ONLINE APPENDIX:
Insurer Competition in Health Care Markets

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A Estimation and Computation: Further Details and Results

A.1 Hospital Demand: Details

Our consumer demand model outlined in Section 3.2 predicts that a individual k, who lives in market m, is enrolled in MCO j, and has diagnosis l, visits hospital i with probability

$$\sigma^H_{i,j,k,m|l}(\mathcal{G}) = \frac{\exp(\delta_i + z_i \upsilon_{k,l}\beta^z + d_{i,k}\beta^d_m)}{\sum_{h\in\mathcal{G}^H_{jm}} \exp(\delta_h + z_h \upsilon_{k,l}\beta^z + d_{h,k}\beta^d_m)} ,$$

where $\mathcal{G}^M_{j,m}$ is the network of hospitals available on insurer j in market m. The ex ante probability that a individual k visits hospital i given his insurer network is then given by

$$\sigma^H_{i,j,k,m}(\mathcal{G}_m) = \gamma^a_{\kappa(k)} \sum_{l\in\mathcal{L}} \gamma_{\kappa(k),l}\sigma^H_{i,j,k,m|l}(\mathcal{G}_m) . \quad (1)$$

We estimate this model via maximum likelihood using our admission data. In each market we normalize one hospital fixed effect to zero. We choose the largest hospital in each market to ensure comparability across markets.

We define 5 diagnosis categories using ICD-9-CM codes and major diagnosis category (MDC) codes, as shown in Table 1. The categories are cardiac, cancer, labor, digestive diseases, and neurological diseases. The sixth category, "other diagnoses," includes all other categories in the data other than newborn babies (defined as events with MDC 15 where the patient is less than 5 years old). The hospital "service" variables are defined using American Hospital Association data for 2003-2004 (if observations are missing for a particular hospital in one year we fill them in from the other). These variables summarize the services offered by each hospital; they cover cardiac, imaging, cancer, and birth services. Each hospital is rated on a scale from 0 to 1, where 1 implies that the hospital offers the least common of a list of relevant services and 0 implies that it offers none of the services. Details are given in Table 2. Finally, since we do not observe household income for non-state agency enrollees (and we estimate our demand system using observed admissions from all enrollees), we use the mean household income in each zip code from Census data (winsorized at 5%).

A.2 Hospital and Insurer Demand: Results

Table 3 shows estimates from our hospital demand system (omitting hospital fixed effects due to space constraints). The results are in line with Ho (2006) and the previous hospital choice literature. The coefficient on distance is negative and varies across markets (likely reflecting differences in transportation options and

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costs), with similar magnitudes to those in Ho (2006). The non-interacted effects of teaching hospitals and other hospital characteristics are absorbed in the fixed effects; however, the interactions show that patients with very complex conditions (cancer and neurological diseases) attach the highest positive weight to teaching hospitals. Many of the interactions are difficult to interpret, but it is clear that patients with cardiac diagnoses place a strong positive weight on hospitals with cardiac services, cancer patients on those with cancer services (although, as in Ho (2006), this coefficient is not significant at p=0.1), and women in labor on hospitals with birthing services.

Table 4 shows estimates from our insurer demand system outlined in Section 3.3 (omitting insurer-market fixed effects). The coefficient on premium is negative and significant, with premium sensitivity decreasing with income; elasticities are provided in the main text. The coefficient on WTP is positive for every age-gender group, and significant at p=0.01 for all groups except enrollees aged 0-19. Coefficient magnitudes are larger for males aged 20-34 and 35-44 than for women in the same age groups. This partially reflects the fact that the higher probability of admission for women of child-bearing age translates to a higher standard deviation in the WTP variable for women than for men (so that a smaller coefficient is needed to generate the same valuation for a 1 standard deviation increase in WTP). Further discussion of the estimates is contained in the main text.

A.3 Predicted and Counterfactual Hospital and Insurer Demand: Details

Given parameter estimates from our hospital and insurer demand systems, we construct estimates for insurer and hospital demand given any set of premiums and hospital-insurer networks as follows:

- *Insurer Demand:* For each insurer j and household type $\lambda \in$ {single, two-party, family}, we predict expected insurer household demand as $\hat{D}_{j,\lambda,m}(\mathcal{G}, \phi) \equiv \sum_{f \in \mathcal{F}_{\lambda,m}} \hat{\sigma}_{f,j,m}(\mathcal{G}, \phi)$, where $\mathcal{F}_{\lambda,m}$ is the set of households of type λ in market m, and $\hat{\sigma}_{f,j,m}$ is the our predicted probability that household f chooses MCO j given by (10). Similarly, for each insurer j, we form a prediction of the expected number of

Table 1: Definition of Diagnosis Categories

Category	MDC or ICD-9-CM codes
Cardiac	MDC: 05 (and not cancer)
	ICD-9-CM: 393-398; 401-405; 410-417; 420-249
Cancer	ICD-9-CM: 140-239
Neurological	MDC: 19-20
	ICD-9-CM: 320-326; 330-337; 340-359
Digestive	MDC: 6 (and not cancer or cardiac)
	ICD-9-CM: 520-579
Labor	MDC 14-15 (and aged over 5)
	ICD-9-CM: 644; 647; 648; 650-677; V22-V24; V27

Notes: Patient diagnoses were defined using MDC codes in the admissions data where possible. In other cases, supplemental ICD-9-CM codes were used.

Table 2: Definition of Hospital Services

Cardiac	Imaging	Cancer	Births
CC laboratory	Ultrasound	Oncology services	Obstetric care
Cardiac IC	CT scans	Radiation therapy	Birthing room
Angioplasty	MRI		
Open heart surgery	SPECT		
	PET		

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

Table 3: Estimates: Hospital Demand System

Interaction Terms	Variable	Parameter	Std. Err.
Interactions: Teaching	Income ($000)	0.008***	0.002
	PPO enrollee	0.123*	0.065
	Cancer	0.098	0.108
	Cardiac	−0.521***	0.082
	Digestive	−0.237**	0.096
	Labor	−0.069	0.098
	Neurological	1.281***	0.172
Interactions: Nurses Per Bed	Income ($000)	0.000	0.001
	PPO enrollee	0.054*	0.032
	Cancer	0.121**	0.055
	Cardiac	0.073*	0.039
	Digestive	−0.087**	0.044
	Labor	−0.179***	0.046
	Neurological	−1.009***	0.097
Interactions: For-Profit	Income ($000)	−0.000	0.002
	PPO enrollee	0.033	0.047
	Cancer	0.012	0.084
	Cardiac	0.107*	0.056
	Digestive	−0.122*	0.066
	Labor	0.324***	0.063
	Neurological	0.609***	0.113
Interactions: Cardiac Services	Income ($000)	0.008***	0.002
	PPO enrollee	0.254***	0.046
	Cardiac	0.251***	0.050
Interactions: Imaging Services	Income ($000)	−0.003**	0.002
	PPO enrollee	0.142***	0.051
	Cancer	0.139*	0.083
	Cardiac	0.049	0.063
	Digestive	0.037	0.061
	Labor	−0.475***	0.065
	Neurological	−0.775***	0.123
Interactions: Cancer Services	Income ($000)	−0.013***	0.005
	PPO enrollee	−0.133	0.127
	Cancer	0.444**	0.225
Interactions: Labor Services	Income ($000)	0.006***	0.002
	PPO enrollee	−0.168***	0.048
	Labor	1.164***	0.069
Distance interactions:	HSA 1	−0.107***	0.003
	HSA 2	−0.155***	0.004
	HSA 3	−0.235***	0.008
	HSA 4	−0.274***	0.009
	HSA 5	−0.240***	0.005
	HSA 6	−0.186***	0.005
	HSA 7	−0.246***	0.013
	HSA 8	−0.149***	0.004
	HSA 9	−0.106***	0.003
	HSA 10	−0.165***	0.008
	HSA 11	−0.276***	0.004
	HSA 12	−0.132***	0.003
	HSA 13	−0.312***	0.008
	HSA 14	−0.114***	0.005
	Number of Admissions	38064	
	Hospital Fixed Effects	Yes	
	Pseudo-R2	0.540	

Standard errors in parentheses
$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Notes: Results from estimated hospital demand model. Specification includes hospital fixed effects (not reported).

individual enrollees on each insurer by $\hat{D}^{E}_{j,m}(\mathcal{G},\phi) \equiv \sum_{f\in\mathcal{F}_m} N_f \hat{\sigma}_{f,j,m}(\mathcal{G},\phi)$, where N_f is the number individuals in household f.

Table 4: Estimates: Insurer Demand System

Premium (α_0^{ϕ})	-0.0648***
	(0.00137)
Log(Income) × Premium (α_1^{ϕ})	0.00563***
	(0.000123)
WTP (α^W Age 0-19)	-0.0281
	(0.265)
WTP (α^W Male, Age 20-34)	8.909***
	(0.619)
WTP (α^W Female, Age 20-34)	0.936***
	(0.0910)
WTP (α^W Male, Age 35-44)	4.388***
	(0.363)
WTP (α^W Female, Age 35-44)	1.885***
	(0.127)
WTP (α^W Male, Age 45-54)	1.643***
	(0.166)
WTP (α^W Female, Age 45-54)	2.314***
	(0.132)
WTP (α^W Male, Age 55-64)	0.917***
	(0.114)
WTP (α^W Female, Age 55-64)	1.838***
	(0.138)
Drive Time to Kaiser (α^K HSA 2)	-0.0420***
	(0.00119)
Drive Time to Kaiser (α^K HSA 3)	-0.0351***
	(0.00220)
Drive Time to Kaiser (α^K HSA 4)	-0.0175***
	(0.00483)
Drive Time to Kaiser (α^K HSA 5)	-0.0226***
	(0.00352)
Drive Time to Kaiser (α^K HSA 6)	-0.0182***
	(0.00316)
Drive Time to Kaiser (α^K HSA 7)	-0.0286***
	(0.00732)
Drive Time to Kaiser (α^K HSA 10)	-0.0548***
	(0.0135)
Drive Time to Kaiser (α^K HSA 11)	-0.0218***
	(0.00125)
Drive Time to Kaiser (α^K HSA 12)	-0.0253***
	(0.000979)
Drive Time to Kaiser (α^K HSA 13)	-0.0190***
	(0.00375)
Drive Time to Kaiser (α^K HSA 14)	-0.0366***
	(0.00240)
Number of Households	162,719
HSA-Insurer Fixed Effects	Yes
Pseudo-R2	.1811

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Results from estimated insurer demand model. Drive Time to Kaiser represents the calculated drive time to the nearest Kaiser hospital from a household's zipcode. In HSA 1 and 8, Kaiser is not available to enrollees and a distance coefficient was not estimated; and in HSA 9, no Kaiser hospital existed (only medical offices), and the Kaiser drive time was normalized to 0 for all zipcodes in this market. Specification includes market-insurer fixed effects (not reported).

- *Hospital Demand:* For each hospital i and MCO j, we predict the number of expected admissions from type-κ individuals: $\hat{D}^H_{i,j,\kappa,m}(\mathcal{G},\phi) \equiv \sum_{f\in\mathcal{F}_m} \hat{\sigma}_{f,j,m}(\mathcal{G},\phi) \sum_{k\in f,\kappa(k)=\kappa} \hat{\sigma}^H_{ijkm}(\mathcal{G})$, where $\hat{\sigma}^H_{ijkm}(\cdot)$ is the predicted probability that individual k of type κ in family f visits hospital i on MCO j's network given by (1) and our hospital demand estimates. We aggregate this value to the total predicted number of expected admissions across all individuals for hospital i from MCO j, and scale by the expected admission DRG weight for patients of type κ (given by $E[DRG_a|\kappa]$), as follows: $\hat{D}^H_{i,j,m}(\mathcal{G},\boldsymbol{\phi}) \equiv \sum_{\forall\kappa} E[DRG_a|\kappa] \times \hat{D}^H_{i,j,\kappa,m}(\cdot)$.

Weighting $\hat{D}^H_{i,j,\kappa,m}(\cdot)$ by the average admission DRG weight for a type-κ individual accounts for potential differences in disease severity across admissions. Since this multiplies both hospital unit-DRG adjusted prices and costs, we capture the impact of selection of enrollees by age-sex categories and location across plans (e.g., as insurer hospital networks change) on expected reimbursements and costs.

A.4 Hospital System Bargaining

In our empirical application, we allow hospitals to jointly negotiate as part of a system within a market.[1] Let $\boldsymbol{\mathcal{S}}$ be a partition of the set of hospitals $\mathcal{H}$ into hospital systems (under the realistic assumption that hospitals can be part of only one system), and let $\mathcal{S} \in \boldsymbol{\mathcal{S}}$ represent the set of hospitals in a given system $\mathcal{S}$. A hospital system $\mathcal{S}$ can also represent a single hospital if $|\mathcal{S}| = 1$.

Define the profits for a hospital system $\mathcal{S}$ to be the sum of the profits of all hospitals $h \in \mathcal{S}$: $\pi_{\mathcal{S}}(\mathcal{G},\boldsymbol{p},\boldsymbol{\phi}) = \sum_{h\in\mathcal{S}} \pi^H_h(\mathcal{G},\boldsymbol{p},\boldsymbol{\phi})$. We assume that each insurer must carry all or none of the hospitals in a system in a given market, but can negotiate a separate price for each hospital within the system. Every hospital system $\mathcal{S} \in \boldsymbol{\mathcal{S}}$ and insurer $j \in \mathcal{M}$ engages in simultaneous bilateral Nash bargaining over all prices for the given system so that each price $\{p_{i,j}\}_{i\in\mathcal{S}}$ maximizes the Nash product of the hospital system and insurer profits:

$$p_{i,j} = \arg\max_{p_{i,j}} \Bigg[\underbrace{\pi^M_j(\mathcal{G},\boldsymbol{p},\boldsymbol{\phi}) - \pi^M_j(\mathcal{G}\setminus\mathcal{S},\boldsymbol{p}_{-ij},\boldsymbol{\phi})}_{\text{MCO } j\text{'s ``gains from trade'' with system } \mathcal{S}} \Bigg]^{\tau_j} \times \Bigg[ \underbrace{\pi^H_i(\mathcal{G},\boldsymbol{p},\boldsymbol{\phi}) - \pi^H_i(\mathcal{G}\setminus\mathcal{S},\boldsymbol{p}_{-ij},\boldsymbol{\phi})}_{\text{Hospital system } \mathcal{S}\text{'s ``gains from trade'' with MCO } j} \Bigg]^{(1-\tau_j)} \quad \forall i \in \mathcal{S}, \forall \mathcal{S} \in \boldsymbol{\mathcal{S}}\,, \qquad (2)$$

where we use our general version of MCO profits given by (11) in the main text. This is the system bargaining analogue to (4) in the main text, where the disagreement outcome between hospital $i \in \mathcal{S}$ and MCO j involves MCO j dropping all hospitals in $\mathcal{S}$. Every hospital in the same system has the same first-order-condition for (2):

$$\underbrace{\sum_{i\in\mathcal{S}} p^*_{i,j} D^H_{i,j}}_{\text{system payments}} = (1-\tau_j)\Bigg[\underbrace{\left(\phi_j \Phi'[\Delta_{\mathcal{S},j}\boldsymbol{D}_j] - [\Delta_{\mathcal{S},j} D^E_j]\eta_j\right)}_{\text{(i) } \Delta \text{ MCO revenues net of non-hosp costs}} - \underbrace{\Bigg(\sum_{h\in\mathcal{G}^M_j\setminus\mathcal{S}} p^*_{hj}[\Delta_{\mathcal{S},j} D^H_{hj}]\Bigg)}_{\text{(ii) } \Delta \text{ MCO } j \text{ payments to other hospitals}} \Bigg] + \tau_j \Bigg[\underbrace{\sum_{i\in\mathcal{S}} c_i D^H_{i,j}}_{\text{(iii) system costs}} - \underbrace{\sum_{i\in\mathcal{S}} \sum_{n\in\mathcal{G}^H_{\mathcal{S}}, n\neq j} ([\Delta_{\mathcal{S},j} D^H_{i,n}](p^*_{i,n} - c_i)}_{\text{(iv) } \Delta \text{ system profits from other MCOs}} \Bigg] \quad \forall \mathcal{S} \in \boldsymbol{\mathcal{S}}\,, \qquad (3)$$

where $[\Delta_{\mathcal{S},j}\boldsymbol{D}_j]$, $[\Delta_{\mathcal{S},j} D^E_j]$, and $[\Delta_{\mathcal{S},j} D^H_{hj}]$ represent changes in these objects when MCO j and system $\mathcal{S}$ come to a disagreement. As before, we drop all arguments of demand terms for expositional convenience, and assume that demand terms without market subscripts represent sums of those terms across all markets. Note that (3) is equivalent to (6) in the main text (using the simpler version of MCO profits) if there are no hospital systems, or if hospitals in the same system bargain independently. As before, we refer to terms (i)-(iv) as the premium and enrollment, price reinforcement, hospital cost, and recapture effects.

[1] Allowing systems to jointly negotiate across markets does not affect the analysis as we have assumed that insurer and hospital demand is separable across markets (c.f. Dafny, Ho and Lee (2015)).

A.5 Derivation of Error Terms

The error terms used in the construction of our estimating moments are:

$$\omega_j^1 = -\left[\sum_{h\in\mathcal{G}_j}\left(\frac{\partial \hat{D}^H_{h,j}(\cdot)}{\partial \phi_j} + \frac{(1-\tau^\phi)(\partial GFT^E_j/\partial\phi_j)}{\tau^\phi GFT^E_j}\hat{D}^H_{h,j}(\cdot)\right)\varepsilon^A_{h,j}\right] \qquad \forall j\ ,$$

$$\omega_j^2 = -(\sum_{h\in\mathcal{G}_j}\hat{D}^H_{h,j}(\cdot)\varepsilon^A_{h,j})/\phi_j\Phi'\hat{\boldsymbol{D}}_j(\cdot) - \nu_j \qquad \forall j\ ,$$

$$\omega^3_{\mathcal{S}j} = \left(\sum_{i\in\mathcal{S}}\varepsilon^A_{ij}\hat{D}^H_{ij}\right) + (1-\tau_j)\sum_{h\in\mathcal{G}^M_j\setminus\mathcal{S}}\varepsilon^A_{hj}[\Delta_{\mathcal{S},j}\hat{D}^H_{h,j}] + \tau_j\sum_{i\in\mathcal{S}}\sum_{n\in\mathcal{G}^H_{\mathcal{S}},n\neq j}\varepsilon^A_{i,n}[\Delta_{\mathcal{S},j}D^H_{i,n}] \qquad \forall j,\mathcal{S}\in\boldsymbol{\mathcal{S}}\ ,$$

where ν_j, referenced in the definition of ω_j^2, represents mean zero independent measurement error in MLR^o_j.

A.6 Counterfactual Simulations: Details

In all of our exercises, a counterfactual equilibrium is defined as a set of hospital networks, premiums, and prices $\{\mathcal{G}^{CF},\boldsymbol{\phi}^{CF},\boldsymbol{p}^{CF}\}$, and implied "demand" objects:

- $\hat{\boldsymbol{D}}^{CF} \equiv \{\{\hat{\boldsymbol{D}}^{CF}_{j,m}\},\{\hat{\boldsymbol{D}}^{E,CF}_{j,m}\},\{\hat{\boldsymbol{D}}^{H,CF}_{h,j,m}\}\}_{\forall j,m}$
- $\partial\hat{\boldsymbol{D}}^{CF} \equiv \{\{\partial\hat{\boldsymbol{D}}^{CF}_{j,m}/\partial\phi_j\},\{\partial\hat{\boldsymbol{D}}^{E,CF}_{j,m}/\partial\phi_j\},\{\partial\hat{\boldsymbol{D}}^{H,CF}_{h,j,m}/\partial\phi_j\}\}_{\forall j,m}$
- $\Delta\hat{\boldsymbol{D}}^{CF} \equiv \{\{\Delta_{\mathcal{S},j}\hat{\boldsymbol{D}}^{CF}_{j,m}\},\{\Delta_{\mathcal{S},j}\hat{\boldsymbol{D}}^{E,CF}_{j,m}\},\{\Delta_{\mathcal{S},j}\hat{\boldsymbol{D}}^{H,CF}_{h,j,m}\}_{\forall h}\}_{\forall\mathcal{S},j,m}$

such that (i) $\mathcal{G}^{CF}_{j,m}$ is the same as in our observed data for all MCOs j active in market m; (ii) single household premiums ϕ_j for all insurers satisfy (13) in the main text given $\hat{\boldsymbol{D}}^{CF}$, $\partial\hat{\boldsymbol{D}}^{CF}$ and $\boldsymbol{p}^{CF}$; (iii) all negotiated hospital prices $\boldsymbol{p}^{CF}$ satisfy (16) in the main text given $\hat{\boldsymbol{D}}^{CF}$, $\Delta\hat{\boldsymbol{D}}^{CF}$, and $\boldsymbol{p}^{CF}$; and (iv) all demand terms $\hat{\boldsymbol{D}}^{CF}$, $\partial\hat{\boldsymbol{D}}^{CF}$, and $\Delta\hat{\boldsymbol{D}}^{CF}$ are consistent with networks $\mathcal{G}^{CF}$, premiums $\boldsymbol{\phi}^{CF}$, and behavior given by our estimated models of hospital and insurer demand.

To compute a new equilibrium, we iterate on the following steps, where for each iteration ι:

1. *Update Premiums and Demand Terms.* Given negotiated hospital prices $\boldsymbol{p}^{\iota-1}$, we repeat the following for each iteration ι':

   (a) Update terms $\hat{\boldsymbol{D}}^{\iota'}$ and $\partial\hat{\boldsymbol{D}}^{\iota'}$ given premiums $\phi^{\iota'-1}$ and counterfactual networks $\mathcal{G}^{CF}$ using estimated hospital and insurer demand systems;

   (b) Update $\phi_j^{\iota'}$ using (12) in the main text and $\hat{\boldsymbol{D}}^{\iota'}$ and $\partial\hat{\boldsymbol{D}}^{\iota'}$ terms;

   until premiums converge within a tolerance of \$0.1 (using a sup-norm across all insurers). When updating premiums, we hold fixed the recovered value of $\hat{\omega}^1_j$ (scaled by the predicted number of hospital admissions) for all MCOs. This provides updated values of $\boldsymbol{\phi}^\iota$, $\hat{\boldsymbol{D}}^\iota$ and $\partial\hat{\boldsymbol{D}}^\iota$. Update $\Delta\hat{\boldsymbol{D}}^\iota$ using $\boldsymbol{\phi}^\iota$.

2. *Update Negotiated Hospital Prices.* Using updated values of $\boldsymbol{\phi}^\iota$, $\hat{\boldsymbol{D}}^\iota$ and $\Delta\hat{\boldsymbol{D}}^\iota$, (16) in the main text is used to update $\boldsymbol{p}^\iota$. Since (16) in the main text only defines total payments for hospital systems, there is only an equation for each hospital system and insurer pair, and not for each hospital and insurer pair; however, negotiated prices at the hospital level are required to determine an equilibrium. To proceed, we assume that the ratios of negotiated (DRG-adjusted) per-admission prices within a hospital system are the same as those observed in the data: i.e., for any two hospitals h and h' in the same hospital system and MCO j, $p^{CF}_{hj}/p^{CF}_{h'j} = p^o_{hj}/p^o_{h'j}$, where $p^o_{\cdot}$ are observed per-admission hospital prices.

   We implement this using the following matrix inversion: $\boldsymbol{p}^\iota = (\boldsymbol{A}^\iota)^{-1}\boldsymbol{B}^\iota$, where each row of vectors $\boldsymbol{p}^\iota$ and $\boldsymbol{B}^\iota$ and square matrix $\boldsymbol{A}^\iota$ corresponds to a particular hospital i and MCO j.[2] Each entry of

[2] This is similar to the procedure used in Crawford et al. (2015).

$\boldsymbol{p}^\iota$, p^ι_{ij}, is the negotiated price per-admission for that given hospital-MCO pair. Each entry of B^ι_{ij} is:

$$B^\iota_{ij} = (1-\tau_j)\left[\left(\phi_j \Phi'[\Delta_{\mathcal{S}j}\hat{D}^\iota_j]\right) - \eta_j[\Delta_{\mathcal{S}j}\hat{D}^{E,\iota}_j]\right] + \tau_j\left[\sum_{h\in\mathcal{S}}\sum_{n\in\mathcal{G}^H_{\mathcal{S}}} c_h[\Delta_{\mathcal{S}j}\hat{D}^{H,\iota}_{hn}])\right] + \tilde{\omega}^3_{\mathcal{S}j}\sum_{i\in\mathcal{S}}\hat{D}^H_{ij} \qquad i\in\mathcal{S}$$

if ij is the first observation in the vector for a given system $\mathcal{S}$, $i\in\mathcal{S}$, and MCO j; and $B^\iota_{ij}=0$ otherwise. The parameter $\tilde{\omega}^3_{\mathcal{S}j} \equiv \hat{\omega}^3_{\mathcal{S}j}/(\sum_{i\in\mathcal{S}}\hat{D}^H_{ij})$ is recovered during estimation, and held fixed in our counterfactual simulations. Finally, $\boldsymbol{A}^\iota$ is a matrix where each entry $A^\iota_{r;c}$, corresponding to a row r and c which in turn each represent a given hospital-MCO pair, is given by:

- $A^\iota_{ij;hj} = \hat{D}^{H,\iota}_{hj}$ for all hospitals h in the same system and HSA as i (including i);
- $A^\iota_{ij;hj} = (1-\tau_j)[\Delta_{\mathcal{S}j}\hat{D}^{H,\iota}_{hj}]$ if hospital h is on a different system as i, but located in the same HSA as hospital i;
- $A^\iota_{ij;hn} = \tau_j[\Delta_{\mathcal{S}j}\hat{D}^{H,\iota}_{hn}]$ for all hospitals h in the same system and HSA as i (including i) for $n\neq j$;

if ij is the first observation in the vector for a given system $\mathcal{S}$ and MCO j. If row ij corresponds to a repeat observation for a given system $\mathcal{S}$ and MCO j, then

- $A^\iota_{ij;ij} = 1$;
- $A^\iota_{ij;hj} = -p^o_{ij}/p^o_{hj}$ where h is on the same hospital system as i, and hj is the first entry for the hospital system and MCO j in the matrix.

All other elements of $\boldsymbol{A}^\iota$ are 0.

Note that $\boldsymbol{A}\times\boldsymbol{p}^o = \boldsymbol{B}$ is equivalent to (16) in the main text for the observed prices and demand terms, with the additonal restriction that hospital prices within a hospital system for a particular MCO are assumed to be a constant ratio with respect to one another.

We repeat until between iterations, premiums do not differ by more than \$0.1, and predicted household demand across insurers and household types do not differ by more than one household.

A.7 Decomposition of Bargaining Effect Changes

We decompose the change in negotiated prices into changes in the components introduced earlier in Section 2.2. Beginning with equation (3), we divide through by the number of admissions from insurer j to hospital system $\mathcal{S}$ to obtain an equation for the average negotiated price per admission within each system. The difference between counterfactual and observed prices can be written as

$$\bar{p}^{CF}_{\mathcal{S}j} - \bar{p}^{o}_{\mathcal{S}j} = \underbrace{(1-\tau_j)\left[\frac{[\Delta_{\mathcal{S},j}\hat{D}^o_j]}{\hat{D}^{H,o}_{\mathcal{S}j}}(\phi^{CF}_j - \phi^o_j)\right]}_{\text{(ia) } \Delta \text{ Premium Effect}} \tag{4}$$

$$+ \underbrace{(1-\tau_j)\left[(\frac{[\Delta_{\mathcal{S},j}\hat{D}^{CF}_j]}{\hat{D}^{H,CF}_{\mathcal{S},j}} - \frac{[\Delta_{\mathcal{S},j}\hat{D}^o_j]}{\hat{D}^{H,o}_{\mathcal{S},j}})(\phi^{CF}_j) - (\frac{[\Delta_{\mathcal{S},j}\hat{D}^{E,CF}_j]}{\hat{D}^{H,CF}_{\mathcal{S},j}} - \frac{[\Delta_{\mathcal{S},j}\hat{D}^{E,o}_j]}{\hat{D}^{H,o}_{\mathcal{S},j}})(\eta_j)\right]}_{\text{(ib) } \Delta \text{ Enrollment Effect}}$$

$$- \underbrace{(1-\tau_j)\left[(\frac{\sum_{h\in\mathcal{G}^M_j\setminus\mathcal{S}} p^{CF}_{h,j}[\Delta_{\mathcal{S}j}\hat{D}^{H,CF}_{h,j}]}{\hat{D}^{H,CF}_{\mathcal{S},j}}) - (\frac{\sum_{h\in\mathcal{G}^M_j\setminus\mathcal{S}} p^{o}_{h,j}[\Delta_{\mathcal{S},j}\hat{D}^{H,o}_{h,j}]}{\hat{D}^{H,o}_{\mathcal{S},j}})\right]}_{\text{(ii) } \Delta \text{ Price Reinforcement Effect}}$$

$$+ \underbrace{\tau_j\left[\frac{\sum_{i\in\mathcal{S}} c_i\hat{D}^{H,CF}_{i,j}}{\hat{D}^{H,CF}_{\mathcal{S},j}} - \frac{\sum_{i\in\mathcal{S}} c_i\hat{D}^{H,o}_{i,j}}{\hat{D}^{H,o}_{\mathcal{S},j}}\right]}_{\text{(iii) } \Delta \text{ Hospital Cost Effect}}$$

$$- \underbrace{\tau_j\left[\sum_{n\in\mathcal{G}^H_{\mathcal{S}},n\neq j} \frac{\sum_{i\in\mathcal{S}}(p^{CF}_{i,n} - c_i)\Delta_{\mathcal{S},j}\hat{D}^{H,CF}_{i,n}}{\hat{D}^{H,CF}_{\mathcal{S}j}} - \frac{\sum_{i\in\mathcal{S}}(p^{o}_{in} - c_i)\Delta_{\mathcal{S},j}\hat{D}^{H,o}_{i,n}}{\hat{D}^{H,o}_{\mathcal{S}j}}\right]}_{\text{(iv) } \Delta \text{ Recapture Effect}},$$

where terms with a "o" and "CF" superscript denote observed "baseline" (before the removal or addition of an insurer) and counterfactual values respectively; other terms are the recomputed equilibrium values (at new premiums and prices) after the insurer has been removed; and for each hospital system $\mathcal{S}$, $\hat{D}^H_{\mathcal{S},j} \equiv \sum_{i\in\mathcal{S}} \hat{D}^H_{i,j}$, and $\bar{p}_{\mathcal{S},j} \equiv \sum_{i\in\mathcal{S}}(p_{i,j}\hat{D}^H_{i,j})/\sum_{i\in\mathcal{S}}(\hat{D}^H_{i,j})$. We discuss each effect briefly in turn, using the example of removing BC from the market for clarity.

Changes in term (i) in (3) (premium and enrollment effects) can be decomposed into:

(ia) *Premium effect*: This is the increase in insurer j's premium when BC is removed from the market, multiplied by the baseline change in number of enrollees when the hospital system is dropped (scaled by the number of admissions system $\mathcal{S}$ received from j). The larger the premium increase when the insurer is removed from the market, the higher the price increase for system $\mathcal{S}$.

(ib) *Enrollment effect*: The change in insurer j's profit reduction (net of non-hospital costs) from losing system $\mathcal{S}$ when BC is removed from the market. The first term of (ib) represents this change-in-change in premium revenues (holding fixed premiums), and the second term represents the change-in-change in insurer non-hospital marginal costs. Since the loss in insurer j's enrollment when system $\mathcal{S}$ is removed from the network is smaller when BC is not present, and since premium revenues exceed non-hospital marginal costs, we expect this overall term to be negative—i.e., that insurer j's outside option should improve when BC is removed.

Changes in terms (ii) - (iv) in (3) upon removal of an insurer are:

(ii) *Price reinforcement effect*: When BC is removed from the market, we expect a reduction in j's loss in demand upon losing system $\mathcal{S}$, but an indeterminate overall effect on other-hospital prices. Thus, the direction of this overall effect is indeterminate.

(iii) *Hospital cost effect*: If system $\mathcal{S}$ contains a single hospital this term will equal zero. For multiple-hospital systems there may be a small change in average cost per admission when BC exits the market due to a re-allocation of differentially sick enrollees across plans and hospitals.

(iv) *Recapture effect*: The change in the contribution to profits that system $\mathcal{S}$ can recapture from other insurers if removed from j's network, when BC is removed from the market. We expect the first term (recapture after BC is removed) to be smaller in magnitude than the second, because consumers have fewer other plans to which they can switch. In fact when we remove BC the first term goes to zero because the only remaining insurer choice is Kaiser, which as a vertically integrated plan, will not allow consumers to retain access to system $\mathcal{S}$. Thus the system's outside option is weakened when BC exits the market, implying a negative effect on the price increase through this term.

As discussed previously, we hold fixed the hospital-insurer specific per-admission residual in the price bargaining equation throughout our counterfactual exercises, and thus (4) will hold exactly.

A.8 Robustness: Switching Costs and Inertia

There is evidence to suggest that enrollees in our setting are responsive to hospital network changes, and do not face insurmountable frictions when switching plans. In 2005 (the year after our sample), BS removed 24 hospitals on its CA network for CalPERS enrollees, 13 of which were owned by Sutter Health. Approximately 20% of enrollees on BS in three counties surrounding Sacramento switched to BC that year, with another 9% moving to Kaiser.[3] Our model's estimates predict that BS's enrollment would fall by just under 10% in the Sacramento HSA if Sutter hospitals were dropped. We note that this difference can partially be accounted for by the fact that the CalPERS BS plan also dropped 17 physician groups (including some owned by Sutter) in that year.[4] This analysis suggests that, if switching costs do exist, they do not lead us to substantially over-estimate switching probabilities in response to network changes. Indeed, even without accounting for switching costs or other frictions, we may be *understating* the extent to which insurers lose enrollees upon dropping a hospital system if there are also changes to physician or other services, and these are not adequately controlled for by our measures of hospital network utility (WTP).[5]

To examine the sensitivity of our results to the estimated responsiveness of consumers to hospital network changes, we repeat our analysis by increasing *and* decreasing our estimated α_κ^W WTP coefficients by 25%, re-estimating the bargaining parameters and insurer marginal costs as in Section 3.4, and recomputing counterfactual outcomes. Although the parameter estimates change slightly, the counterfactual results and substantive findings are qualitatively similar.

References

Crawford, Gregory S., Robin S. Lee, Michael D. Whinston, and Ali Yurukoglu. 2015. "The Welfare Effects of Vertical Integration in Multichannel Television Markets." NBER Working Paper 21832.

Dafny, Leemore S., Katherine Ho, and Robin S. Lee. 2015. "The Price Effects of Cross-Market Hospital Mergers." NBER Working Paper 22106.

[3] "CalPERS Announces Enrollment Results; No Consumer Stampede to Retain Sutter," Press Release, CalPERS, December 14, 2004.

[4] See Dafny, Ho and Lee (2015) for a discussion of why physician and hospital mergers can yield positive price effects for the merging parties.

[5] As we rely on within-market across-zip-code variation in hospital network utility to identify the coefficients on WTP terms ($\{\alpha_\kappa^W\}$), this can occur if physician offices are not located in the same zip codes as affiliated hospitals and if the utility from physician networks is absorbed by insurer-market fixed effects.