On-line Appendices: Mergers When Prices Are Negotiated: Evidence from the Hospital Industry

Appendix A1: Derivation of the A term

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

$$\overline{W_m}(N_m, \vec{p_m}) = \frac{\tau}{\alpha} \sum_{i=1}^{I} 1\{m(i) = m\} W_i(N_m, \vec{p_m}) - TC_m(N_m, \vec{p_m}). \tag{22}$$

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

$$\frac{\partial V_m}{\partial p_{mj}} = \frac{\partial \overline{W_m}(N_m, \vec{p_m})}{\partial p_{mj}} - \frac{\partial TC_m(N_m, \vec{p_m})}{\partial p_{mj}}. \tag{23}$$

Note that

$$\begin{aligned} \frac{\partial \overline{W_m}(N_m, \vec{p_m})}{\partial p_{mj}} &= -\tau \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\} c_{id} w_{id} f_{id} \frac{e^{\delta_{ijd}}}{\sum_{k \in N_m} e^{\delta_{ikd}}} \\ &= -\tau \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\} c_{id} w_{id} f_{id} s_{ijd} \end{aligned} \tag{24}$$

and that

$$\begin{aligned} \frac{\partial TC_m(N_m, \vec{p_m})}{\partial p_{mj}} &= \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\}(1 - c_{id}) f_{id} w_{id} s_{ijd} \\ &+ \sum_{i=1}^{I} \sum_{d=1}^{D} 1\{m(i) = m\}(1 - c_{id}) f_{id} w_{id} \sum_{k \in N_m} p_{km} \frac{\partial s_{ikd}}{\partial p_{mj}}. \end{aligned} \tag{25}$$

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:

$$\frac{\partial V_m}{\partial p_{mj}} = \tag{26}$$
$$-\tau \sum_{i=1}^{I}\sum_{d=1}^{D} 1\{m(i)=m\} c_{id} w_{id} f_{id} s_{ijd} - \sum_{i=1}^{I_m}\sum_{d=1}^{D} 1\{m(i)=m\}(1-c_{id}) w_{id} f_{id} s_{ijd}$$
$$-\alpha \sum_{i=1}^{I}\sum_{d=1}^{D} 1\{m(i)=m\}(1-c_{id}) c_{id} w_{id}^2 f_{id} s_{ijd} \left(\sum_{k\in N_m} p_{km} s_{ikd} - p_{mj}\right).$$

Appendix A2: Extra tables

Table A1 replicates Table 4 from the paper and adds bootstrapped standard errors. The key message from this table is that the own- and cross-price elasticity estimates are very precise.

Table A1—: Mean and associated standard errors of 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
	(0.012)	(0.005)	(0.001)	(0.0004)	(0.001)
2. Inova Fairfax	0.011	−0.141	0.018	0.006	0.004
	(0.0008)	(0.013)	(0.0014)	(0.0006)	(0.0003)
3. HCA Reston	0.008	0.055	−0.149	0.022	0.002
	(0.0006)	(0.004)	(0.011)	(0.002)	(0.0001)
4. Inova Loudoun	0.004	0.032	0.037	−0.098	0.001
	(0.0003)	(0.003)	(0.003)	(0.01)	(0.00008)
5. Fauquier	0.026	0.041	0.006	0.002	−0.153
	(0.002)	(0.004)	(0.0006)	(0.0002)	(0.015)
6. Outside option	0.025	0.090	0.022	0.023	0.050
	(0.002)	(0.008)	(0.0017)	(0.002)	(0.004)

Note: Elasticity is $\frac{\partial s_j}{\partial p_k}\frac{p_k}{s_j}$ where j denotes row and k denotes column. Standard error estimates in parentheses are calculated using 100 bootstrap draws.

Table A2 presents the estimates from the bargaining model allowing the bargaining weights to vary by MCO/hospital system pair. There is significant variation in the bargaining parameter estimates across hospitals within a MCO but those estimates tend to be imprecise.

Table A3 presents an additional robustness specification. The table presents the parameter estimates fixing the MCO bargaining weights that span the possible

Table A2—: Bargaining parameter estimates with extra bargaining parameters

Parameter	Estimate	S.E.
MCO welfare weight (τ)	2.75**	(0.51)
MCO 1 bargaining weight Inova Health System	0.33	(0.20)
MCO 1 bargaining weight Loudoun Hospital	0.30	(0.22)
MCO 1 bargaining weight Prince William Hospital	0.29	(0.23)
MCO 1 bargaining weight HCA	0.04*	(0.05)
MCO 1 bargaining weight Potomac Hospital	0.22	(0.20)
MCO 1 bargaining weight Virginia Hospital Center	0.11	(0.13)
MCO 1 bargaining weight Fauquier Hospital	0.23	(0.16)
MCO 2 bargaining weight Inova Health System	0.35	(0.36)
MCO 2 bargaining weight Loudoun Hospital	0.72	(0.69)
MCO 2 bargaining weight Prince William Hospital	1.00**	(0)
MCO 2 bargaining weight HCA	0.04	(0.05)
MCO 2 bargaining weight Potomac Hospital	0.76	(0.75)
MCO 2 bargaining weight Virginia Hospital Center	0.96	(1.03)
MCO 2 bargaining weight Fauquier Hospital	0.57	(0.56)
MCO 3 bargaining weight Inova Health System	0.67	(0.77)
MCO 3 bargaining weight Loudoun Hospital	0.35	(0.33)
MCO 3 bargaining weight Prince William Hospital	0.89	(0.99)
MCO 3 bargaining weight HCA	0.73	(1.07)
MCO 3 bargaining weight Potomac Hospital	0.67	(0.80)
MCO 3 bargaining weight Virginia Hospital Center	1.00	(1.39)
MCO 3 bargaining weight Fauquier Hospital	0.26	(0.27)
MCO 4 bargaining weight Inova Health System	0.51	(0.41)
MCO 4 bargaining weight Loudoun Hospital	0.04	(0.14)
MCO 4 bargaining weight Prince William Hospital	0.08	(0.10)
MCO 4 bargaining weight HCA	0.75	(0.75)
MCO 4 bargaining weight Potomac Hospital	0.14	(0.11)
MCO 4 bargaining weight Virginia Hospital Center	0.47	(0.44)
MCO 4 bargaining weight Fauquier Hospital	0.03	(0.18)
Year 2003	2,360	(9,585)
Year 2004	5,850	(12,051)
Year 2005	5,976	(7,484)
Year 2006	6,409	(11,407)

Note: ** denotes significance at 1% level and * at 5% level. This specification allows for different bargaining weight parameters for each MCO/hospital-system pair. Significance tests for bargaining parameters test the null of whether the parameter is different than 0.5. We report non-bootstrapped standard errors here.

support. Very low bargaining weights generate implied marginal costs that are negative. Very high bargaining weights imply that mergers have little impact on negotiated prices.

Table A3—: Variation in outcomes by bargaining weight

	MCO bargaining weight					
	0	0.1	0.25	0.5	0.75	0.9
Mean effective own price elasticity	0.04	0.22	0.91	2.52	7.34	23.55
Mean estimated MC ($1,000)	−278	−43	−1.26	7.2	10.3	11.5
Estimated MCO welfare weight (τ)	–	5.17	2.7	2.79	2.9	3.0
Mean % Δ price from PW merger for MCO 1	18.3	11.8	6.3	3.1	1.0	0.05

Note: the first three rows of each column reports the results of an estimation similar to Specification 1 from Table 5 but with the MCO bargaining weight fixed to alternate values. When the bargaining weight is set to 0, τ is not identified. The final row reports counterfactuals for each estimation.

Table A4 presents the analog of Table 6 for the alternative, posted premium competition model. In general, the Lerner indices are similar to those in the base model. Consequently, the implications of the posted premium model are very similar to our base model for the counterfactuals we consider.

Table A4—: Lerner indices and actual and effective price elasticities for posted premium competition model

System name	Lerner index	Actual own price elasticity	Effective own price elasticity	Own price elasticity without insurance
Prince William Hosp.	0.48	0.13	2.10	5.16
Inova Health System	0.42	0.07	2.38	3.10
Fauquier Hospital	0.15	0.17	6.85	6.11
HCA (Reston Hosp.)	0.39	0.15	2.56	7.34
Potomac Hospital	0.12	0.15	8.26	6.77
Virginia Hospital Ctr.	0.59	0.13	1.71	6.43

Note: reported elasticities and Lerner indices use quantity weights. These results are from the calibrated posted premium competition model described in Section V.

Appendix A3: Derivation of the FOCs for the Prince William separate bargaining

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

$$(27)\quad NB^{m,j}(p_{mj}|\vec{p_{m,-j}}, \vec{p_{m,-s}}) = \Big(q_{mj}(N_m, \vec{p_m})[p_{mj} - mc_{mj}] + \sum_{k \in J_s, k \neq j} (q_{mk}(N_m, \vec{p_m}) - q_{mk}(N_m \backslash j, \vec{p_m}))[p_{mk} - mc_{mk}]\Big)^{b_{s(m)}} \Big(V_m(N_m, \vec{p_m}) - V_m(N_m \setminus j, \vec{p_m})\Big)^{b_{m(s)}}.$$

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 (12), the FOC for this problem is:

$$(28)\quad b_{s(m)} \frac{q_{mj} + \sum_{k \in S_j} \frac{\partial q_{mk}}{\partial p_{mj}}[p_{mk} - mc_{mk}]}{q_{mj}(N_m, \vec{p_m})[p_{mj} - mc_{mj}] - \sum_{k \in J_s, k \neq j} \lambda_{mjk}[p_{mk} - mc_{mk}]} = -b_{m(s)} \frac{\frac{\partial V_m}{\partial p_{mj}}}{V_m(N_m, \vec{p_m}) - V_m(N_m \setminus j, \vec{p_m})}.$$

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 (28). The FOCs for the other Inova hospitals will now resemble (28) but the disagreement values will reflect removing all Inova legacy hospitals from the network and having diversion quantities only for Prince William.

Appendix A4: Details of the posted premium competition model

This appendix provides more details on the bargaining problem, calibration and computation of the model where MCOs simultaneously post premiums to compete for enrollees, à la Bertrand. We start by expositing the Nash bargaining problem.

First, 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. 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 and for the spill of patients in case of disagreement.

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. To account for the equilibrium spill of patients following disagreement, we redefine normalized quantities (from its earlier definition in the base model in (8)) as

(29)
$$q_{mj}(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}}) = \sum_{i=1}^{I} \sum_{d=0}^{D} S^*_{im}(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}}) f_{id} w_d s_{ijd}(N_m, \vec{p_m}),$$

where (29) substitutes the endogenous plan choice S^* for the fixed plan assignment from (8). Hospital system returns are now

(30)
$$\pi_s(N_1, \ldots, N_M, \vec{p_1}, \ldots, \vec{p_M}) = \sum_{m=1}^{M} \sum_{j \in J_s} q_{mj}(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}})[p_{mj} - mc_{mj}].$$

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:

$$(31) \quad NB^{m,s}(p_{mj_{j \in J_s}} | \vec{p_{m,-s}}) = \Big(\sum_{j \in J_s} \pi_s(N_1, \ldots, N_M, \vec{p_1}, \ldots, \vec{p_M}) - \pi_s(\vec{p_1}, \ldots, \vec{p_M}, N_1, \ldots, N_{m-1}, N_m \setminus J_s, N_{m+1}, \ldots, N_M) \Big)^{b_{s(m)}} \Big(R^*_m(N_m, N_{-m}, \vec{p_m}, \vec{p_{-m}}) - R^*_m(N_m \setminus J_s, N_{-m}, \vec{p_m}, \vec{p_{-m}}) \Big)^{b_{m(s)}}.$$

The price vector that solves the posted premium competition model is the vector of prices that jointly maximizes the Nash bargaining problems in (31) for each m and s.

We now turn to the details of the calibration of our model, starting with the calibration of the premium sensitivity parameter. Ericson and Starc (2012) report a value of 2.271 for 40-year-olds from the Massachusetts Connector for 2008. We use this number as the mean age in our data is approximately 38. We further divide the Ericson and Starc 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 $\alpha_2 = 0.0019$.

Turning to the coefficient on hospital welfare at the premium stage, we use $\alpha_1 =$

$\frac{\tau\alpha_2}{\alpha}$ with the estimated τ (Table 5, Specification 1) and α (Table 3). Scaling the utility from the second stage by τ/α expresses the consumer welfare from second stage utility in dollars. The marginal utility of a dollar in equation (20) is α_2, as this is the coefficient on premiums. Multiplying by α_2 turns the welfare dollar value into utility at the plan choice stage. The scaling of the utility functions differs across the different equations because the unobservables are normalized to both be type 1 extreme value, which implicitly means that an equation with more noise will have a smaller marginal utility of money.

One other calibration is required because, unlike in the base model, we need to know the ex-ante distribution of illness for each patient at the point when the patient chooses a health plan.[38] 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.[39]

Next, we need to specify the ξ_m value for each MCO m. We use $\xi_m = \log\left(\frac{\sum_i S_{im}}{\sum_i S_{i0}}\right)$. 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,[40] which allows us to compute the actual (and not relative) share. The calibration of ξ_m here is meant to capture the heterogeneity in enrollment numbers across plans. As in Berry (1994), if the first two terms in (20) summed to 0, the values of ξ_m that we choose would match observed market shares exactly.[41] The first two terms in (20) will not sum to 0 exactly, so our chosen value will approximate shares imperfectly. The most important effect that we aim to capture with this parametrization is the relative attractiveness of different MCOs.

Finally, we discuss the computation of the equilibrium of the posted premium competition model. We solved for the first-order conditions for the price setting game using the implicit function theorem. A full derivation of the equilibrium first-order conditions is available from the authors upon request. Using these first-order conditions, we compute counterfactual equilibria in C using a Newton-Raphson method. This procedure is very computationally intensive. In order to minimize the computational burden, we compute the equilibrium for 20 enrollee draws chosen at random from the discharge data rather than the full set of enrollees from the discharge data.

[38]In the base 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.

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

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

[41]Berry, S. 1994. "Estimating Discrete Choice Models of Product Differentiation." *RAND Journal of Economics*, 25: 242-262.