Centralized and Decentralized Equilibria in Provider Network Breadth

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Abstract

Health insurer competition in provider networks raises the question of how broad should networks be. In this paper I use a structural model of insurer competition in service-level provider networks to derive the social planner's solution, and to simulate the impact of competition between private insurers on provider network breadth. I find that the social planner, who maximizes consumer surplus subject to insurers' participation constraints, would choose complete networks. Collusion between private insurers generates an equilibrium that is farther away from the social planner's solution. Certain network adequacy rules can help approximate the first-best.

Keywords: Health insurance, Hospital networks, Adverse selection, Competition.

JEL codes: I11, I13, I18, L13.

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1 Introduction

The introduction of managed care in different countries has been accompanied with increasing differentiation between health insurers. Provider networks are one such dimension of differentiation. Insurers establish networks of preferred providers to limit where their patients can go. The design of provider networks responds to risk selection incentives, cost incentives, and market structure. Although there is a better understanding of how risk selection influences insurers' network coverage decisions (Serna, 2024; Shepard, 2022; Ho and Lee, 2017), much less is known about how insurer competition impacts provider networks.

In this paper I empirically characterize a centralized equilibrium where the regulator chooses network breadth, and compare it against different decentralized equilibria with insurer competition. By showing the importance of insurer competition for producing broad provider networks, the findings of my paper contribute to the policy debate around the use network adequacy rules to guarantee high-quality access to healthcare in markets with universal coverage.

I provide this characterization in the context of the Colombian health care system. This system is ideal to study the impact of insurer competition for several reasons. Managed care was introduced in Colombia during 1993 with law 100. Private insurers in this system offer a national health insurance plan with equal benefits to all Colombians. The national plan has near-universal coverage and enrollment is mandatory. Private insurers in this health system can design their provider networks separately for each health service in the national plan, but they cannot charge premiums nor design cost-sharing rules. Premiums, cost-sharing, and benefits are all regulated by the government and standardized across insurers and providers. This setting allows me to isolate the effect of managed care competition on provider network breadth, and provide assessments on the benefits of managed care and on the optimality of broad provider networks.

To settle intuition on the effects of interest, I specify a simple theoretical model of insurer competition on provider network breadth. Allowing for adverse selection and moral hazard in network breadth, the model shows that a monopolist insurer chooses a narrow network, while the social planner chooses a broad network. A version of the model with an insurance mandate (as in Colombia) maintains these predictions. The model also shows that in an insurance duopoly, the equilibrium is one where insurers maximally differentiate and coverage is under-provided to relatively unhealthy consumers. To examine the impact of competition on provider network breath more systematically, I move to the empirical model.

My empirical setup builds on the model and estimates from Serna (2024). The main object of interest in this model is insurers' service network breadth, defined as the fraction of providers in a market that deliver a service and are covered by the insurer. On the demand side of the model, new consumers choose their insurer based on out-of-pocket costs and service network breadth. On the supply side, insurers are heterogeneous in their average costs and fixed costs, and compete by choosing their vector of service network breadth to maximize long-run profits.

The model is estimated using enrollment and claims data from all enrollees in the contributory system in Colombia from 2010 to 2011. Demand estimates show that there is substantial adverse selection on service network breadth. Sicker, relatively unprofitable individuals have a higher willingness-to-pay for network breadth in services that they are more likely to claim compared to healthy, relatively profitable individuals. Cost estimates show that insurers enjoy substantial economies of scope across services and that some insurers have systematically lower fixed costs than others. Taken together, the model estimates imply that insurers respond to demand-side selection incentives by offering narrow networks in unprofitable services, but respond to scope economies and fixed cost incentives by offering broad networks.

The observed equilibrium in service network breadth is asymmetric, with some insurers choosing broad networks and some choosing narrow networks for the same service. The empirical model rationalizes this asymmetry in several ways. First, estimates indicate that there is substantial preference and cost heterogeneity across insurers. For example, the demand model shows that there is a trade-off between network breadth and out-of-pocket costs, and that this trade-off varies with the consumer's health status and across services. Second, the degree of insurer competition in each health service can generate variation in network breadth across services and markets. While Serna (2024) exploits the first explanation to get at the impact of risk selection and fixed costs, this paper is related to the second explanation on the impact of insurer competition on service network breadth.

Mirroring the discussion of the theoretical framework, I use the model estimates to conduct a counterfactual exercise where the social planner chooses the vector of service network breadth for each insurer to maximize consumer surplus subject to insurers' participation constraints. The results from this counterfactual provide strong empirical evidence for the first-best solution in the simple theoretical model. In a world with mandatory enrollment, the social planner would choose complete service networks relative to the observed scenario. For instance, mean network breadth for hospitalizations would more than double from a baseline of 0.32. Although the first-best solution involves broader coverage and potentially better access to care, it also involves substantially higher healthcare costs for the system. The social planner therefore trades-off costs and coverage in a similar way than consumers do.

I proceed to analyze whether a decentralized equilibrium where private insurers compete in service network breadth can bring market outcomes closer to the social planner's solution. To do so, I compute equilibrium outcomes under a scenario where some insurers collude and maximize joint profits. Preference and cost heterogeneity across insurers make it difficult to predict what would happen with network breadth in a collusive agreement. However, I find that regardless of which insurers collude, the new equilibrium is one where all insurers choose narrower service networks. For example, findings show that mean network breadth decreases 5.3 percent and consumer surplus decreases 1.8 percent when the three largest insurers collude. This finding suggests that network coverage is increasing in the degree of insurer competition and hence maintaining strong levels of competition can improve access to healthcare.

The current regulation of the Colombian health care system allows insurers to discriminate provider networks across health services, which essentially implies discrimination on the consumer's health status. For example, an insurer can choose to cover obstetric care but not renal care at a particular provider. Because promoting insurer competition to increase network coverage can be difficult to achieve policy-wise, in my last exercise I explore the effects of policies that address risk selection incentives more directly. I focus on a type of network adequacy rule that prohibits discrimination of provider networks across services. My findings show that under this rule, mean network breadth doubles for almost every service. The higher healthcare costs associated with broader networks are completely borne by insurers, but consumer surplus increases around 14 percent for both healthy and sick individuals. In general, results suggest that policies that address risk selection can bring equilibrium network breadth closer to the social planner's solution.

The findings of this paper contribute to the literature on insurer competition and provider network formation. In the first line of research, Ho and Lee (2017) study the impact of insurer competition on premiums. Complementary to their work, I study the effects of competition on provider network breadth. In the second line of research, Liebman (2022); Ghili (2022); Ho and Lee (2019) analyze insurers' use of network exclusions to achieve lower prices during bilateral negotiations with hospitals. I add to this literature by quantifying how different levels of competition affect network exclusions. My empirical setting relates to Kreider et al. (2022) and Finkelstein et al. (2019) by allowing me to quantify the impact of selection on access to health insurance among relatively low-income populations.

My paper provides an approximation to the question of whether narrow networks are desirable for society and whether insurance markets are competitive. Ho and Lee

(2019) address similar questions in the case of a monopoly insurer. Several other papers also study the trade-offs to broad and narrow provider networks including Liebman and Panhans (2021); Atwood and Sasso (2016); Dafny et al. (2015b). My paper quantifies the trade-off between network breadth and costs both corroborating and complementing this prior work. On the question of whether insurance markets are competitive, Dafny (2010) concludes that in the group health insurance industry, firms in concentrated insurance markets see higher premium growth. Dafny et al. (2015a) report similar results in the context of the Health Insurance Marketplaces. Finally, Mahoney and Weyl (2017) show that policies that offset adverse selection in health insurance markets can increase premiums when insurers have market power. While these papers focus on the interaction between competition and prices, my setting is one without price competition, allowing me to characterize the inteplay between competition, adverse selection, and non-price elements of the insurance contract.

The rest of this paper is organized as follows. Section 2 presents a simple theoretical model of insurer competition. Section 3 summarizes the background, data, model, and estimates. Section 4 presents the results of a centralized equilibrium where the social planner chooses network breadth. Section 5 derives the equilibrium network breadth when insurers maximize joint profits. Section 6 provides results of an alternative policy where insurers are prohibited from discriminating networks across health services. Section 7 concludes.

2 Theoretical Framework

To establish intuition on how insurer competition affects hospital networks, I develop a simple model of competition in network breadth. Suppose a consumer is of type $\theta \sim U[\underline{\theta}, \overline{\theta}]$, with $\overline{\theta} > \underline{\theta} \geq 0$. The consumer's type denotes their sickness level, so higher θ means the individual is in worse health. Consumers can choose from a set of insurers $\{1, ..., j, ..., J\}$ that offer network breadth $H_j \in \{0, 1\}$, where 0 denotes a narrow network and 1 denotes a broad network.[1]

The expected medical cost of a type-θ consumer is $c(H_j, \theta)$, with $c_\theta(H_j, \theta) > 0$, $c(1, \theta) > c(0, \theta)$, $c_\theta(1, \theta) > c_\theta(0, \theta)$, and $c(1, \theta) < 2c(0, \theta)$. The consumer pays a fraction r of her expected medical cost. This cost structure captures adverse selection because different consumer types have different costs conditional on network breadth. The cost structure also captures moral hazard because the medical cost depends on network breadth conditional on the consumer type. Consumer θ's utility function for contract H_j is:

$$U(H_j, \theta) = \theta\beta_j(1 + H_j) - rc(H_j, \theta)$$

where $\beta_j > 0$ is a preference parameter that introduces preference heterogeneity across insurers. Suppose individuals can choose uninsurance, the utility of which equals zero. Consumers buy insurance if:

$$U(H, \theta) \geq 0 \iff \theta \geq \frac{rc(H, \theta)}{\beta(1 + H)}$$

For the problem to be non-trivial, assume also that $\overline{\theta} > \frac{rc(0,\theta)}{\beta}$. Insurers offer only one level of network breadth and make per-enrollee profits equal to $\pi(H_j, \theta) = R(\theta) - (1 - r)c(H_j, \theta)$, where $R(\theta)$ is a risk-adjusted transfer from the government and $R_\theta(\theta) > 0$. Assume that the risk adjustment formula is imperfect so $R_\theta(\theta) < c_\theta(H_j, \theta)$. Moreover, assume that it is always profitable to serve the healthiest consumer under a broad network $R(\underline{\theta}) > (1-r)c(1, \underline{\theta})$, but unprofitable to serve the sickest consumer under a narrow network $R(\overline{\theta}) < (1 - r)c(0, \overline{\theta})$.

Monopoly. The monopolist's problem is to choose network breadth to maximize

[1]For simplicity in exposition, network breadth is a binary choice: narrow or broad. Choosing $H_j = 0$ means the insurer covers a small number of hospitals, but it does not mean the insurer has no coverage. For instance, in a case where there are two hospitals in the market, a narrow-network insurer will choose to cover one hospital, while a broad-network insurer would choose to cover both hospitals.

profits given by:

$$\Pi(H) = \int_{\frac{rc(H,\theta)}{\beta(1+H)}}^{\overline{\theta}} (R(t) - (1-r)c(H,t))dt$$

The choice of network breadth affects the monopolist's total demand, the composition of consumer types that buy insurance, and the cost of providing insurance.

Claim. The monopolist chooses a narrow network. This implies that

$$\int_{\frac{rc(1,\theta)}{2\beta}}^{\overline{\theta}} (R(t) - (1-r)c(1,t))dt < \int_{\frac{rc(0,\theta)}{\beta}}^{\overline{\theta}} (R(t) - (1-r)c(0,t))dt$$

We can rewrite the previous expression as

$$\int_{\frac{rc(1,\theta)}{2\beta}}^{\frac{rc(0,\theta)}{\beta}} (R(t) - (1-r)c(1,t))dt < (1-r)\int_{\frac{rc(0,\theta)}{\beta}}^{\overline{\theta}} (c(1,t) - c(0,t))dt$$

Using the fact that $c(1,\theta) < 2c(0,\theta)$ we obtain the following inequality

$$\int_{\frac{rc(1,\theta)}{2\beta}}^{\frac{rc(0,\theta)}{\beta}} (R(t) - (1-r)c(0,t))dt < (1-r)\int_{\frac{rc(1,\theta)}{2\beta}}^{\overline{\theta}} c(0,t)dt,$$

which holds under the assumptions that $\overline{\theta} > \frac{rc(0,\theta)}{\beta}$, $R(\underline{\theta}) > (1-r)c(1,\underline{\theta})$, and $R(\overline{\theta}) < (1-r)c(0,\overline{\theta})$. With a monopolist insurer, the lowest consumer type that participates in the market satisfies $\hat{\theta} = \frac{rc(0,\hat{\theta})}{\beta}$.

Social planner. A social planner who maximizes the sum of consumer welfare, insurer profits, and government spending has the following objective function:

$$W(H) = \int_{\frac{rc(H,\theta)}{\beta(1+H)}}^{\overline{\theta}} (t\beta(1+H) - c(H,t))dt$$

Here we can think of β as a parameter that converts units of welfare into dollars. Risk-adjusted payments in this function cancel out because they are transfers from the government to the insurer.

Claim. The social planner chooses a broad network, which implies that:

$$W(1) = \int_{\frac{rc(1,\theta)}{2\beta}}^{\overline{\theta}} (2t\beta - c(1,t))dt > \int_{\frac{rc(0,\theta)}{\beta}}^{\overline{\theta}} (t\beta - c(0,t))dt = W(0)$$

Under the assumption that $c(1,\theta) < 2c(0,\theta)$ we obtain the following:

$$\begin{aligned} W(1) = \int_{\frac{rc(1,\theta)}{2\beta}}^{\overline{\theta}} (2t\beta - c(1,t))dt &> \int_{\frac{rc(0,\theta)}{\beta}}^{\overline{\theta}} (2t\beta - c(1,t))dt \\ &> \int_{\frac{rc(0,\theta)}{\beta}}^{\overline{\theta}} (2t\beta - 2c(0,t))dt > \int_{\frac{rc(0,\theta)}{\beta}}^{\overline{\theta}} (t\beta - c(0,t))dt = W(0) \end{aligned}$$

In this case the lowest type that participates in the market satisfies $\tilde{\theta} = \frac{rc(1,\tilde{\theta})}{2\beta}$. Moreover, $\tilde{\theta} < \hat{\theta}$, suggesting that in a monopoly market fewer consumers buy insurance than is socially efficient, and these consumers are relatively sicker. With a monopolist insurer, network breadth is also under-provided relative to the social planner's solution in a market where consumers can choose uninsurance.

Insurance mandate. Now consider a scenario where there is an insurance mandate requiring that every consumer purchases insurance or that the market is covered. In this case the profit of a monopolist choosing network breadth is:

$$\Pi(H) = \int_{\underline{\theta}}^{\overline{\theta}} (R(\theta) - (1-r)c(H,\theta))d\theta$$

The monopolist chooses a narrow network because with fixed total revenues $\Pi(1) < \Pi(0)$, and this solution is independent of adverse selection.

The social planner's objective function is:

$$W(H) = \int_{\underline{\theta}}^{\overline{\theta}} (\theta\beta(1+H) - c(H,\theta))d\theta$$

The planner chooses a broad network because the assumption that $c(1,\theta) < 2c(0,\theta)$

implies the following

$$W(0) = \int_{\underline{\theta}}^{\overline{\theta}} (\theta\beta - c(0,\theta))d\theta < \int_{\underline{\theta}}^{\overline{\theta}} (2\theta\beta - 2c(0,\theta))d\theta < \int_{\underline{\theta}}^{\overline{\theta}} (2\theta\beta - c(1,\theta))d\theta = W(1)$$

Note that to the extent that consumer θ's valuation for a broad network is positively correlated with their cost (adverse selection), it is socially desirable to provide a broad network to all consumers under mandatory enrollment. Instead, with zero correlation, the cost function satisfies $c(H,\theta) = c(H)$, and the social planner's objective function becomes:

$$W(H) = \int_{\underline{\theta}}^{\overline{\theta}} (\theta\beta(1+H) - c(H))d\theta = \frac{(\overline{\theta}^2 - \underline{\theta}^2)}{2}\beta(1+H) - (\overline{\theta} - \underline{\theta})c(H)$$

In this case it is optimal to provide a broad network if and only if the average consumer's valuation for a broad network is at least the average consumer's cost under a broad network: $(\overline{\theta} + \underline{\theta})\frac{\beta}{2} \geq c(1) - c(0)$. The fact that the social planner's solution with adverse selection coincides with the solution without adverse selection under certain conditions on the average consumer reflects the confounding effect of moral hazard.

Duopoly. To derive intuition on the impact of insurer competition on network coverage relative to monopoly, suppose two insurers $\{a, b\}$ compete in the market with mandatory enrollment, and assume that $\beta_b < \beta_a < 2\beta_b$. The consumer type that is indifferent between enrolling with insurer a or enrolling with b satisfies the following:

$$\theta' = \theta'(H_a, H_b) = \frac{r(c(H_a,\theta') - c(H_b,\theta'))}{\beta_a(1+H_a) - \beta_b(1+H_b)}$$

Profits to each insurer are given by:

$$\Pi_a(H_a, H_b; t) = \int_{\theta'}^{\overline{\theta}} (R(t) - (1-r)c(H_a, t))dt$$
$$\Pi_b(H_a, H_b; t) = \int_{\underline{\theta}}^{\theta'} (R(t) - (1-r)c(H_b, t))dt$$

Assume that $\theta'(0,1) < \frac{\overline{\theta}+\underline{\theta}}{2} < \theta'(1,0)$. The normal-form matrix of this game is:

<table>
<tr><td></td><td></td><td colspan="2">b</td></tr>
<tr><td></td><td></td><td>$H=0$</td><td>$H=1$</td></tr>
<tr><td rowspan="2">a</td><td>$H=0$</td><td>$\int_{\underline{\theta}}^{\overline{\theta}} \pi_a(0,0;t)dt$, 0</td><td>$\int_{\theta'}^{\overline{\theta}} \pi_a(0,1;t)dt$, $\int_{\underline{\theta}}^{\theta'} \pi_b(0,1;t)dt$</td></tr>
<tr><td>$H=1$</td><td>$\int_{\theta'}^{\overline{\theta}} \pi_a(1,0;t)dt$, $\int_{\underline{\theta}}^{\theta'} \pi_b(1,0;t)dt$</td><td>$\int_{\underline{\theta}}^{\overline{\theta}} \pi_a(1,1;t)dt$, 0</td></tr>
</table>

The game has a unique Nash equilibrium where insurers maximally differentiate $(H_a, H_b) = (0, 1)$. Appendix A derives each firm's best response correspondence. The duopoly solution is a separating equilibrium with a "strange property" (Rothschild and Stiglitz, 1976): sicker consumers are offered lower network breadth compared to healthier consumers due to adverse selection. Unhealthy consumers are thus not better off than they would be in the absence of healthy individuals.

This simple model highlights the tension between the social planner's solution and a decentralized equilibrium with a monopolist insurer in the presence of adverse selection. With mandatory enrollment, the monopolist is essentially a cost-minimizing firm, while the social planner chooses the most generous network conditional on every consumer participating. As a result, network breadth is under-provided in monopoly markets with insurance mandates. Competition between insurers generates an equilibrium that is closer to the social planner's solution but does not fully implement the first-best. To compare how different levels of competition impact network breadth and determine whether they bring the market closer to the social planner's solution, I proceed to the empirical application.

3 Empirical Application

I use enrollment and claims data from everyone enrolled in the contributory system in Colombia between 2010 and 2011, around 22 to 24 million enrollees. Individuals in the contributory system are able to pay for their tax contributions, unlike those covered by the subsidized system, which is fully funded by the government. The enrollment files contain information on the enrollees' sex, age, municipality of residence, insurer, and days enrolled in the year. The claims data report date in which the claim was filed, insurer that reimbursed the claim, provider that rendered the claim, associated health service, and negotiated price of the health service.

Private insurers offer access to the national health insurance plan, providing equal benefits to all Colombians. Almost every aspect of the insurance plan is regulated by the government including cost-sharing rules, premiums, and benefits. The only source of revenue for insurers in this health system are the government's capitated risk-adjusted transfers. The government makes two types of transfers to insurers: one at the beginning of every calendar year, which compensates insurers for their enrollee's sex, age, and location; and another one at the end of every year, which compensates insurers for a coarse list of diseases.

The Colombian insurance market is highly concentrated. Table 1 shows that the three largest insurers in the contributory system covered 46 percent of enrollees in the country during 2011. Figure 1 also shows that half of Colombian states had less than 7 insurers. Market concentration raises questions about the efficiency of network coverage through private insurers.

Table 1: National market shares

Insurer	Market share
EPS013	20.62
EPS016	15.16
EPS037	12.74
EPS002	8.82
EPS010	7.17
EPS017	6.96
EPS005	4.89
EPS018	4.34
EPS003	3.94
EPS008	3.76
EPS023	2.95
EPS009	1.80
EPS001	1.65
EPS012	1.55

Note: Table shows the national market share in the number of enrollees for each insurer during 2011.

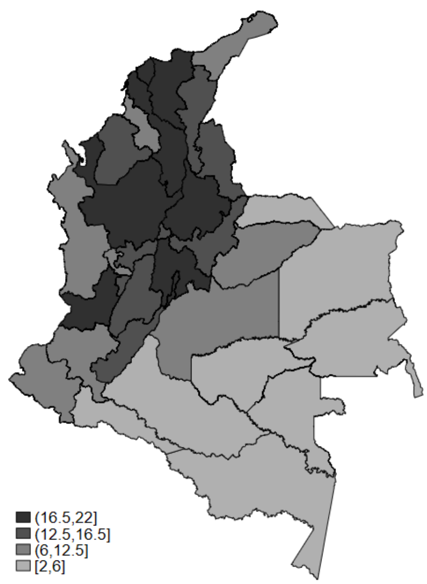

Figure 1: Number of insurers per state

3.1 Hospital Networks

Even though cost-sharing and premiums are regulated, insurers in Colombia can choose which health services to cover at which providers. Insurers also negotiate service prices with providers when determining network inclusions. Although the government stipulates a set of network adequacy rules, these rules apply only to the provision of primary care, oncology, and urgent care, which are a small subset of all the services offered in the national plan.

I use service-level provider network data from the National Health Superintendency for 2010 and 2011 to construct insurers' service network breadth following Serna (2024). Appendix table 1 presents the complete list of services. Service network breadth is defined as the fraction of providers in a market that deliver a service and are covered by the insurer. Service network breadth is the insurer's choice variable in this health system. With growing concerns about proliferation of narrow networks in countries like Colombia and the US, analyzing the determinants of network breadth is a primary task for the design of health insurance policies.

Individuals who enroll with a particular insurer have access to all the providers in its network across markets. Even when living in rural or isolated municipalities with few clinics, consumers typically travel to the capital city in their state to receive care. Enrollment decisions are thus often made on the basis of network breadth in the consumer's state of residence. I thus assume that the relevant market for insurers' network coverage decisions and consumer's enrollment decisions is a Colombian state.

The left-hand panel of figure 2 shows the distribution of network breadth in Bogotá, the capital city of the country. Network breadth varies substantially across insurers and services in given market. With zero premiums and fixed plan characteristics, this variation in network breadth is unusual. Serna (2024) rationalizes these differences in network breadth within a market with findings of substantial preference and cost heterogeneity across insurers and services.

Network breadth also varies considerably across markets as seen in the right-hand

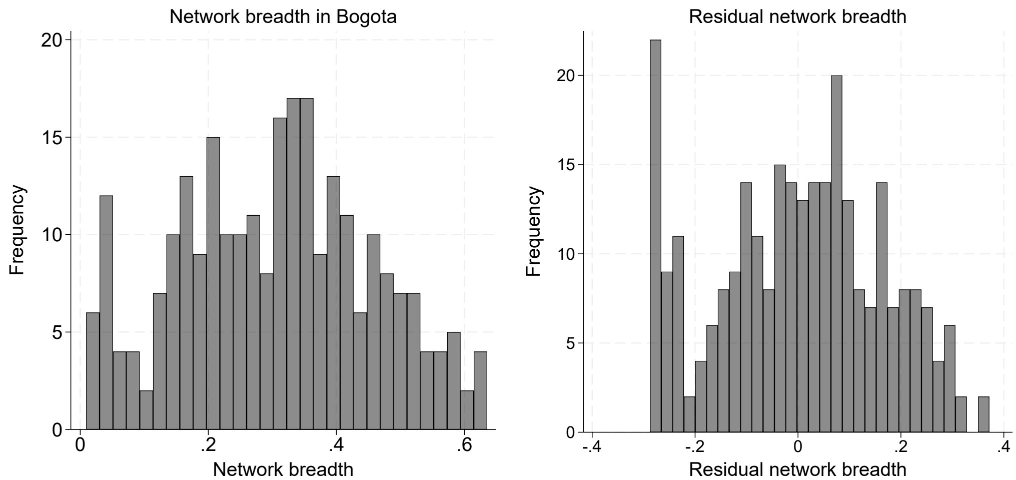

Figure 2: Distribution of (residual) network breadth

Note: The left-hand panel of the figure shows the distribution of network breadth in Bogotá. The right-hand panel shows the distribution of residual network breadth after controlling for insurer-by-service fixed effects. In both panels insurers EPS008, EPS009, EPS012, and EPS023 are excluded.

panel of figure 2. The figure shows the distribution of residual network breadth after controlling for insurer-by-service fixed effects. This variation may be the result of differences in insurer market structure, provider market structure, and/or market size, the first of which I focus on in this paper.

3.2 Market Structure

I provide descriptive statistics on the association between insurer market structure and market outcomes in this subsection. Figure 4 presents a scatterplot of average network breadth (across insurers and services) and the Herfindahl-Hirschman Index (HHI) per market. The HHI is calculated from insurer market shares in the number of enrollees. The figure shows that markets with relatively high concentration tend to have higher average network breadth per service, a correlation that contradicts the predictions from the theoretical framework.

However, this correlation masks an underlying adverse selection effect. Figure

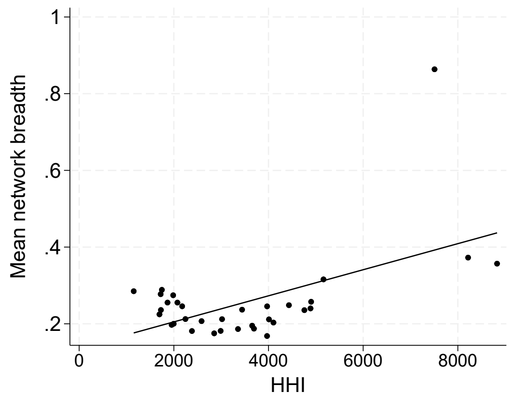

Figure 3: HHI and mean network breadth

Note: Figure shows a scatter plot of mean network breadth in a market (across insurers and services) and the Herfindahl-Hirschman Index based on the number of enrollees in a market. The solid line represents a linear fit.

4 shows the same scatterplot for average network breadth in general medicine in the left-hand panel and in cardiac care in the right-hand panel. General medicine has a relatively high claim probability among both healthy and sick individuals, while cardiac care services are mostly claimed by patients with chronic conditions. Insurers' risk selection incentives therefore differ across these services.

The figure shows a positive correlation between HHI and average network breadth in general medicine, but a negative correlation with average network breadth for cardiac care. This suggests that insurer market concentration has different effects on network breadth depending on the degree of adverse selection in each service. The two panels also suggest that drawing conclusions about the effect of insurer market structure from correlation exercises alone and ignoring network breadth variation across services may be misleading.

3.3 Empirical Model

To characterize the impact of insurer competition on network breadth more systematically, I build on the data, empirical model, and estimates from Serna (2024). That

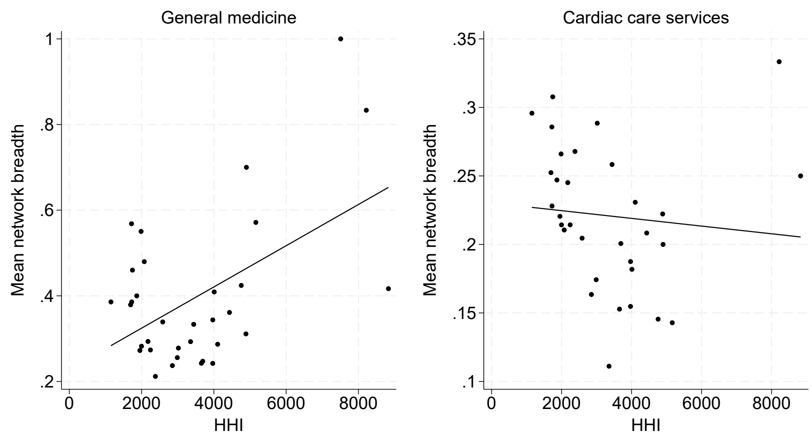

Figure 4: HHI and mean network breadth for general medicine and cardiac care

Note: Figure shows a scatter plot of Herfindahl-Hirschman Index and mean network breadth in general medicine in the left panel and mean network breadth in cardiac care in the right panel. The solid line represents a linear fit.

paper presents a detailed description of the Colombian data, model, identification strategy, and estimates that I use here. I summarize these modelling aspects in appendix C, but provide the main empirical micro-foundations for the theoretical model below.

The Colombian insurance market is characterized by substantial consumer inertia. Conditional on staying in the contributory system, less than 6 percent switch out of their insurer. This suggests that when choosing service network breadth, insurers take into account the effects that this choice may have on future profits from enrollees who are "locked-in", who age, and who transition across diagnoses. High inertia on insurer choice also suggests that insurers compete mainly on new enrollees. Take one market m, insurer j's profit function in this market is:

$$\Pi_j = \sum_{\theta} \pi_{j\theta}(H_{jk}, H_{-jk})N_\theta + \sum_{s=t+1}^{T} \zeta^s \sum_{\theta}(1-\rho_{\theta'})\mathcal{P}(\theta'|\theta)\pi_{j\theta'}(H_{jk}, H_{-jk})N_{\theta'} - C_j(H_j, \xi_j)$$

where θ is a consumer type potentially capturing their (unobserved to insurers) sickness level, H_{jk} is insurer j's network breadth for service k, ζ is a discount factor,

ρ is the probability that the consumer drops out of the contributory system, $\mathcal{P}$ is the transition probability from type θ in period t to type θ' in period $t+1$, N_θ is the market size of type-θ consumers, and C_j is a fixed network formation cost. Moreover, $H_j = \{H_{jk}\}_{k=1}^{|K_m|}$ and $H = \{H_j\}_{j=1}^{|J|}$.

The profit per consumer type θ is:

$$\pi_{j\theta}(H_{jk}, H_{-jk}) = (R_\theta - (1 - r_\theta)AC_{j\theta}(H_j))s_{j\theta}(H)$$

Here, R_θ is a risk-adjusted transfer, $AC_{j\theta}$ is insurer j's average cost for a type-θ consumer, r_θ is consumer θ's coinsurance rate, and $s_{j\theta}$ is insurer j's demand from type-θ consumers. Assume that $\frac{\partial AC_{j\theta}}{\partial \theta} > 0$, $\frac{\partial AC_{j\theta}}{\partial H_{jk}} > 0$, $\frac{\partial C_j(\cdot)}{\partial H_{jk}} > 0$, $\frac{\partial^2 C_j(\cdot)}{\partial H_{jk}^2} > 0$, $\frac{\partial s_{j\theta}}{\partial H_{jk}} > 0$, and $\frac{\partial s_{j\theta}}{\partial H_{-jk}} < 0$.

Insurers compete in every market by choosing their service network breadths to maximize profits. The first-order condition (FOC) of the insurer's problem is:

$$\frac{\partial \Pi_j}{\partial H_{jk}} = \underbrace{\sum_\theta \Big((R_\theta - (1 - r_\theta)AC_{j\theta})\frac{\partial s_{j\theta}}{\partial H_{jk}} - (1 - r_\theta)s_{j\theta}\frac{\partial AC_{j\theta}}{\partial H_{jk}}\Big)N_\theta}_{\text{Current profit derivative (CP)}} \tag{1}$$

$$+ \sum_{s=t+1}^{T} \zeta^s \sum_\theta \underbrace{(1 - \rho_{\theta'})\mathcal{P}(\theta'|\theta)\Big((R_{\theta'} - (1 - r_{\theta'})AC_{j\theta'})\frac{\partial s_{j\theta'}}{\partial H_{jk}} - (1 - r_{\theta'})s_{j\theta'}\frac{\partial AC_{j\theta'}}{\partial H_{jk}}\Big)N_{\theta'}}_{\text{Future profit derivative (FP)}} - \frac{\partial C_j}{\partial H_{jk}} = 0$$

Consider the first line of equation (1). Adverse selection is captured by the positive correlation between the insurer's average cost and changes in demand from specific consumer types $AC_{j\theta}\frac{\partial s_{j\theta}}{\partial H_{jk}} > 0$. This correlation increases with network breadth, which in turn increases the insurer's marginal cost. Adverse selection may therefore lead an insurer to choose narrower networks, because the choice of network breadth changes –and in particular worsens– the composition of consumer types that the insurer enrolls.

The first-order condition also provides intuition on how insurer competition impacts network breadth. Suppose for simplicity that insurers have the same average cost structure $AC_{j\theta} = AC_{\theta}$, and focus on the effects of a change in network breadth weighted across insurers by their market share $s_{j\theta}$. We can rewrite equation (1) as:

$$\sum_{\theta}(R_{\theta} - (1-r_{\theta})AC_{\theta})\Big(\sum_{j}\frac{\partial s_{j\theta}}{\partial H_{jk}}s_{j\theta}\Big) - \sum_{\theta}(1-r_{\theta})\frac{\partial AC_{\theta}}{\partial H_{jk}}\overbrace{\Big(\sum_{j}s_{j\theta}^{2}\Big)}^{HHI_{\theta}} + \sum_{s=t+1}^{T}\zeta^{s}\sum_{j\theta}s_{j\theta}FP - \sum_{j\theta}s_{j\theta}\frac{\partial C_{j}}{\partial H_{jk}} = 0 \quad (2)$$

Equation (2) shows that market concentration reinforces the adverse selection effect when firms have homogeneous cost structure and average costs are increasing in network breadth. In the second term of the equation, HHI has a multiplicative effect on the increase in insurers' average cost following an increase in network breath. Concentrated markets with adverse selection can thus be characterized by having narrower networks than markets with adverse selection but with stronger competition between health insurers. In a setting with heterogeneous costs and preferences however predictions of how market concentration impacts network breadth can be ambiguous as seen in section 5.

I derive insurer demand in the profit function from a discrete choice specification. New enrollee i's utility for insurer j in market m is:

$$u_{ijm} = \underbrace{\beta_{ij}\sum_{k}q_{\theta k}H_{jkm} - \alpha_{i}c_{\theta jm}(H_{jm}) + \phi_{jm}}_{\delta_{\theta jm}} + \varepsilon_{ijm}$$

where $q_{\theta k}$ is the probability that a type-θ consumer makes a claim in service k such that $\sum_{k} q_{\theta k} = 1$, $c_{\theta jm}$ is the expected out-of-pocket cost at insurer j (aggregated across services), ϕ_{jm} is an insurer-by-market fixed effect, and ε_{ijm} is a type-I extreme value shock. Consumer types, θ, are defined by combinations of sex, age group, and diagnosis. The coefficients in the utility function are given by $\beta_i = (x_i \quad x_j)'\beta$, $\alpha_i = x_i'\alpha$. The vector x_i includes dummies for sex, age group, diagnoses, rural, and income level. Finally, x_j is an indicator for (anecdotally) high-quality insurers (EPS010, EPS016, EPS013).

The dependence of the average out-of-pocket cost to network breadth is captured by the pass-through of insurers' average cost to consumers' out-of-pocket cost via coinsurance rates: $c_{\theta jm} = r_\theta AC_{\theta jm}(H_{jm})$. Appendix C presents details on the specification of insurers' average cost function $AC_{\theta jm}$, which allows insurers to enjoy economies of scope across services. Given the distribution of the preference shock, insurer j's demand in market m among type-θ enrollees is

$$s_{j\theta m} = \frac{\exp(\delta_{\theta jm})}{\sum_{g=1}^{|J_m|} \exp(\delta_{\theta gm})}$$

where $|J_m|$ is the set of insurers in market m.

3.4 Estimation

Demand and cost estimates are provided in appendix C.4. Appendix table 2 shows that consumers prefer broad networks overall and dislike out-of-pocket costs. The preference for network breadth is lower among healthy individuals, and the disutility for out-of-pocket costs is lower among individuals with chronic diseases. These parameters estimates imply substantial heterogeneity in willingness-to-pay for service network breadth across consumers. For instance, patients with renal disease are willing to pay almost 27 times more for an additional provider in the network for renal care relative to a healthy patient.

Estimation of the average cost function in appendix table 3 shows that broad-network insurers have higher average costs per enrollee. This is consistent with broad-network insurers negotiating higher service prices with providers in their network. Insurers also enjoy substantial scope economies, potentially due to price discounts at providers where they cover several services. Although not presented in the table for exposition purposes, findings also show substantial heterogeneity in average costs across insurers.

Appendix tables 4 and 5 present estimates of dropout and transition probabilities, which are computed non-parametrically outside of the model. These probabilities factor into the estimation of fixed costs in appendix table 6, which is derived from insurers' FOCs. Findings show that fixed costs are strictly convex in network breadth and vary significantly across insurers. In particular, insurers' cost structure explains half of the variation in total profits when an insurer unilaterally increases network breadth for a particular service, while heterogeneity in willingness-to-pay coming from the demand function explains the other half. This suggests that adverse selection –sicker, less profitable individuals choosing insurers with greater coverage in certain services– and cost incentives are main determinants of insurers' network breadth choices.

To gauge the importance of market structure in driving network coverage decisions, a typical counterfactual exercise would predict new market outcomes after an insurer is removed from the market (e.g., Ho and Lee, 2017). However, preference and cost heterogeneity across services make it challenging to predict changes in service network breadth after an insurer is removed from consumers' choice sets. For example, if the removed insurer has market power in renal care but not in cardiac care, network breadth might increase in the former but not in the latter after the removal.

4 Centralized Equilibrium

The first step to understand the impact of competition is to derive a benchmark for network breadth. I use as benchmark the level of network breadth per service that a social planner would choose for every insurer. While deriving a social welfare function and interpreting what this function means are both challenging tasks, I approximate the social planner's problem using the empirical model of section 3.3.

The social planner's objective is to maximize consumer surplus subject to insurers' participation constraints. In the participation constraints, insurers need to make at least the median total profit in the market, $\overline{\Pi}_m$. My proxy for consumer surplus is the long-run expected utility obtained from the demand model:

$$CS_m(H_m) = \sum_{\theta} \Big(EU_i(H_m)\ N_{\theta m} + \sum_{s=t+1}^{T} \zeta^s \sum_{\theta'} (1-\rho_{\theta' m}) \mathcal{P}(\theta'|\theta) EU_i'(H_m) N_{\theta' m} \Big)$$

where the short-run expected utility, following McFadden (1996), is

$$EU_i = \log \Big(\sum_{j} \exp(\beta_{ij} \sum_{k} q_{\theta k} H_{jkm} - \alpha_i c_{\theta jm}(H_{jm}) + \phi_{jm}) \Big)$$

The social planner solves the following optimization problem per market:

$$\begin{aligned} &\max_{H_m}\ CS_m(H_m) \\ &\text{s.t}\ \ \Pi_{jm}(H_m) \geq \overline{\Pi}_m\ \forall j \end{aligned}$$

To reduce the computational burden, I solve the social planner's problem only in the market of Bogotá. Moreover, because this problem involves searching over 240 parameters (20 services for each of 12 insurers), I redefine the optimization routine over 20 parameters. These parameters correspond to network breadth for general medicine and hospitalizations for each insurer, holding network breadth for the rest of services fixed at their values in the observed equilibrium. I focus on general medicine and hospitalizations because they are services commonly used by both healthy and sick individuals across the diagnoses considered in the model. Appropriate access to primary care services such as general medicine has also been associated with better health outcomes (Bailey and Goodman-Bacon, 2015).

By redefining the social planner's problem in this way, the solution will reflect only a partial equilibrium. Results are presented in table 2. The table shows the percentage change between the social planner's solution and the observed scenario in mean network breadth across all services, average costs per enrollee, insurer total average costs, consumer surplus for sick and healthy individuals, and mean network breadth for consultations and hospital admissions.

I find that the social planner chooses complete networks for each insurer, which translates into 105 percent increase in network breadth for general medicine and a 123 percent increase in network breadth for hospital admissions relative to the observed scenario. In the social planner's solution insurers' participation constraints are binding for those with above-median profits in the observed scenario, but slack for those with below-median profits.

Although complete coverage of general medicine and hospital admissions reduce total average costs by 13 percent, it also quadruples the fixed cost of network formation. The reduction in average costs is a combination of insurers exploiting their scope economies and healthy individuals reallocating evenly across insurers. The substantial fixed cost increase is due to the fact that insurers do not have economies of scale in these two services. Complete coverage in these two services increases consumer surplus around 14 percent for both sick and healthy individuals.

Table 2: Networks, costs, and welfare for social planner

Variable	Centralized equilibrium
Overall mean network breadth	14.29
Total average cost	-13.04
Total network formation cost	334.30
Consumer surplus (sick)	14.07
Consumer surplus (healthy)	14.33
Network breadth general medicine	105.64
Network breadth hospital admissions	123.77

Note: Table presents the percentage change between the social planner's solution and the observed scenario in overall mean network breadth, total average cost, total network formation costs, long-run consumer welfare for the healthy and sick, network breadth for general medicine, and network breadth for hospital admissions. The counterfactual is calculated with data from Bogotá only.

The trade-off between total costs and network breadth highlights a potential reason for why the social planner's solution is not attainable in practice. A policy that imposes complete network coverage in some services is costly and may generate incentives for insurers to drop coverage of other services altogether. Although my counterfactual results in table 2 can not speak to these latter incentives, adverse selection suggests that this one way in which insurers may respond to network adequacy rules requiring complete networks in highly claimed services.

5 Collusive Equilibrium

I now turn to quantifying how changes in the level of competition among insurers affect network breadth relative to the social planner's benchmark ("first best"). If the first-best is not attainable in practice due to administrative costs or other hassle costs, two important questions come to mind: first, can a decentralized equilibrium where insurers compete in service network breadth implement the first-best solution, and second, if it does, what level of competition attains the first-best. To answer these questions I use the empirical model to simulate the inverse counterfactual scenario where insurers collude. For simplicity, I compute the new market equilibrium assuming only three insurers maximize joint profits. This counterfactual mirrors the monopolist solution in the theoretical model of section 2.

It is not straightforward ex-ante what the effect of joint profit maximization is on service network breadth. For example, we might expect collusion to result in narrower networks because the colluding firms internalize the negative externality that they impose on their competitor's demand. However, because of scope economies and fixed costs, collusion might also generate cost efficiencies that incentivize the colluding firm to increase network breadth.

Take one market with two firms j and g, in this counterfactual scenario the firms solve the following maximization problem:

$$\max_{H_j, H_g} \; \Pi_j(H_j, H_g, H_{-jg}) + \Pi_g(H_j, H_g, H_{-jg})$$

In the first-order condition for the merged firm, the derivative of per-enrollee profits with respect to H_{jk} is:

$$\frac{\partial \pi^*_\theta}{\partial H_{jk}} = (R_\theta - (1-r_\theta)AC^*_{\theta j})\frac{\partial s^*_{\theta j}}{\partial H_{jk}} - (1-r_\theta)s^*_{\theta j}\frac{\partial AC^*_{\theta j}}{\partial H_{jk}} + (R_\theta - (1-r_\theta)AC^*_{\theta g})\frac{\partial s^*_{\theta g}}{\partial H_{jk}} \quad (3)$$

where the upper-script (*) denotes objects that are evaluated at the new equilibrium with collusion. Relative to the baseline scenario, the second term in equation (3) captures how collusion may affect the colluding firm's cost structure. If $\frac{\partial AC_{\theta j}}{\partial H_{jk}} > \frac{\partial AC^*_{\theta j}}{\partial H_{jk}}$, then the new equilibrium may be characterized by broader networks because the colluding firm has larger economies of scope.

The third term in equation (3) captures the externality that firm j imposes on firm g's per-enrollee profits. Because $\frac{\partial s_{\theta g}}{\partial H_{jk}} < 0$, the merged firm internalizes the reduction in g's demand when j increases network breadth. Collusion can therefore lead the merged firm to choose narrower networks relative to the scenario where firms compete separately. These ambiguous predictions suggest that the effect of market concentration on network coverage will depend on relative magnitudes of preference and cost heterogeneity across insurers and services.

Results from this counterfactual exercise are presented in table 3. Columns (1) and (2) show results where different sets of insurers collude. In column (1) the three largest insurers in the market maximize joint profits, while in column (2) smaller insurers collude. The findings reveal that regardless of which insurers maximize joint profits, the direction of the effect on network breadth is the same. Lower levels of competition between insurers lead to narrower networks in a setting with an insurance mandate, consistent with the theoretical model. The magnitude of the effect does depend on which insurers collude because of preference and cost heterogeneity. In particular, effects on service network breadth are larger when ex-ante large insurers form a collusive agreement and thus capture a higher fraction of the market.

Focusing on column (1) where EPS017, EPS008, and EPS005 maximize joint profits – the ex-ante three largest insurers–, I find that mean network breadth falls by 5.3 percent. The reduction in coverage generates a 1.8 percent reduction in surplus for consumers with and without chronic diseases. Consumer surplus falls by a similar magnitude across individuals with different health status because the reduction in network breadth is similar across services. For example, panel B of the table shows that network breadth falls 5.6 percent for cardiac care services and 4.6 percent for general medicine. These findings imply that collusion exacerbates risk selection incentives. Serna (2024) shows that insurers engage in risk selection by offering narrow networks in unprofitable services. The fact that network breadth decreases substantially across services when firms maximize joint profits, suggests that lower levels of competition facilitate risk selection.

The findings also suggest that a market equilibrium with strong competition between private health insurers, even if premiums and cost-sharing are regulated, more closely approximates the social planner's solution. Table 2 showed that the social planner would choose complete networks for general medicine and hospitalizations (holding other services fixed), while table 3 indicates that network breadth for these two services would be 53 percent farther away from the first-best if firms collude.

In each counterfactual, profits for the insurers that collude increase and mean network breadth decreases relative to the observed scenario where they act as independent firms. In the case where EPS017, EPS008, and EPS005 maximize joint profits, table 4 shows that total profits increase around 8.4 percent for EPS017, 3.7 percent for EPS008, and 11 percent for EPS005. Mean network breadth also decreases 2, 99, and 6 percent, respectively, relative the observed equilibrium. The fact that profits for every firm in the collusive agreement increase relative to the observed

Table 3: Networks, costs, and welfare under collusion

	Variable	Insurers	
		17, 08, 05 (1)	13, 02, 37 (2)
A. Overall	Mean network breadth	-5.26	-1.10
	Consumer surplus (sick)	-1.83	-0.64
	Consumer surplus (healthy)	-1.83	-0.60
B. Service network breadth	Otorhinolaryngologic care	-5.11	-1.17
	Cardiac care	-5.56	-0.97
	Gastroenterologic care	-5.97	-1.02
	Renal care	-6.56	-1.03
	Gynecologic care	-4.68	-1.05
	Orthopedic care	-6.15	-0.99
	Imaging	-4.24	-1.07
	General medicine	-4.55	-1.23
	Laboratory	-2.80	-1.16
	Hospital admission	-4.71	-0.91

Note: Panel A presents the percentage change in mean network breadth and long-run consumer surplus for sick and healthy individuals in the collusive scenario. Column (1) presents results when EPS017, EPS008, and EPS005 collude. column (2) when EPS013, EPS002, and EPS037 collude. Panel B presents the percentage change of mean network breadth by service category.

scenario but network breadth decreases provide evidence that collusion strengthens risk selection. The exercise of market power in insurance markets is therefore tied to the provision of narrow hospital networks.

Table 4: Networks and profits for colluding firms

Variable	EPS017	EPS008	EPS005	EPS013	EPS002	EPS037
Mean network breadth	-2.02	-99.01	-6.43	-11.23	-5.50	-7.19
Total profits	8.39	3.67	10.96	2.73	6.25	4.64
Avg. cost per enrollee	2.26	3.28	3.88	6.25	3.24	3.15

Note: Table presents the percentage change in mean network breadth, total profits, and short-run average cost per enrollee for the insurers that collude.

6 Network Adequacy Rules

Implementing the first-best solution or promoting competition between insurers can be difficult to achieve policy-wise. Instead, conditional on the existing market structure, a social planner can implement policies that combat risk selection more directly. In Colombia, where insurers can discriminate networks by health service, prohibiting their leverage across services can limit risk selection incentives. In this section I examine the role of a network adequacy rule that forces insurers to cover all the services a provider can deliver if the provider is in-network, which implies that network breadth must the same across services. While insurers still have discretion on whether to cover the provider at all, the policy addresses insurers' main mechanism for risk selection.

Formally, insurer j chooses $H_k = H \; \forall k$ in each market. The first order condition of its profit maximization problem in a given market is:

$$\frac{1}{K}\sum_{k}\sum_{\theta}\left(\frac{\partial \pi_{\theta j}}{\partial H_{jk}}N_{\theta} + \sum_{s=t+1}^{T}\zeta^{s}\sum_{\theta'}(1-\rho_{\theta'})\mathcal{P}(\theta'|\theta)\frac{\partial \pi'_{\theta j}}{\partial H_{jk}}N_{\theta'}\right) - \frac{1}{K}\sum_{k}\frac{\partial C_{j}}{\partial H_{jk}} = 0$$

Panel A of table 5 shows that forcing insurers to cover all services at a hospital increases mean network breadth by 78 percent from a baseline of 0.24. This change in coverage translate into roughly a 14 percent increase in consumer surplus for both sick and healthy individuals despite having to make higher out-of-pocket payments. Panel B of the table shows that network breadth increases substantially across all services. But the percentage changes are larger for services that were underprovided in the observed scenario due to risk selection incentives. For instance, mean network breadth for renal care increases 78 percent, while mean network breadth for hospital admissions increases 60 percent. Prohibiting discrimination of networks across services thus reduces the impact of selection incentives.

Eliminating variation in network breadth across services generates an equilibrium that closely resembles the social planner's solution from table 2. Consumer surplus for both healthy and sick individuals increase by a similar magnitude across the two scenarios as well. The fact that providing complete networks in general medicine and hospital admissions generates similar welfare effects as an equilibrium where network breadth doubles in every service, suggests that only network breadth in a few services play a major role for access to care. This finding provides an avenue for the design of healthcare policies that relate to hospital networks such as network adequacy rules. As long as these rules guarantee appropriate access to care in key services, patients can be made better off. But the impact on health care costs should also be taken into consideration when evaluating such policies.

Table 5: Networks, costs, and welfare under network adequacy

	Variable	Network adequacy
A. Overall	Mean network breadth	78.32
	Consumer surplus (sick)	13.72
	Consumer surplus (healthy)	13.84
B. Service network breadth	Otorhinolaryngologic care	92.53
	Cardiac care	59.43
	Gastroenterologic care	84.42
	Renal care	78.17
	Gynecologic care	72.70
	Orthopedic care	80.72
	Imaging	59.52
	General medicine	58.16
	Laboratory	41.25
	Hospital admission	60.46

Note: Panel A presents the percentage change in mean network breadth and long-run consumer welfare for sick and healthy individuals, in the scenario with a network adequacy prohibiting discrimination of networks across services. Panel B presents the percentage change in mean network breadth by service category.

7 Conclusion

Private health insurers in different health systems typically compete on the breadth of their provider networks. The design of hospital networks responds to insurers' risk selection incentives, which has lead to a proliferation of narrow-network insurers.

Whether narrow hospital networks are desirable for society remains an open question. Understanding the trade-offs associated with a broad or a narrow network, and how these trade-offs relate to competition between private insurers is important for the design of popular health care policies such as network adequacy rules.

In this paper I study the effect of insurer competition on provider network breadth. I develop and estimate a model of insurer competition in service-level network breadth using data from the Colombian health care system. I find that a social planner who maximizes consumer surplus subject to insurers' participation constraints, would choose complete networks in services such as general medicine and hospital admissions. The social planner's solution increases consumer surplus by 14 percent, but also substantially increase the system's health care costs.

Simulations of the model allowing insurers to collude show that network breadth is an increasing function of the degree of insurer competition. While policies that promote competition may be difficult to implement, I find that both risk adjustment and a simple network adequacy rule that prohibits the discrimination of networks across services can closely implement the social planner's solution. More broadly, findings suggest that competition between insurers is necessary to maintain proper access to care for patients, and that policies related to hospital networks should carefully consider their impact on health care costs.

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Appendix A Duopoly Equilibrium

Consider the normal-form matrix of the duopoly game with mandatory enrollment in section 2. I start by deriving insurer a's best response correspondence.

Conditional on $H_b = 0$, profits to insurer a from choosing each level of network breadth are given by:

$$\Pi_a(0,0;t) = \int_{\underline{\theta}}^{\overline{\theta}} (R(t) - (1-r)c(0,t))dt$$

$$\Pi_a(1,0;t) = \int_{\frac{r(c(1,\theta)-c(0,\theta))}{2\beta_a-\beta_b}}^{\overline{\theta}} (R(t) - (1-r)c(1,t))dt$$

Comparing these profits and under the assumption that $c(1,\theta) < 2c(0,\theta)$ yields:

$$\int_{\underline{\theta}}^{\theta'} (R(t) - (1-r)c(0,t))dt > -(1-r)\int_{\theta'}^{\overline{\theta}} c(0,t)dt$$

therefore, $\Pi_a(0,0;t) > \Pi_a(1,0;t)$.

Conditional on $H_b = 1$, profits to insurer a from choosing each level of network breadth are given by:

$$\Pi_a(0,1;t) = \int_{\frac{r(c(0,\theta)-c(1,\theta))}{\beta_a-2\beta_b}}^{\overline{\theta}} (R(t) - (1-r)c(0,t))dt$$

$$\Pi_a(1,1;t) = \int_{\underline{\theta}}^{\overline{\theta}} (R(t) - (1-r)c(1,t))dt$$

Comparing these profits, we obtain the following relation:

$$(1-r)\int_{\theta'}^{\overline{\theta}} (c(1,t) - c(0,t))dt > \int_{\underline{\theta}}^{\theta'} (R(t) - (1-r)c(1,t))dt$$

which holds under the assumption that $\frac{\overline{\theta}-\underline{\theta}}{2} > \theta'(0,1)$. Therefore, $\Pi_a(0,1;t) > \Pi_a(1,1;t)$.

Moving to insurer b's best response correspondence, suppose $H_a = 0$. Profits to insurer b from choosing each level of network breadth are given by:

$$\Pi_b(0,0;t) = \int_{\underline{\theta}}^{0} (R(t) - (1-r)c(0,t))dt = 0$$

$$\Pi_b(0,1;t) = \int_{\underline{\theta}}^{\frac{r(c(0,\theta)-c(1,\theta))}{\beta_a - 2\beta_b}} (R(t) - (1-r)c(1,t))dt$$

hence, $\Pi_b(0,1;t) > \Pi_b(0,0;t)$.

Now suppose $H_a = 1$, profits to insurer b are:

$$\Pi_b(1,0;t) = \int_{\underline{\theta}}^{\frac{r(c(1,\theta)-c(0,\theta))}{2\beta_a - \beta_b}} (R(t) - (1-r)c(0,t))dt$$

$$\Pi_b(1,1;t) = \int_{\underline{\theta}}^{0} (R(t) - (1-r)c(1,t))dt = 0$$

therefore, $\Pi_b(1,0;t) > \Pi_b(1,1;t)$.

Appendix B Additional Descriptives

Table 1: List of services

Service code	Description
01	**Neurosurgery:** Procedures in skull, brain, and spine
02	**Other neurologic care:** Procedures in nerves and glands
03	**Otorhinolaryngologic care:** Procedures in face and trachea
04	**Pneumologic care:** Procedures in lungs and thorax
05	**Cardiac care:** Procedures in cardiac system
06	**Angiologic care:** Procedures in lymphatic system and bone marrow
07	**Gastroenterologic care:** Procedures in digestive system
08	**Hepatologic care:** Procedures in liver, pancreas, and abdominal wall
09	**Renal care:** Procedures in urinary system
10	**Gynecologic care:** Procedures in reproductive system
11	**Orthopedic care:** Procedures in bones and joints
12	**Other orthopedic care:** Procedures in tendons, muscles, and breast
13	**Diagnostic aid:** Diagnostic procedures in skin and subcutaneous cellular tissue
14	**Imaging:** Radiology and non-radiology imaging
15	**Internal and general medicine:** Consultations
16	**Laboratory:** Laboratory and blood bank
17	**Nuclear medicine:** Nuclear medicine and radiotherapy
18	**Rehab and mental health:** Rehabilitation, mental health care, therapy
19	**Therapy (chemo and dialysis):** Prophylactic and therapeutic procedures
20	**Hospital admissions:** Inpatient services

Appendix C Model Summary

In this section I describe the empirical model of insurer competition in service-level network breadth presented in Serna (2024). Insurers first compete in every market by simultaneously choosing their vector of network breadths; then observing networks and expected out-of-pocket costs, new consumers make enrollment decisions. After making their first enrollment choice, consumers do not switch out of their insurer. I assume a zero switching rate because I observe less than one percent of enrollees who have continuous enrollment spells switch after one year.

C.1 Demand

Demand is specified over new consumers who have no inertia on insurer choice and who are myopic. The utility of a new consumer i who is of type θ for insurer j in market m is:

$$u_{ijm} = \beta_i \sum_k q_{\theta k} H_{jkm} - \alpha_i c_{\theta jm}(H_{jm}) + \phi_{jm} + \varepsilon_{ijm} \tag{4}$$

A consumer's type is given by the combination of sex, age category (19-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75 or more), and diagnosis (cancer, cardiovascular disease, diabetes, renal disease, pulmonary disease, arthritis, asthma, other disease, healthy). Moreover, H_{jkm} insurer j's network breadth for service k in market m, $q_{\theta k}$ is the probability that a consumer of type θ makes a claim in service k such that $\sum_k q_{\theta k} = 1$, $c_{\theta jm}$ is the expected out-of-pocket cost at insurer j (aggregated across services), ϕ_{jm} is an insurer-by-market fixed effect, and ε_{ijm} is a type-I extreme value shock.

The coefficients in the utility function are given by $\beta_i = x_i', \alpha_i = x_i'\alpha$, where x_i are consumer demographics and diagnoses that capture preference heterogeneity for network breadth and out-of-pocket costs. In particular, x_i includes sex, age group dummies, diagnoses dummies, dummies for type of municipality (urban, normal, rural), and income level dummies (at most two times or more than two times the minimum monthly wage).

The first term to the right-hand side of equation (4) is a reduced-form representation of the consumer's network valuation. Network breadth per service is weighted by the claim probability to account for the fact that consumers with certain diagnoses will prefer broader networks in services that are related to treatment of their health condition. For example, patients with renal disease will care more about network breadth for dialysis than network breadth for procedures in the stomach.

The out-of-pocket cost in the second term on the right-hand side of equation (4) is a function of network breadth across services, $H_{jm} = \{H_{jkm}\}_{k=1}^{K}$, and is aggregated across services with weights equal to the claim probabilities. The dependence of out-of-pocket costs to service-level network breadth reflects a cost-coverage trade-off for consumers: broad-network insurers negotiate higher prices with hospitals in their network, which translates into higher out-of-pocket costs for enrollees. The positive relation between network breadth and service prices is explained by the insurer's inability to use replacement threats during negotiations with hospitals when the insurer already has a broad network (Ho and Lee, 2019).

The utility function, which is defined over new consumers, assumes that individuals know their diagnoses beforehand. This suggests either that individuals have a medical family history or that they have had healthcare encounters before choosing their insurer. Since new consumers to may move from the subsidized system, knowledge of their health status prior to enrollment decisions in the contributory system is highly likely. Moreover, the majority of insurers that participate in the subsidized system are different from those that participate in the contributory system. For at most one-sixth of new enrollees in my data their insurer may be the same across the two systems.

The assumption of consumer myopia also suggests that consumers make enrollment choices with knowledge of their current health status only, but that they do not take into account the progression of their diseases nor demographics. For healthy consumers, this implies that the choice of a narrow-network insurer is potentially utility maximizing. While for an individual with chronic diseases, the utility maximizing choice is potentially that of a broad-network insurer. These choices can also be rationalized by a model where consumers are forward-looking but have either zero switching costs or high discount rates. Consumer myopia is therefore not required to explain narrow-network insurers in equilibrium.

C.2 Supply

Unlike consumers who are myopic, I assume insurers are forward looking. Insurers internalize the future profits associated with each new consumer that enrolls with it, since consumers do not switch after making their first enrollment decision. Insurers compete in every market by simultaneously choosing their vector of service-level network breadth to maximize profits. Insurer profits are given by:

$$\Pi_{jm}(H_m) = \sum_{\theta} \Big(\underbrace{\pi_{ijm}(H_m,\theta)N_{\theta m}}_{\text{current profit}} + \underbrace{\sum_{s=t+1}^{T} \zeta^s \sum_{\theta'} (1-\rho_{\theta' m})\mathcal{P}(\theta'|\theta)\pi_{ijm}(H_m,\theta')N_{\theta' m}\Big)}_{\text{future profit}}$$
$$\underbrace{- \sum_{k} \Big(\omega H_{jkm} + \xi_{jkm}\Big) H_{jkm}}_{\text{network formation cost}} \quad (5)$$

where $N_{\theta m}$ is the market size of consumers type θ in market m, ζ is a discount factor (set to 0.95 in estimation), $\rho_{\theta' m}$ is the probability that a consumer type θ drops out of the contributory system in period $t+1$, and $\mathcal{P}$ is the transition probability from state θ in period t to state θ' in period $t+1$.

I assume both $\rho_{\theta' m}$ and $\mathcal{P}$ are exogenous for several reasons. On the one hand, dropping out of the contributory system depends mostly on unemployment or mortality, both of which are likely independent of network breadth choices. On the other hand, transition probabilities across states reflect only the transition across diagnoses, since age and sex are deterministic. Transitions across the diagnoses considered in the model depend mostly on the natural progression of the disease.

In the profit function, π_{ijm} is the per-enrollee profit given by:

$$\pi_{ijm}(H_m,\theta) = (R_{\theta m} - (1-r_i)AC_{\theta jm}(H_{jm}))s_{ijm}(H_m)$$

Here $R_{\theta m}$ is the risk-adjusted transfer from the government plus revenues from copayments, r_i is consumer i's coinsurance rate, s_{ijm} is consumer i's choice probability for insurer j in market m (which comes from the demand model), and $AC_{\theta jm}$ is the average cost of consumer type θ at insurer j in market m. The average cost is a flexible function of network breadth as seen below

$$\log(AC_{\theta jm}(H_{jm})) = \tau_0\Big(\sum_{k}^{K_m} q_{\theta k} A_k\Big) + \tau_1\Big(\sum_{k}^{K_m} q_{\theta k} H_{jkm}\Big) + \frac{1}{2K_m}\tau_2 \sum_{k}^{K_m}\sum_{l\neq k}^{K_m} q_{\theta k} q_{\theta l} H_{jkm} H_{jlm} + \lambda_\theta + \eta_m + \delta_j$$

This cost structure represents a reduced-form approximation to an equilibrium where insurers and hospitals negotiate service prices and consumers make claims for those services. In the average cost function, A_k is the government's reference price for service k, which insurers use as starting point in their bilateral negotiations with hospitals.[2] K_m is the set of services available in market m, λ_θ is a consumer type fixed effect, η_m is a market fixed effect, and δ_j is an insurer fixed effect.

The dependence of the insurer's average cost to its choice of service-level network breadth will capture whether broad-network insurers bargain higher prices with hospitals in their network. The model would rationalize this bargaining argument with a positive estimate of τ_1. The data also shows that insurers that offer a broad network in one service, tend to offer broad networks in other services. If offering greater network breadth across services is always costlier, the model would have a difficult time explaining the existence of broad-network insurers in equilibrium. The average cost function thus includes interactions of network breadth between pairs of services to capture whether insurers enjoy scope economies. A negative estimate of τ_2 would imply that it is cheaper for the insurer to offer a broad network in service k if service l also has a broad network.

In addition to cost differences in average costs, insurers differ in the third compo-

[2] The service reference prices were created by the government with a group of medical experts in 2005. These prices reflect the cost of providing each service and are updated every year based on inflation. The reference prices are paid to hospitals only in the event of car accidents, natural disasters, or terrorist attacks. That is, in any of these events, healthcare claims are reimbursed directly by the government to the hospitals and do not go through insurance.

nent of the profit function, namely, the network formation cost. Network formation costs are administrative costs associated with setting up these service-level networks. This cost is non-linear in network breadth and heterogeneous across services. The parameter ω in equation (5) captures whether network formation costs are convex in network breadth. Moreover, $\xi_{jkm} = \xi_k + \vartheta_{jkm}$ is a cost shock with a service-specific component ξ_k and an unobserved (to the econometrician) component ϑ_{jkm}.

C.3 Identification

The main source of variation that identifies the preference for network breadth in the demand model is the variation in claim probabilities across consumer types. These claim probabilities are plausibly exogenous to the extent that the diseases considered in the model require explicit treatment guidelines and therefore do not vary with network breadth. Insurer-by-market fixed effects also absorb the endogenous variation in network breadth that stems from insurer competition in every market.

The main concern associated with identification of the coefficient on out-of-pocket costs in the demand model is variation in hospital quality. For example, if an insurer covers a high-quality hospital, then we would likely see high demand for that insurer (because consumers value having access to high-quality hospitals) as well as high out-of-pocket costs (because the hospital has a relatively high bargaining power), which would bias α_i towards zero. Variation in hospital quality introduces endogenous variation in network breadth across insurers and markets. Inclusion of insurer-by-market fixed effects can thus help control for this source of endogenous variation.

In the case of the average cost function, coefficients are identified from variation in average costs within insurer and across consumer types. The rich set of fixed effects included in this function account for potential unobserved cost variation within consumer types. Intuitively, identification of the average cost parameters requires observing two insurers that are identical (in terms of the characteristics of their enrollees) except for their network breadth.

Identification of the network formation cost relies on instrumental variables, since insurers choose network breadth with knowledge of their cost shocks ξ_{jkm}. The instruments include the claim probabilities, network breadth in 2010, and their interactions.

C.4 Model Estimates

The following tables summarize the model estimates from Serna (2024).

Table 2: Insurer demand

Variable		Network breadth	OOP spending (million)
Mean		2.34 (0.42)	-2.41 (0.11)
Interactions			
Demographics	Male	0.15 (0.02)	0.06 (0.07)
	Age 19-24	-0.60 (0.05)	1.51 (0.12)
	Age 25-29	-1.19 (0.05)	0.70 (0.12)
	Age 30-34	-1.46 (0.05)	0.56 (0.15)
	Age 35-39	-1.50 (0.05)	0.30 (0.18)
	Age 40-44	-1.31 (0.05)	0.49 (0.17)
	Age 45-49	-1.17 (0.05)	0.51 (0.14)
	Age 50-54	-0.95 (0.05)	0.69 (0.12)
	Age 55-59	-0.88 (0.06)	0.39 (0.14)
	Age 60-64	-0.43 (0.06)	0.16 (0.14)
	Age 65 or more	(ref)	(ref)
Diagnoses	Cancer	0.55 (0.05)	0.46 (0.09)
	Diabetes	-0.11 (0.08)	0.41 (0.12)
	Cardio	-0.50 (0.04)	0.19 (0.08)
	Pulmonary	-0.60 (0.11)	1.11 (0.14)
	Renal	1.87 (0.14)	1.52 (0.08)
	Other	-0.43 (0.06)	0.88 (0.09)
	Healthy	(ref)	(ref)
Insurer	High-quality	1.07 (0.31)	—
Location	Rural	4.08 (0.04)	-0.21 (0.09)
	Urban	(ref)	(ref)
Income	Low	0.28 (0.03)	-1.72 (0.14)
	High	(ref)	(ref)
N		5,544,805	
N enrollees		500,000	
Pseudo-R^2		0.15	

Note: Table presents conditional logit model of insurer choice estimated by maximum likelihood on a random sample of 500,000 new enrollees. Includes insurer-by-market fixed effects. Robust standard errors in parenthesis.

Table 3: Insurer average costs per enrollee

Variable	Coefficient	Std. Error
Network breadth	0.44	(0.08)
Scope economies	-93.0	(45.0)
Reference price	40.9	(6.63)
Insurer		
EPS001	-0.02	(0.05)
EPS002	-0.16	(0.04)
EPS003	-0.14	(0.04)
EPS005	-0.24	(0.04)
EPS008	0.17	(0.05)
EPS009	0.20	(0.04)
EPS010	-0.06	(0.06)
EPS012	-0.02	(0.04)
EPS013	-0.13	(0.03)
EPS016	-0.01	(0.03)
EPS017	-0.11	(0.04)
EPS018	0.06	(0.06)
EPS023	-0.18	(0.04)
EPS037	(ref)	(ref)
N	8,662	
R^2	0.66	

Note: Table presents OLS regression of logarithm of average costs per consumer type on network breadth, economies of scope, and service reference prices. Includes insurer, market, and consumer type fixed effects. Robust standard errors in parenthesis.

Table 4: Dropout probabilities

	mean	sd
Diagnosis		
Cancer	4.79	(2.40)
Diabetes	2.75	(0.83)
Cardio	2.79	(0.90)
Pulmonary	4.04	(1.51)
Renal	4.42	(1.79)
Other	2.62	(1.11)
Healthy	45.00	(7.29)
Age group		
19-24	12.00	(17.73)
25-29	8.72	(13.36)
30-34	8.13	(13.47)
35-39	8.47	(14.07)
40-44	8.47	(14.59)
45-49	8.51	(14.93)
50-54	8.88	(15.32)
55-59	9.09	(15.77)
60-64	9.20	(15.84)
65-69	9.63	(15.93)
70-74	10.37	(15.95)
75 or more	12.38	(16.43)
Sex		
Female	8.42	(13.07)
Male	10.55	(16.50)

Note: Table reports average and standard deviation in parenthesis of dropout probabilities. I use the data from *all* enrollees to the contributory system in 2010 and 2011, regardless of enrollment spell length, to compute these probabilities. For each consumer type θ, the dropout probability is the number of individuals of type θ observed only in 2010 but not 2011, divided by the total number of type θ individuals in 2010.

Table 5: Transition probabilities

Diagnosis	Cancer	Cardio	Diabetes	Renal	Pulmonary	Other	Healthy
Cancer	31.6	1.7	13.9	1.4	0.7	4.7	46.0
	(6.7)	(1.4)	(9.0)	(1.3)	(0.6)	(1.9)	(17.6)
Diabetes	3.0	55.7	17.0	0.9	1.3	2.1	20.0
	(2.6)	(7.8)	(10.0)	(1.0)	(1.1)	(1.0)	(14.0)
Cardio	4.3	2.8	55.4	1.4	1.1	3.4	31.6
	(3.6)	(1.8)	(20.5)	(1.2)	(1.0)	(0.9)	(22.4)
Pulmonary	5.5	1.9	19.1	23.4	0.7	7.8	41.6
	(4.6)	(1.4)	(8.9)	(15.2)	(0.6)	(3.4)	(23.1)
Renal	4.4	3.6	21.4	1.2	37.1	5.8	26.5
	(3.5)	(3.0)	(13.2)	(1.3)	(6.2)	(3.1)	(15.4)
Other	5.6	1.6	15.6	2.3	0.8	34.3	39.8
	(4.0)	(1.3)	(10.6)	(2.0)	(0.4)	(5.8)	(9.5)
Healthy	5.5	1.2	10.8	1.4	0.4	4.5	76.2
	(4.2)	(0.8)	(6.8)	(1.4)	(0.3)	(2.1)	(10.9)

Note: Table reports average and standard deviation in parenthesis of transition probabilities. Using data from continuously enrolled new *and* current enrollees in 2010 and 2011, the probability that type θ transitions into θ' equals the number of type θ in 2010 that end up with diagnosis l' in 2011, divided by the number of type θ individuals in 2010.

Table 6: Model of insurer network formation costs

$\log(MVP_{jmk})$	coef	se
Network breadth	6.69	(0.40)
Insurer		
EPS001	-1.04	(0.31)
EPS002	-0.15	(0.28)
EPS003	-0.55	(0.28)
EPS005	-0.64	(0.27)
EPS008	0.09	(0.41)
EPS009	0.63	(0.31)
EPS010	0.71	(0.30)
EPS012	0.29	(0.36)
EPS013	0.52	(0.23)
EPS016	0.77	(0.23)
EPS017	-0.51	(0.29)
EPS018	-1.26	(0.38)
EPS023	0.07	(0.27)
EPS037	(ref)	(ref)
Constant	6.68	(0.25)
N	1,060	
R^2	0.35	

Note: Table presents OLS regression of log marginal variable profit on network breadth and insurer fixed effects with data from markets 25, 11, 76, 05, and 13. Robust standard errors in parenthesis.

Table 7: Insurer demand

Diagnosis list
Healthy
Cardiovascular disease
Other Disease
Cervical Cancer
Breast Cancer
Other Renal Disease
Other Cancer
Chronic Kidney Disease
Diabetes
Skin Cancer
Lymphoma
Stomach Cancer
HIV-AIDS
Lung Cancer

Note: Table presents list of diagnoses used in the improved risk adjustment counterfactual.