Insurer-Provider Networks in the Medical Care Market*

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Abstract

Managed care health insurers in the US restrict their enrollees' choice of hospitals to specific networks. This paper investigates the causes and welfare effects of the observed hospital networks. A simple profit maximization model explains roughly 63 per cent of the observed contracts between insurers and hospitals. I estimate a model that includes an additional effect: hospitals that do not need to contract with all insurance plans to secure demand (for example, providers that are capacity constrained under a limited or selective network) may demand high prices that not all insurers are willing to pay. Hospitals can merge to form "systems" which may also affect bargaining between hospitals and insurance plans. The analysis estimates the expected division of profits between insurance plans and different types of hospitals using data on insurers' choices of network. Hospitals in systems are found to capture markups of approximately 19 per cent of revenues, in contrast to non-system, non-capacity constrained providers, whose markups are assumed to be about zero. System members also impose high penalties on plans that exclude their partners. Providers that are expected to be capacity constrained capture markups of about 14 per cent of revenues. I show that these high markups imply an incentive for hospitals to under-invest in capacity despite a median benefit to consumers of over $330,000 per new bed per year.

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1 Introduction

The effects of managed care health insurers on the price and quality of medical care have been widely researched[1]. One aspect of their impact, however, has not been addressed in detail: the restriction imposed by each insurance plan on the network of hospitals from which its enrollees can choose. In a previous paper (Ho, 2005a), I consider the short term welfare effects of these constraints. I estimate that restricted consumer choice of hospitals leads to a welfare loss of approximately $1.04 billion per year assuming fixed prices[2]. In this paper I analyze the process by which the contracting equilibrium is determined, noting the effects that can generate a static welfare loss of this kind. I also consider dynamic welfare effects. The division of the profits generated by each contract is determined by bargaining between the hospital and the insurer. This implies an incentive for both firms to invest in characteristics that will increase their leverage during the bargaining process. This paper demonstrates one dimension on which hospitals' investment incentives may be at odds with consumer preferences: hospitals that expect to fill their beds may have an incentive to under-invest in capacity. I show that investment in new beds would generate a benefit to consumers of over $330,000 per bed per year assuming fixed premiums, far outweighing the effect on hospital and insurer profits. However, the bargaining process implies a negative incentive for capacity constrained hospitals to invest.

I base my analysis on a dataset that defines the network of every managed care plan in 43 markets across the US. On average 17 per cent of insurer-hospital pairs in my data do not arrange contracts to provide care. The proportion varies from zero in some markets to as many as 40 per cent in others. I define selective markets as those in which at least four of the five major plans fail to reach agreement with at least one major hospital. By this definition roughly 20 per cent of observed markets are selective. 76% of enrollees in managed care plans do not have a free choice of hospitals. The data therefore show that, even in markets with reasonably small numbers of insurers

[1] For example, Miller and Luft (1997) review fifteen studies of the effects of managed care on quality. They find no compelling evidence of a reduction in quality of care, although patients show less satisfaction with managed care than with traditional plans. Cutler, McClellan and Newhouse (2000) consider the causes of the expenditure reductions achieved by managed care plans in the treatment of heart disease. They show that virtually all the difference in spending between indemnity plans and HMOs comes from lower unit prices rather than the quantity of services or a difference in health outcomes.

[2] As discussed in that paper, any premium increase resulting from a move to less selective hospital networks would offset this welfare loss. The overall result of the observed restricted networks may in fact be an increase in total welfare compared to the unselective case.

and hospitals (12 and 15 per market on average, respectively), substantial numbers of potential contracts are not agreed upon.

I use demand estimates from my previous paper to calculate the producer surplus (defined as plan revenues less hospital costs of care) generated by each potential hospital network for each plan in the data, taking into account patient flows across plans and hospitals. A simple analysis shows that around 63 per cent of contractual decisions are explained by this definition of producer surplus. An understanding of the price-setting negotiation between insurers and providers is needed to explain the rest of the data. I discuss the intuition that explains how the potential for price discrimination by hospitals, made possible by consumers' ability to move across plans, can influence contractual decisions even holding surplus fixed. The intuition applies to hospitals that are highly differentiated from their peers or that expect to be capacity constrained and to groups of providers that have merged to form hospital systems. In addition, system hospitals may effectively force plans to contract with all or none of the hospitals in the system. Reduced form analysis is consistent with these predictions.

I also discuss short term welfare effects. The selective equilibrium can be inefficient even when the excluded hospital is full at equilibrium and the consumers with the highest value for it are the ones treated. The inefficiency is generated because consumers are forced to make sub-optimal choices across insurers in order to access their preferred hospital. The resulting loss of consumer welfare may outweigh the benefit derived when the highest-valuation patients are given preferential access to the hospital[3].

I estimate the profits secured by different types of hospitals using data on insurers' choices of hospital networks and insurer and hospital characteristics. This is a two-sided matching problem with heterogeneous agents. The analysis is complicated by the existence of multiple potential equilibria and by problems with endogenous regressors. Several recent papers develop methodologies that address these issues. However, their approaches often make restrictive assumptions regarding the nature of the unobservables and most are feasible only for problems involving small numbers of firms[4]. This paper adopts a different approach developed in Pakes, Porter, Ho and Ishii (2005) in

[3]This is the welfare effect estimated in Ho (2005a). The restriction of consumer choice of hospitals, and the resulting distortion of their choice of plans, imply a welfare loss of $1.04 billion per year assuming fixed prices.

[4]For example, Seim (2001), Andrews, Berry and Jia (2004) and Ciliberto and Tamer (2004) all propose methods to analyze market entry problems. Fox (2005) and Sorensen (2005) set out estimation methods for two-sided matching problems. However, Sorensen's nested solution method is infeasible in the large markets studied here, while Fox's

which plans choose their networks in a simultaneous-moves game conditional on their expectations regarding other plan choices and the prices demanded by hospitals. The equilibrium implicitly establishes markups for a hospital's services that are functions of the characteristics of the hospital itself and the distribution of consumer, hospital, and plan characteristics in the particular market.

I estimate the markups of three specific hospital types: those that expect to be capacity constrained, "star" hospitals (providers that are very attractive to consumers) and those that are members of hospital systems. I find that hospitals with exogenous characteristics predicting capacity constraints capture \$1800 per patient treated more than other providers. This implies markups of approximately 14 per cent of revenues, in contrast to non-system, non-capacity constrained providers, which I assume receive approximately zero markups. The profits of hospitals in systems are approximately \$140,000 per month higher than other providers; this translates to a markup of about 19 per cent of revenues. They also charge high penalties from plans that contract with some but not all of the hospitals in their system. The results are therefore consistent with several recent papers that suggest that hospital mergers may prevent plans from using the threat of exclusions to control prices[5]. Star hospitals may also capture high profits but these are imprecisely estimated. In addition, I find that hospitals with low costs have higher markups than their competitors, consistent with simple bargaining models.

Finally, I outline the implications of the results. The methodology used in this paper does not fully detail how the multiplicity of possible equilibria is resolved. Instead my analysis provides a reduced form characterization of the markup equation that is generated by the equilibrium that does materialize. More precise details of the bargaining game would be needed to determine how that equilibrium is chosen and this would be required before I could provide a detailed analysis of counterfactuals. I do, however, analyze the relationship between hospital characteristics and markups. This provides helpful information for assessing which bargaining models best describe the hospital-insurer price negotiation. To the extent that policy and environmental changes do not affect the reduced form relationship, the results can also be used to predict how changes in market characteristics are likely to affect hospital markups.

The dynamic welfare effects implied by the estimates are considered in this spirit. In particular

simpler methodology does not permit an analysis of the division of profits between upstream and downstream firms.

[5] See, for example, Lesser and Grinsburg (2001), Mays, Hurley and Grossman (2003), and Capps and Dranove (2004).

I predict the impact of hospital investment to remove capacity constraints, assuming no effect of this change on plan networks or other market characteristics[6]. The investment would result in a median benefit to consumers of $0.17 per person per new bed per year, or $331,890 per year per additional bed for the market as a whole. Insurer profits would increase as a result of the change. However, I find that the hospital markups generated by capacity constraints outweigh the additional revenues from new patients and imply that, at least in the short term, these providers have no incentive to invest to remove their constraints. The results demonstrate that hospitals may benefit from artificially restricting their capacity below the level that would be observed in a world without bargaining and that this may significantly reduce consumer surplus.

Several strands of the health economics literature are relevant to this paper. A number of authors demonstrate that the prices paid by plans to hospitals are consistent with simple bargaining models[7]. Gal-Or (1997, 1998) develops a Nash bargaining model in a two-plan, two-hospital setting. Vistnes (2000) has a model of two-stage competition between hospitals: providers compete first for preferential acesss to health plans and then for individual patients. Finally, Eggleston, Norman and Pepall (2004) use a similar theoretical framework in a market containing health plans, hospitals and physician groups to look at the effects of horizontal and vertical integration on prices. However, no previous empirical papers have addressed the determinants of the observed network choices or the effect of the contractual process on long term investment incentives.

In the next two sections I describe the contractual process between insurers and hospitals and introduce the dataset. Section 4 outlines the demand estimates from Ho (2005a) and uses them to generate a measure of surplus. Section 5 discusses the intuition regarding bargaining; Section 6 contains reduced form results; and Section 7 introduces the full empirical model. Results and counterfactuals are given in Sections 8 and 9 and the final section concludes.

[6] I assume that hospital capacity is determined prior to the contracting process and that the relationship identified between capacity constraints and hospital markups is causal. See Section 2 for a discussion of the rationale for this assumption.

[7] Most of these regress the prices paid to hospitals on measures of hospital and plan bargaining power. Examples are Brooks, Dor and Wong (1996), Zwanziger and Mooney (2000) and Feldman and Wholey (2001). In addition, Town and Vistnes (2001) and Capps, Dranove and Satterthwaite (2004) both investigate the effect of the hospital's value to consumers on its profits. They estimate consumer preferences over hospitals and regress hospital profits or prices on variables that summarize consumer demand for the hospital.

2 Industry Background and Assumptions

Each year, every privately insured consumer in the US chooses a health plan, generally from a menu offered by his employer[8]. The insurer contracts with hospitals and physicians to provide any care needed during the year. When the consumer requires medical care, he may visit any of the providers listed by the health plan, and receive services at zero charge or after making a small out-of-pocket payment.

There is some variety in the restrictiveness of different types of managed care plan. If an individual is insured by a Health Maintenance Organization (HMO) he may visit only the hospitals in that plan's network. Point of Service (POS) plan enrollees can visit out-of-network hospitals but only if referred by a Primary Care Physician. Preferred Provider Organizations (PPOs) and indemnity plans are the least restrictive insurers: enrollees do not need a PCP referral to visit an out-of-network hospital, although PPOs may impose financial penalties for doing so, for example in the form of increased copayments or deductibles. The focus of this paper is on HMO and POS plans, since their network choices have the strongest effect on both consumers and hospitals; 53 per cent of the privately-insured population was enrolled in an HMO/POS plan in 2000.

Every HMO/POS plan contracts separately with every hospital in its network. The exact form of the contracts varies but all specify a price to be paid to the provider per unit of care (for example a price per inpatient day or per diagnosis-related group (DRG)). Prices vary both across providers for a given insurer and across insurers for a given provider; contracts are usually renegotiated annually[9]. Both parties in the negotiation need to balance consumer demand for services against the price agreed. A health plan would prefer to contract with the hospitals that are valued by its likely customers, particularly the customers on the margin of joining, but must also take into account the fact that hospitals in demand may seek higher prices than their less differentiated counterparts. Hospitals seek to maximize their returns by contracting with plans that both offer high prices and provide a steady flow of patients.

In order to model the contractual process I need to specify the timing of the different hospital

[8] 57 per cent of the population is insured through an employer, compared to 5 per cent who purchase insurance independently and 24 per cent in Medicare and Medicaid. (See the website www.statehealthfacts.org.)

[9] Prices paid to hospitals were regulated at the state level in the 1960s and 1970s. However, since Medicare and Medicaid switched from cost-based to prospective payment systems, and managed care encouraged increased price competition between hospitals, rate regulation has virtually disappeared. It remains only in Maryland: markets in this state are excluded from my supply-side analysis.

and plan decisions. The stages of my model are as follows:

Stage 1:	Plans and hospitals agree on contracts
Stage 2:	Plans set premiums
Stage 3:	Consumers and employers jointly choose plans
Stage 4:	Sick consumers visit hospitals; plans pay hospitals per service provided

My main focus is on Stage 1. I assume fixed premiums throughout most of my calculations; I include a robustness test to consider the effects of potential premium adjustments in Section 8. I analyze Stages 3 and 4 in Ho (2005a): my methodology is outlined in section 4.1 and the results of that study are incorporated where necessary in this paper.

A few additional comments are in order. First, I assume that the plan's choice of quality and products, together with the hospital's choices of capacity, location, services and quality, are made prior to Stage 1. My analysis conditions on these decisions. I therefore do not explicitly model issues such as product-based price discrimination (the plan's choice between HMO and POS products can be seen as a way of dividing the market into segments with different price elasticities of demand) and the hospital's decision regarding investment in new capacity given that offered by its competitors. Similarly, I assume that hospital merger decisions are made prior to the contractual process[10]. Second, I focus on inpatient care. According to the American Hospital Association, 65% of hospital revenues in 2001 were derived from inpatient care; the remainder came from outpatient services.

My dataset contains no exclusive contracts (either hospitals reaching agreement exclusively with a single insurer or vice versa) and few vertically integrated organizations. Many hospitals and insurers attempted vertical integration in the 1990s but this has become increasingly rare in recent years. The literature implies that the breadth of skills needed to run both a hospital and a plan is too large for the vertically integrated model to be viable except in very specific

[10] These assumptions seem reasonable because the relevant variables change more slowly over time than hospital-insurer contracts. For example, over 90% of hospitals did not alter their offerings of angioplasty, ultrasound, open heart surgery or neonatal intensive care units over the four-year period 1997-2001; 70 percent of hospitals changed their capacity levels by fewer than 20 beds over the same four-year period. The correlation between market-level bed capacity (beds per thousand population) in 1980 and that in 2001 is 0.63. Plan product offerings and hospital locations are similarly static. Hospital-insurer contracts, in contrast, are usually renegotiated annually. My goal is to estimate the short-term effects of these hospital and plan characteristics on equilibrium contracts. Long-term investment decisions regarding capacity are considered in Section 9.

circumstances[11]. The key exception to this pattern is Kaiser Permanente, a dominant HMO in California and elsewhere that owns a large number of hospitals. I do not attempt to explain the vertical integration phenomenon in this paper. I condition on the existence of Kaiser health plans and hospitals in my analysis of both the supply and demand sides of the market (since they are important members of the plan and hospital choice sets, particularly in California) but exclude them from my models of firm behavior.

The health plan must take state and federal legislation into account when choosing its providers. Many states have implemented Any Willing Provider laws which prohibit health insurers from excluding qualified health care providers that are willing to accept the plans' terms and conditions. However, these regulations have been argued to remove the benefits of managed care, since they prevent plans from trading volume for lower provider prices. Perhaps for this reason they apply to hospitals in only seven states (in other areas they are largely limited to pharmacies). I have data covering two markets within these states; I find that plans are just as likely to exclude hospitals in these markets as elsewhere. I therefore assume that these regulations have no impact on plan decisions in the markets I consider. In addition, some states have implemented Essential Community Provider laws, which require insurers to contract with providers that offer "essential community services", such as public hospitals and teaching hospitals, and to contract with enough hospitals to serve the needs of the local population. I assume these regulations do not affect the decision of a plan to exclude any particular hospital since consumer demand forecasts would prevent it from dropping too many hospitals in any case.

3 The Dataset

This paper pulls together information from several datasets. I take data on the characteristics of health insurers from two datasets from Atlantic Information Services[12]. The data cover all managed care insurers in 43 major markets across the US for Quarters 3 and 4 of 2002[13]. I supplement this

[11] See, for example, Burns and Pauly (2002) and Burns and Thorpe (2000)

[12] These are *The HMO Enrollment Report* and *HMO Directory 2002*. Both are based on plan state insurance filings.

[13] The markets are: Atlanta GA, Austin TX, Baltimore MD, Boston MA, Buffalo NY, Charlotte NC, Chicago IL, Cincinnati OH, Cleveland OH, Columbus OH, Dallas TX, Denver CO, Detroit MI, Fort Worth TX, Houston TX, Indianapolis IN, Jacksonville FL, Kansas City MO, Las Vegas NV, Los Angeles CA, Miami FL, Milwaukee WI, Minneapolis MN, New Orleans LA, Norfolk VA, Oakland CA, Orange County CA, Orlando FL, Philadelphia PA, Phoenix AZ, Pittsburgh PA, Portland OR, Sacramento CA, St. Louis MO, Salt Lake City UT, San Antonio TX, San Diego CA, San Francisco CA, San Jose CA, Seattle WA, Tampa FL, Washington DC, and West Palm Beach FL.

information with data from the *Weiss Ratings' Guide to HMOs and Health Insurers* for Fall 2002. Data on plan performance comes from the *Health Employer Data and Information Set* (HEDIS) and the *Consumer Assessment of Health Plans* (CAHPS) 2000, both of which are published by the National Committee for Quality Assurance (NCQA). These data measure clinical performance and patient satisfaction in 1999. Hospital characteristics are taken from the American Hospital Association (AHA) dataset for 2001 and from the MEDSTAT Marketscan Research Database for 1997-98. My previous paper, Ho (2005a), uses all these datasets: further details on the data, and the methodology used to create additional variables (such as plan market shares) that are employed again in this analysis, are given there. My demand estimation includes all 665 hospitals and all 516 managed care plans in the data. When I consider the supply side I exclude one of the 43 markets, Baltimore MD, since the state of Maryland sets hospital prices centrally rather than permitting the plan-hospital bargaining analyzed here. In the remaining 42 markets I consider only non-Kaiser plans for which premiums are observed; I also exclude a few extremely selective insurers that I regard as outliers[14]. The remaining data contain 441 plans in total[15]. I model these plans' contracts with all non-Kaiser hospitals in each market: there are 633 hospitals in total in the supply-side dataset. I condition on the observed contracts of each excluded plan and hospital in each market.

Descriptive statistics for the hospitals and plans in the data are given in Tables 1 and 2 respectively. The hospitals have 339 beds and 1.26 registered nurses per bed on average; 20% are teaching hospitals. The average market share of the HMO/POS plans in the dataset is 3%[16]. Premiums average $141 per member per month. 35% of insurers are POS plans; 76% have been in existence for over 10 years. Plan performance scores vary widely, from an average rating of 0.15 (for the percent of children receiving all required doses of MMR, Hepatitis B and VZV vaccines before their 13th birthday) to an average of 0.73 (the proportion of women aged 52-69 who had received a

[14] I exclude plans that drop more than four of the top six hospitals because these may have different reasons for their contracting decisions than other plans in the data. I also exclude two specific outliers: Scott and White Health Plan of Austin, TX and Group Health Cooperative of Puget Sound. These are different from most other plans in the market in that they are locally-based, consumer-driven insurers that are heavily focused on primary care.

[15] The supply side analysis includes a prediction of plan market shares given the networks offered by every plan in the market. I condition on the existence of "excluded" plans (Kaiser plans, those that are very selective and those for which premiums are unobserved) when calculating the shares of the plans that are modelled explicitly. I also take account of indemnity and PPO plans, making assumptions about their characteristics, and allow consumers to choose the outside option of being uninsured, as described in detail in Ho (2005a).

[16] Shares are measured as percent of the nonelderly population in the market.

mammogram within the previous two years). The two most frequently-occurring plans are Aetna and CIGNA, with 15% and 10% of observations respectively.

The final dataset analyzed in this paper defines the network of hospitals offered to enrollees by every HMO/POS plan in every market considered in March/April 2003. The information was collected from individual plan websites; missing data were filled in by phone. Figure 1 documents the observed variation across both markets and plans in the extent to which plans exclude major hospitals from their networks[17]. Markets are categorized on a scale from 1 to 5, where 1 is the least selective, indicating that each of the five largest plans (by enrollment) contracts with all eight largest hospitals (by number of admissions). In markets ranked 5, at least four of the largest plans exclude at least one major hospital; the other categories lie between these extremes. Markets are fairly evenly spread across the five categories: 15 markets are ranked 1 or 2 (not selective) and 21 are ranked 4 or 5 (very selective). The figure also shows the distribution of plans by the number of major hospitals excluded and the variation in this distribution across types of market. Plans' selective behavior varies widely: 208 plans exclude no major hospitals, but 62 plans exclude at least four of the eight major hospitals in their markets.

Table 3 compares the means of a number of market characteristics in selective and unselective markets. There are few significant differences. Selective markets do not have significantly smaller populations, higher managed care penetration, more hospitals, or more beds per capita than unselective markets and are not clustered geographically. There are no significant demographic differences. The only difference that is significant at p=0.05 (or in fact at p=0.2) is the standard deviation of the distances between hospitals in the market. Plans seem to be more willing to exclude hospitals in areas where hospitals are clustered into several groups, perhaps because each provider in a given group is a reasonable substitute for the others. The raw data therefore do not offer an obvious explanation for the observed variation; however, they do provide a hint that demand effects may be important. These are taken into account in the analysis described in Section 4.

The hospital-level data offer further clues to help explain the observed contracting choices. Table 4 defines four variables that summarize the services offered by each hospital. The summary variables cover cardiac services, imaging, cancer and birth services. Each hospital is rated on a

[17] Figure 1 and Table 3 both exclude Baltimore MD.

scale from 0 to 1, where 1 implies that the hospital offers the least common of a list of relevant services and 0 implies that it offers none of the services. I interact these variables with consumer characteristics in the model of demand for hospitals. They can also be used to investigate which hospital characteristics are correlated with market share. Table 5 sets out the results of a regression of hospital market shares on hospital characteristics. All four service variables, and the indicator for teaching hospitals, are positively and significantly related to market share. Together with hospital location, they will be key determinants of hospital capacity constraints (which, as we shall see, generate market power and the ability to negotiate positive profit margins) later in the analysis.

4 Effect of the Network on Total Plan and Hospital Profits

4.1 Demand Estimates

In order to understand the equilibrium network outcomes I need to analyze Stages 3 and 4 of the model, in which consumers choose their health plans taking into account the hospitals they expect to visit in the coming year. The parameter estimates generated in Ho (2005a) are used as an input to this paper's supply side analysis. The demand estimation process has three stages:

1. The first step is to estimate demand for hospitals using a discrete choice model that allows for observed differences across individuals. With some probability consumer i (whose type is defined by age, gender, and zipcode tabulation area (ZCTA)) becomes ill. His utility from visiting hospital h given diagnosis l is given by:

$$u_{ihl} = \eta_h + x_h\alpha + x_h\upsilon_{il}\beta + \varepsilon_{ihl}$$

   where x_h, η_h are vectors of observed and unobserved hospital characteristics respectively, υ_{il} are observed characteristics of the consumer such as diagnosis and location and ε_{ihl} is an idiosyncratic error term assumed to be iid Type 1 extreme value[18]. Hospital characteristics include location, the number of beds, the numbers of nurses and doctors per bed and details of services offered, ownership, and accreditation. This equation is estimated using standard maximum likelihood techniques and micro (encounter-level) data from the MEDSTAT

[18] This model was first proposed in McFadden (1973).

MarketScan Research Database for 1997-98. The data provide information on the hospital admissions of indemnity plan and PPO enrollees[19].

2. Secondly, I use the estimated coefficients to predict the utility provided by each plan's hospital network. Individual i's expected utility from the hospital network offered by plan j in market m is calculated as:

$$EU_{ijm} = \sum_l p_{il} \log \left(\sum_{h \epsilon H_j} \exp(\eta_h + x_h \hat{\alpha} + x_h \upsilon_{il} \hat{\beta}) \right)$$

where p_{il} is the probability that individual i will be hospitalized with diagnosis l.

3. Finally, I use aggregate data from Atlantic Information Services, the NCQA and the AHA to estimate the health plan demand model. I use a methodology similar to that set out in Berry, Levinsohn and Pakes (1995). The utility of individual i from plan j in market m is given by:

$$\tilde{u}_{ijm} = \xi_{jm} + z_{jm}\lambda + \gamma_1 EU_{ijm} + \gamma_2 \frac{prem_{jm}}{y_i} + \omega_{ijm}$$

where z_{jm} and ξ_{jm} are observed and unobserved plan characteristics respectively, $prem_{jm}$ are plan premiums, y_i is the income of individual i, and ω_{ijm} represents idiosyncratic shocks to consumer tastes, again assumed to be iid Type 1 extreme value. I consider HMO and POS plans only[20]. The characteristics included in z are premium, the size of the physician network, plan age, a list of eight clinical quality variables (taken from the NCQA's HEDIS dataset) and two variables summarizing consumer assessment of plans on dimensions such as availability of needed care and speed with which care is received (from their CAHPS dataset). The results of this stage of the analysis are reproduced in Table 6. I find that consumers place a positive and significant weight on their expected utility from the hospital network when choosing a plan. The coefficient magnitudes imply that a one standard deviation increase in expected

[19] It would be preferable to estimate consumers' hospital choices using data for managed care enrollees. However, this is not feasible because the available data do not identify the hospital networks offered by each managed care plan, so the choice sets of managed care enrollees are unobserved. Instead I consider the choices made by indemnity and PPO enrollees, whose choice set is unrestricted. I assume that indemnity/PPO enrollees have the same preferences over hospitals as HMO/POS enrollees, conditional on their diagnosis, income and location. I test this assumption using data for HMO/POS enrollees in Boston; see Ho (2004) for details.

[20] I include two additional potential choices for each consumer: an indemnity/PPO plan option, defined using assumptions about the characteristics of these insurers in each market, and the outside option of being uninsured.

utility is equivalent to a reduction in premium of $39 per member per month (a little less than one standard deviation).

4.2 Producer Surplus Generated by the Network

With the demand estimates in hand, I now move on to consider the observed health plan-hospital contracts. The simplest model of pair-wise contracting assumes that each insurer-provider pair bargains independently over the division of a surplus of size M. The implication (whatever the bargaining framework used) is that firms reach agreement if and only if $M > 0$. I investigate this theory by using my demand estimates to predict the producer surplus generated by each insurance plan when it contracts with each potential hospital network: that is, the total profit to be divided between the plan and all the hospitals with which it contracts. The producer surplus generated by plan j in market m when it contracts with hospital network H_j is:

$$S_{jm}(H_j, H_{-j}) = \sum_i \left(n_i s_{ijm}(H_j, H_{-j}) \left[prem_{jm} - p_i \sum_{h \epsilon H_j} s_{ih}(H_j) cost_h \right] \right) \tag{1}$$

where n_i is the population in consumer-type cell i (defined by ZCTA, age, and gender), p_i is the probability that a type-i person will be admitted to hospital, $cost_h$ is the average cost of treatment at hospital h, and $prem_{jm}$ is plan j's premium in market m. The quantities $s_{ijm}(H_j, H_{-j})$ and $s_{ih}(H_j)$ are plan j's and hospital h's predicted shares of type-i people when networks H_j and H_{-j} are offered by plan j and other plans respectively. These are predicted using the demand estimates and take account of the flow of consumers across plans, and across hospitals given their choice of plans, in response to network changes.

The surplus definition does not include plans' non-hospital variable costs. Each plan faces a number of costs of enrolling consumers: these include payments to primary care physicians and prescription drug costs, for example, in addition to the costs of treatment at hospitals. Unfortunately, I do not have access to data on plan variable costs and therefore cannot include them in the surplus term[21]. I take some steps towards accounting for this issue later in the analysis by estimating the cost of enrolling consumers directly. The details of this robustness test are discussed in Section 7.

[21] The analysis does allow for the existence of additional fixed costs, since these would cancel out when we consider the surplus change from a change in networks.

The calculation takes account of hospital capacity constraints. If any network combination implies that any hospital is over 85 per cent of its maximum capacity level, I reallocate patients randomly to non-capacity constrained hospitals in the market. I assume that patients are treated in the order in which they arrive and that the timing of sickness is random: each plan therefore has the same percentage of enrollees reallocated for any given capacity constrained hospital. The adjustment affects patients' hospital choices and therefore their predicted costs of care but does not impact consumers' choices of plan or premium levels[22].

Premiums are assumed fixed in this calculation. In reality, when plan j considers a deviation from its observed network, it probably predicts that its own premium and those of other plans will adjust in response to the network change. I cannot estimate these adjustments accurately since I do not yet have a model for the prices paid to hospitals after a network change. I also encounter data limitations: I do not have access to panel data and so cannot observe the reaction of plan premiums to network changes over time. However, I include a robustness test for the fixed premium assumption; this is discussed in Section 8.

4.3 Does the Producer Surplus Term Explain the Observed Contracts?

The next step is to use the producer surplus estimates to identify the surplus, to be divided between the insurer and all hospitals in its network, that is generated by each potential contract. I repeat this calculation for each of the 6747 potential contracts between the 441 plans and the 633 hospitals in the data, keeping all other plans' networks fixed. The results are summarized in Table 7. I find that the estimated producer surplus generated by the contract ($\Delta Surplus$, the total surplus with the contract less that without it) is greater than zero for 68 per cent of the 5587 agreed contracts. The surplus that would be created by the contract is less than zero for just 39 per cent of the 1160 potential contracts that were not agreed upon[23]. So the simplest hypothesis explains the data in

[22] A hospital is predicted to be over 85% of maximum capacity if predicted admissions * average length of stay at the hospital is greater than 85% of the number of beds * 365 days. By using the surplus variable without adjusting consumers' choices of plan, I am assuming that the plan does not expect consumers to predict their probability of treatment at each hospital in its network when choosing their insurer. Instead consumers are expected to assume they will have access to every hospital on the list. Consumers may update this belief if a hospital is consistently capacity constrained (although many of the non-Medicare, non-Medicaid enrollees considered in this paper will have little experience of seeking hospital treatment on which to base their updates). Unfortunately, without a panel dataset, there is no variation in the data to identify the extent of any such updating.

[23] The histogram of the $\Delta Surplus$ variable for agreed contracts is very similar to that for contracts that were not agreed upon. The means are $0.040 million and $0.039 million per month respectively, with variances of $0.24 million and $0.13 million. The difference in means is not significant at p=0.2.

approximately 63 per cent of cases. One way to interpret the fit of this simple model is to calculate a pseudo-R^2 measure. If we place equal weight on correctly predicting the set of observed contracts and the set that are not observed, the pseudo-R^2 is just 0.33[24].

It is worth noting here that my definition of producer surplus measures the effect of the contract on the profits to be divided between the plan and all the hospitals in its network. That is, I take account of the effect of a particular contract on the plan's profits from other hospitals with which it already has contracts. I do not, however, account for the other relevant externality: the fact that if a hospital agrees on a contract with one plan this will affect consumer flows and therefore its revenues and profits from other plans in its market. This interaction between the negotiations of particular plans may well explain why my producer surplus measure imperfectly predicts the data. The discussion in the next section considers this issue in more detail[25].

5 The Price Negotiation

The producer surplus results rationalize some but not all of the variation in the data. We would like to explain the 32 per cent of contracts agreed upon when the predicted surplus increase is negative and the 61 per cent not agreed upon when $\Delta Surplus$ is positive[26]. To do so we need to consider the price negotiations which determine how the producer surplus is divided between insurers and hospitals. This section provides some intuition on the effect of these negotiations on equilibrium contracts. The goal is to justify my focus on particular hospital characteristics in the empirical analysis.

Consider a simple example of the negotiation in Stage 1 of the four-stage game set out in Section 2. Insured consumers receive two types of service from their plan: acute care from the hospitals in the network and preventive services from the plan's primary care physicians (PCPs). Hospitals

[24] The pseudo-R^2 is defined as $1 - \frac{\sum(y_i - \hat{y}_i)^2}{\sum(y_i - \bar{y}_i)^2}$, where y_i is the observed outcome, $\hat{y}_i$ is its predicted probability, and $\bar{y}_i$ is the mean value in the data. This is the same measure used to assess goodness of fit in Stata's logit and probit calculations. Placing equal weights on the sets of observed and unobserved contracts implies the following definition for the pseudo-R^2: $1 - \frac{\sum \frac{1}{N_i}(y_i - \hat{y}_i)^2}{\sum \frac{1}{N_i}(y_i - \bar{y}_i)^2}$, where N_i is the number of times the i'th alternative is observed in the data.

[25] The fact that my producer surplus measure does not fully explain the data does not necessarily imply that the outcome does not maximize total producer surplus, nor that it is inefficient. However, the discussion in Section 5 notes that an inefficient outcome is possible.

[26] Two assumptions made in the surplus calculation may help rationalize the contracts: the assumptions of fixed premiums and zero plan non-hospital variable costs. Both assumptions will be addressed in robustness tests of the full empirical model.

and plans bargain over the prices to be paid to the hospitals for treating the plans' enrollees. When a hospital-plan pair has agreed on a contract, the hospital is required to treat every enrollee from the plan who requests care, provided it has spare capacity. Each plan then sets a single premium level and consumers choose their plans for the year.

Not much is known about the exact form of the bargaining process used, how much it varies across plan-hospital pairs or across markets, or the extent of asymmetric information between insurers and hospitals. Interviews with plan and hospital representatives who are involved in contractual negotiations suggest that plans often have the final decision rights over whether to agree to contracts. The simplest bargaining model with this property has hospitals making simultaneous take-it-or-leave-it offers to all plans in the market and plans choosing whether to accept these offers. I therefore consider this model as the leading case and use it in the empirical estimation of Section 7. However, other models with this property may be possible[27] and plans may not have decision rights in some markets. The intuition discussed here also applies to many models beyond my leading case.

Many take-it-or-leave-it offers models, including the leading case, imply that hospitals that are undifferentiated and that do not expect to be full receive zero profits. Plans capture 100% of the surplus created and will include hospital h in their networks provided it generates positive producer surplus. Evidence from the interviews I conducted indicates that this may be a reasonable representation of many markets where managed care is strong and hospitals compete for contracts. The Executive Director of one hospital system described a potential outcome in such markets:

> "There are examples where there were too many hospitals in an area and the plans played them off against each other to the point where the price paid was no more than marginal cost."

The more interesting situation arises when hospitals tailor their characteristics in order to capture positive profits. Interviewees noted that the negotiations could be very different in these markets. A hospital Director said the following:

> "In market X [where hospitals are very strong], the prices [the best hospitals] charge

[27] For example, Ho (2005b) discusses and solves a simple model with no uncertainty. Plans make take-it-or-leave-it offers to hospitals. Their perfect information regarding hospital and plan characteristics implies that they only make offers that they know will be accepted.

are based on their very high patient satisfaction results and their strong reputation. They can get high prices from any plan in the market and they don't need them all."

The CEO of a small hospital in a different market had a similar story:

> "Large [hospitals] in this market can dictate whatever prices they want. The bigger names can demand the higher prices."

The intuition needed to help explain the data derives from the fact that consumers may be willing to switch plans if necessary to access these popular hospitals. These providers may choose to price discriminate by charging high prices that not all plans are willing to pay[28]. The effect follows most clearly for three types of hospitals:

1. The hospital may be sufficiently differentiated from its competitors that all or most consumers are willing to pay more for its services than for other hospitals in the market and are willing to change plans to access it. This is most likely for hospitals that offer very high-tech services, teaching hospitals, and hospitals with a high reputation for quality[29]. I describe these as "star" hospitals. I discuss in Section 7 the characteristics used to define these providers in the empirical estimation.

2. The hospital may be somewhat differentiated from its competitors and may expect to be capacity constrained: that is, it may expect to fill its beds without treating all consumers who wish to access it. In many models this implies two effects. First, capacity constrained hospitals are particularly likely to choose to contract selectively because this strategy acts as a profitable form of rationing, helping the hospital to avoid lower-valuation consumers who would otherwise displace those with a higher willingness-to-pay[30]. Second, the capacity

[28] This intuition is similar to a monopolist which restricts volume in order to maximize profits. Perfect price discrimination across consumers is impossible because enrollees are aggregated into plans, each of which charges a single premium, and may choose to move between plans. One effect of selective contracting is to concentrate high-valuation consumers into the plans that are willing to pay the highest prices, increasing the hospital's revenues per patient treated and also potentially its total profits.

[29] Hospital location also plays an important role in differentiating the provider from its competitors. However, location alone may not be sufficient to generate "star" hospital status.

[30] The capacity constraints make a hospital more likely, all else equal, to choose to contract selectively. They may also improve the hospital's ability to negotiate selective contracts, acting as a commitment device to persuade plans that no further arrangements will be made with other insurers in the market. Both effects make capacity constrained providers more likely than other similar hospitals to post high prices that not all plans are willing to pay.

constraint may alter the nature of the bargaining game, essentially forcing plans to compete for contracts with the hospital and pushing its prices up even further[31].

3. Finally, if a sufficiently large proportion of the hospitals in the market merge to form a single system, the combined organization may be very attractive to consumers and the number of competitors that remain may be small. This too may imply that many consumers are willing to switch plans to access the system and that selective contracting increases its profits.

In all three cases a given insurer may choose to exclude the hospital, focusing instead on those consumers whose low valuation for h and higher valuation for its other services prevents them from switching, if other plans have a higher maximum willingness-to-pay for the contract[32]. The effect of consumers' willingness to move across plans is important here. The value of $\Delta Surplus$ generated by a contract may be positive, but if the price demanded by the hospital (and which other plans are willing to pay) is high enough to prevent the plan from capturing any profits, the contract will not be agreed upon. Enrollees with a particularly high valuation for the hospital will switch plans to access it. A selective equilibrium emerges because of these interactions between the contracts negotiated by different plans in the market.

The existence of systems may also help to explain the contracts that are agreed upon despite a negative incremental surplus. I observe in the data that some plans contract with some but not all members of a hospital system, but this practice is infrequent. I rationalize this observation with the idea that, if a hospital system has significant market power (as in point 3.), it may impose penalties on plans that contract with some but not all of its members. Even systems with little market power may choose a bundling strategy, charging relatively more for contracts with individual hospitals than for those with the entire organization, to maximize the surplus captured from each plan. In both cases plans may be deterred from cherry-picking from the members of a system[33].

[31] This benefit may prompt particular hospitals to choose to be capacity constrained; this is the issue analyzed in Section 9.2. The intuition in the case where hospitals make offers to plans is similar to that in Kreps and Scheinkman (1983). Allowing firms to choose capacity levels before bargaining begins permits them to move from Bertrand to Cournot competition, implying positive hospital profits. The case where plans make offers to hospitals is demonstrated in Ho (2005b).

[32] A particular plan may be willing to pay less for the contract than other insurers for two reasons. First, it may have a better outside option than other plans due to variation in consumers' preferences for other plan characteristics. Second, its non-switching enrollees may have a lower valuation for h than those in other plans.

[33] The efficient outcome would result in the plan only contracting with hospitals with which it generated positive surplus. A system with high market power could demand a share of the profits generated from non-system hospitals. Some friction is required to prevent this outcome: this could be a cost of contracting that is paid once per non-system

The selective equilibrium may have implications for welfare. The simple model in Ho (2005b) demonstrates that it may be inefficient for a plan to exclude a hospital even if that provider is full in equilibrium and even if the consumers with the highest value for hospital h are the ones treated. The inefficiency is generated because consumers are forced to make suboptimal choices across health plans in order to gain access to the hospital. The resulting loss of consumer welfare, which may outweigh the gain derived when the highest-valuation patients are given preferential access to h, would be avoided if both plans contracted with it. The intuition is similar for the examples concerning systems and attractive hospitals[34].

6 Reduced Form Analyses and Identification

The intuition outlined in Section 5 offers one possible reason why hospital-plan pairs which would generate positive producer surplus may not reach agreement: a hospital that does not need contracts with all plans may charge a sufficiently high price that only those with the highest willingness-to-pay agree to the contract. In addition, the contracts that are agreed upon despite a negative estimated surplus may be explained by the penalties for excluding hospitals imposed by hospital systems. The full econometric model presented in Section 7 tests these theories by estimating the incremental profits captured by capacity constrained providers, star hospitals, and system members. In this section I conduct a very simple preliminary analysis to show that the patterns in the data are consistent with the intuition.

Table 8 shows the results of a probit regression of the following form:

$$\Pr(contract) = \Phi\left(\beta_0 + \beta_1 system + \beta_2 samesysdrop + \beta_3 capcon\right)$$

where *system* is an indicator variable for membership of a hospital system and *samesysdrop* measures the effect of the contract on the number of other hospitals in the plan's network for which same-system members have been excluded. The final variable, *capcon*, is an indicator variable for hospitals that were over 100% or over 85% of their maximum capacity in the previous year. I

hospital and only once per system, or an inability of one hospital to transfer funds to another member of the same system to compensate it for lost revenues.

[34] This is the welfare effect estimated in Ho (2005a). The restriction of consumer choice of hospitals, and the resulting distortion of their choice of plans, imply a welfare loss of \$1.04 billion per year assuming fixed prices. The model in Ho (2005b) shows that a welfare loss is still possible in the case where prices are permitted to adjust.

also include market fixed effects. Both system variable coefficients are negative and significant. This implies that plans are less likely to agree to contracts with system hospitals than with other providers and that they tend to contract either with an entire system or with none of its members. The estimated capacity constraints coefficients are also negative and significant, consistent with the theories set out above[35].

This regression demonstrates the variation in the data that will be used to identify the full model. For example, the incremental profits captured by capacity constrained hospitals will be identified using variation in the probability of agreement across capacity constrained and non-capacity constrained providers, both within and across markets. The basic intuition is that, since we observe capacity constrained hospitals refusing to agree to contracts more frequently than other providers, they must demand higher profits than their competitors. The producer surplus generated by these hospitals when they agree on contracts with particular plans provides an upper bound on the profits they capture. The predicted producer surplus generated when they do not reach agreement offers a lower bound on their profits. We can estimate the average profit of capacity constrained hospitals by taking averages over these observations. A similar intuition applies to other types of hospital.

7 A Model for Estimation

7.1 The Plan Profit Equation

The next step is to estimate a model that accounts for the existence of multiple potential equilibria and the possibility of endogenous regressors. I adopt the methodology developed in Pakes, Porter, Ho and Ishii (2005). The first step is to define the plan profit equation.

The profit of plan j is the surplus generated given its chosen network H_j minus its costs:

$$\pi^P_{jm}(H_j, H_{-j}) = S_{jm}(H_j, H_{-j}) - c^{HOSP}_{jm}(H_j, H_{-j}) - c^{NONHOSP}_{jm}(H_j, H_{-j}) \tag{2}$$

where $c^{HOSP}_{jm}(H_j, H_{-j})$ is the cost of the plan's contracts with hospitals (generated by hospital

[35] Providers above their maximum capacity are defined as those with admissions > 365*number of beds/average length of stay. The results remain significant when I also add the change in surplus when the contract is agreed and the cost per admission of the hospital. They are also robust to clustering the error terms by plan or by hospital.

profits) and $c_{jm}^{NONHOSP}(H_j, H_{-j})$ represents its non-hospital costs.

I assume that each hospital receives a two-part payment: a fixed element and a per-patient markup, $fc_{j,h}(.)$ and $mk_{j,h}(.)$ respectively[36]. If prices are set by bargaining both these quantities depend on hospital and plan threat points and are therefore functions of characteristics of the hospital, the plan, and the market as a whole. I would ideally use a model of the plan-hospital bargaining process to estimate their values directly. However, the fact that each firm's threat point is endogenous (depending on the observed or expected outcome of all other pairs' negotiations), together with the number of insurers and providers bargaining in each market, makes this approach infeasible[37]. Instead I adopt a simpler methodology, projecting hospital profits onto a set of hospital, insurer and market characteristics. That is, I estimate a reduced form function that summarizes the relationship of these variables to hospital profits[38]. More specifically, the payment to each hospital is:

$$pmt_{jhm}(.) = fc(x_{j,h,m})\theta_1 + N_{jhm}(H_j, H_{-j})mk(x_{j,h,m})\theta_2 \tag{3}$$

where $x_{j,h,m}$ are plan, hospital and market characteristics, θ_1 and θ_2 are parameters to be estimated, and $N_{jhm}(H_j, H_{-j})$ is the number of plan j's enrollees treated by hospital h[39]:

$$N_{jhm}(H_j, H_{-j}) = \sum_i n_i p_i s_{ijm}(H_j, H_{-j}) s_{ih}(H_j).$$

Subtracting the sum across hospitals of the costs implied by equation (3), we obtain plan profits[40]

[36] Contracts in reality fall into at least three categories. Many plans pay hospitals on a per diem or case rate basis. The former involves a daily charge plus a separate charge for major procedures such as open heart surgery; the latter implies a single rate, usually for a surgery such as open heart surgery or organ transplants, that includes a specified number of inpatient days. Capitation contracts may also be used: here a hospital receives a fixed payment in return for which it provides or covers the cost of all hospital services needed by a designated population of enrollees.

[37] The contract between a given plan-hospital pair is affected by the outcome of the negotiations between all other pairs in the market: for example the willingness-to-pay of other insurers and the availability and price demands of other hospitals all depend on the outcomes of their own negotiations and all affect the threat points of both plan and provider. Modeling this set of negotiations explicitly would be very complicated given that there are on average 12 plans and 15 insurers in each market.

[38] Prior approaches to analyzing the fraction of the surplus that goes to hospitals look at the marginal value of the hospital to a network conditional on assumptions regarding the networks in existence, but do not attempt to analyze the determinants of these networks. See for example Capps, Dranove and Satterthwaite (2004) and Town and Vistnes (2001).

[39] Note that both this number of patients and the surplus term also depend on the x's: the form of the dependence is modelled explicitly using the demand estimates from Ho (2005a).

[40] A number of existing papers estimate the share of the surplus captured by a given hospital as a function of its characteristics and those of the plan and the market (conditional on the existence of the contracts; see Capps, Dranove and Satterthwaite (2003), Town & Vistnes (2001)). An analogous methodology would estimate the plan's share of the incremental surplus created when each hospital was added to the network. The current approach is

as:

$$\pi^P_{jm}(H_j, H_{-j}, x, \theta) = S_{jm}(H_j, H_{-j}) - \sum_{h\epsilon H_j} fc(x_{j,h,m})\theta_1$$
$$- \sum_{h\epsilon H_j} N_{jhm}(H_j, H_{-j}) mk(x_{j,h,m})\theta_2 - c^{NONHOSP}_{jm}. \tag{4}$$

The fourth term in equation (4) relates to non-hospital costs. I would ideally estimate the cost of enrolling each type of consumer, defined by age and sex, by including the following expression in the profit equation:

$$c^{NONHOSP}_{jm}(H_j, H_{-j}, c_i) = \sum_i N_{jim}(H_j, H_{-j})c_i$$

where $N_{jim}(H_j, H_{-j})$ is the predicted number of enrollees of type i in plan j given the equilibrium hospital networks and c_i is the cost of insuring that type (to be estimated). Unfortunately the available data are not rich enough to estimate c_i in addition to the hospital cost parameters. In the main specification I set $c_i = 0$ for all i, assuming that non-hospital costs have little effect on plans' network choices. As a robustness test I include the predicted total number of plan enrollees. The test is discussed further in Section 8; it has little effect on the overall results.

I allow for two sources of randomness. The first is measurement error on the part of the econometrician: I denote this u_{jH_j}. We can therefore write the plan profits observed by the econometrician as:

$$\pi^{P,o}_{jm}(H_j, H_{-j}, x, \theta) = \pi^P_{jm}(H_j, H_{-j}, x, \theta) + u_{jH_j}. \tag{5}$$

Second, the plan may predict its profits from contracting with any particular hospital with error, perhaps because of uncertainty regarding other plans' network choices. I denote this error φ_{jh}. The plan's prediction of its profits from choosing network H_j can therefore be written as

$$E_\varphi(\pi^P_{jm}(H_j, \tilde{H}_{-j}, \tilde{x}, \varphi, \theta)|I_{jm}) = \pi^P_{jm}(H_j, H_{-j}, x, \theta) - \sum_{h\epsilon H_j} \varphi_{jh} \tag{6}$$

similar. If we write $\pi^P_{jm} = \alpha(x_{j,h,m})S_{jm} = \sum_h N_{jh}\alpha_{jh}(prem_{jm} - \cos t_h)$, where α_{jh} is the share of the surplus retained by the plan when negotiating with hospital h, and ignore plan non-hospital costs, this is equivalent to: $\pi^P_{jm} = S_{jm} - \sum_h N_{jh}(1-\alpha_{jh})(prem_{jm} - \cos t_{jh})$. The value estimated by the current methodology's markup term (if $fc_{j,h}(.) = 0$) is $mk_{j,h}(.) = (1-\alpha_{jh})(prem_{jm} - \cos t_h)$. That is, in the absence of a prediction for the hospital's effect on premiums and therefore the surplus per patient, $mk_{j,h}(.)$ estimates not $(1-\alpha_{jh})$ but the average profit per patient captured by the hospital.

where $\tilde{H}_{-j}$ and $\tilde{x}$ are the random variables before their realizations are known by the plan and $E(\varphi_{jh}|I_{jm}) = 0$ by construction.

The next step is to decide which variables to include in the expressions for fixed costs and markups. The list must be parsimonious: a large number of coefficients is unlikely to be identified given the limited data available and the fairly small variation in plan choice of networks observed. I use the intuition discussed in Section 5 to inform the choice of variables. The main ideas to be tested are that hospitals that expect to be capacity constrained, those in systems, and those for which all or most consumers would switch plans should be most likely to fail to agree with plans (holding surplus fixed). System hospitals may also demand a higher price from a given plan if another same-system hospital is excluded than if it is not. Finally, even very simple bargaining models predict that lower-cost providers generate a higher total surplus, all else equal, and therefore earn higher markups than their competitors. I account for these predictions by including the following variables:

1. A measure of the extent to which particular hospitals are expected to be capacity constrained. I derive an exogenous predictor of this variable by calculating the number of patients treated at each hospital under the thought experiment that every plan contracts with every hospital in the market[41]. This variable can therefore be thought of as an indicator for potentially capacity constrained hospitals.

2. Hospitals in systems and those for which at least one same-system hospital is excluded.

3. Star hospitals: those that are highly differentiated from their competitors in the market. I identify these hospitals using indicator variables for teaching hospitals and hospitals that provide high-tech imaging services[42]. I also use the US News and World Report's hospital rankings for 2003[43].

[41] I define a hospital to be capacity constrained if the predicted number of patients exceeds the number of beds * 365 / average length of stay in the hospital.

[42] The imaging service considered is positron emission tomography. 22% of hospitals in the dataset provide this service.

[43] US News magazine publishes an annual report giving hospital ratings for 17 different specialties and overall. The rating for a particular specialty summarizes scores for reputation; severity-adjusted mortality ratios; and other care-related factors such as the number of nurses per bed and the technology available. The reputation score was compiled by asking a random sample of board-certified physicians which five hospitals they believed to be the best in their specialty and taking the percentage of responding physicians who cited the hospital. The overall index is a sum of the hospital ratings for each specialty. 544 of the hospitals in the sample (86%) have an index of zero. I use an indicator variable for the 23 hospitals (4%) with an index above 2.6.

4. A measure of hospital costs per admission[44].

5. I also include a constant term in $mk_{j,h}(.)$: this identifies the average profit per patient received by non-system hospitals that are not capacity constrained.

Table 9 sets out the results of a probit regression that shows that hospital cardiac and imaging services are key predictors of expected capacity constraints[45]. As noted in Section 3, these and other hospital services are also positively and significantly related to hospital market share. This is consistent with the intuition described in Section 5: in order to demand high prices, capacity constrained hospitals must not just be small but also be popular with at least a subset of consumers, implying a high value to a subset of plans.

In reality the profit received by a particular provider depends not just on its own characteristics but on those of the plan and the market. For example, the price demanded by a system hospital can be no higher than the maximum willingness-to-pay of other plans in the market, and this depends on the attributes of other plans, consumers, and hospitals in the area. I would ideally include plan and market characteristics, and interactions with network attributes, to identify these effects. However, I have difficulty in identifying the coefficients on these terms[46]. It is perhaps unrealistic, given my limited data, to hope to estimate more than the most basic effects. The results reported therefore have no market characteristics: they identify only the average dollar profit per patient earned by each type of hospital[47].

There is not enough information in the data to allow for free interactions with both the fixed and the per patient component of the contracts. The results presented below are based on a specification where the fixed component of the contract depends on whether the hospital is in a system and whether another member of that system is excluded by the plan and the variable component depends on whether the hospital is capacity constrained, whether it is a star and the

[44] I also tried using costs per bed per night rather than costs per admission; this generated very similar results.

[45] The coefficients on teaching status, system membership and distance from the city center are not significant. Distance from consumers' homes is an important predictor of demand for hospitals but this does not imply that only city-center hospitals, or only those located in suburban areas, are predicted to be full.

[46] Plan and market characteristics that are not interacted with network attributes do not vary across potential choices for a given plan and therefore cannot affect its choice. These characteristics therefore cannot be identified in the fixed cost term of the plan profit equation unless interacted with network attributes. It makes more sense to include these variables in the markup term, where they will be interacted with N_{jh}; however, in practice there was not enough variation in the data to generate significant coefficients.

[47] The capacity constraints variable is calculated using the predicted allocation of patients across hospitals when all plans offer a free choice: it therefore incorporates information on market characteristics. The other variables, however, relate only to hospital characteristics.

cost per admission of the hospital. When I estimated models where the variables were moved across the marginal and fixed components the individual coefficients were often insignificant but there was little difference in the implications of the estimates.

7.2 Details on the Estimation Strategy

The standard models that might be used to estimate the plan profit equation (such as the logit model) would use the profits for the different networks given by equation (4) and assume that plans chose networks to maximize these profits. We would then make the additional assumption of iid errors and estimate using maximum likelihood. However, the independence assumption may be difficult to accept for at least two reasons. First, econometrician measurement error leads to a correlation between the errors and the other right hand side variables of the plan profit equation (such as the surplus that is observed by the econometrician). In order to account for this we would need to know the joint distribution of the errors and the observed profit determinants; we are unlikely to have information on this joint distribution. Second, plan prediction error causes analogous problems.

The methodology developed in Pakes, Porter, Ho and Ishii (2005), and which I use here, avoids these problems by using a method of moments approach with inequality constraints. The methodology assumes that the bargaining process follows the leading model outlined in Section 5. That is, it assumes that every hospital makes simultaneous take-it-or-leave-it offers to every plan in the market and plans simultaneously choose whether to accept these offers. The primary identifying assumption used in estimation follows immediately from this bargaining model. Plan j's expected profits from the observed network H_j must be higher than its expected profits from the alternative network formed by reversing its contract with any hospital h in the market[48]. I denote this alternative network H_j^h.That is, I assume that:

$$E_\varphi(\pi^P_{jm}(H_j, \tilde{H}_{-j}, \tilde{x}, \varphi, \theta)|I_{jm}) \geq E_\varphi(\pi^P_{jm}(H_j^h, \tilde{H}_{-j}, \tilde{x}, \varphi, \theta)|I_{jm}) \tag{7}$$

[48] Reversing a contract means removing the contract if it exists or introducing it if it is not observed in the data. That is, I assume that every observed contract must increase the plan's expected profits. Any contract that does not exist in the data must decrease the expected profits of the plan that turned it down.

for every hospital h in the market[49,50]. Define the observed difference between the plan's profits generated by the observed network and those from the alternative network to be:

$$\Delta\pi^{P,o}_{jm}(H^h_j, H_j, H_{-j}, x, \theta) = \pi^{P,o}_{jm}(H_j, H_{-j}, x, \theta) - \pi^{P,o}_{jm}(H^h_j, H_{-j}, x, \theta)$$

where $\pi^{P,o}_{jm}(.)$ is defined in equation (5). We will require a set of instruments z_{jm} such that $z_{jm}\epsilon I_{jm}$, the plan's information set, and

$$E(u_{jH_j} \mid z) = 0. \tag{8}$$

Then equation (7) implies:

$$E(E_{\varphi}(\pi^P_{jm}(H_j, \tilde{H}_{-j}, \tilde{x}, \varphi, \theta)|I_{jm})|\ z) \geq E(E_{\varphi}(\pi^P_{jm}(H^h_j, \tilde{H}_{-j}, \tilde{x}, \varphi, \theta)|I_{jm})|\ z)$$

where the outer expectation is taken by the econometrician. This inequality together with equation (8) and the fact that $E(\varphi_{jh}|\ z) = 0$ for all $z\epsilon I_{jm}$ imply that:

$$E(\Delta\pi^{P,o}_{jm}(H^h_j, H_j, H_{-j}, x, \theta)|\ z) \geq 0. \tag{9}$$

Note that all unobservables have dropped out of this inequality. Translating expectations into sample means, the equation for estimation is therefore:

$$\frac{1}{M}\sum_m \frac{\sqrt{n_m}}{n_m}\sum_{j=1}^{n_m}\left[\Delta\pi^{P,o}_{jm}(H^h_j, H_j, H_{-j}, x, \theta) \otimes g(z)\right] \geq 0 \tag{10}$$

where M is the number of markets in the sample, n_m is the number of plans in market m, $\otimes$ is the Kronecker product operator and $g(z)$ is any positive-valued function of z. Each market is weighted by the square root of the number of plans in the market, since we expect less noise in the market average for markets containing many plans. All θ that satisfy this system of inequalities are included in the set of feasible parameters. If no such θ exists we find values that minimize the

[49] Several combinations of networks may satisfy this necessary condition; that is, there may be multiple potential equilibria. This does not prevent consistent estimation of the parameter vector ϑ: I simply search for parameters consistent with the assumption that the observed set of networks constitute a Nash equilibrium, without attempting to model how that equilibrium was chosen from the set of potential equilibria.

[50] We also require that, when one plan deviates from its observed network, the others still succeed in securing the networks they request. This follows from the assumption of simultaneous take-it-or-leave-it offers.

sum of the absolute values of the amount by which each inequality is violated.

Identification in this model comes from comparing the profits of each plan when it chooses its observed network to those from its alternatives. For example, the identifying assumption implies that, if the plan is observed to contract with a capacity constrained hospital, then the change in producer surplus it expects to result from the contract must be greater than the hospital's expected profits. If the plan drops the provider, the expected change in producer surplus must be less than those profits. Any feasible alternative networks could be used to generate these comparisons. I consider seven inequality conditions. The first six are defined by reversing the plan's contracts with each of the six largest hospitals in turn[51]. The seventh is an average over the analogous inequalities for all remaining hospitals in the market[52].

The instruments are required to be independent of the error terms u_{jH_j} and φ_{jh}; they must also be positive (to ensure that no inequalities are reversed by the interaction with z). I use the characteristics included in the fixed cost and markup terms (the x's) other than the cost per admission, which I omit due to concerns about measurement error. I also include indicator variables and interactions of indicators for several market and plan characteristics. The characteristics included are: a high number of beds per population, a high proportion of the hospitals in the market being in systems, a high proportion of the population aged 55-64, whether the plan is local and whether the plan has good breast cancer screening services and poor mental health services[53]. None of these instruments is a function of the observed equilibrium. Each is known to the plan when it makes its choice. Each is also correlated with x: for example, plans can more easily exclude hospitals in markets with a younger, less sick population or with more beds per population. System hospitals are more often excluded in markets with a high proportion of hospitals in systems. The logic is similar for the other instruments.

Pakes, Porter, Ho and Ishii (2005) show that we can also generate inequalities from the hospital's

[51] The largest hospitals are defined by numbers of beds.

[52] There are at least 7 hospitals in each market in the dataset. The methodology could easily be extended to more alternatives per plan. For example, each insurer could consider reversing two contracts at a time rather than just one. I try including these additional alternatives as a robustness test and find little change in the overall results. I limit my main analysis to reversing single contracts because of concern that the reduced form function for hospital profits could change after a major network change.

[53] Low proportion means less than the mean percentile, except for beds per population where quartiles of the distribution were used.

profit equation. We write hospital profits as:

$$\pi_{hm}^{H}(M_h, M_{-h}, x, \theta) = \sum_{j \epsilon M_h} fc(x_{j,h,m})\theta_1 + \sum_{j \epsilon M_h} N_{jhm}(H_j, H_{-j}) mk(x_{j,h,m})\theta_2$$

where M_h is the network of plans chosen by hospital h and M_{-h} is the set of networks chosen by other hospitals in the market. Our assumptions regarding unobservables are analogous to those for the plan profit equation. The assumed take-it-or-leave-it offers model implies that the hospital expects to receive positive profits on average over all the offers it makes to plans in its market. This assumption generates an additional inequality constraint that can be added to the estimation procedure[54,55]. The additional information provided by the hospital inequality improves the precision of the estimates considerably. I therefore report the results generated from the full set of inequalities.

Pakes, Porter, Ho and Ishii (2005) provides a proof that the estimator is consistent for the set of parameters identified by the model. It also contins the methodology used to generate confidence intervals for the identified set of parameters. I use the simulation methodology described there, estimating the limit distribution of the data used to define the inequalities, taking repeated draws on this distribution and calculating a new estimate for each draw. The resulting vector of simulated values is used to find a 95 per cent confidence interval[56].

[54] The hospital profit equation models how each hospital's match with a particular plan affects its total profits including those from other plans in the market (as consumers switch plans in response to network changes). That is, we model the externalities faced by hospitals as well as those faced by plans. We also allow system hospitals to account for the effect of each contract on the profits of the system as a whole rather than those of the individual provider.

[55] An additional assumption is needed here. We require that, if a hospital deviated from its observed contracts, this would not affect the networks of other plans and hospitals in the market. This implies that the hospital must be able to make an alternative offer to a particular plan which would prompt that plan to reverse its contract with that hospital (turn down the contract if it is observed in the data and vice versa) without changing those with other hospitals in the market. This assumption seems reasonable for plans that are observed to contract with all or most providers in the area. It is more troubling for plans that contract with just a small subset of hospitals; these may choose to respond to a high offer from one hospital by replacing it with another that was not previously included in the network. I conduct a robustness test for the effect of this assumption by replacing the hospital inequalities with those generated by a different condition: that the profit paid by each plan to each hospital is weakly positive. The estimates are less precise than those from the main specification but the overall results are consistent. It is also reassuring to note that plans do in general contract with the majority of hospitals in their markets. 83% of plan-hospital pairs in the data agree on contracts; this number rises to 91% when we consider just the 6 largest hospitals in each market. I also exclude from the analysis any plan that drops more than four of the six largest hospitals in its area.

[56] The confidence intervals have not been adjusted to account for variance introduced by the estimated demand parameters. This is unlikely to significantly affect the results since the standard errors in this first stage were relatively low.

8 Results

8.1 Overall Results

The results are reported in Table 10. The estimate of θ for every specification was a singleton: that is, there was no parameter vector that satisfied all the inequality constraints[57]. The first column of the table reports results for the main specification. The point estimates all have the expected sign. Four of the five coefficients are significant at the traditional five per cent level; the constant term in the markup is significant at the 18 per cent level in a one-sided test. However, the confidence intervals are reasonably large. The graphs in Figure 2 show the simulated distributions of four of the coefficients. There is significant variance about the point estimates. This together with the robustness tests noted below makes statements about precise magnitudes difficult. The overall picture, however, is very clear. Hospitals in systems take a larger fraction of the surplus and also penalize plans that do not contract with all members. Capacity constrained hospitals also capture high markups and hospitals with higher costs per patient receive lower markups per patient than other providers.

To help interpret the magnitudes of the results, note that the average cost per admission for hospitals in the data is around \$11,000[58]. The markups over these costs that I estimate vary by cost and type of hospital. For hospitals that are neither in a system nor capacity constrained the point estimates imply negative markups. This probably indicates that the estimated constant in the markup term is too small. The constant is the most imprecisely estimated of all the coefficients and if one looks at its distribution (shown in Figure 3) it is easy to see that the point estimate may well be different from its actual value. I assume a value of 5.5 for the constant, well within the 95% confidence interval, as this implies an average profit of zero for non-capacity constrained hospitals that are not in systems[59]. Given this, the other estimates can be interpreted as follows. Capacity constrained hospitals receive an extra \$1800 per patient which, when their costs are taken into

[57] As discussed in Pakes, Porter, Ho and Ishii (2004), this does not imply that we should reject the specification. The result could easily be caused by the random disturbances in the inequalities. The probability that all inequalities are satisfied can be made arbitrarily small by increasing the number of inequality restrictions.

[58] The cost variable, taken from the AHA survey 2001, is defined as total hospital expenses including items such as depreciation and interest expense.

[59] The Kaiser Family Foundation report "Trends and Indicators in the Changing Health Care Marketplace, 2004 Update" provides data on hospital costs and profits. The average community hospital payment-to-cost ratio from private payors in 2001 was 113.2%, implying margins of 11.5% of revenues. The assumption of zero markups for non-capacity constrained non-system hospitals implies an average profit margin over all hospitals of 12%.

account, translates into an average markup of approximately 14 per cent of revenues. Hospitals that are not capacity constrained but are in systems capture $140,000 in incremental profits per month per plan, which given their average patient load translates into a markup of about $2500 per patient. When costs per admission are also taken into account, system hospitals are predicted to have average profits of around 19 per cent of revenues. I estimate a penalty of $780 per patient for excluding a hospital from a system.

Columns 2-4 of Table 10 add the different variables identifying star hospitals. The measure in column 2 is an indicator variable for hospitals with a high US News Index. Column 3 uses the variable $I(teach_h)(1 - percent\_other\_teach_h)$, an indicator for teaching hospitals multiplied by 1 - the per cent of other hospitals in the market that are teaching hospitals. Column 4 uses an analogous variable $I(imaging_h)(1 - percent\_other\_imaging_h)$ where $I(imaging_h)$ is an indicator for the 22% of hospitals that offer positron emission tomography. The relevant coefficient in all three specifications is positive but it is never significant. However, adding these variables changes the other coefficients only slightly.

8.2 Robustness Tests

The results in the previous section are consistent with the intuition outlined in Section 5: that hospitals in systems and those that are expected to be capacity constrained seek rents and are optimally excluded by some plans in equilibrium. Hospitals in systems also seem to demand higher prices from plans that exclude their partners than from other plans. Could some other effect be causing these results? The first robustness test takes account of the non-hospital costs of enrolling consumers[60]. I would like to estimate these costs for consumers of different age or sickness levels by including the number of each type of enrollee in the plan profit equation. Unfortunately there is not enough variation in the data to estimate more than one variable: the average cost per enrollee. The results are reported in Table 11. The cost per enrollee is very imprecisely estimated but has the expected positive sign. The magnitude implies a cost of $30 per member per month. The other coefficients are similar to the main specification.

[60] The producer surplus variable takes account of hospital costs. In particular it accounts for changes in the number of admissions to hospital when the age or gender profile of a particular plan's enrollees changes. However, it does not allow the average cost per admission of a particular hospital to vary with the age and sex of the patients admitted. This implies an assumption that the average patient mix of each hospital is fixed even when plan patient mixes change.

Inaccuracies in the estimated demand system could cause problems with the capacity constraints variable. For example, if the demand for hospital h is biased up, so that the surplus increase when the hospital is added to plan j's network is inflated, this would also imply an upward bias on the estimated hospital profit[61]. This is an alternative explanation for the estimated profits of capacity constrained hospitals: hospital h could be predicted to be full simply because its demand is biased up; both surplus and hospital profits would then be mechanically overestimated[62]. I test for this by replacing the indicator variable for predicted capacity constraints with a variable less closely tied to the demand estimates: an indicator for hospitals that were full in the previous year. I choose not to include this variable in the main specification because it is endogenous: any serial correlation in the disturbance from the model would induce a bias in its coefficient. However, the endogeneity implies a negative bias, so a positive coefficient is still meaningful. The results are reported in Table 11. They are comparable to the main model: the capacity constraints coefficient is smaller than that in the main specification but still positive.

The final test concerns the assumption of fixed premiums. If premiums would in reality fall when certain types of hospital were dropped then both the surplus increase from adding them, and the hospital profit needed to explain plans' unwillingness to agree contracts, would be biased down. As already mentioned, I cannot account perfectly for premium adjustments in response to network changes because I do not observe premiums over time. However, I can use my estimated results to perform a robustness test. I allow all plans to simultaneously adjust premiums to maximize their profits (revenues less prices paid) where prices are determined by the estimates from the main specification[63]. This premium adjustment is conducted as part of the producer surplus calculation for all networks considered; the supply side estimation is then repeated using the new measure of producer surplus. The results are reported in Table 11: they are noisier than those for the main analysis but imply the same overall picture.

[61] This is particularly likely to be a problem if plan j is horizontally differentiated on a dimension not identified by the model. In that case the plan's estimated average quality would be biased up (to explain its ability to exclude hospitals); its increase in surplus when excluded hospitals are added would also be inflated. I exclude the plans that are most clearly horizontally differentiated from the dataset: these are Kaiser Permanente, Group Health Cooperative of Puget Sound and Scott & White Plan of Austin TX.

[62] This argument would not, however, explain the reduced form results for capacity constrained hospitals.

[63] I impose these predicted "optimal" premiums for both observed and unobserved contracts. The predicted values are quite different from those observed in the data. This is not surprising given the rudimentary nature of the model used: in particular, ignoring plans' non-hospital costs and assuming fixed hospital prices across types of procedure probably generates significant noise.

Though none of the robustness tests change the qualitative nature of the results, some of the coefficients do change in magnitude. This is consistent with the results of a number of other robustness tests not reported here and again implies that conclusions about overall effects can be drawn from the results but that it is difficult to make statements about precise magnitudes.

One further issue should be mentioned here: I have no data on plans' physician networks and therefore cannot account for them in the model. It is possible that a plan might decide not to contract with a particular hospital because this would involve establishing new physician contracts. There is no obvious reason why these physician contracting costs should be higher for a hospital that expects to be capacity constrained than for other hospitals but this point might go some way to explaining the result for hospital systems. If the physician networks associated with two hospital systems do not overlap this provides an additional incentive for a plan to contract with all of one system or all of another rather than taking some hospitals from each. In the absence of relevant data it is difficult to say more on this issue; it may mean that the monetary costs of excluding a same-system hospital are overstated.

Are there other possible explanations for the results set out here? We could tell a story where teaching hospitals, or suburban providers, contracted with a subset of plans for reasons not related to bargaining. For example, teaching hospitals might prefer to concentrate on research rather than treating patients; suburban hospitals might only contract with the plans that covered their particular geographical areas. If these hospitals also tended to be capacity constrained this would confound our results. However, as shown in Table 9, neither teaching hospital status nor distance from the city center is significantly related to predicted capacity constraints. Alternatively, it is possible that capacity constrained hospitals turn down contracts with plans not because they wish to drive up prices but because their costs increase when they reach full capacity. However, in that case we should observe capacity constrained hospitals investing in new beds at a faster rate than other providers. In fact there is no significant difference between the investments made by the two types of hospitals in my data[64]. In addition, published data from the Kaiser Foundation show that aggregate hospital capacity levels fell significantly between 1985 and 2000, the period of dramatic expansion of managed care. The data also show that capacity constrained hospitals are clustered in

[64] Capacity constrained hospitals increased their number of beds between 1997 and 2001 by 5.4 beds (3.7%); the equivalent value for other hospitals was 2.5 beds (3.2%). The difference is not significant at p=0.1.

markets with small numbers of hospitals, that is in low-competition markets. Both correlations are consistent with the idea that hospitals limit their capacity only in markets where price bargaining is important and where they they have enough influence to capitalize on the resulting negotiating power[65].

9 Implications of the Results

9.1 Explaining the Observed Contracts

The producer surplus term considered alone explained 68 per cent of agreed contracts and 39% of those not observed. It had a pseudo-R^2 value of just 0.33 when the sets of observed and unobserved contracts were weighted equally. We can now compare the performance of the full model to this benchmark. I use equation (4) to predict the change in plan profits when each hospital is added to each plan's network, holding other plan choices fixed. I then regress this predicted profit change on hospital, insurer and market characteristics that are known to the plan when it makes its choice. I use the estimated coefficients to predict the plan's expected profits from the contract. This is the variable that should predict the observed contract choices if the model is correct[66]. I find that the expected profit variable explains 78 per cent of the observed contracts and 46 per cent of the contracts that are not observed in the data, a significant improvement over the producer surplus variable alone. The pseudo-R^2 value increases to 0.52[67,68].

The estimates are also consistent with evidence gathered in interviews. A number of interviewees noted that the dominant influence on the division of the surplus belonged to insurers in some

[65] The Kaiser Family Foundation report "Trends and Indicators in the Changing Health Care Marketplace, 2004 Update" reports that total community hospital bed capacity fell from 421 to 292 beds per 100,000 population between 1985 and 2000. My data indicate that the correlation of the percent of hospitals in the market that are capacity constrained to the number of hospitals in the market is -0.44.

[66] The variables included in the regression are indicator variables for hospitals in systems, teaching hospitals and capacity constrained hospitals; US News hospital rankings; the number of beds per thousand population, number of hospitals, number of plans and standard deviation of the distances between hospitals in the market and plan brand dummies. All of these variables are known to the insurer when it makes its choice. I exclude hospital costs due to concern about econometrician measurement error.

[67] The distribution of the expected profit change variable for observed contracts is now quite different from that for contracts that are not agreed upon. The means are \$0.103 million and \$0.04 million per month respectively; the variances are \$0.017 million and \$0.020 million. The difference in means is significant at p=0.01.

[68] It is worth noting here that we might not expect the full model to generate a dramatically higher pseudo-R^2 value than the producer surplus term alone. The surplus term accounts for the profits generated by each contract; the full model simply adds the effect of strategic interactions between insurers and providers. These interactions may not change the outcome of the negotiation (from agreement to disagreement or vice versa) in the majority of cases. Seen in this light, the improvement in fit caused by the full model is quite large.

markets and to providers in others. As the Director of Operations Analysis in one hospital chain put it:

> "There are counteracting effects here: the outcome [of any plan decision, like excluding a particular hospital] depends on where the balance of power lies."

This makes sense in light of the estimation results. Hospitals are likely to dominate both in very low-capacity markets and in areas where many hospitals have merged to form systems. (In Salt Lake city, for example, two systems own six of the nine largest hospitals; we would expect hospitals to have high leverage here.) Plan power should be high in high-capacity markets with few systems.

9.2 Investment Incentives for Capacity Constrained Hospitals

"We're ... following a financial model that creating a ticket scarcity is a bigger plus than a ticket surplus. That should generate better revenue."

(*Ted Leland, Stanford Athletic Director, on the University's plans to decrease the capacity of its football stadium from 85,000 to 50,026. Palo Alto Weekly, June 10 2005.)*

The benefit that hospitals derive from capacity constraints implies a potential disincentive to invest that may have negative welfare effects[69]. Organizations outside the medical care market (such as Stanford University) have been observed to respond to similar incentives by significantly reducing the capacity of their facilities. Rational hospitals may well do the same if the potential profit effects are sufficiently strong. I examine this issue both in general and for three specific hospitals that are predicted to be capacity constrained: St. Luke's Medical Center in Milwaukee WI, SW Texas Hospital in San Antonio TX, and South Austin Hospital in Austin TX. For each I calculate the change in consumer surplus, plan profits and hospital profits that the model predicts would occur if the capacity constraints were removed.

Of course the removal of capacity constraints could affect plans' network choices. The model in this paper cannot predict the new equilibrium outcome for contracts since as mentioned I do not

[69] The estimates imply that capacity constrained hospitals receive higher profits per patient than other providers, all else equal. In this section I consider whether they also receive higher total profits, indicating an incentive to under-invest in new beds. There are at least two reasons why this is possible, both of which are discussed in Section 5. First, capacity constraints may improve the hospital's ability to negotiate the selective contracts it needs to price discriminate successfully. Second, the constraints may alter the nature of the bargaining game in the hospital's favor.

fully detail how a single configuration of hospital networks is chosen from the multiple potential equilibria. In addition the change could lead to investment by other hospitals or to entry or exit. The model cannot predict such developments. I therefore do not attempt a full analysis of the new equilibrium. I limit myself to a simple outline of the impact of the change if plans' choices of networks and all other market characteristics were fixed. Even this requires an additional assumption: that the institutional changes do not affect the reduced form function used to describe hospital markups[70]. While not entirely realistic this enables me to derive at least an approximate estimate of magnitudes. Finally, I also assume fixed premiums throughout the calculation.

The consumer surplus calculation finds the dollar value of consumers' gain in utility when reallocation of patients from full hospitals to other, less-preferred providers is no longer necessary. The utility gain is defined as:

$$\Delta CS_m = \sum_j \sum_i n_i s_{ijm} \frac{\gamma_1}{\lambda_i} (EU_{ijm}^{nocapcon} - EU_{ijm}^{capcon})$$

where EU_{ijm}^{capcon} is the utility a consumer with perfect foresight would expect to receive from the hospital network given the probability of reallocation away from the full hospital, $EU_{ijm}^{nocapcon}$ is the expected utility for the network when the capacity constraints are removed, and γ_1 and λ_i are the coefficients on the expected utility from the network and premium in the plan demand equation respectively[71].

The plan profit calculation uses the expression for profits given by equation (4). The profit change from the removal of capacity constraints is given by:

$$\Delta \pi_{jm}^{capcon} = \pi_{jm}^{nocapcon}(H_j, H_{-j}) - \pi_{jm}^{capcon}(H_j, H_{-j})$$

where $\pi_{jm}^{capcon}(H_j, H_{-j})$ is calculated using the parameter estimates in Table 10 and $\pi_{jm}^{nocapcon}(H_j, H_{-j})$ sets the values for capacity constrained hospitals to zero. I adjust $S_{jm}(H_j, H_{-j})$ and $N_{jhm}(H_j, H_{-j})$ for the reallocation of patients across hospitals when the capacity constraints are removed. The

[70] I assume a value of 5.5 for the constant in the markup term, implying zero average profits for non-system, non-capacity constrained hospitals.

[71] I assume that consumers do not have perfect foresight: they choose their plan under the belief that they can access any hospital on its list. The utility reduction from capacity constraints is caused when consumers realize a lower utility from the network than they expected. I multiply by $\frac{\gamma_1}{\lambda_i}$ to convert from utils into dollars. Note that, in all three specific examples, only one hospital in the market is predicted to be capacity constrained.

change in hospital profits is calculated similarly. The reported results for plan profits include all plans in the market; the hospital calculation includes just the capacity constrained hospital.

The results are set out in Table 12. The first row gives the median effect of investment to remove all hospital capacity constraints; the effects for three specific hospitals are then listed separately. The results are most easily understood by considering the specific examples which are reasonably representative of the overall data. The first two hospitals considered, St. Luke's in Milwaukee and SW Texas Methodist Hospital in San Antonio, are large providers with significant high-tech services: each has over 700 beds. In both cases the model predicts that the removal of capacity constraints would have a substantial positive effect on consumer surplus: increases of \$0.13 and \$0.31 per person per new bed per year respectively. These figures translate to benefits of \$228,000 and \$469,000 per additional bed per market per year. The effects on producer surplus are smaller. The loss in hospital markups from reduced bargaining power outweighs the increased revenue from new patients and implies that both hospitals would lose money from the change (even if it involved zero investment): the losses are \$21,635 and \$13,322 per year per additional bed respectively. Plans in Milwaukee would experience a very small profit increase of \$792 per bed per year; those in San Antonio would see a slightly larger profit increase of \$21,700 per bed per year. The third example is somewhat different and is representative of a second type of hospital that the model predicts to be capacity constrained. South Austin hospital is a smaller suburban provider with fewer high-tech services, just 182 beds, and lower costs of care than its competitors. In this case the consumer surplus estimates translate to a \$326,000 benefit to consumers per year per additional bed. The hospital's low costs imply that plan profits would increase by a much higher \$49,000 per year per new bed and hospital profits would actually increase if the capacity constraints were removed.

Overall, then, the results have three implications. First, the benefit to consumers of removing hospital capacity constraints is large: a median benefit of over \$330,000 per year for each new bed provided. The available data on the average cost of new hospital capacity implies a payback period of less than two years when the impact on consumers is taken into account[72]. Second, plan profits

[72] Discussions with the COOs of several hospitals in the markets considered imply a capital cost of approximately \$350,000 per new bed, assuming that a new wing is needed to house the new capacity, and staffing costs of around \$65,000 per bed per year. Of course additional investment may be needed to maintain the quality of services provided by these hospitals. However, as indicated by the three specific examples considered here, the hospitals predicted to be capacity constrained are not in general the very high-tech providers in the data. Even including this investment in quality, the payback period is likely to be short.

increase as a result of the change even if premiums are assumed fixed. Any premium increases would further increase the benefit to plans: for example, an increase of 10 cents per person per year for each new bed would generate a median total gain in plan revenues (across all plans in the market) of around $165,000 per new bed per year[73]. Finally, however, hospitals on average face a decrease in total profits if they invest to remove their capacity constraints[74]. Of course these figures are approximate: the calculation uses figures that are not precisely estimated and relies on a number of simplifying assumptions. However, when put together with the estimates showing the positive effect of capacity constraints on per-patient profits, the results send a strong message. The contractual process between plans and hospitals generates hospital investment incentives that are at odds with patient preferences.

10 Discussion and Conclusion

The analyses in this paper demonstrate some of the causes of the observed hospital-insurer networks at the firm level. Four factors are important: consumer demand for a particular hospital; hospital costs of care; expected capacity constraints; and the existence of hospital systems. Together these rationalize the majority of the observed contracts and those that are not observed.

The full model for estimation assumes that hospitals make simultaneous offers to plans and that the price has both fixed and variable components. It then simply imposes Nash equilibrium conditions to estimate the parameters. Previous papers have modeled the negotiation in more detail than the very simple framework used here but have not accounted for some of the hospital characteristics that this paper shows are important. The results given here can therefore help determine which bargaining models best describe the hospital-health plan price negotiation; that is an additional contribution of this paper.

The estimates also relate to a fairly substantial literature on the challenges faced by HMOs

[73] The benefit to each individual plan is much smaller, however: an average of $14,000 per new bed per year if premiums increased by 10 cents per person. This small benefit, which implies a more than 20 year payback period for plans, explains why the prospect of profitable investment in new capacity does not in general lead to vertical mergers.

[74] Of course these hospitals do not have negative incentives to invest overall: in fact they would benefit from increasing their number of beds as long as they remained capacity constrained. The results imply a disincentive to invest in new beds beyond this point, since the hospital's threat to turn down low price offers then ceases to be credible. This implies an incentive to under-invest in capacity for three reasons: because the credibility of the threat increases with the extent of the capacity constraint; because hospitals are probably unable to predict future demand accurately; and because they prefer not to have enough beds to handle positive shocks to demand.

and POS plans in controlling costs. The original rationale for managed care was that the threat of selective contracting could be used as a lever to prevent hospitals demanding high prices. A number of recent papers have set out interview and other evidence suggesting that health plans' leverage has declined in recent years prompting them to move away from selective contracting towards offering more choice[75]. The major causes of the reduced leverage suggested by these papers are a rising consumer demand for choice and an extensive consolidation of hospitals resulting in increased provider market power. Capacity constraints are also mentioned as a source of hospital leverage. The evidence set out in my first paper (Ho 2005a) supports the first hypothesis: consumers do have a significant preference for choice. If this has developed recently, in response to experience of the restrictions imposed by managed care, it explains some of the move away from selective contracts. The results of this paper are among the first to support the other two hypotheses. Without access to data on actual prices paid it is impossible to know whether the reduced form function estimated here has changed as a result of plans' selective contracting: that is, whether high-priced hospitals would demand even more if no plans turned them down. However, I do show that hospitals in systems and those that expect to be full are the most often excluded when the surplus they generate is positive, consistent with the theory that they have the highest leverage. Further research would be useful, particularly in a setting where price data was available, to investigate these issues in more detail.

The final implication of this paper relates to welfare. I demonstrate an important consequence of the contractual process: the high profits captured by capacity constrained hospitals imply an incentive to under-invest in capacity that could translate to a significant loss to consumers. Plan incentives are somewhat better aligned with consumer preferences but are less relevant given that hospitals, not insurers, are the organizations required to make the investment. While the analysis involves a number of assumptions that limit the accuracy with which these welfare effects can be measured, the potential distortion to provider incentives is clear enough to merit further research.

[75] See for example Lesser and Ginsburg (2001) and Lesser, Ginsburg and Davis (2003).

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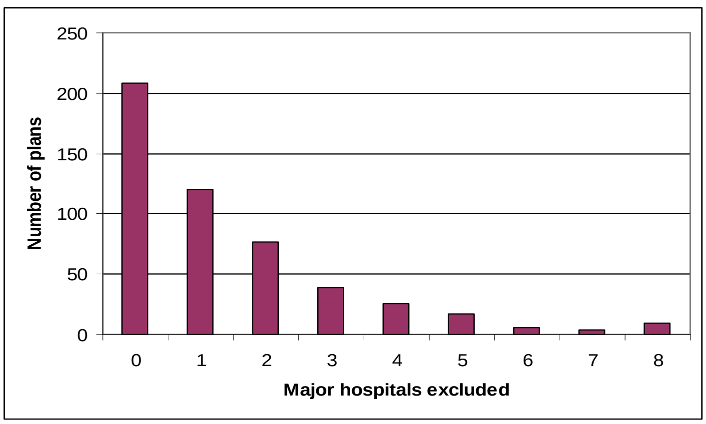
Figure 1: Variation in Plan Networks Across and Within Markets

This figure summarizes the variation in selectivity of plans' hospital networks both across and within markets. Markets are categorized on a scale from 1 to 5, where 1 is the least selective.

Category	Definition	Number of markets	Examples
1	The 5 largest plans (by enrollment) contract with all 8 largest hospitals (by number of admissions)	5	San Antonio TX; Atlanta GA
2	One plan excludes at least one hospital	10	Boston MA; Columbus OH
3	Two plans exclude at least one hospital or three plans exclude exactly one hospital each	6	Detroit MI; San Francisco CA
4	Three plans exclude at least one hospital; one of them excludes more than one	13	Houston TX; Miami FL
5	Four or more plans exclude at least one hospital each	8	Portland OR; New Orleans LA

Graph 1: Number of major hospitals excluded by each plan



Graph 2: Number of major hospitals excluded by each plan in selective markets (dark bars; categories 4-5 in the table above) compared to unselective markets (pale bars; categories 1-2 in the table)

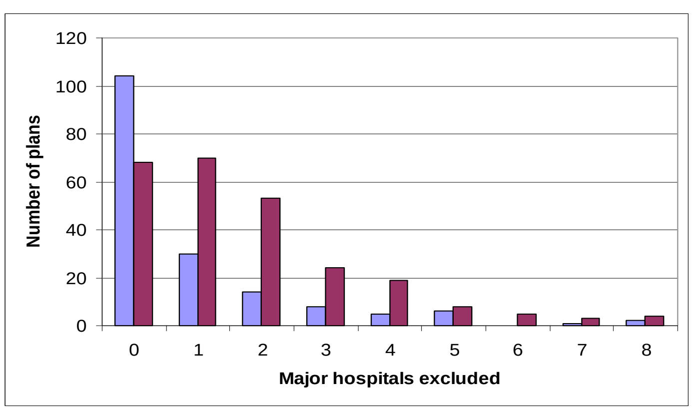


Figure 2: Simulated Distribution of Coefficients, Full Model

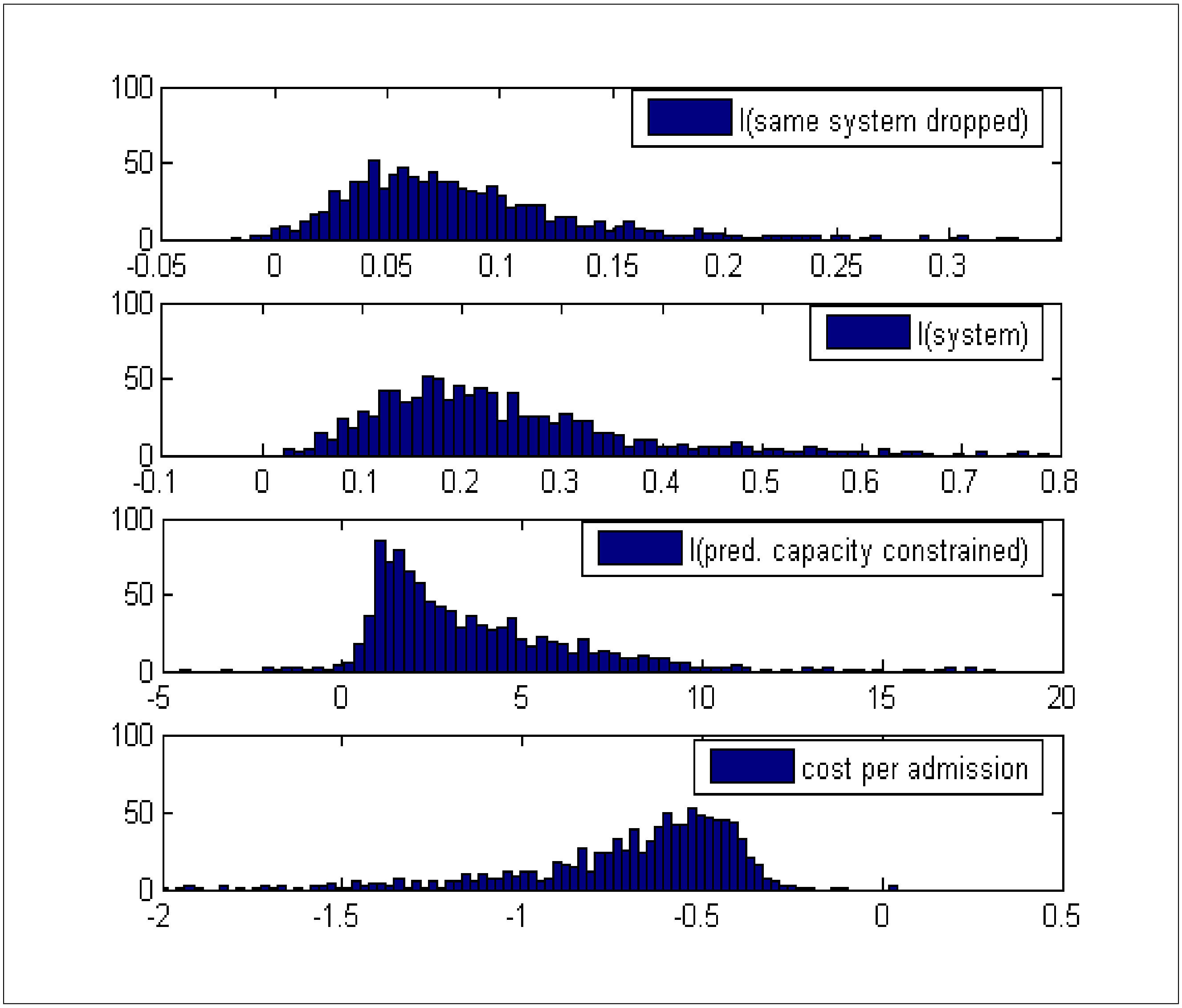


Figure 3: Simulated Distribution of Constant in Markup Equation

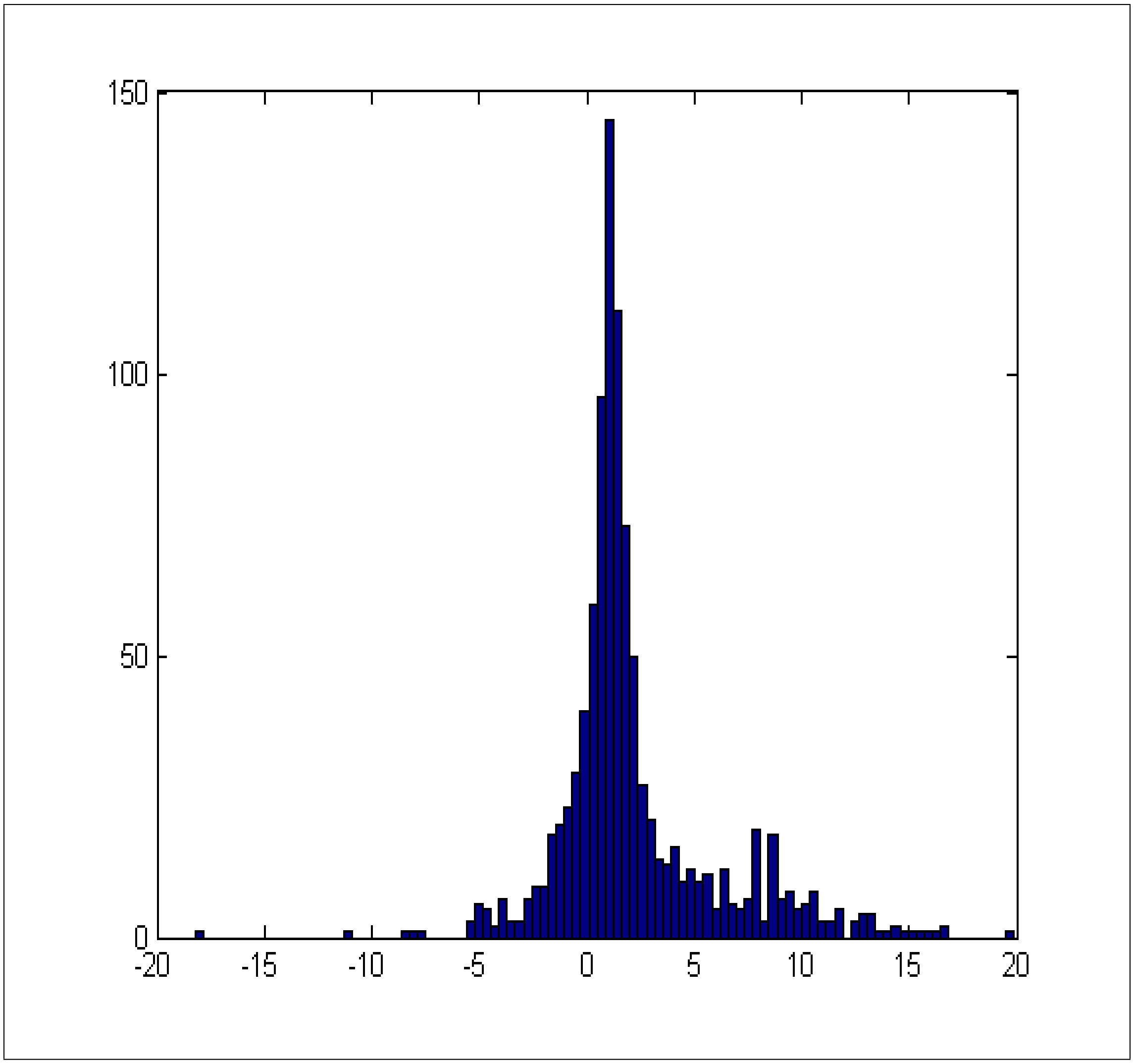


Table 1: Descriptive Statistics for Hospitals

	Mean	Standard Deviation
Number of beds (set up and staffed)	338.66	217.19
Teaching status	0.195	0.397
For-profit	0.202	0.401
Registered nurses per bed	1.263	0.498
Cardiac services	0.812	0.310
Imaging services	0.539	0.287
Cancer services	0.647	0.402
Birth services	0.857	0.348

Notes: N = 665 hospitals. Cardiac, imaging, cancer and birth services refer to four summary variables defined in Table 4. Each hospital is rated on a scale from 0 to 1, where 0 indicates that no procedures in this category are provided by the hospital, and a higher rating indicates that a less common service is offered.

Table 2: Descriptive Statistics for HMO/POS Plans

Variable	Definition	N	Mean	Standard Deviation
Market Share	Plan share of non-elderly market	516	0.03	0.04
Premium pmpm ($)	premiums earned per member per month	478	140.75	44.27
Physicians per 1000 population	number of physician contracts per 1000 popln in markets covered by plan	418	1.56	1.51
Breast cancer screening	% of women aged 52-69 who received a mammogram within last 2 yrs	352	0.73	0.05
Cervical cancer screening	% of adult women who received pap smear within last 3 yrs	352	0.72	0.07
Check-ups after delivery	% of new mothers receiving a check-up withing 8 weeks of delivery	351	0.72	0.11
Diabetic eye exam	% of adult diabetics receiving eye exam within last year	350	0.45	0.11
Adolescent immunization 1	% of children receiving all required doses of MMR and Hep B vaccines before 13th birthday	346	0.31	0.16
Adolescent immunization 2	% of children receiving all required doses of MMR, Hep B and VZV vaccines before 13th birthday	313	0.15	0.11
Advice on smoking	% of adult smokers advised by physician to quit	213	0.63	0.07
Mental illness checkup	% of members seen as outpatient within 30 days of discharge after hospitalizn for mental illness	307	0.68	0.15
Care quickly	Composite measure of member satisfaction re: getting care as soon as wanted	304	0.75	0.05
Care needed	Composite measure of member satisfaction re: getting authorizations for needed/desired care	304	0.72	0.06
Age 0-2	Dummy for plans aged 0 - 2 years	516	0.01	0.08
Age 3-5	Dummy for plans aged 3 - 5 years	516	0.06	0.23
Age 6-9	Dummy for plans aged 6 - 9 years	516	0.17	0.37
Aetna	Plan fixed effect	516	0.15	0.36
CIGNA	Plan fixed effect	516	0.10	0.31
Kaiser	Plan fixed effect	516	0.03	0.16
Blue Cross Blue Shield	Dummy for ownership by BCBS	516	0.16	0.36
POS plan	Dummy for POS plan	516	0.35	0.49

Table 3: Summary Data for Selective and Unselective Markets

	Unselective Markets (Category 1 and 2) Mean (std devn)	Selective Markets (Category 4 and 5) Mean (std devn)	p-value for difference in means
Market population (million)	2.36 (1.11)	2.36 (1.96)	1.00
Number of HMO/POS plans with over 1% market share	6.80 (1.70)	6.57 (1.89)	0.71
Number of hospitals	19.80 (11.40)	21.24 (20.53)	0.78
Beds per 1000 population	2.78 (1.00)	2.90 (0.99)	0.74
Managed care penetration	0.33 (0.17)	0.35 (0.15)	0.66
Average age of population	34.76 (2.19)	34.31 (1.39)	0.49
% of under-65 population aged 55-64	0.09 (0.01)	0.09 (0.01)	0.75
Median total family income of population	$48,890 ($8,460)	$46,130 ($8,642)	0.35
Std devn of total family income of population	$53,687 ($9,805)	$52,797 ($6,511)	0.76
Mean distance between hospitals (miles)	11.71 (5.60)	13.41 (5.12)	0.36
Std devn of distances between hospitals (miles)	7.67** (3.37)	10.30** (4.06)	0.04
No. hospitals with open heart surgery	8.07 (3.67)	10.19 (8.59)	0.31
N	15	21	

Table 4: Definition of Hospital Services

This Table sets out the definition of the hospital service variables summarized in Table 1. Hospitals were rated on a scale from 0 to 1 within four service categories, where 0 indicates that no services within this category are provided by the hospital, and a higher rating indicates that less common (assumed to be higher-tech) service in the category is offered. The categories are cardiac, imaging, cancer and births. The services included in each category are listed in the following table.

Cardiac	Imaging	Cancer	Births
1. Cardiac catheterization lab	1. Ultrasound	1. Oncology services	1. Obstetric care
2. Cardiac Intensive Care	2. CT scans	2. Radiation therapy	2. Birthing room
3. Angioplasty	3. MRI		
4. Open heart surgery	4. SPECT		
	5. PET		

The exact methodology for rating hospitals is as follows. If the hospital provides none of the services, its rating = 0. If it provides the least common service, its rating = 1. If it offers some service X but not the least common service, its rating = (1 - x) / (1 - y), where x = the percent of hospitals offering service X and y = the percent of hospitals offering the least common service.

Table 5: Relation of Hospital Characteristics to Market Shares

	Coefficient estimate	Coefficient estimate
Cardiac services	0.732** (0.104)	0.676** (0.072)
Imaging services	0.233** (0.107)	0.224** (0.074)
Cancer services	0.158** (0.079	0.299** (0.054)
Birth services	0.507** (0.082)	0.394** (0.056)
Teaching hospital	0.243** (0.074)	0.461** (0.051)
Constant	-4.484** (0.097)	-0.005 (0.007)
Market FEs?	No	Yes
Adjusted R^2	0.27	0.69

Notes: Regression of the log of hospital market shares on hospital characteristics. N = 633 hospitals (the 665 providers in the full dataset less 14 Kaiser hospitals and 18 hospitals in Baltimore MD that were excluded from the supply-side analysis). Standard errors are reported in parentheses; **significant at p=0.05; *significant at p=0.1. Cardiac, imaging, cancer and birth services refer to the four hospital service variables defined in Table 4.

Table 6: Results of Plan Demand Estimation

	Coefficient Estimate
Premium ($00 pmpm)	-0.94 (1.13)
Expected utility from hospital network (EUrep$_{jm}$ or EU$_{ijm}$)	0.59** (0.21)
Premium ($00 pmpm) / Income ($000 per year)	0.002 (43.9)
Physicians per 1000 population	0.21** (0.09)
Breast cancer screening	-0.38 (2.66)
Cervical cancer screening	4.40** (2.09)
Check-ups after delivery	0.18 (1.38)
Diabetic eye exams	-1.19 (1.60)
Adolescent immunization 1	-4.11** (1.17)
Adolescent immunization 2	3.08 (3.76)
Advice on smoking	6.17** (2.08)
Mental illness check-ups	2.70** (1.30)
Care quickly	0.78 (5.63)
Care needed	0.85 (3.99)
Plan age: 0 - 2 years	1.36 (0.97)
Plan age: 3 - 5 years	-0.64 (1.97)
Plan age: 6 - 9 years	-0.25 (0.58)
POS plan	-1.11** (0.13)
Constant	-10.50* (5.65)
Large plan fixed effects	Yes
Market fixed effects	Yes

Notes: N=559 plans. Standard errors (adjusted for the three-stage estimation process) are reported in parentheses. ** significant at p=0.05; * significant at p=0.1.

Table 7: Effect of Producer Surplus on Contract Probability

	Number of contracts	$\Delta Surplus \geq 0$	$\Delta Surplus < 0$
Contract observed	5587	68.2%	31.8%
Contract not observed	1160	61.4%	38.6%

Notes: Number of plan-hospital pairs for which producer surplus would increase, be unaffected, or decrease when the hospital was added, under the assumptions described in Section 4.2. For example, the data predict an increase in producer surplus for 59.3 per cent of the 1160 contracts that were not agreed.

Table 8: Effect of Hospital Characteristics on Contract Probability

	Coefficient estimate	Coefficient estimate
System	-0.159** (0.046)	-0.160* (0.046)
Same system hospital excluded	-0.513** (0.120)	-0.514** (0.020)
Cap constrained 1	-0.400** (0.149)	
Cap constrained 2		-0.390** (0.084)
Constant	0.668** (0.121)	0.704** (0.121)
Market FEs?	Yes	Yes
Pseudo-R^2	0.218	0.220

Notes: Probit analysis to predict contracts using indicator variables for hospitals in systems and capacity constrained hospitals. N=6747 contracts. Standard errors in parentheses; **significant at p=0.05; *significant at p=0.1. "System" is an indicator variable for hospitals in systems. "Same system hospital excluded" is the increase, when the contract is agreed, in the number of network hospitals for which a same-system hospital is excluded by the plan. "Cap constrained 1" is an indicator variable for hospitals that were over capacity in the previous year (that is, those with admissions > 365 * number of beds / average length of stay in 2001). "Cap constrained 2" is an indicator variable for hospitals that were over 85 per cent of capacity in the previous year.

Table 9: Relation of Hospital Characteristics to Predicted Capacity Constraints

	Coefficient estimate	Coefficient estimate
Cardiac services	0.919* (0.464)	1.253** (0.550)
Imaging services	0.772** (0.289)	0.986** (0.335)
Cancer services	0.014 (0.225)	0.015 (0.254)
Birth services	0.228 (0.285)	0.206 (0.317)
Teaching hospital	0.110 (0.192)	0.131 (0.220)
System	0.135 (0.179)	0.158 (0.205)
Distance from city center	0.001 (0.008)	-0.001 (0.008)
Constant	-3.039** (0.496)	-3.623** (0.726)
Market FEs?	No	Yes
Pseudo-R^2	0.07	0.13

Notes: Probit analysis to predict the "predicted capacity constraints" variable using hospital characteristics. N = 633 hospitals (the 665 providers in the full dataset less 14 Kaiser hospitals and 18 hospitals in Baltimore MD that were excluded from the supply-side analysis). Standard errors in parentheses; **significant at p=0.05; *significant at p=0.1. The dependent variable is an indicator for hospitals where the predicted number of patients, under the thought experiment that every plan contracts with every hospital in the market, is greater than the number of beds*365 / the average length of stay in the hospital in 2001.

Table 10: Results of Full Model for Estimation

Hospital Characteristics	Main Specification	US News Index	Teaching Hospitals	Imaging Services
Fixed Component (Unit = $ million per month)				
Hospital in System	0.140	0.161	0.164	0.145
	[0.07, 0.60]	[0.11, 0.60]	[0.05, 0.85]	[0.07, 0.45]
Drop Same System Hospital	0.043	0.045	0.050	0.048
	[0.01, 0.23]	[0.02, 0.19]	[0.00, 0.30]	[0.02, 0.17]
Per patient Component (Unit = $ thousand per patient)				
Constant	1.532	0.134	0.102	1.316
	[-3.88, 11.72]	[-0.80, 2.29]	[-3.42, 11.35]	[-5.37, 11.08]
Capacity Constrained	1.807	1.515	3.057	1.493
	[0.32, 10.82]	[-1.36, 10.16]	[-0.43, 14.94]	[0.75, 11.18]
Cost per Admission	-0.494	-0.481	-0.497	-0.454
	[-1.54, -0.33]	[-1.39, -0.33]	[-1.99, -0.36]	[-1.27, -0.16]
US News Index		1.866		
		[-9.08, 7.69]		
Teach*(1 - % other teach)			0.031	
			[-1.27, 0.70]	
Imaging*(1 - % other imaging)				0.157
				[-2.13, 0.76]

Notes: Results of the full model. N = 441 insurance plans (the 516 in the full dataset less 9 plans in Baltimore MD, 13 Kaiser plans, 42 with unobserved premiums and 8 extremely selective plans that I regard as outliers). 95 per cent confidence intervals in parentheses. The coefficients represent the predicted profits to the hospital: a positive coefficient implies a positive relationship to hospital profits. "Hospital in system" refers to whether the hospital is in a system; "Drop Same System Hospital" refers to an indicator for hospitals for which a same-system hospital has been excluded. Capacity constrained hospitals are those with predicted admissions (when all plans contract with all hospitals) > number of beds * 365 / average length of stay. "US News Index", "Teach*(1 - % other teach)" and "Imaging*(1 - % other imaging)" are the star hospital measures discussed in Sections 7 and 8.

Table 11: Robustness Tests

Hospital Characteristics	Main Specification	Number Enrollees	Last Year Cap Con	Premium Adjustments
Enrollees		0.03		
		[-0.02, 0.11]		
Fixed Component (Unit = $ million per month)				
Hospital in System	0.140	0.323	0.343	0.198
	[0.07, 0.60]	[0.09, 0.42]	[0.08, 0.62]	[0.10, 0.64]
Drop Same System Hospital	0.043	0.116	0.131	0.023
	[0.01, 0.23]	[-0.03, 0.15]	[0.02, 0.25]	[0.01, 0.20]
Per patient Component (Unit = $ thousand per patient)				
Constant	1.532	0.618	-0.632	0.008
	[-3.88, 11.72]	[0.08, 5.65]	[-1.92, 10.73]	[-0.16, 14.05]
Capacity Constrained	1.807	2.072		3.986
	[0.32, 10.82]	[-2.30, 5.10]		[-4.31, 7.50]
Last Year Cap Constrained			1.130	
			[-6.35, 12.26]	
Cost per Admission	-0.494	-0.605	-0.331	-1.098
	[-1.54, -0.33]	[-1.18, -0.35]	[-1.49, -0.14]	[-2.25, -0.81]

Notes: Results of robustness tests. N = 441 insurance plans (the 516 in the full dataset less 9 plans in Baltimore MD, 13 Kaiser plans, 42 with unobserved premiums and 8 extremely selective plans that I regard as outliers). 95 per cent confidence intervals in parentheses. The first test includes the number of enrollees. The second replaces the predicted capacity constraints variable with an indicator variable for capacity constraints in the previous year. Finally, the surplus estimate is adjusted for premium changes in response to changes in network.

Table 12: Investment Incentives for Capacity Constrained Hospitals

Example	CS per person ($ per bed per year)	CS per market ($ per bed per year)	Plan profit ($ per bed per year)	Hospital profit ($ per bed per year)
Median	$0.17	$331,890	$16,876	- $4,564
St. Luke's Milwaukee	$0.13	$227,710	$792	- $21,635
SW Texas Methodist	$0.31	$468,790	$21,677	- $13,322
South Austin Hospital	$0.33	$326,310	$49,071	$30,709

Notes: This table shows the effect of investment to remove capacity constraints. The first row gives the median effect (across markets) of investment to remove all hospital capacity constraints. For some markets this involves investment in more than one hospital. Rows 2-4 list the effects for three specific hospitals: St. Luke's Medical Center in Milwaukee WI, SW Texas Methodist Hospital in San Antonio TX, and South Austin Hospital in Austin TX. All effects are given in $ per new bed per year. Plan profit effects are listed as a sum over plans in the market; hospital profits are given for the capacity constrained hospital alone.