NBER WORKING PAPER SERIES

MERGERS WHEN PRICES ARE NEGOTIATED: EVIDENCE FROM THE HOSPITAL INDUSTRY

Gautam Gowrisankaran
Aviv Nevo
Robert Town

Working Paper 18875
http://www.nber.org/papers/w18875

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 2013

We thank Cory Capps, Allan Collard-Wexler, Greg Crawford, Leemore Dafny, David Dranove, Chris Garmon, Kate Ho, Robin Lee, Matt Lewis, Mike Riordan, Alan Sorensen, Ali Yurukoglu, especially Keith Brand, and numerous seminar participants for helpful comments. Gowrisankaran acknowledges funding from the Center for Management Innovations in Health Care at the University of Arizona. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

At least one co-author has disclosed a financial relationship of potential relevance for this research. Further information is available online at http://www.nber.org/papers/w18875.ack

Mergers When Prices are Negotiated: Evidence from the Hospital Industry
Gautam Gowrisankaran, Aviv Nevo, and Robert Town
NBER Working Paper No. 18875
March 2013, Revised January 2014
JEL No. I11,I18,L11,L13,L31,L38

ABSTRACT

We estimate a bargaining model of competition between hospitals and managed care organizations (MCOs) and use the estimates to evaluate the effects of hospital mergers. We find that MCO bargaining restrains hospital prices significantly. The model demonstrates the potential impact of coinsurance rates, which allow MCOs to partly steer patients towards cheaper hospitals. We show that increasing patient coinsurance tenfold would reduce prices by 16%. We find that a proposed hospital acquisition in Northern Virginia that was challenged by the Federal Trade Commission would have significantly raised hospital prices. Remedies based on separate bargaining do not alleviate the price increases.

Gautam Gowrisankaran
Department of Economics
University of Arizona
P.O. Box 210108
Tucson, AZ 85721-0108
and HEC Montreal
and also NBER
gowrisankaran@eller.arizona.edu

Robert Town
Health Care Management Department
The Wharton School
University of Pennsylvania
3641 Locust Walk
Philadelphia, PA 19104
and NBER
rtown@wharton.upenn.edu

Aviv Nevo
Department of Economics
Northwestern University
2001 Sheridan Road
Evanston, IL 60208-2600
and NBER
nevo@northwestern.edu

1 Introduction

In many markets prices are negotiated by the relevant parties rather than set by one of the sides or determined by means of an auction. Examples are commonplace and include wholesale prices between upstream and downstream firms, prices of houses set between buyers and sellers, and car prices negotiated between consumers and dealers. In all these examples, each side has an incentive to improve its bargaining leverage. One of the ways that parties can achieve a better bargaining leverage is by joining forces: firms through a horizontal merger or consumers by negotiating as a group.[1]

In this paper we estimate a model of competition in which prices are negotiated between managed care organizations (MCOs) and hospitals. We use the estimates to investigate the extent to which hospital bargaining and patient coinsurance restrain prices and to analyze the impact of counterfactual hospital mergers and policy remedies. Our analysis builds on, and brings together, three different literatures, that (i) structurally estimate multi-party bargaining models; (ii) simulate the likely effect of mergers; and (iii) study competition in health care markets. Our contribution is in modeling the effect of final consumers paying some of the costs (through coinsurance); in the estimated numbers; and in the way we estimate the model. The approach we follow in this paper can be used more generally to understand mergers in industries where prices are determined by negotiation between differentiated sellers and a small numbers of "gatekeeper" buyers who act as intermediaries for end consumers.

It is both important and policy relevant to analyze the impact of hospital mergers. MCOs can obtain lower prices from providers than traditional fee-for-service insurance arrangements because of bargaining leverage, and have been significant in restraining medical care prices (Cutler et al., 2000).[2] One strategic response of hospitals to the rise of managed care is to horizontally merge. Indeed, over the last 25 years, hospital markets have become significantly more concentrated due to mergers (Gaynor and Town, 2012), with the hospital industry having the most federal horizontal merger litigation of any industry.[3] Moreover, the

[1]The literature generally but not unanimously finds that larger firms are able to negotiate lower prices, all else equal (see Chipty, 1995; Sorensen, 2003; Ho, 2009).

[2]Hospital prices impact consumers through two possible avenues. There is the direct impact on out-of-pocket medical expenses through coinsurance. More importantly, increases in hospital price increase MCO costs which, in turn, are passed on to enrollees through higher premiums, lower wages, and potentially unemployment (Baicker and Chandra, 2006).

[3]Since 1989, there have been thirteen federal hospital antitrust trials. Most recently, the Federal Trade Commission successfully challenged mergers in Toledo, OH (*In the Matter of ProMedica Health System Inc.* Docket No. 9346, 2011) and Rockford, IL (*In the Matter of OSF Healthcare System and Rockford Health*

hospital industry's large share of GDP (5.3%) implies that understanding its structure and performance has implications for aggregate economic activity.

A standard way to model competition in differentiated product markets is with a Bertrand pricing game. Patient demand for hospitals is inelastic, because patients pay little out of pocket for hospital stays, and therefore the margins predicted by Bertrand pricing imply negative marginal costs. In contrast, the bargaining model we estimate generates more elastic demand in a way that is consistent with consumer preferences. Thus, a principal reason to estimate a bargaining model for this sector is that a Bertrand competition model here can neither reasonably predict baseline marginal costs nor the impact of a merger.

Our model of competition between MCOs and hospitals has two stages. In the first stage, MCOs and hospital systems negotiate the base price that each hospital will be paid by each MCO for hospital care. We model the outcome of these negotiations using the Horn and Wolinsky (1988a) model. The solution of the model specifies that prices for an MCO/hospital-system pair solve the Nash bargaining problem between the pair, conditioning on the prices for all other MCO/system pairs. The Nash bargaining problem is a function of the value to each party from agreement relative to the values without agreement, and hence depends on the objective functions of the parties. We assume that hospitals, which may be not-for-profit, seek to maximize a weighted sum of profits and quantity. We model the MCO's objective function in two different ways. First, in the *MCO agency model*, MCOs act as agents for self-insured employers, seeking to maximize a weighted sum of enrollee welfare and insurer costs. This is consistent with a situation where employers have existing contracts with MCOs to administer healthcare services for their employees in exchange for fixed management fees. Second, in the *MCO Bertrand competition model*, following the price negotiation stage, MCOs set health insurance premiums and compete à la Bertrand for enrollees with a profit maximization objective.

In the second stage, each MCO enrollee receives a health draw. Enrollees who are ill decide where to seek treatment, choosing a hospital to maximize utility. Utility is a function of out-of-pocket expense, distance to the hospital, hospital-year indicators, the resource intensity of the illness interacted with hospital indicators, and a random hospital-enrollee-specific shock. The out-of-pocket expense is the negotiated base price – as determined in the first stage – multiplied by the coinsurance rate and the resource intensity of the illness. The first-stage Nash bargaining disagreement values are then determined by the utilities generated by the

System, Docket No. 9349, 2012).

expected patient choices.

Solving the first-order conditions of the Nash bargaining problem for the MCO agency model, we show that equilibrium prices can be expressed by a formula that is analogous to the standard Lerner index equation, but where actual patient price sensitivity is replaced by the *effective price sensitivity* of the MCO. If hospitals have all the bargaining weight, the actual and effective price sensitivities are equal and prices are the same as under Bertrand competition with targeted prices to each MCO. In the general case, the two will not be equal. While the difference between actual and effective price elasticities depends on a number of factors, in the simple case of identical single-firm hospitals, the effective price sensitivity will be higher than the actual price sensitivity, and hence markups will be lower than under Bertrand competition.

We estimate the model using discharge data from Virginia Health Information and administrative claims data from payors, from Northern Virginia. The use of claims data is novel and helps in two ways. First, the data allow us to construct prices for each hospital-payor-year triple. Second, the data let us construct patient-specific coinsurance rates, which are necessary to model patient behavior.

We estimate the multinomial logit patient choice model by maximum likelihood, and the parameters of the MCO agency model by forming moment conditions based on orthogonality restrictions on marginal costs. We calculate marginal costs by inverting the first-order conditions as explained above. This is the analog for the bargaining model case of the "standard" techniques used to incorporate equilibrium behavior in differentiated products estimation (e.g., Bresnahan, 1987; Goldberg, 1995; Berry et al., 1995). We lack data – principally on plan choice and premiums – necessary to estimate the parameters of the MCO Bertrand competition model. Hence, we estimate and calibrate the parameters of this model using premium sensitivity measures from the literature, MCO market shares from our data, and marginal costs recovered from our MCO agency model estimation.

We find that patients pay an average of 2-3% of the hospital bill as coinsurance amounts. While patients significantly dislike high prices, the own-price elasticity for systems is relatively low, ranging from 0.07 to 0.15, due to the low coinsurance rates. Without any health insurance, own-price elasticities would range from 3.13 to 6.57. Estimated Lerner indices range from 0.21 to 0.68, which are equivalent to those implied by Bertrand pricing by hospitals if own-price elasticities ranged from 4.84 to 1.48.[4] This implies that bargaining incentives

[4]The calibrated MCO Bertrand competition model yields similar results here.

make MCOs act more elastically than individual patients, but less elastically than patients without insurance.

Using the estimated parameters of the model, we examine the impact of a number of counterfactual market structures, focusing on the proposed acquisition by Inova Health System of Prince William Hospital, a transaction that was challenged by the Federal Trade Commission (FTC) and ultimately abandoned. The MCO agency model predicts that the proposed merger would have raised the quantity-weighted average price of the merging hospitals by 3.1%. The MCO Bertrand competition model shows a larger price increase of 7.2%. In terms of the revenue increase at the merged hospitals, this is equivalent to a 30.5% price increase at just Prince William. We consider a remedy implemented by the FTC in a different hospital merger case, where the newly acquired hospitals were forced to bargain separately, in order to re-inject competition into the marketplace. We find that separate bargaining does not eliminate the anticompetitive effects of the Prince William acquisition.

We also examine the impact of different coinsurance rates on restraining prices. We find that mean prices would would rise by 3.7% if coinsurance rates were 0 but drop by 16% if coinsurance rates were 10 times as high as at present (approximately the optimal coinsurance rate for hospitalizations calculated by Manning and Marquis (1996)).

As noted earlier, this paper builds on three related literatures. First, our analysis builds on recent work that structurally estimates multilateral bargaining models. Crawford and Yurukoglu (2012) were the first to develop and estimate a full structural bargaining framework based on Horn and Wolinsky (1988a); they examined bargaining between television content providers and cable companies.[5] The MCO Bertrand competition model is essentially their model (with a slightly different demand model). Our model allows us to examine the impact of coinsurance and other features unique to the healthcare sector. Our econometric approach is differentiated in that the estimation does not require solving for equilibrium prices and the unobserved term reflects cost variation.

Second, our paper relates to the literature that uses pre-merger data to simulate the likely effects of mergers by using differentiated products models with price setting behavior.[6] With a few exceptions (Gaynor and Vogt, 2003), it has been difficult to credibly model the hospital industry within this framework. For instance, as noted above, because consumers typically

[5]Other papers that seek to estimate structural bargaining models include Grennan (2013), Allen et al. (2013), Draganska and Villas-Boas (2011) and Meza and Sudhir (2010).

[6]See, for example, Berry and Pakes (1993); Hausman et al. (1994); Werden and Froeb (1994); Nevo (2000).

pay only a small part of the cost of their hospital care, own-price elasticities are low implying either negative marginal costs or infinite prices under Bertrand competition. We find that the equilibrium incentives of an MCO will both be more elastic and also change in different ways following a hospital merger than would the incentives of its patients. More generally, the impact of a merger on prices in the bargaining context will be different in magnitude and potentially even sign than in a Bertrand setting.[7]

Finally, an existing literature has focused on bargaining models in which hospitals negotiate with MCOs for inclusion in their network of providers. Capps et al. (2003) and Town and Vistnes (2001) estimate specifications that are consistent with an underlying bargaining model but neither paper structurally estimates a bargaining model. We show that their specification corresponds to a special case of our model with zero coinsurance rates and lump-sum payments from MCOs to hospitals. Our work also builds on Ho (2009, 2006), Lewis and Pflum (2011), and Ho and Lee (2013). Ho (2009) is of particular interest. She estimates the parameters of MCO choices of provider network focusing on the role of different networks on downstream MCO competition. Our work, in contrast, focuses on the complementary price setting mechanism between MCOs and hospitals, taking as given the network structure.

The remainder of this paper is organized as follows. Section 2 presents our model. Section 3 discusses econometrics. Section 4 provides our results. Section 5 provides counterfactuals. Section 6 concludes.

2 Model

2.1 Overview

In this section we describe how we model hospital and managed care bargaining, and MCO and hospital choice. The product that is sold by MCOs is health administration services to self-insured employers.[8] Employers acquire these services and insure their employees as part of a compensation package, so employee and employer incentives are largely aligned.[9] In self-insured plans, the employer pays the cost of employee health care (less coinsurance,

[7]Horn and Wolinsky (1988a,b), Chipty and Synder (1999) and O'Brien and Shaffer (2005).

[8]In the U.S., private health insurance is generally acquired through an employer and approximately 60% of employers are self-insured with larger employers significantly more likely to self-insure (Kaiser Family Foundation/Health Research and Educational Trust, 2011).

[9]Baicker and Chandra (2006) find that increases in medical costs are incompletely passed through to wages but that they also have broader labor market consequences.

copays and deductibles) plus an administrative fee to the MCO. The central role of the MCO is to construct provider networks, negotiate prices, provide care and disease management services, and process medical care claims.

We consider two models of MCO interactions with enrollees. First, we propose a model of MCO agency. In this model we assume that employers have ongoing contracts with one MCO, under which the MCO agrees to act in the incentives of the employers that it represents in its negotiation with hospitals, in exchange for fixed management fees that are determined by some earlier market interactions between the MCO and the employer.[10] We then model a two-stage game that takes as given the employer/MCO contracts. In the first stage, MCOs, act as agents on behalf of their enrollees and negotiate with hospital systems the terms of hospitals' inclusion in MCOs' networks. In the second stage, each patient receives a health status draw. Some draws do not require inpatient hospital care, while others do. If a patient needs to receive inpatient hospital care, she must pay a predetermined coinsurance fraction of the negotiated price for each in-network hospital, with the MCO picking up the remainder. Coinsurance rates can vary across patients and diseases. The patient selects a hospital in the MCO's network – or an outside alternative – to maximize her utility.

Second, we consider a model of MCO Bertrand competition. In this model, MCOs maximize their profits when negotiating with hospital systems over the terms of hospitals' inclusions in MCO networks. These negotiations take into account that after the networks are set the MCOs will set premiums and the enrollees choose an MCO. Finally, as in the second stage of the MCO agency model, patients receive health status draws and choose hospitals.[11]

The two models differ in (i) the objective function of the MCO in the negotiation and (ii) whether enrollee plan choices are considered fixed in the case of disagreement (agency model) or allowed to vary (Bertrand competition model). Note, that both models account for consumer preferences in the formation of the network, they just do it in a different way. The MCO agency model assumes that there is agency between employers and MCOs, while in the MCO Bertrand competition model, this accounting occurs through the competitive interactions of the health plan marketplace. Overall, we believe that the true incentives faced by MCOs are likely somewhere between these two models.

[10] According to an industry expert, the most common fee structure that MCOs use for self-insured plans are fixed fees based on the employer size. We thank Leemore Dafny for putting us in contact with this expert.

[11] This model builds on Crawford and Yurukoglu (2012) and is most similar to Ho and Lee (2013)'s model.

2.2 Patient healthcare choice

We now exposit the patient healthcare choice, which is the final stage in both models of bargaining. There is a set of hospitals $j = 1, \ldots, J$, and a set of managed care companies $m = 1, \ldots, M$. The hospitals are partitioned into $S \leq J$ systems. Let J_s denote the set of hospitals in system s.

There is a set of enrollees $i = 1, \ldots, I$. Each enrollee has health insurance issued by a particular MCO. Let $m(i)$ denote the MCO of enrollee i. In the MCO agency model, $m(i)$ is fixed, while in the MCO Bertrand competition model, $m(i)$ is chosen at the end of the first stage, after MCOs set premiums. Each MCO m has a subset of the hospitals in its network; denote this subset N_m. For each m and each $j \in N_m$, there is a base price p_{mj}, which was negotiated in the first stage. Let $\vec{p_m}$ denote the vector of all negotiated prices for MCO m.

Prior to choosing the hospital, taking as given plan enrollment and the networks, each patient receives a draw of her health status that determines if she has one of a number of health conditions that require inpatient care. Let f_{id} denote the probability that patient i at MCO m is stricken by illness $d = 0, 1, ...D$, where $d = 0$ implies no illness, w_d denotes the relative intensity of resource use for illness d, and $w_0 = 0$. In our empirical analysis, w_d is observed. We assume that the total price paid for treatment at hospital j by MCO m of disease d is $w_d p_{mj}$, which is the base price multiplied by the disease weight. Therefore, the base price, which will be negotiated by the MCO and the hospital, can be viewed as a price per unit of w_d. This is essentially how most hospitals are reimbursed by Medicare, and many MCOs incorporate this payment structure into their hospital contracts.

Each patient's insurance specifies a coinsurance rate for each condition, which we denote c_{id}. The coinsurance rate indicates the fraction of the billed price $w_d p_{m(i)j}$ that the patient must pay out of pocket.

For each realized illness $d = 1, \ldots, D$, the patient seeks hospital care at the hospital which gives her the highest utility, including an outside option. The utility that patient i receives from care at hospital $j \in N_{m(i)}$ is given by

$$u_{ijd} = \beta x_{ijd} - \alpha c_{id} w_d p_{m(i)j} + e_{ij}. \tag{1}$$

In equation (1), x_{ijd} is a vector of hospital and patient characteristics including travel time, hospital indicators, and interactions between hospital and patient characteristics (e.g., hospital indicators interacted with disease weight w_d), and β is the associated coefficient vector.

The out-of-pocket expense to the patient is $c_{id}w_d p_{m(i)j}$. As we describe below, we observe data that allow us to impute the base price, the disease weight, and coinsurance rate; hence we treat out-of-pocket expense as observable. We let α denote the price sensitivity. Finally, e_{ij} is an *i.i.d.* error term that is distributed type 1 extreme value.

The outside choice, denoted as choice 0, is treatment at a hospital located outside the market. The utility from this option is given by

$$u_{i0d} = -\alpha c_{id} w_d p_{m(i)0} + e_{i0}. \tag{2}$$

We normalize the quality from the outside option, x_{i0d}, to 0 but we allow for a non-zero base price $p_{m(i)0}$.[12] Finally, we assume that e_{i0} is also distributed type 1 extreme value.

Consumers' expected utilities play an important role in the bargaining game. To exposit expected utility, define $\delta_{ijd} = \beta x_{ijd} - \alpha c_{id} w_d p_{m(i)j}$, $j \in \{0, N_{m(i)}\}$. The choice probability for patient i with disease d as a function of prices and network structure is:

$$s_{ijd}(N_{m(i)}, \vec{p_{m(i)}}) = \frac{\exp(\delta_{ijd})}{\sum_{k \in 0, N_{m(i)}} \exp(\delta_{ikd})}. \tag{3}$$

The ex-ante expected utility to patient i, as a function of prices and the network of hospitals in the plan, is given by:[13]

$$W_i(N_{m(i)}, \vec{p_{m(i)}}) = \sum_{d=1}^{D} f_{id} \ln \left(\sum_{j \in 0, N_{m(i)}} \exp(\delta_{ijd}) \right). \tag{4}$$

Capps et al. (2003) refer to $W_i(N_{m(i)}, \vec{p_{m(i)}}) - W_i(N_{m(i)} \setminus J_s, \vec{p_{m(i)}})$, as the "willingness-to-pay" (WTP) as it represents the utility gain to enrollee i from the system s.

2.3 MCO and hospital bargaining

We now exposit the bargaining stage. There are $M \times S$ potential contracts, each specifying the negotiated base prices for one MCO/hospital system pair. We assume that each hospital

[12] As the empirical analysis includes hospital fixed effects, attributes of the outside option will only rescale the fixed effects and otherwise do not affect choice model coefficient estimates. However, because our bargaining model specifies payments from MCOs, the price of the outside option has implications for the bargaining model parameter estimates and counterfactual equilibrium behavior.

[13] We exclude Euler's constant from this expression.

within a system has a separate base price, and that the price paid to a hospital for treatment of disease d will be its base price multiplied by the disease weight w_d. MCOs and hospitals have complete information about MCO enrollee and hospital attributes, including x_{ijd} and hospital costs.

Following Horn and Wolinsky (1988a) we assume that prices for each contract solve the Nash bargaining solution for that contract, conditional on all other prices. The Nash bargaining solution is the price vector that maximizes the exponentiated product of the values to both parties from agreement (as a function of that price) relative to the values without agreement. It is necessary to condition on other prices because the different contracts may be economically interdependent implying that the Nash bargaining solutions are interdependent. For instance, in our model the value to an MCO of reaching an agreement with one hospital system may be lower if it already has an agreement with another geographically proximate system. Our bargaining model makes the relatively strong assumption that each contract remains the same even if negotiation for another contract fails.

Essentially, the Horn and Wolinsky solution nests a Nash bargaining solution (an axiomatic cooperative game theory concept) within a Nash equilibrium (a non-cooperative game) without a complete non-cooperative structure. The results of Rubinstein (1982) and Binmore et al. (1986) show that the Nash bargaining solution in a bilateral setting corresponds to the unique subgame perfect equilibrium of an alternating offers non-cooperative game. Extending these results, Collard-Wexler et al. (2013) provide conditions such that the Horn and Wolinsky solution is the same as the unique perfect Bayesian equilibrium with passive beliefs of a specific simultaneous alternating offers game with multiple parties.

While the general bargaining framework is the same across the MCO agency and Bertrand competition models, the specifics are different due to differences in objective functions. We now discuss both models in term.

2.3.1 MCO agency model

In the MCO agency model, each MCO, acting on behalf of its contracted employers, seeks to maximize a weighted sum of the consumer surplus of its enrollees net of the payments to hospitals, taking $m(i)$ as fixed. Because $m(i)$ is fixed, a hospital system that does not reach agreement with MCO m will not capture back any of m's patients through plan switches by those patients. Define the ex-ante expected cost to the MCO and the employer that it represents to be $TC_m(N_m, \vec{p_m})$. The MCO pays the part of the bill that is not paid by the patient, hence

$$TC_m(N_m, \vec{p_m}) = \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\}(1 - c_{id}) f_{id} w_d \sum_{j \in 0, N_m} p_{mj} s_{ijd}(N_m, \vec{p_m}). \tag{5}$$

Define the dollar value for the MCO and the employer it represents to be:

$$V_m(N_m, \vec{p_m}) = \frac{\tau}{\alpha} \sum_{i=1}^{I} 1\{m(i) = m\} W_i(N_m, \vec{p_m}) - TC_m(N_m, \vec{p_m}), \tag{6}$$

where τ is the relative weight on employee welfare. If employer/employee/MCO incentives were perfectly aligned then $\tau = 1$. Assume that $N_m, m = 1, \ldots, M$, are the equilibrium sets of network hospitals. For any system s for which $J_s \subseteq N_m$, the net value that MCO m receives from including system s in its network is $V_m(N_m, \vec{p_m}) - V_m(N_m \setminus J_s, \vec{p_m})$.

Hospital systems can be either for-profit or not-for-profit (NFP). NFP systems may care about some linear combination of profits and weighted quantity of patients served. Let mc_{mj} denote the "perceived" marginal cost of hospital j for treating a patient from MCO m with disease weight $w_d = 1$. We assume that the costs of treating an illness with weight w_d is $w_d mc_{mj}$. The perceived marginal costs implicitly allows for different NFP objective functions: a NFP system which cares about the weighted quantity of patients it serves will equivalently have a perceived marginal cost equal to its true marginal cost net of this utility amount (Lakadawalla and Philipson, 2006; Gaynor and Vogt, 2003).

We make three further assumptions regarding the cost structure. First, we assume that marginal costs are constant in quantity (though proportional to the disease weight). Second, we allow hospitals to have different marginal costs from treating patients at different MCOs, because the approach to care management, the level of paperwork, and ease and promptness of reimbursement may differ across MCOs. Finally, we specify that

$$mc_{mj} = \gamma v_{mj} + \varepsilon_{mj}, \tag{7}$$

where mc_{mj} is the marginal cost for an illness with disease weight $w_d = 1$, v_{mj} are a set of cost fixed effects (notably hospital, year, and MCO fixed effects), γ are parameters to estimate, and ε_{mj} is the component of cost that is not observable to the econometrician. Note that we are assuming no capacity constraints, and hence in the event of a disagreement between a hospital and an MCO, the patient will always go to her ex-post second choice.

Define the normalized quantity to hospital j, $j \in N_m$ as

$$q_{mj}(N_m, \vec{p_m}) = \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\} f_{id} w_d s_{ijd}(N_m, \vec{p_m}). \tag{8}$$

Since prices and costs are per unit of w_d, the returns that hospital system s expects to earn from a given set of managed care contracts are

$$\pi_s(M_s, \{\vec{p_m}\}_{m \in M_s}, \{N_m\}_{m \in M_s}) = \sum_{m \in M_s} \sum_{j \in J_s} q_{mj}(N_m, \vec{p_m})[p_{mj} - mc_{mj}] \tag{9}$$

where M_s is the set of MCOs that include system s in their network. The net value that system s receives from including MCO m in its network is $\sum_{j \in J_s} q_{mj}(N_m, \vec{p_m})[p_{mj} - mc_{mj}]$.

Having specified objective functions, we now define the Nash bargaining problem for MCO m and system s as the exponentiated product of the net values from agreement:

$$NB^{m,s}(p_{mj\,j \in J_s} | \vec{p_{m,\text{-}s}}) = \Big(\sum_{j \in J_s} q_{mj}(N_m, \vec{p_m})[p_{mj} - mc_{mj}] \Big)^{b_{s(m)}}$$
$$\Big(V_m(N_m, \vec{p_m}) - V_m(N_m \setminus J_s, \vec{p_m}) \Big)^{b_{m(s)}}, \tag{10}$$

where $b_{s(m)}$ is the bargaining weight of system s when facing MCO m, $b_{m(s)}$ is the bargaining weight of MCO m when facing system s, and $\vec{p_{m,\text{-}s}}$ is the vector of prices for MCO m and hospitals in systems other than s. Without loss of generality, we normalize $b_{s(m)} + b_{m(s)} = 1$.

The Nash bargaining solution is the vector of prices $p_{mj\,j \in J_s}$ that maximizes (10). Let $\vec{p_m^*}$ denote the Horn and Wolinsky (1988a) price vector for MCO m. It must satisfy the Nash bargain for each contract, conditioning on the outcomes of other contracts. Thus, $\vec{p_m^*}$ satisfies

$$p^*_{mj} = \max_{p_{mj}} NB^{m,s}(p_{mj}, \vec{p^*_{m,-j}} | \vec{p^*_{m,-s}}), \tag{11}$$

where $\vec{p^*_{m,-j}}$ is the equilibrium price vector for other hospitals in the same system as j.

2.3.2 MCO Bertrand competition model

In the MCO Bertrand competition model, MCOs negotiate with hospitals knowing that they will have to set premiums for their plans to attract enrollees. We start with the plan choice of enrollee i faced with a premium P_m for each plan m. At this stage, the enrollee does not know her disease realization and e_{ij} hospital-specific shocks. Each enrollee makes a discrete choice of MCO to maximize the utility

$$U_{im} = \alpha_1 W_i(N_m, \vec{p_m}) - \alpha_2 P_m + \xi_m + E_{im}, \tag{12}$$

where α_1 is the dollar transformation of measured welfare from (4), α_2 is the disutility from premiums, ξ_m is the utility from MCO m from attributes other than its patient care and price (e.g., customer service), and E_{im} is an *i.i.d.* unobservable, distributed type 1 extreme value. The enrollee may choose the outside option, $U_{i0} = E_{i0}$, in which case we assume that the enrollee will not be able to use a hospital in Stage 2. The market share of MCO m for patient i as:

$$S_{im}(P_m, P_{-m}) = \frac{\alpha_1 W_i(N_m, \vec{p_m}) - \alpha_2 P_m + \xi_m}{1 + \sum_{n=1}^{M} \alpha_1 W_i(N_n, \vec{p_n}) - \alpha_2 P_n + \xi_n},$$

where we are implicitly conditioning on the choice of hospital networks and prices.

We assume that MCOs simultaneously choose premiums, P_m, knowing all input costs $p_{ns}, \forall n, s$. The goal of the MCO here is to maximize expected profits. Expected profits from a patient are the market share of the patient times the expected margin from attracting her. Overall, then, we can write profits (gross of fixed costs) to MCO m as:

$$R_m(P_m|P_{-m}) = \sum_{i=1}^{I} \left(\overbrace{(P_m - \sum_{d=1}^{D}(1 - c_{id}) f_{id} w_d \sum_{j=0,N_m} p_{ms(j)} s_{ijd}(N_m, \vec{p}_m))}^{\text{Expected margin from } i} S_{im}(P_m, P_{-m}) \right), \tag{13}$$

where we are again implicitly conditioning on hospital networks and prices. Let $R^*_m(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}})$ denote the equilibrium profits to MCO m, given all MCOs' networks and prices. Correspondingly, let $S^*_{im}(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}}), \forall m = 1, \ldots, M$ denote the equilibrium plan market shares to consumer i, given MCOs' networks and prices.

Given the pricing and patient enrollment process, the bargaining process is similar to the MCO agency model, but the threat points are different. In particular, when considering the disagreement point an MCO takes into account that if it does not reach an agreement with a hospital system it will lose some of its patients and readjust its premiums. Formally, the disagreement value from MCO m and hospital system s is $R^*_m(N_m \setminus J_s, N_{-m}, \vec{p_m}, \vec{p_{-m}})$, noting that the definition of R^* accounts for the equilibrium premium response.

Similarly, when considering a disagreement with an MCO, a hospital system considers that it will recapture some the patients from that MCO because of the spill of patients to other MCOs. To account for this, we redefine normalized quantities (from its earlier definition in the agency model in (8)) as

$$q_{mj}(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}}) = \sum_{i=1}^{I} \sum_{d=0}^{D} S^*_{im}(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}}) f_{id} w_d s_{ijd}(N_m, \vec{p_m}), \tag{14}$$

where (14) substitutes the endogenous plan choice S^* for the fixed plan assignment from (8). Note that S^* accounts for patient spill, similarly to R^*. Hospital system returns are now

$$\pi_s(N_1, \ldots, N_M, \vec{p_1}, \ldots, \vec{p_M}) = \sum_{m=1}^{M} \sum_{j \in J_s} q_{mj}(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}})[p_{mj} - mc_{mj}]. \tag{15}$$

The disagreement value from the hospital system is then $\pi_s(\vec{p_1}, \ldots, \vec{p_M}, N_1, \ldots, N_{m-1}, N_m \setminus J_s, N_{m+1}, \ldots, N_M)$.

Using these definitions, we rewrite the Nash bargaining problem (analogously to (10)) as:

$$\begin{aligned} NB^{m,s}(p_{mj_{j \in J_s}} | \vec{p_{m,-s}}) = \Big(\sum_{j \in J_s} & \pi_s(N_1, \ldots, N_M, \vec{p_1}, \ldots, \vec{p_M}) \\ & - \pi_s(\vec{p_1}, \ldots, \vec{p_M}, N_1, \ldots, N_{m-1}, N_m \setminus J_s, N_{m+1}, \ldots, N_M) \Big)^{b_{s(m)}} \\ & \Big(R^*_m(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}}) - R^*_m(N_m \setminus J_s, N_{-m}, \vec{p_m}, \vec{p_{-m}}) \Big)^{b_{m(s)}}. \end{aligned} \tag{16}$$

The price vector that solves the MCO Bertrand competition model is the vector of prices that jointly maximizes the Nash bargaining problems in (16) for each m and s.

2.4 Equilibrium properties of the bargaining stage

To understand more about the equilibrium properties of our model, we solve the first order conditions of the Nash bargaining problems. For ease of exposition we focus on the MCO agency model, and look at $\partial \log NB^{m,s} / \partial p_{mj} = 0$. For brevity, we omit the '*' for the rest of this subsection, even though all prices are evaluated at the optimum, and obtain:

$$b_{s(m)}\frac{q_{mj}+\sum_{k\in J_s}\frac{\partial q_{mk}}{\partial p_{mj}}[p_{mk}-mc_{mk}]}{\sum_{k\in J_s}q_{mk}[p_{mk}-mc_{mk}]}=-b_{m(s)}\underbrace{\frac{\overbrace{\frac{\partial V_m}{\partial p_{mj}}}^{A}}{V_m(N_m,\vec{p_m})-V_m(N_m\setminus J_s,\vec{p_m})}}_{B}. \tag{17}$$

The assumption of constant marginal costs implies that the FOCs (17) are separable across MCOs.

We rearrange the joint system of $\#(J_s)$ first order conditions from (17) to write

$$\vec{q}+\Omega(\vec{p}-\vec{mc})=-\Lambda(\vec{p}-\vec{mc}) \tag{18}$$

where Ω and Λ are both $\#(J_s)\times\#(J_s)$ size matrices, with elements $\Omega(j,k)=\frac{\partial q_{mk}}{\partial p_{mj}}$ and $\Lambda(j,k)=\frac{b_{m(s)}}{b_{s(m)}}\frac{A}{B}q_{mk}$. Solving for the equilibrium prices yields

$$\vec{p}=\vec{mc}-(\Omega+\Lambda)^{-1}\vec{q}, \tag{19}$$

where $\vec{p}$, $\vec{mc}$ and $\vec{q}$ denote the price, marginal cost and adjusted quantity vectors respectively for hospital system s and MCO m. Equation (19), which characterizes the equilibrium prices, would have a form identical to standard pricing games were it not for the inclusion of Λ. One case where $\Lambda=0$ – and hence there is differentiated products Bertrand pricing with individual prices for each MCO – is where hospitals have all the bargaining weight, $b_{m(s)}=0,\forall s$.

Importantly, (19) shows that, as with Bertrand competition models, we can back out implied marginal costs for the bargaining model as a closed-form function of prices, quantities and derivatives, given MCO and patient incentives. Using this insight, (7) and (19) together form the basis of our estimation.

We now show some intuition for the forces at work in the model.

The impact of price on MCO surplus. In order to understand how equilibrium prices are impacted by various factors, we need to develop the A expression from equation (17). We provide this derivation in Appendix A. We focus here on the case where $\tau=1$ (so that MCOs value consumer surplus equally to dollar costs), in which case A is

$$\frac{\partial V_m}{\partial p_{mj}} = -q_{mj} - \alpha \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\}(1 - c_{id}) c_{id} w_{id}^2 f_{id} s_{ijd} \left(\sum_{k \in N_m} p_{mk} s_{ikd} - p_{mj} \right). \quad (20)$$

The first term, $-q_{mj}$, captures the standard effect: higher prices reduce patients' expected utility. The second term accounts for the effect of consumer choices on payments from MCOs to hospitals. As the price of hospital j rises, consumers will switch to cheaper hospitals. This term can be either positive or negative, depending on whether hospital j is cheaper or more expensive than the share-weighted price of other hospitals; the difference is reflected in the expression in the large parentheses.

In our model, as long as coinsurance rates are strictly between zero and one, MCOs use prices to steer patients towards cheaper hospitals, and this will influence equilibrium pricing. To see this, consider a hospital system with two hospitals, one low cost and one high cost, that are otherwise equal. The MCO/hospital system pair will maximize joint surplus by having a higher relative price on the high-cost hospital, as this will steer patients to the low-cost hospital. At coinsurance rates near one, i.e., no insurance, this effect disappears, because patients bear most of the cost and hence the MCO has no incentive to steer to low-cost hospitals beyond patients' preferences. Interestingly, at coinsurance rates near zero (full insurance) this effect also disappears but for a different reason: since the patient bears no expense, the MCO cannot use price to impact hospital choice.

The effect of bargaining on equilibrium prices. Note from equation (19) that price-cost margins from our model have an identical formula to those that would arise if hospitals set prices to patients, and patients chose hospitals using our choice model, but with $\Omega + \Lambda$ instead of Ω. Since Ω is the matrix of actual price sensitivities, we define the *effective price sensitivity* to be $\Omega + \Lambda$. For the special case of a single-hospital system, we can write

$$p_{mj} - mc_{mj} = -q_{mj} \left(\frac{\partial q_{mj}}{\partial p_{mj}} + q_{mj} \frac{b_{m(j)}}{b_{j(m)}} \frac{A}{B} \right)^{-1} \quad (21)$$

so that (the scalar) Λ is equal to $q_{mj} \frac{b_{m(j)}}{b_{j(m)}} \frac{A}{B}$. The term B must be positive or the MCO would not gain surplus from including j in its network. From (20), the first term in A is the negative of quantity, which is negative. If the rest of A were 0, as would happen with identical hospitals, then Λ would be negative. In this case, MCO bargaining increases the effective price sensitivity, and hence lowers prices relative to differentiated products Bertrand competition.

More generally, with asymmetric hospitals and multi-hospital systems, the incentives are more complicated. There may be cases where MCO bargaining may not uniformly lower prices, notably if cost differences across hospitals are large and hence where it is important to steer patients to low-cost hospitals. However, we still generally expect that MCO bargaining lowers prices relative to differentiated products Bertrand competition.

The impact of mergers on prices. Consider now the impact of mergers on prices. Similarly to Bertrand competition, negotiated prices also result in an upward pricing pressure from mergers. For example, as two separate hospitals merge, by raising the price of one of the hospitals some consumers are diverted to the other hospital. Pre-merger these were considered lost profits, post-merger these are captured. This creates an incentive to raise prices relative to the pre-merger prices. However, the impact of a merger in a bargaining model will be different than under Bertrand competition. To see this, note that with Bertrand competition, a merger only changes the cross-price effects. With bargaining, the term B increases with a merger as B is the joint value of the system. Moreover, since B enters into the effective own-price elasticity in (21), with bargaining, the effective own- and cross-price sensitivities both change from a merger. However, the cross-price terms change differently, and potentially less, than with Bertrand competition. Since these effects can be of opposite sign, the net effect of the merger relative to the Bertrand prediction is ambiguous.

Another point to note is that in Bertrand competition, a merger between two hospitals in distinct markets without any patient overlap will not change the pricing incentives and can affect prices only through changes in costs. Yet, if these two distinct markets are served by the same MCO, then this merger will likely change the effective price sensitivity and hence have an impact on price. As an example, an MCO serving two separate markets without overlap and with one hospital each might be willing to trade off a slightly higher price in one market with a slightly lower price in the other. If the hospitals merge into a single system the MCO can negotiate this tradeoff, but cannot do that without a merger. If, for instance, the markets are identical except that one hospital is higher cost, the bargain with the merged system would increase the price for this hospital and decrease it for the lower-cost hospital.

Zero coinsurance rates and the relation to Capps et al. (2003). Now consider the special case of zero coinsurance rates. In this case, prices cannot be used to steer patients, and hence the marginal value to the hospital of a price increase is q_j, while the marginal value to the MCO is $-q_j$. Because a price increase here is effectively just a transfer from the MCO to the hospital system, individual hospital prices within a system do not matter. The FOC for any m and $j, j \in J_s$ then reduces to:

$$\sum_{k \in J_s} q_{mk}[p_{mk} - mc_{mk}] = \frac{b_{s(m)}}{b_{m(s)}} \left[V_m(N_m, \vec{p_m}) - V_m(N_m \setminus J_s, \vec{p_m}) \right]. \tag{22}$$

Hence, prices will adjust so that system revenues are proportional to the value that the system brings to the MCO. Because the prices of systems other than s enter into the right hand side of (22) through V_m, (22) still results in an interdependent system of equations. However, these equations form a linear system and hence we can solve for the equilibrium price vector for all systems in closed form with a matrix inverse (see Brand, 2013).

There is also a large similarity between our model with zero coinsurance and Capps et al. (2003)'s empirical specification of hospital system profits. Using our notation, Capps et al. argue that hospital system profits from an MCO can be expressed as:

$$\sum_{k \in J_s} q_{mk}[p_{mk} - mc_{mk}] = \frac{b_{s(m)}}{b_{m(s)}} \sum_{i=1}^{I} 1\{m(i) = m\} \frac{1}{\alpha} \left[W_i(N_m, \vec{p_m}) - W_i(N_m \setminus J_s, \vec{p_m}) \right], \tag{23}$$

which is similar to equation (22) except that the right side has willingness to pay rather than the sum of willingness to pay and MCO costs.[14] The Capps et al. formula in (23) would yield the same price as our model with zero coinsurance if hospitals obtained a lump-sum payment for treating patients, with the MCO then paying all the marginal costs of their treatment.

3 Econometrics

3.1 Data

We use data from Northern Virginia to simulate the effects of a merger that was proposed in this area. Our primary data come from two sources: administrative claims data provided by four large MCOs serving Northern Virginia (payor data) and inpatient discharge data

[14]See also Lewis and Pflum (2011) for a similar argument.

from Virginia Health Information. Both datasets span the years 2003 through 2006. These data are supplemented with information on hospital characteristics provided by the *American Hospital Association (AHA) Guide*.

A longstanding challenge in the analysis of hospital markets is the difficulty of acquiring actual transaction-level prices for each hospital-payor pair in the market. The administrative claims data are at the transactions level and contain most of the information that the MCO uses to process the appropriate payment to a hospital for a given patient encounter. In particular, the claims data contain demographic characteristics, diagnosis, procedure performed, diagnosis related group (DRG), and the actual amount paid to the hospital for each claim. There are often multiple claims per inpatient stay and thus the data must be aggregated to the inpatient episode level. We group claims together into a single admission based on the date of service, member ID, and hospital identifier. The claims often have missing DRG information. To address this issue, we use DRG grouper software from 3M to assign the appropriate DRG code to each admission.

Using the claims data, we construct base prices, p_{mjt}, for each hospital-payor-year triple. We use the DRG weight, published by the Center for Medicare and Medicaid Services each year, as the disease weight w_{id}. DRG weights are a measure of the mean resource usage by diagnosis and are the primary basis for Medicare inpatient payments to hospitals. Our use here is appropriate if the relative resource utilization for Medicare patients across DRGs is similar to that of commercial patients. We regress the total amount paid divided by DRG weight on gender, age and hospital dummies, separately for each payor and year. We then create the base price for each hospital as the mean of the fitted regression values using all observations for the payor and year.[15] Our price regressions explain a large part of the within payor/year variation in prices: the R^2 values across the 16 regressions have an (unweighted) mean of 0.41. Our model also relies on the prices for the outside option, which is treatment at a Virginia hospital outside our geographic area. For each MCO m, we let the outside option price p_{m0} be the unweighted mean of the base price vector $\vec{p_m}$.

An alternative method of constructing prices would be to directly use the contracts between hospitals and MCOs. However, the complexity of these contracts resulted in difficulties in constructing apples-to-apples prices across MCOs and hospitals. As an example, we exam-

[15]We have also explored alternative approaches to calculating prices including using amount paid as the dependent variable with the addition of DRG dummy variables as regressors. The quantitative implications of our estimates are robust to these different price construction methodologies.

ined one hospital in our data, which had (1) contracts with a fixed payment for each DRG; (2) per-diem contracts with fixed daily rates for medical, surgical and intensive care patients; (3) contracts with a set discount off of charges; and (4) a hybrid of the above, with switching between reimbursement regimes based on the total charges. To avoid having to deal with a myriad of contracts, we use the claims data to formulate the price measures as described above.

The claims data also contain information on the amount of the bill the patient paid out-of-pocket. This information allows us to construct patient-specific out-of-pocket coinsurance rates. Different insurers report coinsurance rates differently on the claims. In order to provide a standardized coinsurance measure across patients and MCOs, we formulate an expected coinsurance rate. We do this by first formulating a coinsurance amount which is the out-of-pocket expenditure net of deductibles and co-payments divided by the allowed amount. The allowed amount is the expected total payment the hospital is receiving for providing services to a given MCO patient.[16] The resulting coinsurance variable is censored at zero. Then, separately for each MCO, we estimate a tobit model of coinsurance where the explanatory variables are age, female indicator, age×female, DRG weight, age×DRG weight and female×DRG weight. We then create the expected coinsurance rate for each patient as the predicted values from this regression. In our coinsurance regressions, the percent of observations censored at 0 ranges from 31% to 98% across payors, reflecting variations in coinsurance practices across MCOs. The parameters generally indicate that the coinsurance rate is decreasing in age, higher for women, and decreasing in DRG weight.[17]

The Virginia discharge data contain much of the same information as the claims data but, in general, the demographic, patient ZIP code, and diagnoses fields are more accurate, and an observation in these data is at the (appropriate) inpatient admission level. The discharge data also contain more demographic information (e.g., race), and the identity of the payor, and are a complete census of all discharges at the hospital.

For these reasons, we use the discharge data to estimate the patient choice model. We limit our sample to general acute care inpatients whose payor is one of the four MCOs in our payor data and who reside in Northern Virginia, defined as Virginia Health Planning District

[16]Some MCOs do not distinguish between deductibles and copayments. For these MCOs, we identify copayments by treating expenditures of an even dollar amount (e.g., 25, 30, 50, 60, 70, 80, 90, 100, 125, 135, 140, 150, etc.) as a deductible (implying no variation in out-of-pocket expenditure across the hospitals) and coding the coinsurance amount in that case as 0.

[17]These parsimonious tobit regressions explain the data reasonably well. The mean of the absolute value of the prediction errors normalized by the mean coinsurance rate range from 0.90 to 1.14.

(HPD) 8 plus Fauquier County.[18] We exclude patients transferred to another general acute care hospital (to avoid double counting); patients over 64 years of age (to avoid Medicare Advantage and supplemental insurance patients); and newborn discharges (treating instead the mother and newborn as a single choice). We restrict our sample to patients discharged at a hospital in Virginia. The outside choice, $j = 0$, consists of people in this area who were treated at a hospital in Virginia other than one in our sample.[19]

We obtain the following hospital characteristics from the *AHA Guide* of the relevant year: staffed beds, residents and interns per bed, and indicators for FP ownership, teaching hospital status, and the presence of a cardiac catheterization laboratory, MRI, and neonatal intensive care unit. We compute the driving time from the patient's zip code centroid to the hospital using information from MapQuest.

3.2 Estimation and identification of patient choice stage

We estimate the patient choice model by maximum likelihood using the discharge data augmented with price and coinsurance information from the payor data. The model includes hospital-year fixed effects and interactions of hospital fixed effects with patient disease weight.

Since we include hospital-year fixed effects, all identification comes from variation in choices of a hospital within hospital-year groups. Thus, for instance, our coefficient on distance is identified by the extent to which patients who live nearer a given hospital choose that hospital relative to patients who live further away in the same year choose that hospital. Note that different coinsurance rates across MCOs imply different out-of-pocket prices. Thus, our model will identify α from the variation within a hospital-year in choices, based on different coinsurance rates and different negotiated prices across payors.

3.3 Estimation and identification of MCO agency model

We estimate the remaining parameters of the MCO agency model, namely b, the bargaining weights, γ, the cost fixed effects, and τ, the weight MCOs put on the WTP measure by imposing the bargaining model. Our estimation conditions on the set of in-network hospitals

[18]HPD8 is defined as the counties of Arlington, Fairfax, Loudoun and Prince William; the cities of Alexandria, Fairfax, Falls Church, Manassas and Manassas Park; and the towns of Dumfries, Herndon, Leesburg, Purcellville and Vienna.

[19]We do not have data from Virginia residents who sought treatment out-of-state, for instance in Maryland or Washington, DC, but believe this number is small.

and treats the negotiated prices as the endogenous variable. Combining equations (19) and (7) we define the econometric error as

$$\vec{\varepsilon}(b,\gamma,\tau) = -\gamma\vec{v} + mc(b,\tau) = -\gamma\vec{v} + \vec{p} + (\Omega + \Lambda(b,\tau))^{-1}\vec{q}, \tag{24}$$

where (24) now makes explicit the points at which the structural parameters enter. We estimate the remaining parameters with a GMM estimator based on the moment condition that $E[\varepsilon_{mj}(b,\gamma,\tau)|Z_{mj}] = 0$, where Z_{mj} is a vector of (assumed) exogenous variables. Recall that Ω and Λ are functions of equilibrium price (which depends on ε) and thus are endogenous.

Our estimation depends on exogenous variables Z_{mj}. We include all the cost fixed effects v_{mj} in Z_{mj}. In specifications that include variation in bargaining weights, we include indicators for the entities covered by each bargaining parameter. Finally, we include four other exogenous variables in the "instrument" set: predicted willingness-to-pay for the hospital, predicted willingness-to-pay for the system, predicted willingness-to-pay per enrollee for each MCO, and predicted total hospital quantity, where these values are predicted using the overall mean price. From our model, price is endogenous in the first-stage bargaining model because it is chosen as part of a bargaining process where the marginal cost shock ε is observed. By construction, these four exogenous variables will not be correlated with ε but will correlate with price, implying that they will be helpful in identifying the effect of price.

Our bargaining model must identify τ, b, and γ. Essentially, τ is identified by the extent to which MCOs value consumer surplus from hospital choice relative to payments to hospitals, which then is reflected in their negotiated equilibrium prices. The four willingness-to-pay "instruments" are (assumed exogenous) demand shifters that provide variation in enrollees' characteristics (notably location, disease severity, and coinsurance rates) and from this in expected equilibrium prices. The orthogonality condition between them and ε will help identify τ by imposing the implications of the model as to equilibrium prices. The estimation of the γ parameters is essentially a linear instrumental variables regression conditional on recovering marginal costs. We believe that the bargaining weights have somewhat similar equilibrium implications to fixed effects and hence it would be empirically difficult to identify the b and γ parameters at the same level, e.g., MCO fixed effects for bargaining weight and for marginal costs. Hence, when we include MCO fixed effects for bargaining weights we do not include these fixed effects for marginal costs.

3.4 Calibration of MCO Bertrand competition model

To evaluate the implications of the Bertrand model, we need the values of the parameters from the plan choice equation (12), α_1 and α_2. In addition, we require knowledge of the exogenous variables that are not in the data: the ex-ante distribution of illness for each patient, the MCO customer service quality ξ_m and, as with the MCO agency model, MCO marginal costs mc_m. We estimate and calibrate these parameters in a number of different ways.

First, we calibrate the premium sensitivity parameter α_2, which is the disutility of spending an extra dollar on health insurance, using the premium sensitivity parameter reported by Ericson and Starc (2012). Ericson and Starc report a value of 2.271 and we divide this value by 1,200 to account for the fact that our model is at the annual level and measures premiums in dollars (they use monthly coverage and measure premiums in hundreds of dollars), obtaining $\alpha_2 = 0.0019$.

The parameter α_1 indicates how welfare should be scaled in the same premium equation where α_2 enters. We use $\alpha_1 = \frac{\tau\alpha_2}{\alpha}$ with the estimated τ (Table 5, Specification 1) and α (Table 3). Scaling by $\frac{\tau}{\alpha}$ provides the value in dollars (as in (6)), and multiplying by α_2 imposes the rationality assumption that a dollar is worth the same at both stages.

Unlike in the MCO agency model, we need to know the ex-ante distribution of illness for each patient at the point when the patient chooses a health plan.[20] We assume that each patient in our sample would, ex-ante, have obtained either her actual observed illness or illness 0. We take the ex-ante probability of obtaining her actual observed illness as 10.9% per year, which is the weighted average hospital discharge rate for individuals age 25-64.[21]

Next, we need to specify the ξ_m value for each MCO m. We take the total number of inpatient observations in our payor data to represent the relative market share of each MCO. We calculate the outside good MCO share as 14.3% based on a survey of employed Virginia residents who report not having health insurance coverage,[22] which allows us to compute the actual (and not relative) share. We then calculate $\xi_m = \log\left(\frac{\sum_i S_{im}}{\sum_i S_{i0}}\right)$. Finally, as we cannot estimate hospital marginal costs for this model, we use the estimated marginal costs estimates from our base MCO agency model specification (Table 5, Specification 1) for our

[20]In the MCO agency model, the estimating equations are unaffected by whether one patient has two illnesses or the two illnesses occur to two different patients, and by the fraction of enrollees having illness 0.

[21]Authors' calculation based on the National Hospital Discharge Survey, 2005, available at http://www.cdc.gov/nchs/data/series/sr_13/sr13_168.pdf.

[22]American Community Survey, 2005, available at https://www.census.gov/acs/www/.

computations here and set $b_{s(m)} = 0.5, \forall s, m$ as in this specification.

The equilibrium computation of the MCO Bertrand competition model is computationally intensive.[23] For this reason, our analysis here makes two simplifications. First, we set coinsurance $c_{id} = 0, \forall i, d$ when computing this model. Second, we compute the equilibrium for this model based on a small set of patient draws rather than using the universe of discharge data, as we do in our other equilibrium computations.

4 Results

4.1 Institutional setting: Inova/Prince William merger

We use the model to study the competitive interactions between hospitals and MCOs in Northern Virginia. In late 2006, Inova Health System, a health care system with hospitals solely in Northern Virginia, sought to acquire a not-for-profit institution that operated a single general acute-care hospital, Prince William Hospital (PWH). Inova operated a large tertiary hospital in Falls Church, Fairfax Hospital, with 884 licensed beds, which offered all major treatments from low acuity ones to high-end ones such as transplants. Inova also operated four, roughly similar community hospitals: Fair Oaks, Alexandria, Mount Vernon, and Loudoun Hospitals. Inova's previous acquisitions included Alexandria Hospital, in 1997 and Loudoun Hospital, in 2005. PWH had 180 licensed beds and was located in Manassas.

The Federal Trade Commission, with the Virginia Office of the Attorney General as co-plaintiff, challenged the acquisition in May, 2008. Subsequently, the parties abandoned the transaction.[24] The FTC alleged that the relevant geographic market consisted of all hospitals in Virginia Health Planning District 8 (HPD8) and Fauquier County. This geographic area included five other hospitals, although Northern Virginia Community Hospital closed in 2005. Of the remaining four, Fauquier, Potomac, and the Virginia Hospital Center are independent while Reston Hospital Center was owned by the HCA chain. The closest competitor to the Inova system was the Virginia Hospital Center.

The product market alleged by the FTC was general acute care inpatient services sold to MCOs. Given these market definitions, the market is highly concentrated. In its complaint the FTC calculated a pre-merger HHI (based on MCO revenues) of 5,635 and the post-

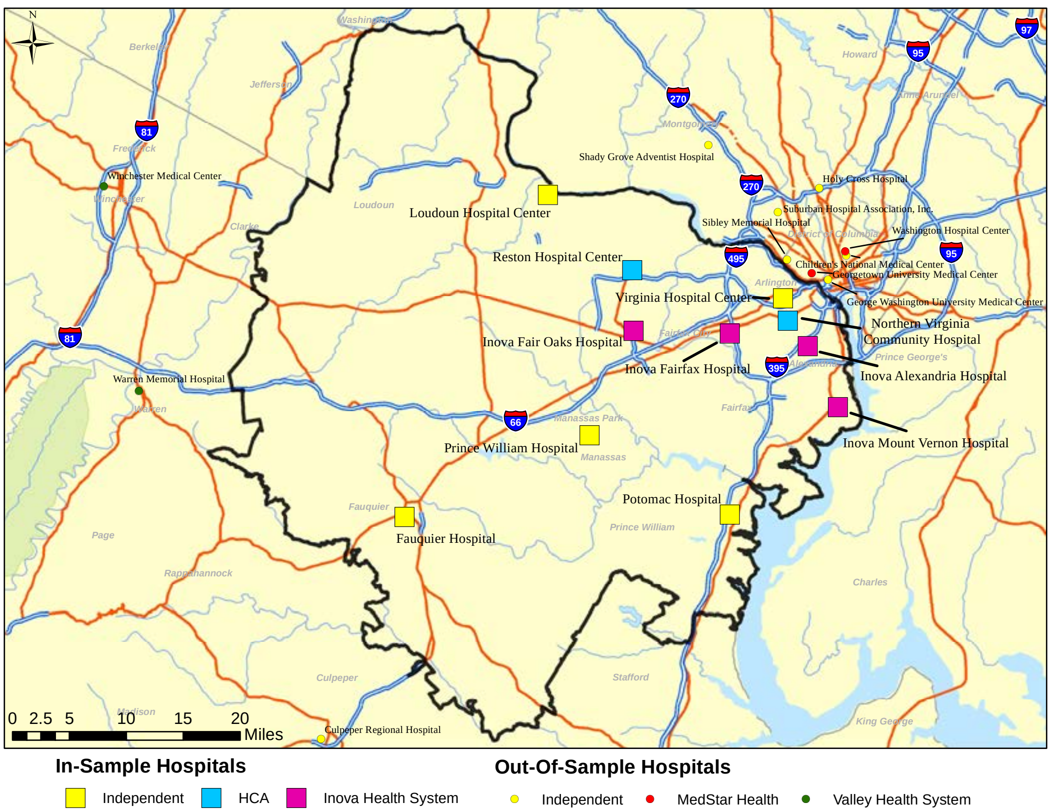
[23] A full derivation of the equilibrium FOCs is available from the authors upon request.

[24] PWH was later acquired by the Novant Health, a multi-hospital system based in North Carolina.

merger HHI of 6,174. The pre-merger and change in the HHI are well above the thresholds the antitrust agencies use for assessing the presumption of competitive harm from a merger.

Figure 1 presents a map of the locations of the hospitals in Northern Virginia as of 2003, the start of our sample. The heavy line defines the boundary of HPD8 and Fauquier County. The two closest hospitals to PWH are members of the Inova system – Fair Oaks and Fairfax – and, according to MapQuest, are 21 and 29 minutes drive times from PWH, respectively.

Figure 1: 2003 Northern Virginia hospital locations



All 11 hospitals in the market contracted with the four MCOs in our sample. The four MCOs in our sample represent 56% of private pay discharges in this market. None of these MCOs pay on a capitated basis.

4.2 Summary Statistics

Table 1 presents the mean base prices for the set of hospitals used in the analysis. There is significant variation in base prices across the hospitals prior to the merger. These differences do not reflect variation in the severity of diagnoses across hospitals as our construction of prices controls for disease complexity. The range between the highest and lowest hospital is 36% of the mean PWH price, which is in the middle of the price distribution.

Table 1 also presents other characteristics of the hospitals in HPD8 and Fauquier County. Hospitals are heterogeneous with respect to size, for-profit status and the degree of advanced services they provide. Seven of the eleven hospitals provided some level of neonatal intensive care services by the end of our sample, and most hospitals have cardiac catheterization laboratories that provide diagnostic and interventional cardiology services.

Table 1: Hospital characteristics

Hospital	Mean beds	Mean price $	Mean FP	Mean NICU	Mean cath lab
Prince William Hospital	170	10,273	0	1	0
Alexandria Hospital	318	9,757	0	1	1
Fair Oaks Hospital	182	9,799	0	0.5	1
Fairfax Hospital	833	11,881	0	1	1
Loudoun Hospital	155	11,565	0	0	1
Mount Vernon Hospital	237	12,112	0	0	1
Fauquier Hospital	86	13,270	0	0	0
N. VA Community Hosp.	164	9,545	1	0	1
Potomac Hospital	153	11,420	0	1	1
Reston Hospital Center	187	9,973	1	1	1
Virginia Hospital Center	334	9,545	0	0.5	1

Note: we report (unweighted) mean prices across year and payor. “FP” is an indicator for for-profit status, “Mean NICU” for the presence of a neonatal intensive care unit, and “Cath lab” for the presence of a cardiac catheterization lab that provides diagnostic and interventional cardiology services. The Mean NICU values of 0.5 reflect entry.

Source: AHA and authors’ analysis of MCO claims data.

Table 2 presents statistics by hospital for the sample of patients we use to estimate the hospital demand parameters. The patient sample is majority white at every hospital. Not surprisingly, there is significant variation in the mean DRG weight across hospitals. PWH’s mean DRG weight is 0.82 as reflective of its role as a community hospital. The patient-

Table 2: Patient sample

Hospital	Mean age	Share white	Mean DRG weight	Mean travel time	Mean coins. rate	Discharges Total	Discharges Share
Prince William Hospital	36.1	0.73	0.82	13.06	0.032	9,681	0.066
Alexandria Hospital	39.3	0.62	0.92	12.78	0.025	15,622	0.107
Fair Oaks Hospital	37.7	0.54	0.94	17.75	0.023	17,073	0.117
Fairfax Hospital	35.8	0.58	1.20	18.97	0.023	46,428	0.319
Loudoun Hospital	37.2	0.74	0.81	15.54	0.023	10,441	0.072
Mount Vernon Hospital	50.3	0.66	1.38	16.18	0.022	3,749	0.026
Fauquier Hospital	40.5	0.90	0.92	15.29	0.033	3,111	0.021
N. VA Comm. Hosp.	47.2	0.48	1.43	16.02	0.016	531	0.004
Potomac Hospital	37.5	0.60	0.93	9.62	0.024	8,737	0.060
Reston Hospital Center	36.8	0.69	0.90	15.35	0.021	16,007	0.110
Virginia Hospital Center	40.8	0.59	0.98	15.88	0.017	12,246	0.084
Outside option	39.3	0.82	1.39	0.00	0.029	2,113	0.014
All Inova	37.5	0.59	1.09	17.37	0.024	85,540	0.641
All others	38.1	0.68	0.92	13.74	0.023	60,199	0.359

Source: Authors' analysis of VHI discharge data and MCO claims data.

weighted mean DRG weight across all of Inova's hospitals in 1.09 with its Fairfax and Mt. Vernon facilities treating patients with the highest resource intensity. About 1.4% of patients in our sample choose care at a Virginia hospital that is not in our sample, a figure that ranges from 0.9% to 2.3% across the four MCOs in our sample. Patients choosing the outside option had a high mean DRG weight of 1.39. Not reported in the table, the five most frequent choices that constitute the outside good are two large tertiary care centers (Valley Health Winchester Medical Center in Winchester and the University of Virginia Health System in Charlottesville) and three psychiatric specialty hospitals.[25]

Table 2 also reveals heterogeneity in travel times. Notably, patients travel the furthest to be admitted at Inova Fairfax hospital, the largest hospital and only tertiary care hospital in our sample. Interestingly, Inova Fairfax also has the lowest mean patient age reflecting the popularity of its obstetrics program. Coinsurance rates potentially play an important role in our model, and Table 2 presents mean coinsurance rates by hospital. The average coinsurance rate is low but meaningfully larger than zero. Average coinsurance rates across

[25]Our sample excludes discharges with a psychiatric major diagnostic category however a small number of psychiatric patients have multiple diagnoses with the primary diagnosis not being psychiatric.

hospitals range from 1.7 to 3.3% with a mean of 2.4%, which aligns with national data from three of the largest insurers.[26] There is significant variation across payors in the use of coinsurance which helps in our identification of α, as average coinsurance rates vary between 0.2% and 4.4% across MCOs in our data.

Finally, Table 2 provides the shares by discharges among hospital systems in this area. Within this market, Inova has a dominant share, attracting 64% of the patients. PWH is the third largest hospital in the market with a 6.6% share. There is a large variation in the mean price that the different MCOs pay hospitals which is a challenge for our model to explain. The highest-paying MCO pays hospitals, on average, over 100% more than the lowest paying MCO. While this variation is high, large variations across hospitals and payors are not uncommon (Ginsburg, 2010). In our framework, there are three possible reasons for this variation, differences in bargaining weight, differential costs of treating patients across MCOs, and differences in enrollee geographic distributions, characteristics, and preferences.

4.3 Patient choice estimates

Table 3 presents coefficient estimates from the model of hospital choice. In addition to the negotiated price, the explanatory variables include hospital/year fixed effects, hospital indicators interacted with the patient's DRG weight, and a rich set of interactions that capture dimensions of hospital and patient heterogeneity that affect hospital choice.

Consistent with the large literature on hospital choice, we find that patients are very sensitive to travel times. The willingness to travel is increasing in the DRG weight and decreasing in age. An increase in travel time of 5 minutes reduces each hospital's share between 17 and 41%. The parameter estimates imply that increasing the travel time to all hospitals by one minute reduces consumer surplus by approximately \$167.[27]

The parameter on out-of-pocket price is negative and significant indicating that, in fact, inpatient prices do play a role in admissions decisions.[28] However, in contrast to travel time,

[26]According to analysis based on claims data for over 45 million covered lives from the Health Care Cost Institute (HCCI), the average total out-of-pocket expenditures is approximately 4.8%. HCCI's figure includes deductibles and co-payments which we have removed from our coinsurance variable and thus the two estimates are well aligned. See HCCI 2012 Health Care Cost and Utilization Report available at http://www.healthcostinstitute.org/2012report for details.

[27]The patient's price sensitivity to travel likely reflects the fact that they will be visited by members of their social support network who may make several trips per day.

[28]Ho and Pakes (2011) using data from California, also find that the patient's choice of hospital is influenced by the prices paid by the MCOs.

Table 3: Multinomial logit demand estimates

Variable	Coefficient	Standard error
Base price × weight × coinsurance	-0.0008^{**}	(0.0001)
Travel time	-0.1150^{**}	(0.0026)
Travel time squared	-0.0002^{**}	(0.0000)
Closest	0.2845^{**}	(0.0114)
Travel time × beds / 100	-0.0118^{**}	(0.0008)
Travel time × age / 100	-0.0441^{**}	(0.0023)
Travel time × FP	0.0157^{**}	(0.0011)
Travel time × teach	0.0280^{**}	(0.0010)
Travel time × residents/beds	0.0006^{**}	(0.0000)
Travel time × income / 1000	0.0002^{**}	(0.0000)
Travel time × male	-0.0151^{**}	(0.0007)
Travel time × age 60+	-0.0017	(0.0013)
Travel time × weight / 1000	11.4723^{**}	(0.4125)
Cardiac major diagnostic class × cath lab	0.2036^{**}	(0.0409)
Obstetric major diagnostic class × NICU	0.6187^{**}	(0.0170)
Nerv, circ, musc major diagnostic classes × MRI	-0.1409^{**}	(0.0460)

Note: ** denotes significance at 1% level. Specification also includes hospital-year interactions and hospital dummies interacted with disease weight. Pseudo R^2=0.445, N=1,710,801.

Table 4: Mean estimated 2006 demand elasticities for selected hospitals

Hospital	(1) PW	(2) Fairfax	(3) Reston	(4) Loudoun	(5) Fauquier
1. Prince William	−0.125	0.052	0.012	0.004	0.012
2. Inova Fairfax	0.011	−0.141	0.018	0.006	0.004
3. HCA Reston	0.008	0.055	−0.149	0.022	0.002
4. Inova Loudoun	0.004	0.032	0.037	−0.098	0.001
5. Fauquier	0.026	0.041	0.006	0.002	−0.153
6. Outside option	0.025	0.090	0.022	0.023	0.050

Note: Elasticity is $\frac{\partial s_j}{\partial p_k}\frac{p_k}{s_j}$ where j denotes row and k denotes column) patients are relatively insensitive to the gross price paid from the MCO to the hospital, largely because of the low coinsurance rates that they face. Table 4 presents the estimated price elasticities of demand for selected hospitals. Own-price elasticities range from -0.098 to -0.153 across the five reported hospitals. The fact that our elasticity estimates are substantially less than 1 imply that under Bertrand competition the observed prices could only be rationalized with negative marginal costs, even for stand-alone hospitals.

4.4 Bargaining model estimates

Table 5: Bargaining parameter estimates from MCO agency model

	Specification 1		Specification 2	
Parameter	Estimate	S.E.	Estimate	S.E.
MCO welfare weight (τ)	2.79	(2.87)	6.69	(5.53)
MCO 1 bargaining weight	0.5	–	0.52	(0.09)
MCOs 2 & 3 bargaining weight	0.5	–	1.00**	(7.77×10^{-10})
MCO 4 bargaining weight	0.5	–	0.76**	(0.09)
Cost parameters				
Prince William Hospital	8,635**	(3,009)	5,971**	(1,236)
Inova Alexandria	10,412*	(4,415)	6,487**	(1,905)
Inova Fairfax	10,786**	(3,765)	6,133**	(1,211)
Inova Fair Oaks	11,192**	(3,239)	6,970**	(2,352)
Inova Loudoun	12,014**	(3,188)	8,167**	(1,145)
Inova Mount Vernon	10,294*	(5,170)	4,658	(3,412)
Fauquier Hospital	14,553**	(3,390)	9,041**	(1,905)
No. VA Community Hosp.	10,086**	(2,413)	5,754**	(2,162)
Potomac Hospital	11,459**	(2,703)	7,653**	(902)
Reston Hospital Center	8,249**	(3,064)	5,756**	(1,607)
Virginia Hospital Center	7,993**	(2,139)	5,303**	(1,226)
MCO 2 cost	−9,043**	(2,831)	–	–
MCO 3 cost	−8,910**	(3,128)	–	–
MCO 4 cost	-4,476	(2,707)	–	–
Year 2004	1,130	(1,303)	1,414	(1,410)
Year 2005	1,808	(1,481)	1,737	(1,264)
Year 2006	1,908	(1,259)	2,459*	(1,077)

Note: ** denotes significance at 1% level and * at 5% level. Significance tests for bargaining parameters test the null of whether the parameter is different than 0.5. We report bootstrapped standard errors with data resampled at the payor/year/system level.

Table 5 presents the coefficient estimates and standard errors from the GMM MCO agency bargaining model estimation. We estimate two specifications. In Specification 1, we fix the bargaining weights to $b_{m(s)} = 0.5$ (which implies that $b_{s(m)} = 0.5$ also) and allow for marginal cost fixed effects at the hospital, MCO, and year levels. In Specification 2, we allow the bargaining parameters to vary across MCOs (lumping MCO 2 and 3 together) but omit the MCO cost fixed effects.[29] We bootstrap all standard errors at the payor/year/system level.

Focusing first on Specification 1, the point estimate on τ indicates that MCOs place over twice as much weight on enrollee welfare as on reimbursed costs, though the coefficient is not statistically significantly different from 0 or 1. A value of τ other than 1 may reflect employers placing a different weight on welfare than enrollees but may also be due to errors in measuring coinsurance rates or physician incentives to steer patients to low-price hospitals (see Dickstein, 2011). The hospital cost parameter estimates show a large variation in the implied costs across the MCOs reflecting variation in the data on mean hospital prices across the MCOs. The variation across hospitals given an MCO will help identify our bargaining parameters. There is also an increasing cost trend over time.

Turning to the results from Specification 2, here we estimate three different bargaining weights $b_{m(s)}$. We find significant variation in bargaining weights across MCOs, with all MCOs having more leverage than hospitals. Only MCO 1's bargaining parameter is not significantly different than 0.5. This variation is driven by the same price variation that generated the estimated cost heterogeneity in Specification 1. The estimates from Specification 2 imply that MCOs 2 and 3 have a bargaining weight of essentially 1, so that hospitals have a bargaining weight of 0. Thus, MCOs 2 and 3 are able to drive hospital surpluses down to their reservation values. Because our parameter estimates are identified from the differences in prices across hospitals, we believe that they allow us to perform credible counterfactuals that reflect reasonable estimates of what would happen relative to the baseline. We consider Specification 1 to be more salient for two reasons: (1) it is consistent with the interpretation of bargaining weights as relative discount factors (Rubinstein, 1982; Collard-Wexler et al., 2013) which do not vary across hospital systems and MCOs; and (2) the results from Specification 2 that all hospital prices for two MCOs are equal to their reservation values implies that hospital mergers (even to monopoly) will have little impact on prices, a finding that is not consistent with the empirical hospital merger literature (Gaynor and Town, 2012).

[29] We lump MCOs 2 and 3 together because they have similar characteristics and negotiated similar prices with the hospitals.

Table 6: Simulation results from MCO Bertrand competition model

Variable	Mean value in MCO Bertrand competition model	Base value Mean value in MCO agency model
Hospital prices	\$11,088	\$13,618
Hospital margin per patient	\$4,796	\$4,893
MCO premiums	\$1,706	–
MCO margin per enrollee	\$792	–
Consumer surplus	\$4,398	–
Health insurance take-up (%)	84.5	–

Note: hospital prices are patient-weighted base prices excluding the outside good, hospital margins are patient-weighted, MCO premiums and margins are enrollee-weighted, and consumer surplus is per capita.

We now turn to the MCO Bertrand competition model. For this model, we calibrate the parameters as described in Section 3.4. Table 6 provides the calibrated estimates from this model. Overall, the results are broadly similar to the MCO agency model, although hospital base prices are somewhat lower while per-patient margins are slightly lower.[30] MCO premiums are estimated at \$1,706 per year for hospitalization insurance, of which \$792 represents a margin over marginal cost. Ex-ante consumer surplus from having health insurance – and hence being able to use hospitals – is an average of \$4,398. The take-up rate of health insurance is 84.5%.

Table 7 lists the estimated (unweighted) mean 2006 Lerner index, $\frac{P-mc}{P}$, by hospital system. The mean Lerner indices range from 0.21 to 0.68, and are relatively high for both Inova and PWH. Importantly, Table 7 also presents the actual own-price elasticity,[31] effective price elasticities for both MCO objective functions, and own-price elasticity that would exist without insurance. We calculate effective price elasticities using the inverse elasticity rule $elast_{mj} = -(\frac{P-mc}{P})^{-1}$.

For PWH, the actual price elasticity is 0.12 while the effective price elasticity is much higher in both the MCO agency and Bertrand competition models. If patients faced the

[30]The relatively high margins reflect differential insurance take-up, where more severely ill patients disproportionately enroll with an MCO.

[31]To calculate an actual price elasticity for system s, we first calculate the derivative of system quantity with respect to each of its hospital's prices, $\sum_{k\in J_s} \frac{\partial s_k}{\partial p_j}$, and then approximate the derivative with respect to system price as the mean of these derivatives across member hospitals $j \in J_s$.

Table 7: Lerner indices, actual and effective price elasticities

System name	Lerner index (MCO agency model)	Actual own price elasticity	Effective own price elasticity (MCO agency model)	Effective own price elast. (MCO Bertrand model)	Own price elasticity without insurance
Prince William Hosp.	0.60	0.12	1.67	1.72	4.99
Inova Health System	0.43	0.07	2.33	2.15	3.13
Fauquier Hospital	0.21	0.15	4.84	6.75	5.66
HCA (Reston Hosp.)	0.45	0.15	2.20	2.05	7.45
Potomac Hospital	0.48	0.15	2.07	3.54	6.60
Virginia Hospital Ctr.	0.68	0.13	1.48	1.46	6.57

full cost of their treatment instead of having insurance, our first stage estimates imply that PWH's price elasticity would rise to 4.98. For Inova, the own-price elasticity is even lower than for PWH, at 0.07, because it is a large system, but the effective own-price elasticity is slightly higher than for PWH for both models.

Importantly, the effective price elasticities are consistent with profit maximization with positive marginal costs and similar for most of the hospitals across the two models. The effective price elasticities also lie in between actual price elasticities and price elasticities without insurance for most hospitals. It is well-understood that the risk-reduction component of insurance dampens consumer price responsiveness relative to having no insurance. In a Bertrand model, this will raise equilibrium prices. However, we find that MCO bargaining leverage serves to partially overcome this insurance moral hazard problem, driving equilibrium prices closer to what they would be in a world without health insurance.

5 Counterfactuals

5.1 Industry structure counterfactuals

We now use the estimates from both models to perform antitrust and health policy counterfactual experiments. This subsection evaluates the impact of counterfactual industry structures, focusing on the proposed Inova/PWH merger that the FTC successfully blocked in 2008. We perform the experiments from both the MCO agency (Specification 1 in Table

Table 8: Impact of counterfactual industry structures, MCO agency model

Counterfactual	System	%Δ Price	%Δ Quantity	%Δ Profits
1. Inova/PWH merger	Inova & PWH	3.1	−0.5	9.3
	Rival hospitals	3.6	1.2	12.0
	Change at Inova+PW relative to PW base	30.5	−4.9	91.5
2. Inova/PWH merger with separate bargaining	Inova & PWH	3.3	−0.5	8.8
	Rival hospitals	3.5	1.2	11.2
3. Loudoun demerger	Inova & Loudoun	−1.8	0.1	−4.7
	Rival hospitals	−1.6	−0.2	−4.7
	Change at Inova relative to Loudoun base	−14.7	0.8	−38.5
4. Breaking up Inova	All hospitals	−6.8	0.05	−18.9

Note: price changes are calculated using quantity weights. The price changes relative to PWH or Loudoun base reflect the total system revenue change divided by the base revenue of this hospital.

5) and Bertrand competition models. In addition to examining the proposed Inova/PWH merger, we also examine the impact of imposing separate bargaining in this merger; the de-merger of Loudoun Hospital from Inova; and breaking up the Inova system.[32]

We first analyze the counterfactual results for the MCO agency model, which are reported Table 8. Counterfactual 1 finds that the Inova / PWH merger leads to a significant increase in prices and profits for the new Inova system. The net quantity-weighted price increase is approximately 3.1% and the net increase in profits is 9.3%. Considering the relative size of PWH to the Inova system, a 3.1% price increase across the joint systems from this transaction is quite substantial, amounting to 30.5% of base PWH revenues. Patient volume at the merged system goes down only slightly, by 0.5%, reflecting both the fact that coinsurance rates are low (and hence that patient demand is inelastic) and the equilibrium increase in prices by rival hospitals. Not reported in the table, managed care surplus, which is weighted consumer surplus net of payments to hospitals, drops by approximately 27% from this merger.

In the Evanston Northwestern hospital merger case, the FTC imposed a remedy requir-

[32]For payors with very low coinsurance rates, we compute the no-coinsurance solution from Brand (2013) for this table, due to convergence difficulties. For other payors, we find prices that jointly set the vector of FOCs to 0. We have no proof of uniqueness of equilibrium except for the no-coinsurance solution, but we have not found any evidence of multiple equilibria.

ing the Evanston Northwestern system to negotiate separately with MCOs (with firewalls in place) from the newly acquired hospital, Highland Park Hospital.[33] We examine the implications of this type of policy by simulating a world where Inova acquires PWH and the PWH negotiator bargains with a firewall from the other Inova hospitals. We simulate this counterfactual by assuming that the disagreement values for PWH negotiations reflect the case where only PWH is excluded from the network, and analogously for the 'legacy-Inova' disagreement values.[34]

Even though the negotiations are separate, the PWH bargainer might internalize the incentives of the system, namely that if a high price discouraged patients from seeking care at PWH, some of them would still divert instead to other Inova hospitals which is beneficial for the parent organization. Counterfactual 2 imposes the Evanston Northwestern remedy and assumes that the negotiators recognize these true incentives faced by the system in their bargaining. We find that the conduct remedy performs similarly to the base merger outcomes, with a post-merger price increase of 3.3% and a managed care surplus loss of 27.8%.

The FTC in its Evanston decision hoped that this conduct remedy would re-inject competition into the market by reducing the leverage of the hospital that bargains separately; e.g., PWH could only threaten a small harm to the MCO from disagreement. However, this remedy also reduces the leverage of the MCO since if it offers an unacceptable contract to PWH, some of its but-for PWH patients would certainly go to other Inova hospitals. The increase in disagreement values on both sides implies that the impact of this remedy (relative to the outcome under the merger absent the remedy) is theoretically ambiguous. Empirically, separate negotiations do not appear to solve the problem of bargaining leverage by hospitals.

Counterfactual 3 examines the impact of Inova divesting Loudoun Hospital, which it acquired in 2005 without antitrust opposition. The counterfactual predictions tell a different story for the Inova/Loudoun demerger than the Inova/PWH merger. A divesture of Loudoun Hospital leads to a net reduction in price of 1.8% for the Inova system a reduction in profits of 4.7%, and an increase in managed care surplus by 13.5%. The price decrease translates into an approximate 14.7% price decrease relative to Loudoun's discharge share of the Inova system. The smaller price impact is consistent with the FTC challenging Inova's proposed Prince William acquisition but not its Loudoun acquisition. Finally, Counterfactual 4 simulates

[33] *In the Matter of Evanston Northwestern Healthcare Corporation, Docket No. 9315, Opinion of the Commissioners*, 2008.

[34] Appendix B provides the first order conditions for this case.

the impact of breaking up the entire Inova system into separately-owned hospitals. This breakup leads to a 7% market-wide decline in prices and a 54.8% increase in consumer surplus, suggesting that the creation of large hospital systems during the 1990s led to higher hospital prices.

Table 9 presents the implications of the proposed Inova/PWH merger for the MCO Bertrand competition model and also displays the analogous results from the MCO agency model for comparison purposes. The MCO Bertrand competition model generates larger price increases from the Inova/PWH merger for the merging parties than does the MCO agency model: 7.2% instead of 3.1%. Premiums rise by 3.4% following the merger. The combined effect leads to significantly lower consumer surplus (4.4%) and a decrease in insurance take-up of 1.6%. The effect of a hospital merger depends on the curvature of the objective functions. In the MCO Bertrand competition model the MCO objective function is relatively more concave and therefore the merger effects are larger.

Table 9: Mean Inova/PWH Merger effects across MCO objective functions

	MCO Bertrand competition model	MCO agency model
Inova/PWH prices	7.2%	3.1%
Other hospitals prices	2.2%	3.6%
Inova/PWH margin per patient	16.9%	9.8%
Other hospitals margin per patient	6.6%	10.7%
MCO premiums	3.4%	–
MCO margin per enrollee	1.0%	–
Consumer surplus	-4.4%	–
Health insurance take-up	-1.6%	–

Note: hospital prices are patient-weighted base prices excluding the outside good, hospital margins are patient-weighted, MCO premiums are enrollee-weighted, MCO margins are enrollee-weighted, and consumer surplus is per capita.

We also examine the robustness of our MCO agency model results to different specifications. First, we analyze the impact of Inova/PW merger using the estimates from Table 5, Specification 2 for the two MCOs with bargaining weights less than one. We find that our base Specification 1 generates a price increase of 1.7% for Inova and Prince William from the merger for these two payors, while Specification 2 generates a price increase of 4.2% for these payors. Next, we examine the polar case of $b_{m(s)} = 0, \forall m, s$. As we showed in Section 2.4, this case corresponds to Bertrand competition. We estimated marginal costs here that range from $-$1.27 million to $-$1,328. We performed the Inova/PWH merger counterfactual with these estimates. For three MCOs (for one MCO the simulation did not converge), Inova and Prince William prices went up a weighted 75% following the merger, while other hospital prices increased 58%. The large increases here are not credible and stem from the inaccurate marginal cost estimates. For the other polar case of $b_{m(s)} = 1$, as each MCO makes a take-it-or-leave-it offer to each hospital system, it would offer prices exactly equal to marginal costs before and after the merger, generating results that we view as implausible.

5.2 Coinsurance counterfactuals

The welfare consequences of the moral hazard impact of health insurance has long tradition in economics (Pauly, 1968). Less studied is the indirect impact of health insurance cost-sharing arrangements on equilibrium provider prices. By covering out-of-pocket expenses, health insurance dampens the incentive of consumers to respond to differential prices in selecting healthcare providers which, as we discussed above, likely affects equilibrium prices. Our model allows us to examine the equilibrium impact of coinsurance on the insurer's cost of hospital care.

Table 10: Impact of counterfactual coinsurance levels

Counterfactual	System	%Δ Price	%Δ Quantity	%Δ Profits
1. No coinsurance	All hospitals	3.7	0.01	9.8
2. Coinsurance 10 times current	All hospitals	-16.1	0.9	-0.4
3. Inova/PWH merger, no coinsurance	Inova & PWH	2.9	0	7.4
	Rival hospitals	1.3	0	3.9

Note: price changes are calculated using prices weighted by quantity.

Table 10 presents these results. Counterfactual 1 examines the extreme case of insurance policies that cover all inpatient care expenses at the margin. We find that quantity-weighted prices would be 3.7% higher than in the base case if coinsurance rates were zero. The reason for the price increase is straightforward. Patient demand would go from having a moderate elasticity to no elasticity at all. Thus, these results indicate that both patient coinsurance and MCO bargaining leverage play a role in constraining prices in this market.

We also consider higher coinsurance rates in Counterfactual 2. Estimates of the optimal health insurance design in the presence of moral hazard indicate that coinsurance rates should be approximately 25% (see Manning and Marquis, 1996).[35] In this counterfactual, we consider the impact of a tenfold increase in the coinsurance rates on the equilibrium, which yields roughly equivalent coinsurance rates to the Manning and Marquis ones. The increase in cost sharing has a large impact, with quantity-weighted prices dropping by 16% and quantity increasing slightly, relative to the base case. This counterfactual suggests that analyses of the optimal benefit design of insurance contracts, which do not consider the additional impact of increasing cost sharing on the price of health care, likely understate the gains from increased coinsurance rates.

Finally, Counterfactual 3 considers the interaction of no coinsurance and the Inova/PWH merger. It is hypothesized that increasing patient cost sharing can partially undo the price impact of hospital mergers. Theoretically, however, the steering effect of coinsurance can either enhance or mitigate the increase in bargaining leverage from merger. We explore these possibilities in the context of our model by calculating the predicted impact of the Inova/PWH merger when patient cost sharing is zero. We find a lower increase from the merger at Inova/PWH, of 2.9% instead of 3.1%, than when we allow for positive coinsurance rates. In other words, the steering effect from coinsurance enhances the effect of the merger.

6 Conclusion

Many bilateral, business-to-business transactions are between oligopoly firms negotiating prices over a bundle of imperfectly substitutable goods. In this paper we develop a model of the price negotiations game between managed care organizations and hospitals. We show that standard oligopoly models will generally not accurately capture the pricing behavior under these bargaining scenarios. We then develop a GMM estimator of the negotiation process and estimate the parameters of the model using detailed managed care claims and patient discharge data from Northern Virginia.

We find that patient demand is quite inelastic – with own-price elasticities of about 0.12 on average – due to the fact that patients typically only pay out-of-pocket 2 to 3 percent of the cost of their hospital care at the margin. Consistent with our theoretical model, prices

[35] Manning and Marquis (1996) optimal insurance contract also includes a $25,000 (in 1995 dollars) total out-of-pocket maximum.

are significantly constrained by MCO bargaining leverage. Prices under MCO bargaining are still much higher than they would be in the absence of insurance. Moreover, they are similar across two different plausible objective functions for MCOs, one where they act as agents of employers through long-run contracts, and the other where they compete for enrollees à la Bertrand.

We find that the proposed merger between Inova hospital system and Prince William Hospital, which the FTC challenged, would have significantly raised prices. The market we study is more concentrated than the average market but not an outlier,[36] implying that hospital mergers in other MSAs may also cause price increases and hence be cause for antitrust concern. Conduct remedies used by the FTC in other hospital merger cases, with separate, fire-walled negotiating teams, would not help. Finally, we find that a large increase in the coinsurance rate would significantly reduce hospital prices. Patient cost-sharing has recently trended upwards and our model indicates that if this trend continues it could result in a significant reduction in provider prices.

While our focus is on negotiations between hospitals and MCOs, we believe our framework can be applied in a number of alternative settings where there are a small number of "gatekeeper" buyers. Our approach allows us to write the equilibrium pricing in a way that is similar to the standard Lerner index inverse elasticity rule, by substituting effective demand elasticities for the demand elasticities. This approach further allows us to construct a simple GMM estimator for marginal costs, bargaining weights and underlying incentives. An interesting extension to explore in future work is formal identification of the bargaining weights. We conjecture that the identification of these weights might be similar to identification of the nature of competition and that some of the results in Haile and Berry (2010) would generalize to our case.

References

Allen, J., Clark, R., and Houde, J.-F. (2013). Price negotiation in differentiated product markets: The case of insured mortgages in Canada. Working Paper.

Baicker, K. and Chandra, A. (2006). The labor market effects of rising health insurance premiums. *Journal of Labor Economics*, (3):609 634.

[36]In 2006, the average MSA concentration was approximately 3,250 with approximately 25% of MSAs having an HHI greater than 5,000 (Gaynor and Town, 2012). The reported HHI of 5,635 for Northern Virginia uses a market definition that is much smaller than the Washington, DC MSA.

Berry, S., Levinsohn, J., and Pakes, A. (1995). Automobile prices in market equilibrium. *Econometrica*, 63(4).

Berry, S. and Pakes, A. (1993). Some applications and limitations of recent advances in empirical industrial organization: Merger analysis. *American Economic Review*, 83(2):247–252.

Binmore, K., Rubinstein, A., and Wolinsky, A. (1986). The Nash bargaining solution in economic modelling. *The RAND Journal of Economics*, pages 176–188.

Brand, K. (2013). Price equilibrium in empirical models of hospital competition. Working Paper, Federal Trade Commission.

Bresnahan, T. F. (1987). Competition and collusion in the American automobile industry: The 1955 price war. *Journal of Industrial Economics*, 35(4):457–482.

Capps, C., Dranove, D., and Satterthwaite, M. (2003). Competition and market power in option demand markets. *RAND Journal of Economics*, 34(4):737–763.

Chipty, T. (1995). Horizontal integration for bargaining power: Evidence from the cable television industry. *Journal of Economics & Management Strategy*, 4(2):375–397.

Chipty, T. and Synder, C. (1999). The role of firm size in bilateral bargaining: A study of the cable television industry. *The Review of Economics and Statistics*, 81(2):326–340.

Collard-Wexler, A., Gowrisankaran, G., and Lee, R. S. (2013). Bargaining in bilateral oligopoly: An alternating offers representation of the "Nash-in-Nash" solution.

Crawford, G. and Yurukoglu, A. (2012). The welfare effects of bundlig in multichannel television Markets. *American Economic Review*, 102(2):643–685.

Cutler, D., McClellan, M., and Newhouse, J. (2000). How does managed care do it? *RAND Journal of Economics*, 31(3):526–548.

Dickstein, M. (2011). Physician vs. patient incentives in prescription drug choice. Working Paper.

Draganska, Michaela, D. K. and Villas-Boas, S. B. (2011). A larger slice or a larger pie? an empirical investigation of bargaining power in the distribution channel. *Marketing Science*, 29:57–74.

Ericson, K. M. and Starc, A. (2012). Pricing regulation and imperfect competition on the massachusetts health insurance exchange.

Gaynor, M. and Town, R. (2012). Provider competition. In Pauly, M., McGuire, T., and Barros, P., editors, *Handbook of Health Economics, Volume 2*, pages 499–637. Elsevier.

Gaynor, M. and Vogt, W. B. (2003). Competition among hospitals. *Rand Journal of Economics*, 34(4):764–785.

Ginsburg, P. (2010). Wide variation in hospital and physician payment rates evidence of provider market power. HSC Research Brief No. 16, Center for Studying Health System Change.

Goldberg, P. K. (1995). Product differentiation and oligopoly in international markets: The case of the U.S. automobile industry. *Econometrica*, 63(4).

Grennan, M. (2013). Price Discrimination and Price Bargaining: Empirical Evidence from Medical Devices. *American Economic Review*.

Haile, P. and Berry, S. (2010). Identification in differentiated products markets using market level data. Cowles Foundation Working Paper 1744.

Hausman, J., Leonard, G., and Zona, D. (1994). Competitive Analysis with Differentiated Products. *Annales D'Economie et de Statistique*, 34:159–180.

Ho, K. (2006). The welfare effects of restricted hospital choice in the US medical care market. *Journal of Applied Econometrics*, 21(7):1039–1079.

Ho, K. (2009). Insurer-Provider Networks in the Medical Care Market. *American Economic Review*, 99(1):393–430.

Ho, K. and Lee, R. S. (2013). Insurer competition and negotiated hospital prices.

Ho, K. and Pakes, A. (2011). Physician responses to financial incentives: evidence from hospital discharge records,. Working Paper.

Horn, H. and Wolinsky, A. (1988a). Bilateral monopolies and incentives for merger. *RAND Journal of Economics*, 19(3):408–419.

Horn, H. and Wolinsky, A. (1988b). Worker substitutability and patterns of unionisation. *The Economic Journal*, 98(391):484–497.

Kaiser Family Foundation/Health Research and Educational Trust (2011). Employer health benefits annual survey.

Lakadawalla, D. and Philipson, T. (2006). The nonprofit sector and industry performance. *Journal of Public Economics*, 90(8-9):1681–1698.

Lewis, M. and Pflum, K. (2011). Diagnosing hospital system bargaining power in managed care networks,. Working Paper.

Manning, W. and Marquis, M. (1996). Health insurance: The tradeoff between risk pooling and moral hazard. *Journal of Health Economics*, 15(5):609–639.

Meza, S. and Sudhir, K. (2010). Do private labels increase retailer bargaining power? *Quantatative Marketing and Economics*, 8(3):333–363.

Nevo, A. (2000). Mergers with differentiated products: The case of the ready-to-eat cereal industry. *The RAND Journal of Economics*, 31(3):395–421.

O'Brien, D. and Shaffer, G. (2005). Bargaining, bundling, and clout: The portfolio effects of horizontal mergers. *RAND Journal of Economics*, 36(3):573–595.

Pauly, M. (1968). The economics of moral hazard: Comment. *American Economic Review*, (58):531–537.

Rubinstein, A. (1982). Perfect equilibrium in a bargaining model. *Econometrica*, (50):97–109.

Sorensen, A. (2003). Insurer-hospital bargaining: Negotiated discounts in post-deregulation connecticut. *The Journal of Industrial Economics*, 51(4):469–490.

Town, R. and Vistnes, G. (2001). Hospital competition in HMO networks. *Journal of Health Economics*, 20(5):733–752.

Werden, G. and Froeb, L. (1994). The effects of mergers in differentiated products industries: Logit demand and merger policy. *Journal of Law, Economics and Organization*, 10(2):407–426.

Appendix A: Derivation of the A term

For on-line publication

For ease of notation, define the welfare for all patients at MCO m from the choice stage to be

$$\overline{W_m}(N_m, \vec{p_m}) = \frac{\tau}{\alpha} \sum_{i=1}^{I} 1\{m(i) = m\} W_i(N_m, \vec{p_m}) - TC_m(N_m, \vec{p_m}). \tag{25}$$

In Section 2.4, we defined the A term as $\frac{\partial V_m}{\partial p_{mj}}$. Note that

$$\frac{\partial V_m}{\partial p_{mj}} = \frac{\partial \overline{W_m}(N_m, \vec{p_m})}{\partial p_{mj}} - \frac{\partial TC_m(N_m, \vec{p_m})}{\partial p_{mj}}. \tag{26}$$

Note that

$$\begin{aligned} \frac{\partial \overline{W_m}(N_m, \vec{p_m})}{\partial p_{mj}} &= -\tau \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\} c_{id} w_{id} f_{id} \frac{e^{\delta_{ijd}}}{\sum_{k \in N_m} e^{\delta_{ikd}}} \\ &= -\tau \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\} c_{id} w_{id} f_{id} s_{ijd} \end{aligned} \tag{27}$$

and that

$$\begin{aligned} \frac{\partial TC_m(N_m, \vec{p_m})}{\partial p_{mj}} = &\sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\}(1 - c_{id}) f_{id} w_{id} s_{ijd} \\ &+ \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\}(1 - c_{id}) f_{id} w_{id} \sum_{k \in N_m} p_{km} \frac{\partial s_{ikd}}{\partial p_{mj}}. \end{aligned} \tag{28}$$

Further, note that $\frac{\partial s_{ijd}}{\partial p_{mj}} = -\alpha c_{id} w_{id} s_{ijd}(1 - s_{ijd})$ if $k = j$ and otherwise $\frac{\partial s_{ikd}}{\partial p_{mj}} = \alpha c_{id} w_{id} s_{ikd} s_{ijd}$.

Putting this all together gives:

$$\begin{aligned} \frac{\partial V_m}{\partial p_{mj}} = &-\tau \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\} c_{id} w_{id} f_{id} s_{ijd} - \sum_{i=1}^{I_m} \sum_{d=1}^{D} 1\{m(i) = m\}(1 - c_{id}) w_{id} f_{id} s_{ijd} \\ &- \alpha \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\}(1 - c_{id}) c_{id} w_{id}^2 f_{id} s_{ijd} \left(\sum_{k \in N_m} p_{km} s_{ikd} - p_{mj} \right). \end{aligned} \tag{29}$$

Appendix B: Derivation of the FOCs for the Prince William separate bargaining

For on-line publication

We start by considering the (notationally simpler) case where each hospital and MCO pair bargain with separate contracts, even if the hospital is part of a system. Consider a system s and a hospital $j \in J_s$. Define $NB^{m,j}(p_{mj}|\vec{p_{m,\text{-}j}}, \vec{p_{m,\text{-}s}})$ to be the Nash bargaining product for this contract. Analogously to (10), we have:

$$NB^{m,j}(p_{mj}|\vec{p_{m,\text{-}j}}, \vec{p_{m,\text{-}s}}) =$$
$$\Big(q_{mj}(N_m, \vec{p_m})[p_{mj} - mc_{mj}] + \sum_{k \in J_s, k \neq j} (q_{mk}(N_m, \vec{p_m}) - q_{mk}(N_m \setminus j, \vec{p_m}))[p_{mk} - mc_{mk}]\Big)^{b_{s(m)}}$$
$$\Big(V_m(N_m, \vec{p_m}) - V_m(N_m \setminus j, \vec{p_m})\Big)^{b_{m(s)}}. \tag{30}$$

In words, the disagreement value of system s for this contract is now that it withdraws hospital j. In this case, it will lose its profits from hospital j but will gain profits from the additional diversion quantity $\lambda_{mjk} \equiv (q_{mk}(N_m \setminus j, \vec{p_m}) - q_{mk}(N_m, \vec{p_m}))$ from each other hospital $k \neq j$ that it owns. The MCO's disagreement value from failure for this contract is now the difference in value from losing hospital j instead of from losing system s.

Analogously to (17), the FOC for this problem is:

$$b_{s(m)} \frac{q_{mj} + \sum_{k \in S_j} \frac{\partial q_{mk}}{\partial p_{mj}}[p_{mk} - mc_{mk}]}{q_{mj}(N_m, \vec{p_m})[p_{mj} - mc_{mj}] - \sum_{k \in J_s, k \neq j} \lambda_{mjk}[p_{mk} - mc_{mk}]}$$
$$= -b_{m(s)} \frac{\frac{\partial V_m}{\partial p_{mj}}}{V_m(N_m, \vec{p_m}) - V_m(N_m \setminus j, \vec{p_m})}. \tag{31}$$

We now consider the case where Inova acquires Prince William but where Prince William bargains separately from the rest of the Inova system. In this case, the FOCs for the Prince William contracts will be exactly as in (31). The FOCs for the other Inova hospitals will now resemble (31) but the disagreement values will reflect removing all Inova legacy hospitals from the network and having diversion quantities only for Prince William.