment intensity and outcomes if patients who must travel a long distance to the hospital do not get prompt emergency care), bed capacity, the characteristics of hospitals in different residential markets (size, ownership status, and teaching status), and area managed care enrollment rates—may also affect hospital decisions and be correlated with or mediate hospital competition. In all models that include $HHI_k^{\text{pat}*}$, we include controls for the distance to the nearest hospital, zip-code level hospital bed capacity per probabilistic AMI patient, and the zip-code density of hospital characteristics. The latter two of these are constructed analogously to $HHI_k^{\text{pat}*}$. To calculate our measure of bed capacity $CAP_k^{\text{pat}*}$, for example, we begin with a measure of capacity, CAP_k^{pat}, that assumes that hospitals face separate demand functions for each zip code in their service areas:

$$CAP_k^{\text{pat}} = \sum_{j=1}^{J} \hat{\alpha}_{jk} \cdot \frac{B_j}{\sum_{i \text{ living in } k} \hat{\pi}_{ij}},$$

where B_j represents the number of beds in hospital j. Then, we calculate the bed capacity per probabilistic patient faced by each hospital, CAP_j^{hosp}, as a β_{kj}-weighted average of CAP_k^{pat}. The measure of capacity that we use in estimation, $CAP_k^{\text{pat}*}$, assigns CAP_j^{hosp} to patients based on the vector of averaged expected probabilities of hospital choice in the patient's zip of residence:

$$CAP_k^{\text{pat}*} = \sum_{j=1}^{J} \hat{\alpha}_{jk} \cdot \left[\sum_{k=1}^{K} \hat{\beta}_{kj} \cdot \left(\sum_{j=1}^{J} \hat{\alpha}_{jk} \cdot \frac{B_j}{\sum_{i \text{ living in } k} \hat{\pi}_{ij}} \right) \right].$$

Zip-code level measures of the probabilistic-patient-weighted density of hospital characteristics $h = 1, \ldots, H$ are constructed in the same way:

$$hosp\_char\_h_k^{\text{pat}*} = \sum_{j=1}^{J} \hat{\alpha}_{jk} \cdot \left[\sum_{k=1}^{K} \hat{\beta}_{kj} \cdot \left(\sum_{j=1}^{J} \hat{\alpha}_{jk} \cdot Z_j^h \right) \right].$$

We describe the construction of area managed-care enrollment rates in Section IV below.

III.3. Modeling the Impact of Hospital Competition on Patient Welfare

We assess the impact of hospital competition on hospital expenditures and health outcomes, using longitudinal data on cohorts of elderly Medicare beneficiaries with heart disease in 1985, 1988, 1991, and 1994. We use zip-code fixed effects to control for all time-invariant heterogeneity across small geographic areas, hospitals, and patient populations; our estimates of the effect of competition are identified using *changes* in hospital markets. We investigate the extent to which managed-care enrollment in an area interacts with hospital market competitiveness to affect treatment intensity and patient health outcomes, and we jointly analyze the effects of competition, hospital bed capacity, and other characteristics. In addition, we include separate time-fixed-effects for individuals from differently sized geographic areas (i.e., smaller and larger metropolitan areas), and include controls for time-varying characteristics of geographic areas (such as the travel distance between individuals' residence and their closest hospital), to address the possibility that our estimated effects of competition are due to still other omitted factors that were correlated with health care costs, health outcomes, and hospital markets. We describe these variables in more detail in the next section.

In zip code k during year $t = 1, \ldots, T$, observational units in our analysis of the welfare consequences of competition consist of individuals $i = 1, \ldots, N_{kt}$ who are hospitalized with new occurrences of particular illnesses such as a heart attack. Each patient has observable characteristics U_{ikt}: four age indicator variables (70–74 years, 75–79 years, 80–89 years, and 90–99 years; omitted group is 65–69 years), gender, and black/nonblack race; plus a full set of interaction effects between age, gender, and race; and interactions between year and each of the age, gender, and race indicators. The individual receives treatment of aggregate intensity R_{ikt}, where R is total hospital expenditures in the year after the health event. The patient has a health outcome O_{ikt}, possibly affected by the intensity of treatment received, where a higher value denotes a more adverse outcome (O is binary in all of our outcome models).

Our basic models are of the form,

$$
\begin{aligned}
(1) \qquad \ln(R_{ikt}) = {} & \delta_k + \sigma_t M_k + U_{ikt}\phi \\
& + HHI_{kt}^{\mathrm{pat}*} * I(1985 \vee 1988)\eta_{1980s} \\
& + HHI_{kt}^{\mathrm{pat}*} * I(1991 \vee 1994)\eta_{1990s} \\
& + OMC_{kt} * I(1985 \vee 1988)\psi_{1980s} \\
& + OMC_{kt} * I(1991 \vee 1994)\psi_{1990s} + \xi_{ikt},
\end{aligned}
$$

where δ_k is a zip-code fixed-effect; σ_t is a time fixed-effect; M_k is a six-dimensional vector of indicator variables denoting the size of individual i's MSA; $I(.)$ is an indicator function; OMC_{kt} is a vector of other market characteristics in zip code k at time t, including $CAP_{kt}^{\mathrm{pat}*}$, controls for the area densities of hospitals of different sizes, ownership statuses, and teaching statuses ($hosp\_char\_1_{kt}^{\text{pat}*}, \ldots, hosp\_char\_H_{kt}^{\text{pat}*}$), and the travel distance to the hospital nearest to zip code k; and ξ_{ikt} is a mean-zero independently distributed error term with $E(\xi_{ikt}|\ldots) = 0$. Based on findings from the previous empirical literature, we allow η and ψ to vary in the 1980s and 1990s.

We estimate three variants of (1). First, for purposes of comparison with previous work, we estimate (1) substituting for $HHI_{kt}^{\text{pat}*}$ conventionally calculated HHIs (as a function of shares of actual patient flows, based on a 75 percent-actual-patient-flow variable-radius geographic market, matched to patients based on their hospital of admission), and substituting for OMC_{kt} the characteristics of hospital of admission $Z_j^1, \ldots, Z_j^H$. Second, in order to investigate how the responsiveness of behavior to competition varies across differently competitive markets, we estimate a nonparametric model as well as a simple linear model of the effect of $HHI_{kt}^{\text{pat}*}$ on R_{ikt} and O_{ikt}. The nonparametric model includes three indicator variables that divide $HHI_{kt}^{\text{pat}*}$ into quartiles (omitted category is the lowest quartile), with quartile cutoffs in all years based on the 1985–1994 pooled distribution of $HHI_{kt}^{\text{pat}*}$ at the zip-code level. Third, we allow η and ψ to vary in areas with above-median versus below-median managed-care enrollment, because theoretical work suggests that insurance market characteristics may alter the impact of hospital competition.

In equation (1), changes in the estimated effect of competition η between the 1980s and 1990s may be due to two factors: changes over time in the response of the level of expenditures or outcomes to changes in competition, or changes over time in the growth rate of expenditures or outcomes in areas with high versus low levels of competition. We investigate the importance of the first effect with three period-by-period "difference-in-difference" models (1985–1988, 1988–1991, 1991–1994) of the effect of changes in competition:

$$\text{(2)} \quad \ln(R_{ikt}) = \delta_k + \sigma_t M_k + U_{ikt}\phi + IQ(HHI_{kt}^{\text{pat}*} - HHI_{kt-1}^{\text{pat}*})\gamma + OMC_{kt}\psi + \xi_{ikt}.$$

In this equation, $IQ(.)$ is a function that returns a three-element vector of indicator variables describing the extent of interquartile changes in competition in zip code k from $t - 1$ to t. Thus, estimates of γ from equation (2) represent the change in resource use or health outcomes for patients in residential areas experiencing interquartile changes in competition, relative to patients in areas without interquartile changes, holding constant patient background, other market characteristics, and zip-code fixed effects. Specifically, the elements of the vector returned by $IQ(.)$ are as follows: $into\_top_{kt} = 1$ in period t if zip code k moved from the second to the first quartile of HHI_{kt}^{pat*} between $t - 1$ and t, $= -1$ in period t if zip code k moved from the first to the second quartile between $t - 1$ and t, and $= 0$ for other changes, no change, and for all observations from period $t - 1$; $out\_of\_btm_{kt} = 1$ in period t if k moved from the fourth to the third quartile between $t - 1$ and t, $= -1$ in period t if k moved from the third to the fourth quartile, and 0 otherwise; and $qtl\_3\_to\_2 = 1$ in period t if k moved from the third to the second quartile between $t - 1$ and t, $= -1$ in period t if k moved from the second to the third quartile, and 0 otherwise. This specification imposes the constraint that changes in competitiveness of opposing direction but between the same quartiles have effects of equal magnitude but opposite sign.

IV. Data

We use data from three principal sources. First, we use comprehensive longitudinal Medicare claims data for the vast majority of nonrural elderly beneficiaries who were admitted to a hospital with a new primary diagnosis of AMI in 1985, 1988, 1991, and 1994. The sample is analogous to that used in Kessler and McClellan [1996, 1998]. Patients with admissions for the same illness in the prior year were excluded. We focus on hospital choice for the initial hospitalization. Decisions by a hospital to transfer a patient, and the extent to which they provide follow-up care and readmissions (or refer patients to other hospitals that provide these services well), are important aspects of quality of care. In addition, many treatments administered within hours of admission for heart disease have important implications for patient outcomes.

Measures of total one-year hospital expenditures were obtained by adding up all inpatient reimbursements (including copayments and deductibles not paid by Medicare) from insurance claims for all hospitalizations in the year following each patient's initial admission for AMI.[8] Measures of the occurrence of cardiac

8. Because Medicare's diagnosis-related group (DRG) payment system for hospitals appears to compensate hospitals on a fixed-price basis per admission for treatment, and Medicare does not bargain with individual hospitals, compe-

complications were obtained by abstracting data on the principal diagnosis for all subsequent admissions (not counting transfers and readmissions within 30 days of the index admission) in the year following the patient's initial admission. Cardiac complications included rehospitalizations within one year of the initial event with a primary diagnosis (principal cause of hospitalization) of either subsequent AMI or heart failure (HF). Treatment of AMI patients is intended to prevent subsequent AMIs if possible, and the occurrence of HF requiring hospitalization is evidence that the damage to the patient's heart from ischemic disease has serious functional consequences. Data on patient demographic characteristics were obtained from the Health Care Financing Administration's HISKEW enrollment files, with death dates based on death reports validated by the Social Security Administration.

Our second principal data source is comprehensive information on U. S. hospital characteristics collected by the American Hospital Association (AHA). The response rate of hospitals to the AHA survey is greater than 90 percent, with response rates above 95 percent for large hospitals (>300 beds). Because our analysis involves nonrural Medicare beneficiaries with AMI, we examine only nonrural, nonfederal hospitals that ever reported providing general medical or surgical services (for example, we exclude

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tition might appear to be irrelevant to Medicare patients' hospital expenditures. However, competition may affect Medicare patients both through "direct" and "spillover" effects.

Competition may have direct effects on Medicare patients because the intensity of treatment of all health problems may vary enormously, and because the DRG system actually contains important elements of cost sharing (e.g., McClellan [1994a, 1997]). For example, many DRGs are related to intensive treatments such as cardiac catheterization and bypass surgery, rather than to diagnoses such as heart attack. Thus, for most health problems, hospitals that provide more intensive treatment and incur higher costs can receive considerable additional payments. To the extent that Medicare provides hospitals with low-powered, cost-plus incentives, it may support MAR-type quality competition and thereby create social losses due to the provision of excessive care.

Even if reimbursement rules and other factors limit the direct impact of competition on publicly insured patients in programs like Medicare, competition for privately insured patients may have important spillover effects. To the extent that competition improves the efficiency of treatment of privately insured patients *and* physicians do not develop distinctive practice patterns for the private and public patients they treat, Medicare patients will also benefit [Baker 1999]. For example, a hospital's decision not to adopt a low-value technology benefits all patients, even if that choice primarily resulted from pressure by private managed-care insurers. Similarly, increased provision of information by providers for private purchasers may have external benefits for all patients. Conversely, spillovers might harm Medicare patients. For example, to the extent that hospitals *do* develop separate practice patterns for Medicare and privately insured patients, hospitals may have a greater incentive to provide intensive treatments for Medicare beneficiaries, to recover the fixed costs of equipment that private insurers will not defray.

psychiatric and rehabilitation hospitals from analysis). To assess hospital size and for purposes of computation of bed capacity per probabilistic patient, we use total general medical/surgical beds, including intensive care, cardiac care, and emergency beds. We divide hospitals into three broad size categories (small ($<$100 beds), medium (100–300 beds), and large ($>$300 beds)) and two ownership categories (public and private). We classify hospitals as teaching hospitals if they report at least twenty full-time residents. Finally, we match patient data with information on annual HMO enrollment rates by state from InterStudy Publications, a division of Decision Resources, Inc. Enrollment rates were calculated by dividing the number of enrollees (exclusive of supplemental Medicare enrollees) by the population. In order to investigate the extent to which the rate of HMO enrollment in an area interacts with hospital market structure, we separate states into those with above- and below-median HMO enrollment rates in each of our study years. The classification of states is shown in Appendix 1.

Table I outlines the exclusion restrictions we imposed, and their consequences for our samples. First, we exclude hospitals

TABLE I
POPULATIONS OF HOSPITALS AND PATIENTS USED IN ANALYSIS (TABLE ENTRIES ARE NUMBER OF OBSERVATIONS MEETING SELECTION CONDITIONS)

	Hospitals		
Year	Nonrural, nonfederal, ever general medical	. . . with valid Medicare ID and AHA data	. . . and with at least 5 AMI patients
1985	2975	2812	2698
1988	2889	2732	2608
1991	2793	2611	2502
1994	2706	2485	2382

	Elderly AMI Patients			
Year	Admitted to nonrural, nonfederal, general medical hospital	. . . with a valid Medicare ID and AHA data	. . . and with at least 5 AMI patients	. . . and who lived within 35 miles of index hospital (100 miles if large teaching hospital)
1985	157,343	152,700	152,359	146,569
1988	145,344	143,229	142,946	137,879
1991	154,224	152,657	152,410	145,555
1994	153,757	150,303	150,058	143,308

(and the patients admitted to them) because of missing Medicare ID information and missing data for hospitals. Although around 6 percent of hospitals have such missing data, less than 2 percent of patients are affected. Second, we exclude hospitals that admit fewer than five AMI patients per year, and also exclude patients who went to hospitals that admit fewer than five AMI patients per year. Hospitals that admit fewer than five AMI patients per year are unlikely to be relevant competitors, and patients choosing such low-volume hospitals are unlikely to be representative of AMI patients generally. Again, Table I shows that the number of hospitals excluded on these grounds is small, and the number of patients excluded is especially small. Third, we exclude AMI patients who were actually admitted to a hospital that was more than 35 miles from their residence, or if they were admitted to a large, teaching hospital, more than 100 miles from their residence. Because AMI is an acute illness, very few AMI patients travel for initial treatment to a hospital outside of our 35/100 mile radius. Those patients whose index admission is outside of this 35/100 mile radius are likely to be traveling, and so their hospital choice decision is likely to differ from the choice decision of patients who become ill while at home. In any event, the share of patients we exclude on this basis is small as well, at under 5 percent. In addition, Table I documents the shrinking number of hospitals in the United States.

Table II describes the elderly population and the hospitals treating them for the years 1985–1994. Table II demonstrates some of the well-known trends in the treatment, expenditures, and outcomes of elderly heart disease patients. The first row of the table shows how dramatically real Medicare inpatient expenditures have grown over the 1985–1994 period—by 34.5 percent. Because reimbursement given treatment choice for Medicare patients did not increase over this period [McClellan 1997], these expenditure trends are attributable to increases in intensity of treatment. The more rapid growth since 1991 was largely attributable to increasing use of nonacute inpatient services, reflecting general trends in Medicare expenditures. Concomitant with this increase in average intensity, average one-year mortality for AMI has declined by 7.3 percentage points (18.1 percent). However, trends in cardiac complications have been mixed: AMI survivors have a slightly higher risk of subsequent HF. The demographics of our patient and hospital populations also reflect broad trends. The share of elderly living in the largest MSAs is falling. Among

TABLE II
DESCRIPTIVE STATISTICS FOR ELDERLY AMI PATIENTS AND HOSPITALS ADMITTING FIVE OR MORE PATIENTS PER YEAR

	1985 mean	1988 mean	1991 mean	1994 mean	% Change 1985–1994
Elderly AMI patients					
1-year expenditures (1993 $)	$14,352	$15,589	$16,984	$19,307	34.5%
(standard deviation)	(13,483)	(15,578)	(17,099)	(19,411)	
1-year mortality rate	0.403	0.391	0.346	0.330	−18.1%
1-year AMI readmission rate	0.060	0.055	0.053	0.053	−11.7%
1-year HF readmission rate	0.077	0.084	0.088	0.086	11.7%
Age 65–69	23.2%	21.9%	21.9%	20.5%	−11.6%
Age 70–74	24.8%	23.6%	23.4%	23.6%	−4.8%
Age 75–79	22.2%	22.1%	21.9%	21.4%	−3.6%
Age 80–89	25.9%	27.7%	28.0%	29.3%	13.2%
Age 90–99	3.9%	4.7%	4.8%	5.2%	33.3%
Black	5.8%	6.1%	6.3%	6.7%	15.5%
Female	49.9%	50.9%	50.3%	49.7%	−0.4%
MSA size <100,000	1.8%	1.9%	1.9%	1.8%	0.0%
MSA size 100,000–250,000	13.2%	14.1%	14.9%	15.5%	17.4%
MSA size 250,000–500,000	12.7%	13.2%	14.1%	14.5%	14.2%
MSA size 500,000–1,000,000	19.5%	20.4%	20.7%	21.2%	8.7%
MSA size 1,000,000–2,500,000	28.7%	28.0%	27.2%	26.5%	−7.0%
MSA size >2,500,000	24.1%	22.3%	21.2%	20.5%	−14.9%
Hospitals					
Large size (>300 beds)	20.0%	17.4%	15.6%	13.5%	−32.5%
Medium size (100–300 beds)	54.4%	54.7%	55.4%	53.9%	−0.9%
Small size (<100 beds)	25.6%	27.9%	29.0%	32.6%	27.3%
Teaching %	16.4%	17.6%	17.0%	19.2%	17.1%
Public %	14.5%	13.8%	12.8%	13.0%	−10.3%

Hospital expenditures deflated using the CPI.

hospitals, the share of large and public hospitals is falling, and the share of teaching hospitals is rising.

Table III shows how hospital markets have changed over the 1980s and 1990s. Travel distances between patients and hospitals rose dramatically, particularly at the bottom of the distribution, likely due to the contraction in the number of hospitals and the migration of elderly to areas with lower densities of hospitals. The median distance to a patient's closest hospital rose by 42 percent, from 1.74 miles to 2.47 miles; the mean and ninety-fifth percentile distance rose somewhat less. Although patients often are not initially admitted to their closest hospital, the median distance to

TABLE III
DESCRIPTIVE STATISTICS FOR HOSPITAL MARKETS

	1985	1988	1991	1994	% Change 1985–1994
Travel distances from patients to hospitals (miles)					
Mean distance to closest hospital (standard deviation)	2.83 (3.85)	3.04 (3.90)	3.28 (4.08)	3.47 (4.13)	22.6%
Median distance to closest hospital	1.74	1.98	2.24	2.47	42.0%
95th %ile distance to closest hospital	10.56	10.74	11.26	11.49	8.8%
Mean distance to hospital of admission (standard deviation)	5.03 (6.18)	5.24 (6.20)	5.48 (6.33)	5.73 (6.57)	13.9%
Median distance to hospital of admission	3.47	3.65	3.93	4.12	18.7%
95th %ile distance to hospital of admission	16.09	16.68	17.14	17.78	10.5%
Characteristics of hospital markets					
HHI^{pat*} (standard deviation)	0.325 (0.183)	0.340 (0.177)	0.354 (0.181)	0.369 (0.175)	13.5%
Conventional 75-percent variable-radius HHI (standard deviation)	0.431 (0.307)	0.441 (0.301)	0.456 (0.304)	0.471 (0.312)	9.3%
Correlation between zip-code average levels of HHI^{pat*} and conventional 75-percent HHI (P-value of h_0: $\rho = 0$)	0.668 (0.000)	0.663 (0.000)	0.668 (0.000)	0.634 (0.000)	−5.1%
Correlation between zip-code average changes in HHI^{pat*} and conventional 75-percent HHI (P-value of h_0: $\rho = 0$)		0.204 (0.000)	0.139 (0.000)	0.164 (0.000)	−19.6%
Bed capacity/AMI patient, mean by patients (standard deviation)	3.725 (1.284)	3.623 (1.291)	3.155 (1.080)	2.893 (1.067)	−22.3%

Descriptive statistics about hospital markets are calculated using weights equal to the number of AMI patients.

a patient's initial hospital of admission rose as well, by 18.7 percent, from 3.47 to 4.12 miles. These same forces led to a decrease in hospital bed capacity and market competitiveness. Our index HHI^{pat*} rose by 13.2 percent between 1985 and 1994, as compared with an increase of 9.3 percent in the conventional 75 percent variable-radius HHI. By either measure, the trend over time in hospital market competitiveness has had major effects on the markets serving a substantial fraction of elderly AMI patients. The measures of competition are strongly positively correlated in both levels and changes. And according to Appendix 2, approximately a quarter of patients experienced an interquartile change in market competitiveness in any two adjacent sample years, with approximately a third of patients experiencing a change between 1985 and 1994.

V. Results

V.1. Effects of Competition

Table IV begins our analysis of the impact of competition on

TABLE IV
EFFECTS OF HOSPITAL COMPETITION ON EXPENDITURES AND OUTCOMES FOR ELDERLY AMI PATIENTS, HHI^{pat*} VERSUS CONVENTIONAL 75 PERCENT-PATIENT-FLOW HHI, PRE- AND POST-1990

	Using HHI^{pat*}				Using conventional 75-percent patient-flow HHI			
	1-year hospital expenditures	1-year mortality	1-year AMI readmit	1-year HF readmit	1-year hospital expenditures	1-year mortality	1-year AMI readmit	1-year HF readmit
Pre-1990 effects of competition and capacity (omitted category = very low HHI)								
Very high HHI	−2.18	0.84	0.58	−0.03	−13.14	2.25	−0.02	−0.16
	(1.04)	(0.67)	(0.32)	(0.39)	(0.62)	(0.39)	(0.19)	(0.22)
High HHI	0.44	0.15	0.34	−0.07	−8.01	1.37	0.23	−0.05
	(0.88)	(0.57)	(0.27)	(0.33)	(0.53)	(0.33)	(0.16)	(0.19)
Low HHI	1.05	0.88	0.11	−0.08	−6.07	1.31	0.03	0.07
	(0.69)	(0.44)	(0.20)	(0.25)	(0.46)	(0.29)	(0.14)	(0.17)
Bed capacity/ AMI patient	4.53	0.31	−0.12	0.03				
	(0.22)	(0.14)	(0.07)	(0.08)				
Post-1990 effects of competition and capacity (omitted category = very low HHI)								
Very high HHI	8.04	1.46	0.54	−0.43	−1.12	1.81	0.24	0.10
	(1.08)	(0.69)	(0.33)	(0.40)	(0.62)	(0.38)	(0.18)	(0.23)
High HHI	4.43	0.46	0.23	−0.30	−0.97	1.64	0.39	0.30
	(0.91)	(0.57)	(0.28)	(0.34)	(0.55)	(0.34)	(0.17)	(0.20)
Low HHI	3.25	0.65	0.16	−0.24	−1.51	0.60	0.38	0.34
	(0.70)	(0.44)	(0.21)	(0.26)	(0.48)	(0.29)	(0.14)	(0.18)
Bed capacity/ AMI patient	1.73	0.42	−0.23	−0.23				
	(0.27)	(0.17)	(0.08)	(0.10)				

Models using HHI^{pat*} control for bed capacity per probabilistic AMI patient and other market characteristics OMC_{kt} as described in the text; models using conventional 75 percent patient-flow HHI control for size, ownership status, and teaching status of the patient's actual hospital of admission. All models include controls for patient characteristics, zip-code fixed effects, and time-fixed-effects that are allowed to vary by six MSA size categories. Heteroskedasticity-consistent standard errors are in parentheses. Very high HHI = 1st quartile of the distribution of HHIs; High HHI = 2nd quartile of the HHI distribution; Low HHI = 3rd quartile of the HHI distribution; Very low HHI = 4th quartile of the HHI distribution. Hospital Expenditures in 1993 dollars. Coefficients from 1-year hospital expenditures model *100 from regressions in logarithms; Coefficients from outcome models in percentage points. N = 572,311.

expenditures and patient health outcomes, and how this has changed over time, with estimates of η from equation (1), controlling for zip-code fixed effects, patient demographics, and allowing for differential time trends in differently sized MSAs. The left panel of Table IV presents results using HHI^{pat*}, controlling for area market characteristics OMC_{kt}; for comparison purposes, the right panel of the table presents results using conventional 75-percent variable-radius HHIs, controlling for the characteristics of hospital of admission. Our data set includes essentially all elderly patients hospitalized with the heart diseases of interest for the years of our study, so that our results describe the actual average changes in expenditures associated with changes in competition. We report standard errors for inferences about average differences that might arise in potential populations (e.g., elderly patients with these health problems in other years).

Before 1991, treatment of AMI patients in the least-competitive areas (very high HHI^{pat*}) was less costly than treatment of patients in the most-competitive areas. Patients from less competitive areas also experienced higher rates of mortality and some cardiac complications than did patients from the most-competitive areas, although these effects were statistically significant at conventional levels only for mortality outcomes for patients in the third quartile of the HHI^{pat*} distribution. Thus, the welfare implications of hospital competition in the 1980s were ambiguous: competition increased expenditures, but may have led to better outcomes. Whether competition increased welfare depends on an assessment of whether the additional health associated with competition was worth the higher associated cost of care.

As of 1991, however, competition among hospitals was unambiguously welfare-improving. Treatment of AMI patients in the least-competitive areas became significantly *more* costly than treatment of AMI in competitive areas. The magnitude of the expenditure effect of moving between the first and fourth quartiles of HHI^{pat*}, 8.04 percent, was substantial. Furthermore, differences in patient health outcomes between differently competitive areas grew substantially. Compared with patients in the most competitive areas, patients from the least-competitive areas experienced 1.46 percentage points higher mortality from AMI, which was statistically significant. Expressed as a share of 1994 average AMI mortality, *competition had the potential to improve*

AMI mortality by 4.4 percent.[9] In addition, patients from the least competitive markets also experienced statistically significantly higher rates of readmission for AMI (and not significantly lower rates of HF), suggesting that the additional survivors were not in especially marginal health.

Table IV also shows that patients from areas with greater bed capacity experience both more costly treatment for their AMI and have higher mortality rates, although they have generally lower rates of cardiac complications. The intensity-increasing effects of hospital capacity were much more pronounced before 1991, while the adverse mortality effects of capacity were relatively constant throughout the sample period. For example, after 1990, a one-standard-deviation increase in bed capacity per probabilistic AMI patient (approximately equal to a unit increase) led to approximately a 0.4 percentage point, statistically significant increase in mortality. Expressed as a share of 1994 average AMI mortality, this translates into approximately a 1.3 percent increase. These effects are robust to the exclusion of controls for market competitiveness.

The post-1990 welfare benefits of competition are nonlinear in the extent of competition. For competitiveness changes between the second and third quartiles of the HHI^{pat*} distribution, the response of expenditures to a unit change in competitiveness is much smaller than the response for changes into or out of the top or bottom quartiles.[10] The benefits of competition are more similar at the top and bottom ends of the distribution. The social benefits in cost savings and improved mortality that would result from moving a geographic area from the least-competitive quartile to the second or third quartile are not statistically distinguishable from the social benefits that would result from moving an area from the second or third to the most-competitive quartile.

The right panel of Table IV confirms that conventionally calculated estimates lead to different inferences about the impact of competition on social welfare than do estimates based on our HHI^{pat*} index. Both before and after 1990, estimates based on

9. As Appendix 3 indicates, these and the subsequent expenditure and mortality results are replicated in linear models of the effect of the *HHI* measures as well.

10. Patient-weighted mean values of HHI^{pat*} for the four quartiles are .635, .431, .308, and .177. Thus, for changes in competitiveness between the second and third quartiles, the response of expenditures to a unit change in competitiveness is 9.594 (=[4.43 − 3.25]/[.431 − .308]), versus 24.809 for changes into or out of the bottom quartile (=3.25/[.308 − .177]) and 17.696 (=[8.04 − 4.43]/[.635 − .431]) for changes into or out of the top quartile.

conventional 75 percent patient-flow HHI measures suggest that hospital competition leads to more costly treatment, although also to lower mortality and complications rates. The fact that conventional estimates of the effect of competition on resource use are positive and greater than our estimates throughout the sample period is consistent with the biases discussed in Section II: bias due to assigning hospital market competitiveness to patients based on hospital of admission (hospitals facing more competition produce higher-quality care and so draw unobservably high-cost patients) and bias due to the specification of geographic markets as a function of actual patient choices and unobservable hospital quality (hospitals that are high-cost and high-quality for whatever reason draw patients from a broader area and so appear to be more competitive).

Changes in the estimated effect of competition η between the 1980s and 1990s may be due to changes over time in the response of the level of expenditures or outcomes to changes in competition, or due to changes over time in the growth rate of expenditures or outcomes in areas with high versus low levels of competition. Table V presents estimates of γ from equation (2), the effect of period-by-period changes in competition on changes in the level of expenditures and health outcomes. The fact that the magnitude and the time path of γ from outcomes models are similar to those of η suggests that the change over time in the effect of competition on health outcomes is largely due to changes in the response of the level of outcomes to changes in competition. On the other hand, the fact that estimates of γ from expenditure models are relatively stable over time and smaller in magnitude than the estimates of η suggests that the change over time in the effect of competition on resource use is more affected by changes over time in the growth rate of expenditures in areas with high versus low levels of competition.

V.2. *Impact of Managed Care on the Effects of Competition*

Tables VI and VII investigate the extent to which managed-care organizations substitute for or mediate the effects of hospital competition.[11] Table VI presents estimates of equation (1), controlling for HMO enrollment rates by state and year, but allowing the impact of hospital competition to vary only for patients from

11. Residents of the District of Columbia are excluded from the analyses of the impact of managed care because of concerns about the validity of measured HMO enrollment rates for DC.

TABLE V

EFFECTS OF PERIOD-BY-PERIOD INTERQUARTILE CHANGES IN HOSPITAL COMPETITION ON EXPENDITURES AND OUTCOMES FOR ELDERLY AMI PATIENTS, BASED ON HHI^{pat*}

	1-year hospital expenditures	1-year mortality	1-year AMI readmit	1-year HF readmit
1985–1988				
Into top HHI quartile	−1.75	0.42	0.38	−0.16
	(1.07)	(0.72)	(0.34)	(0.40)
Out of bottom HHI qtile	4.75	−0.31	0.41	−0.42
	(1.06)	(0.69)	(0.33)	(0.39)
From quartile 3 to qtile 2	1.64	−0.82	0.44	0.06
	(1.11)	(0.74)	(0.36)	(0.41)
1988–1991				
Into top HHI quartile	1.57	0.63	0.25	−0.29
	(1.13)	(0.75)	(0.35)	(0.44)
Out of bottom HHI qtile	1.86	0.89	0.16	0.09
	(1.17)	(0.76)	(0.37)	(0.45)
From quartile 3 to qtile 2	−0.47	0.00	−0.37	0.03
	(1.08)	(0.71)	(0.34)	(0.42)
1991–1994				
Into top HHI quartile	3.07	1.19	0.17	0.11
	(1.13)	(0.70)	(0.34)	(0.42)
Out of bottom HHI qtile	0.05	1.55	−0.12	−0.11
	(1.21)	(0.75)	(0.35)	(0.45)
From quartile 3 to qtile 2	−0.62	0.23	0.13	0.15
	(1.01)	(0.64)	(0.31)	(0.39)

See notes to Table IV for controls used in models with HHI^{pat*}. Heteroskedasticity-consistent standard errors are in parentheses. Base group includes patients experiencing no interquartile change in their hospital market competitiveness. Estimation imposes the constraint that changes in competitiveness of opposing direction but between the same quartiles have effects of equal magnitude but opposite sign. Hospital Expenditures are in 1993 dollars. Coefficients from 1-year hospital expenditures model*100 from regressions in logarithms; coefficients from outcome models in percentage points. N = 284,448 (85–88); N = 282,434 (88–91); N = 288,863 (91–94).

above- and below-median enrollment state/year cells, and not over time. Consistent with previous studies of managed-care spillover effects (e.g., Baker [1999]), the first column of the first row of Table VI shows that the cost of treating Medicare patients varies inversely with the HMO enrollment rate in the area. In addition, Table VI presents the new finding that this reduction in intensity attributable to managed care penetration appears to have no measurable adverse health consequences for elderly heart patients. This result suggests that HMO spillovers not only reduce resource use for Medicare beneficiaries not enrolled in managed-care plans, but that the spillover effects occur with no statistically significant or economically important impact on health outcomes.

TABLE VI
EFFECTS OF HOSPITAL COMPETITION ON EXPENDITURES AND OUTCOMES, BASED ON HHI^{pat*}, BY EXTENT OF HMO ENROLLMENT IN SURROUNDING AREA AT DATE OF ADMISSION

	1-year hospital expenditures	1-year mortality	1-year AMI readmit	1-year HF readmit
Effect of HMO enrollment (omitted category = less-than-median enrollment/population)				
High HMO enrollment	−6.07	−0.94	−0.13	0.16
	(1.21)	(0.79)	(0.38)	(0.46)
Effects of competition and capacity in low enrollment areas (omitted category = very low HHI)				
Very high HHI	−4.98	0.68	0.32	0.06
	(1.13)	(0.74)	(0.35)	(0.42)
High HHI	−3.66	−0.31	−0.02	−0.10
	(0.98)	(0.64)	(0.31)	(0.37)
Low HHI	−2.59	0.65	0.12	0.07
	(0.81)	(0.53)	(0.25)	(0.30)
Bed capacity/AMI patient	4.09	0.19	−0.11	−0.03
	(0.24)	(0.16)	(0.08)	(0.09)
Effects of competition and capacity in high enrollment areas (omitted category = very low HHI)				
Very high HHI	4.98	1.44	0.75	−0.41
	(1.08)	(0.68)	(0.33)	(0.40)
High HHI	2.56	0.67	0.52	−0.23
	(0.87)	(0.55)	(0.27)	(0.32)
Low HHI	2.44	0.79	0.23	−0.22
	(0.65)	(0.41)	(0.19)	(0.24)
Bed capacity/AMI patient	2.17	0.50	−0.20	−0.03
	(0.25)	(0.16)	(0.08)	(0.09)

See notes to Table IV for controls used in models with HHI^{pat*}. Heteroskedasticity-consistent standard errors are in parentheses. Very high HHI = 1st quartile of the distribution of HHIs; high HHI = 2nd quartile of the HHI distribution; low HHI = 3rd quartile of the HHI distribution; very low HHI = 4th quartile of the HHI distribution. Hospital expenditures are in 1993 dollars. Coefficients are from 1-year hospital expenditures model *100 from regressions in logarithms; coefficients from outcome models are in percentage points. Residents of the District of Columbia are excluded from analyses reported in this table because of concerns about the validity of measured HMO enrollment rates for DC. N = 571,106.

Table VI suggests that the rise of managed care over the sample period partially explains the changing relationship between hospital competition, treatment intensity, and patient health outcomes. For patients from states with low HMO enrollment rates as of their date of admission, competition increased expenditures and generally led to (statistically insignificantly) better outcomes. But for patients from states with high HMO enrollment rates as of their date of admission, competition was

TABLE VII
EFFECTS OF HOSPITAL COMPETITION ON EXPENDITURES AND OUTCOMES, BASED ON HHI^{pat*}, BY EXTENT OF HMO ENROLLMENT IN SURROUNDING AREA AT DATE OF ADMISSION, PRE- AND POST-1990

	1-year hospital expenditures	1-year mortality	1-year AMI readmit	1-year HF readmit
Pre-1990 effect of HMO enrollment (omitted category = less-than-median enrollment/population)				
High HMO enrollment	−10.15	−0.77	−0.69	0.08
	(1.51)	(0.99)	(0.48)	(0.57)
Pre-1990 effects of competition and capacity in low enrollment areas (omitted category = very low HHI)				
Very high HHI	−6.45	0.54	0.37	0.47
	(1.18)	(0.77)	(0.37)	(0.44)
High HHI	−3.36	−0.35	−0.01	0.00
	(1.02)	(0.67)	(0.32)	(0.38)
Low HHI	−1.88	0.65	0.14	0.19
	(0.85)	(0.56)	(0.27)	(0.32)
Bed capacity/AMI patient	3.18	0.18	−0.11	0.01
	(0.26)	(0.17)	(0.08)	(0.10)
Pre-1990 effects of competition and capacity in high enrollment areas (omitted category = very low HHI)				
Very high HHI	−0.39	1.11	0.80	−0.37
	(1.24)	(0.79)	(0.38)	(0.46)
High HHI	1.44	0.65	0.71	−0.03
	(1.04)	(0.66)	(0.32)	(0.38)
Low HHI	2.55	1.06	0.14	−0.27
	(0.80)	(0.50)	(0.24)	(0.29)
Bed capacity/AMI patient	3.50	0.51	−0.15	0.16
	(0.29)	(0.18)	(0.09)	(0.10)
Post-1990 effect of HMO enrollment (omitted category = less-than-median enrollment/population)				
High HMO enrollment	−7.41	−0.12	−0.22	−1.15
	(2.28)	(1.50)	(0.72)	(0.87)

Post-1990 effects of competition and capacity in low enrollment areas (omitted category = very low HHI)				
Very high HHI	3.20	1.33	−0.05	−0.97
	(1.65)	(1.08)	(0.52)	(0.63)
High HHI	0.05	0.08	−0.27	−0.51
	(1.56)	(1.02)	(0.48)	(0.59)
Low HHI	−0.12	1.01	−0.20	−0.47
	(1.44)	(0.94)	(0.44)	(0.55)
Bed capacity/AMI patient	0.97	0.45	−0.27	−0.25
	(0.44)	(0.30)	(0.14)	(0.17)
Post-1990 effects of competition and capacity in high enrollment areas (omitted category = very low HHI)				
Very high HHI	8.46	1.60	0.68	−0.21
	(1.18)	(0.75)	(0.36)	(0.44)
High HHI	4.05	0.67	0.34	−0.20
	(0.96)	(0.61)	(0.29)	(0.36)
Low HHI	2.57	0.61	0.21	−0.13
	(0.74)	(0.46)	(0.22)	(0.27)
Bed capacity/AMI patient	0.85	0.46	−0.24	−0.17
	(0.29)	(0.18)	(0.09)	(0.11)

See notes to Table IV for controls used in models with HHI^{pat*}. Heteroskedasticity-consistent standard errors are in parentheses. Very high HHI = 1st quartile of the distribution of HHIs; high HHI = 2nd quartile of the HHI distribution; low HHI = 3rd quartile of the HHI distribution; very low HHI = 4th quartile of the HHI distribution. Hospital expenditures are in 1993 dollars. Coefficients are from 1-year hospital expenditures model *100 from regressions in logarithms; coefficients from outcome models are in percentage points. Residents of the District of Columbia are excluded from analyses reported in this table because of concerns about the validity of measured HMO enrollment rates for DC. N = 571,106.

unambiguously welfare-improving: competition led to lower levels of resource use and lower rates of mortality and subsequent complications.

Table VII further explores the hypothesis that managed care serves as a catalyst through which hospital competition improves welfare, by presenting estimates that allow the interaction between HMO enrollment in an area and hospital market competitiveness to change over time. The top panel of Table VII presents estimates of the impact of area HMO enrollment and interactions of HMO enrollment with area competitiveness for patients admitted to the hospital in 1985 and 1988; the bottom panel of Table VII presents estimates of the impact of area HMO enrollment and HMO enrollment/competitiveness interactions for patients admitted to the hospital in 1991 and 1994. Table VII confirms that managed care and hospital competition are complements in the process of producing cardiac care services. Both before and after 1990, hospital competition leads to greater decreases in resource use and rates of adverse health outcomes in areas with high versus low HMO enrollment (although differences across managed-care environments in the effect of competition on mortality are not statistically significant). However, although HMOs have socially beneficial spillover effects throughout the sample period, the incremental social benefits attributable to hospital-competition/HMO-spillover interactions have become less dramatic over time. Before 1990, competition in low-enrollment areas was socially wasteful—competition led to higher levels of resource use without significant effects on health outcomes—while competition in high-enrollment areas had more ambiguous or positive effects, at least for patients in the most competitive areas versus those from areas in the third quartile of the HHI distribution. But after 1990, competition was welfare-improving in all areas—competition led to significant decreases in resource use without significant increases (and in some cases significant decreases) in the rates of adverse health outcomes. This finding may reflect the diffusion of cost-control measures implemented by more-developed HMOs in high-enrollment areas in the 1980s to relatively low-HMO-enrollment areas by the 1990s. (Indeed, by the 1990s, most low-enrollment areas had HMO enrollment rates that exceeded those of high-enrollment areas in the 1980s.)

VI. Conclusion

Assessing the welfare consequences of competition in health care is a particularly difficult case of an important general problem in industrial organization. The features of markets for hospital services depart substantially from the conditions of perfectly competitive markets, so that theory plausibly suggests that competition may either increase or reduce social welfare. Consequently, empirical assessment of the welfare implications of competition in hospital markets is crucial for testing the validity of alternative theories about the effects of competition in health care. Empirical evidence is also necessary to guide hospital antitrust policy. If competition among hospitals improves social welfare, then strictly regulating coordinated activity could offer social benefits. But if competition among hospitals is socially wasteful, then coordination and mergers should receive more lenient antitrust treatment, or possibly even be encouraged.

In spite of this importance, virtually no previous research has determined the effects of competition on both health care costs and patient health outcomes. Important reasons for this omission are the difficulty of developing suitable data on spending and quality—a particularly challenging problem in the hospital industry—as well as the general problem in applied work in industrial organization of identifying the effects of competition. We address both types of problems here, using methods for identifying the effects of competition that could be applied in other industries which have suitable data on consumer choices and in which broad product characteristics (e.g., hospital size category and teaching status) are very difficult to change.

Our analysis includes all nonrural elderly Medicare beneficiaries hospitalized for treatment of heart disease in a ten-year period that includes the recent growth in managed-care insurance. Our methods develop indices of competition that are based on exogenous determinants of hospital demand, rather than assumptions about the extent of markets and their competitiveness that are either arbitrary or subject to the usual endogeneity problems. We also measure explicitly the key outcomes of market performance, including effects on both patient health and medical expenditures. Finally, because managed-care organizations are likely to be an important mechanism through which competition affects hospital markets, we investigate the extent to which HMO enrollment rates in an area create spillovers that affect medical productivity and the impact of competition on productivity.

We find that, before 1991, competition led to higher costs and, in some cases, lower rates of adverse health outcomes for elderly Americans with heart disease; but after 1990, competition led both to substantially lower costs and significantly lower rates of adverse outcomes. Thus, after 1990, hospital competition unambiguously improves social welfare. Increasing HMO enrollment over the sample period partially explains the dramatic change in the impact of hospital competition; hospital competition is unambiguously welfare-improving throughout the sample period in geographic areas with above-median HMO enrollment rates. Furthermore, point estimates of the magnitude of the welfare benefits of competition are uniformly larger for patients from states with high HMO enrollment as of their admission date, as compared with patients from states with low HMO enrollment.

The socially beneficial impact of post-1990 competition is nonlinear: the effect of an interquartile change in competitiveness on expenditures and outcomes is much greater for areas moving to or from the most- and least-competitive quartiles. Our finding that competition improves welfare post-1990 is not affected by controlling for other factors that may affect hospital market structure, such as distance to the nearest hospital, hospital bed capacity utilization, and other hospital market characteristics. We also find that changes in capacity utilization are themselves important determinants of health care costs and outcomes. Patients from hospital markets with high levels of capacity per unit AMI patient volume experience generally higher costs and higher mortality rates.

Our methods can be used to assess prospectively the impact of specific hospital mergers by answering the following hypothetical question: based on patients' preferences for hospitals (and therefore the matrix of probabilistic patient flows) in a given year, how would uniting ownership of two or more hospitals affect HHI^{pat*} in surrounding areas (see Kessler and McClellan [1999] for a more detailed discussion)? For Medicare patients with AMI, those mergers that would lead to a change in HHI^{pat*} out of the most-competitive quartile or into the least-competitive quartile (or both) would reduce welfare by increasing expenditures and rates of adverse outcomes. On the other hand, our estimates suggest that those mergers that lead to changes in HHI^{pat*} from the third to the second quartile would not have statistically or economically significant welfare implications for this population. This analysis is necessarily incomplete, in that it does not account completely for other potential costs and benefits of mergers, such as their impact on nonelderly patients and those with other illnesses. We leave such issues to future work.

Are our results generalizable to other components of hospital production? Heart disease is the largest single component of hospital production, accounting for around one-sixth of hospital expenditures, so it seems unlikely that the overall effects of competition would differ dramatically, at least for other serious acute health problems. However, less acute conditions provide greater opportunities for patients to choose among hospitals, and also provide hospitals with the opportunity to seek out relatively low-cost patients, both through choices of service offerings and through the choice of health plans with which the hospitals contract. Particularly for nonacute illnesses, it is possible that the growth of higher-powered payment incentives that has accompanied the growth of managed care in the 1990s would encourage hospitals to avoid such patients in the presence of greater competition. Along these lines, it is possible that privately insured patients would be affected differently by competition than publicly insured patients.

Finally, we do not explicitly model the mechanisms by which competition leads to its welfare consequences. Most importantly, we do not model why the welfare effects of competition changed around 1990, in conjunction with the rise of managed care. Our results suggest that spillover effects from increasingly efficient treatment of privately insured patients affect the treatment regimen of publicly insured patients, by mediating the consequences of hospital competition in a way that enhances medical productivity. In particular, managed care appears to increase efficiency by reducing the tendency of hospital competition to result in a "medical arms race" of expenditure growth. Understanding how the productivity-increasing effects of competition occur in health care, and how managed care enhances these effects, is an important topic for further analysis.

APPENDIX 1: STATES WITH HMO ENROLLMENT ABOVE AND BELOW FOUR-YEAR POOLED MEDIAN

	1985	1988	1991	1994
Above median HMO enrollment	Arizona, California, Colorado, Hawaii, Massachusetts, Michigan, Minnesota, New York, Oregon, Rhode Island, Utah, Washington, Wisconsin	Arizona, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Illinois, Indiana, Iowa, Kansas, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, Utah, Washington, Wisconsin	Arizona, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Illinois, Iowa, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nevada, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, Rhode Island, Texas, Utah, Vermont, Washington, Wisconsin	Arizona, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Illinois, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, Rhode Island, Tennessee, Texas, Utah, Vermont, Washington, Wisconsin
Below median HMO enrollment	Alabama, Alaska, Arkansas, Connecticut, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, Wyoming	Alabama, Alaska, Arkansas, Georgia, Idaho, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, North Carolina, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, Wyoming	Alabama, Alaska, Arkansas, Georgia, Idaho, Indiana, Kansas, Kentucky, Louisiana, Maine, Mississippi, Montana, Nebraska, North Carolina, North Dakota, Oklahoma, South Carolina, South Dakota, Tennessee, Virginia, West Virginia, Wyoming	Alabama, Alaska, Arkansas, Georgia, Idaho, Indiana, Iowa, Kansas, Louisiana, Maine, Mississippi, Montana, North Carolina, North Dakota, Oklahoma, South Carolina, South Dakota, Texas, Vermont, Virginia, West Virginia, Wyoming

Median HMO Enrollment rate for four-year period is 7.54 percent.

APPENDIX 2: SHARE OF ELDERLY AMI PATIENTS WITH INTERQUARTILE CHANGES IN HOSPITAL MARKET COMPETITIVENESS

	1985–1988	1988–1991	1991–1994	1985–1994
HHI^{pat*}	24.0%	22.4%	22.0%	34.5%
Conventional 75-percent variable-radius HHI	25.3%	26.7%	23.9%	32.9%

Quartile cut points for HHI^{pat*} are as follows: .2527, .3688, and .5. Quartile cut points for conventional 75-percent variable-radius HHI are as follows: .2831, .4432, and .6571. Quartiles are formed counting one residential zip code (one market) as one observation.

APPENDIX 3: LINEAR MODEL OF THE EFFECTS OF HOSPITAL COMPETITION AND BED CAPACITY ON EXPENDITURES AND OUTCOMES FOR ELDERLY AMI PATIENTS, BASED ON EXOGENOUS HHI^{pat*} VERSUS CONVENTIONAL 75-PERCENT-PATIENT-FLOW HHI

	Using HHI^{pat*}				Using conventional 75-percent patient-flow HHI			
	1-year hospital expenditures	1-year mortality	1-year AMI readmit	1-year HF readmit	1-year hospital expenditures	1-year mortality	1-year AMI readmit	1-year HF readmit
Pre-1990 effects of competition and capacity								
Linear HHI	−10.15	2.52	0.93	−0.96	−15.51	2.57	0.15	−0.22
	(2.78)	(1.78)	(0.86)	(1.02)	(0.71)	(0.44)	(0.21)	(0.26)
Bed capacity/ AMI patient	4.58	0.35	−0.12	0.02				
	(0.22)	(0.14)	(0.07)	(0.08)				
Post-1990 effects of competition and capacity								
Linear HHI	7.16	3.37	0.64	−2.21	−1.67	2.20	0.16	0.02
	(2.81)	(1.78)	(0.86)	(1.03)	(0.70)	(0.43)	(0.21)	(0.26)
Bed capacity/ AMI patient	1.70	0.42	−0.24	−0.25				
	(0.27)	(0.17)	(0.08)	(0.09)				

See notes to Table IV for controls used in models with HHI^{pat*} and the conventional 75 percent patient-flow HHI. Heteroskedasticity-consistent standard errors are in parentheses. Very high HHI = 1st quartile of the distribution of HHIs; high HHI = 2nd quartile of the HHI distribution; low HHI = 3rd quartile of the HHI distribution; very low HHI = 4th quartile of the HHI distribution. Hospital expenditures are in 1993 dollars. Coefficients from 1-year hospital expenditures model *100 from regressions in logarithms; coefficients from outcome models in percentage points. N = 572,311.

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