Centralized and Decentralized Equilibria in Hospital Network Breadth

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Abstract

Health insurer competition in hospital networks raises questions on what the socially optimal network breadth is. In this paper I use a structural model of insurer competition in service-level network breadth to derive the social planner's solution, and to simulate the impact of competition between private insurers on hospital 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. A policy that prohibits network discrimination across services can more closely 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. Hospital networks are one such dimension of insurer differentiation. Insurers establish networks of preferred providers to limit which hospitals patients have access to. The design of hospital networks may respond to risk selection incentives and market structure. Although there is a better understanding of how risk selection influences insurers' network coverage decisions (Shepard, 2022; Serna, 2023), much less is known about how insurer competition impacts hospital networks. In this paper I develop an empirical characterization of a centralized equilibrium where the regulator chooses network breadth, and compare it against different decentralized equilibria with insurer competition.

I provide this characterization in the context of the Colombian health care system. 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 hospital 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 hospitals. The Colombian setting is ideal to isolate the effect of managed care competition on hospital network breadth. This setting can also shed light on the benefits of managed care and on the optimality of broad hospital networks.

To settle intuition on the effects of interest, I specify a simple theoretical model of insurer competition on hospital 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, and shows that when two insurers compete in the market, the equilibrium is one where insurers maximally differentiate and coverage is under-provided to relatively unhealthy consumers. To examine the impact of insurer competition on hospital network breath more systematically, I move to the empirical model.

My empirical setup builds on the model and estimates from Serna (2023). The main object of interest in this model is the insurers' service-level network breadth. Network breadth is defined as the fraction of hospitals in a market that provide a service and are covered by the insurer. On the demand side of the model, new consumers choose their insurer based on expected out-of-pocket costs and service-level network breadth. On the supply side, insurers compete by choosing their vector of service-level network breadths to maximize profits.

The model is estimated using enrollment and claims data from all enrollees to the contributory system in Colombia from 2010 to 2011. Demand estimates show that there is substantial adverse selection in insurer choice based on their service-level networks. Sicker, relatively unprofitable individuals have a high 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 broad networks are more expensive than narrow networks, and that insurers enjoy economies of scope across services. Taken together, these model estimates imply that insurers respond to demand-side selection incentives by offering narrow networks in unprofitable services.

Importantly, the observed equilibrium in service-level network breadth is asymmetric, with some insurers choosing broad networks and some choosing narrow networks for the same service. The model rationalizes this asymmetry in several ways. First, estimates show 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. While Serna (2023) exploits the first explanation to get at the impact of risk selection on hospital network breadth, this paper is related to the second explanation measuring the impact of insurer competition on hospital 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-level network breadth for each insurer to maximize consumer surplus subject to insurers' participation constraints. The results from this counterfactual analysis provide strong empirical evidence for the first-best solution in the simple theoretical model. In a world with mandatory enrollment and service-specific hospital networks, the social planner would choose complete service networks relative to the observed scenario. For instance, median network breadth for hospitalizations would increase 75 percent from a baseline of 0.57. Although the first-best solution involves broader coverage and potentially better access to care, it also increases health care costs for the system by nearly 53 percent. The social planner therefore trades-off cost and coverage in a similar way than consumers do.

I proceed to analyze whether a decentralized equilibrium where private insurers compete in service-level network breadth can bring market outcomes closer to the social planner's solution. To do so, I compute equilibrium outcomes under a scenario where two 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. I find however that regardless of which two insurers collude, the new equilibrium is one where all insurers choose narrower service networks. For example, I find that median network breadth decreases 7 percent and consumer surplus for sick individuals decreases 10 percent when the two largest insurers collude. This finding suggests that network coverage is increasing in the degree of insurer competition.

Current regulation of the Colombian health care system allows insurers to discriminate hospital networks across health services, which essentially implies discrimination on the consumer's health status. This means for example that an insurer can choose to cover obstetric care but not dialysis at a particular hospital. Although the government has established network adequacy rules to address this type of network exclusions, the rules only apply to a few health services offered in the national insurance plan. Since promoting insurer competition to increase network coverage can be difficult to achieve policy-wise, in my last counterfactual I explore the effects of prohibiting network discrimination across services.

Insurers in this counterfactual must cover all the services a hospital can provide if the hospital is in-network, thus network breadth must the same across services. I find that median network breadth doubles for almost every service. These effects are larger than those generated by policies that tackle risk selection more directly such as improving the risk adjustment formula (which was evaluated in Serna (2023)). Prohibiting network discrimination therefore brings the equilibrium network breadth closer to the social planner's solution.

The findings of this paper contribute to the literature on insurer competition and hospital 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 insurer competition on hospital network breadth. In the second line of research, Liebman (2018); Ho and Lee (2019); Ghili (2022) analyze insurers' use of network exclusions to achieve lower prices during bilateral negotiations with hospitals. The focus of my paper is on how different levels of competition affect network exclusions, though I do not explicitly model bilateral negotiations between insurers and hospitals.

In analyzing the causes of narrow hospital networks, this paper is also related to Shepard (2022) who studies the effect of adverse selection on insurers' decision to cover a star hospital in Massachusetts. Moreover, my empirical setting relates to Kreider et al. (2022) and Finkelstein et al. (2019) since it allows 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. Answering these questions involve understanding the trade-offs a social planner faces and deriving an appropriate benchmark for insurer competition. Ho and Lee (2019) address similar questions in the case of a monopoly insurer. I extend their work by considering the effects of different levels of insurer competition on hospital network breadth. Several other papers also study the trade-offs to broad and narrow hospital networks including Liebman and Panhans (2021); Atwood and Sasso (2016); Dafny et al. (2015b). Furthermore, Dafny (2010); Dafny et al. (2015a); Mahoney and Weyl (2017) analyze competition in insurance markets.

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]

[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-

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 participate 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 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.

network insurer would choose to cover both hospitals.

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 over a narrow network is at least the average consumer's cost under a broad network relative to a narrow 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:

		b	
		$H=0$	$H=1$
a	$H=0$	$\int_{\underline{\theta}}^{\overline{\theta}} \pi_a(0,0;t)dt$, 0	$\int_{\theta'}^{\overline{\theta}} \pi_a(0,1;t)dt$, $\int_{\underline{\theta}}^{\theta'} \pi_b(0,1;t)dt$
	$H=1$	$\int_{\theta'}^{\overline{\theta}} \pi_a(1,0;t)dt$, $\int_{\underline{\theta}}^{\theta'} \pi_b(1,0;t)dt$	$\int_{\underline{\theta}}^{\overline{\theta}} \pi_a(1,1;t)dt$, 0

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	21.4
EPS016	15.2
EPS037	11.1
EPS002	9.3
EPS017	7.2
EPS010	7.1
EPS005	4.5
EPS018	4.4
EPS003	4.0
EPS008	3.7
EPS023	3.1
EPS009	1.8
EPS001	1.6
EPS012	1.6

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

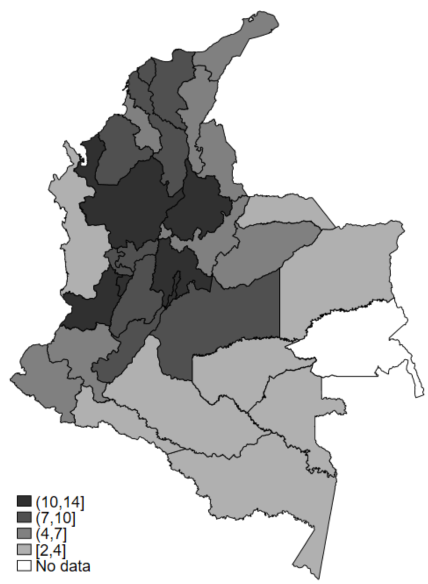

Figure 1: Number of insurers per state

3.1 Hospital Networks

Even though cost-sharing and premiums are regulated, insurers in the Colombia can choose which health services to cover at which hospitals. Insurers also negotiate service prices with hospitals 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 services offered in the national plan.

The national plan covers a list of more than 7 thousand services, procedures, and devices, and around 700 medications as of 2011. The government categorizes these services based on their main anatomical purpose. I use this categorization to construct insurers' service-level network breadth from the claims data following Serna (2023). Appendix table 1 presents the complete list of services.

Network breadth is defined as the fraction of hospitals in a market that provide a service and are covered by the insurer. Service-level network breadth is the insurer's choice variable in this health system. While collapsing networks to an index per service loses information on which hospitals are included in the network, this information is secondary for the purpose of this paper. 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 hospitals in this insurer's 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. The relevant market for insurers' network coverage decisions and consumer's enrollment decisions is therefore a Colombian state.

The left-hand panel of figure 2 shows the distribution of network breadth in Bo-

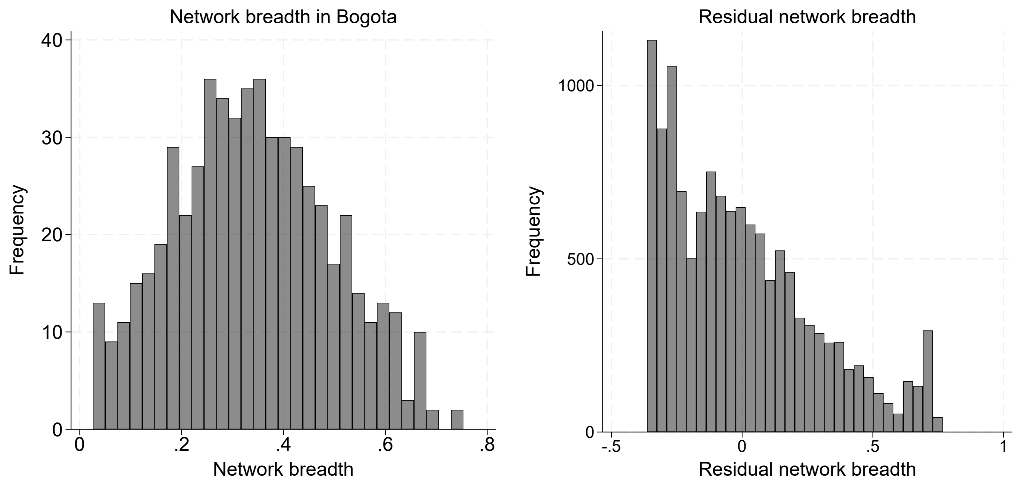

Figure 2: Distribution of (residual) network breadth

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.

gotá, 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 (2023) rationalizes the 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 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, hospital 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

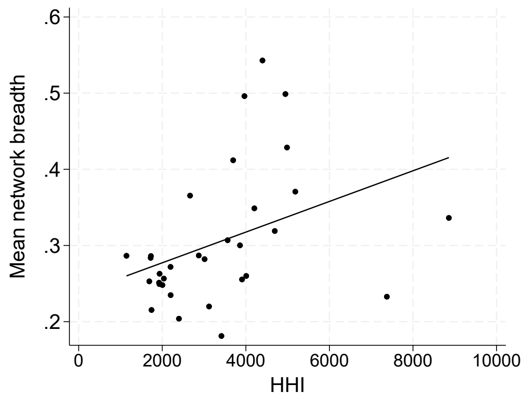

Figure 3: HHI and mean network breadth

Note: 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.

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.

This correlation however masks an underlying adverse selection effect. Figure 4 shows the same scatterplot for average network breadth in consultations in the left-hand panel and in procedures in cardiac vessels in the right-hand panel. Consultations have a relatively high claim probability among both healthy and sick individuals, while procedures in cardiac vessels are mostly claimed by patients with chronic conditions. Insurers' risk selection incentives may therefore differ across these services.

The figure shows a positive correlation between HHI and average network breadth in consultations, but a negative correlation with average network breadth for procedures in cardiac vessels. This suggests that insurer market concentration has different effects on network breadth depending on the degree of adverse selection in each service. Taken together, the two panels also suggest that drawing conclusions about

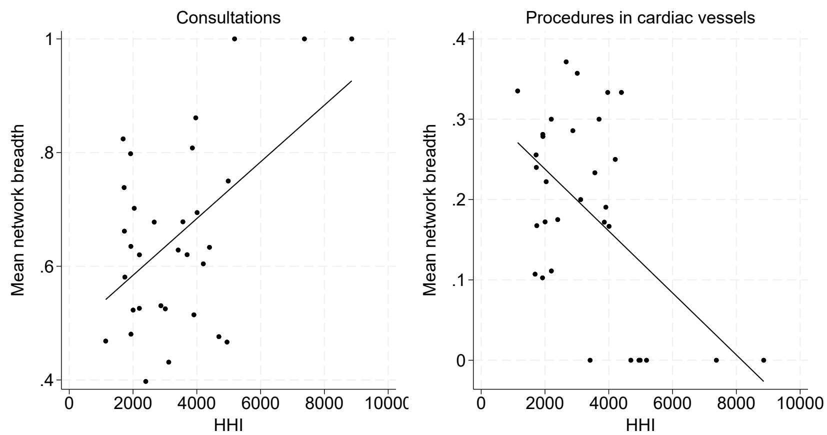

Figure 4: HHI and mean network breadth for consultations and cardiac vessels

Note: Scatter plot of Herfindahl-Hirschman Index and mean network breadth in consultations in the left panel and mean network breadth in procedures in cardiac vessels in the right panel. The solid line represents a linear fit.

the effect of insurer market structure from correlation exercises alone and ignoring network breadth variation across services may be misleading.

3.3 Empirical Model

I build on the data, empirical model, and estimates from Serna (2023), who provides a thorough analysis of the impact of risk selection on service-level hospital network breadth in the context of the Colombian healthcare system. That 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 and provide the main empirical micro-foundations below.

The Colombian insurance market is characterized by substantial consumer inertia. Of those who are enrolled throughout the year in the contributory system, less than 1 percent switch out of their insurer. This suggests that when choosing service-level network breadth, insurers take into account the effects that this choice may have on future profits from enrollees who are "locked-in". High inertia on insurer choice also suggests that insurers mainly compete 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-level 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 $AC_{j\theta}\frac{\partial s_{j\theta}}{\partial H_{jk}}$. 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 than in the absence of selection, because the choice of network breadth changes 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:

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

Market concentration reinforces the adverse selection effect if firms have homogeneous cost structure and if average costs are an increasing function of network breadth. The second term in equation (2) shows that HHI has a multiplicative effect on the increase in insurers' average cost following an increase in network breath. In concentrated markets with adverse selection, network breadth can thus be underprovided relative to markets with adverse selection but with stronger competition between health insurers.

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:

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

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 $\beta_i = x_i', \alpha_i = x_i'\alpha$, where 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 dependence of the average out-of-pocket cost to network breadth is captured with a linear regression as follows $c_{\theta jm} = \mu_\theta AC_{\theta jm}(H_{jm}) + \epsilon_{\theta jm}$. 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 utility shock, insurer j's demand in market m among type-θ enrollees is

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

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 120 times more for an additional hospital in the dialysis network 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 hospitals in their network. Insurers also enjoy scope economies, potentially due to price discounts at hospitals with which they have bargained in the past. Overall, the marginal effect of network breadth on average costs per enrollee is greater than the effect of economies of scope. 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. Appendix table 6 presents first stage results of a regression of network breadth on instruments. These probabilities and instruments factor into the estimation of the network formation cost in appendix table 7, which is derived from insurers' FOCs. Findings shows that network formation costs are strictly convex in network breadth and vary significantly across services. In particular, cost variation explains 48 percent of the variation in total profits when an insurer unilaterally increases network breadth for a service, while heterogeneity in willingness-to-pay coming from the demand function explains the other 52 percent. This suggests that adverse selection –sicker, less profitable individuals choosing insurers with greater coverage in certain services– is a main determinant 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). Preference and cost heterogeneity across services however, make it challenging to predict changes in service-level network breadth after an insurer is removed from consumers' choice sets. For example, if the removed insurer has market power in dialysis but not in cardiac vessels, network breadth might increase in dialysis but decrease in cardiac vessels after the removal.

4 Centralized Equilibrium

The first step to understand the impact of competition is to derive a benchmark scenario for network breadth. I use 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. 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

$$EU_i = \log \Big(\sum_j \exp(\beta_i \sum_k q_{\theta k} H_{jkm} - \alpha_i c_{\theta jm}(H_{jm}) + \phi_{jm}) \Big)$$

The social planner solves the following optimization problem per market:

$$\begin{aligned} &\max_{H_m}\ CS_m(H_m) \\ &\text{s.t}\ \ \Pi_{jm}(H_m) \geq 0\ \forall j \end{aligned}$$

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 580 parameters (58 services for each of 10 insurers), I redefine the optimization routine over 20 parameters. These parameters correspond to network breadth for primary care and hospitalizations for each insurer, holding network breadth for the rest of services fixed at their values in the observed equilibrium. I focus on primary care 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 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 overall median network breadth, average costs per enrollee, insurer total average costs, consumer surplus for sick and healthy individuals, and median network breadth for consultations and hospital admissions.

I find that the social planner chooses complete networks for each insurer, which translates into a 2 percent increase in network breadth for imaging, labs, and consultations and a 75 percent increase in network breadth for hospital admissions.[2] The social planner's solution is to provide complete coverage in these services because insurers' participation constraints are not binding.

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

Variable	% change
Overall median network breadth	0.2
Avg. cost per enrollee	49.2
Total avg. cost	52.7
Consumer surplus (sick)	38.8
Consumer surplus (healthy)	38.9
Network breadth imaging, lab, consultation	2.1
Network breadth hospital admissions	74.8

Note: Table presents the percentage change between the social planner's solution and the observed scenario in overall median network breadth, insurer total average costs, short-run average cost per enrollee, short-run consumer welfare for the healthy and sick, network breadth for imaging, lab, and consultations, and network breadth for hospital admissions. The counterfactual is calculated with data from Bogotá only.

Complete coverage of consultations and hospitalizations increase the system's health care costs by around 53 percent. This effect is a combination of these services

[2] Consultations are aggregated with other entry-level services such as imaging and laboratory testing for expositional purposes. Median network breadth for consultations in the observed scenario is 0.54.

both having relatively high claim probabilities across consumer types and representing a large fraction of insurers' average costs per enrollee. Average costs per enrollee in fact increase 49 percent relative to the observed scenario. The substantial cost increase is mostly borne by insurers, for which profits decrease on average 10 percent. Although consumers bear part of this cost increase in the form of out-of-pocket costs, the welfare gains from having broader networks overcompensates the welfare losses from higher out-of-pocket payments. The table shows that consumer surplus increases around 39 percent across sick and healthy individuals.

The trade-off between total health care costs and network breadth highlights a potential reason why the social planner's solution is not attainable in practice. A policy that imposes complete network coverage in some services may not be politically admissible among insurers if it generates significant declines in their profits. This type of policy may also generate incentives for insurers to drop coverage of other services altogether. Although my counterfactual results in table 2 can not speak to these 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-level 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 two 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-level network breadth. For example, we might expect collusion to result in narrower networks because the colluding firms internalize the negative externality that they separately impose on its competitor's demand. However, because of scope economies, collusion might also generate cost efficiencies that incentivize the colluding firm to increase network breadth.

Take one market, in this counterfactual scenario the two colluding firms j and g 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) to (3) show results where different pairs of insurers collude. The findings reveal that regardless of which two 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 two insurers collude because of preference and cost heterogeneity.

Table 3: Networks, costs, and welfare under collusion

	Variable	EPS013 EPS037 (1)	EPS002 EPS016 (2)	EPS001 EPS003 (3)
A. Overall	Median network breadth	-7.0	-4.9	-5.5
	Avg. cost per enrollee	-1.2	-0.9	-1.1
	Total avg. cost	-9.1	-8.1	-8.2
	Consumer surplus (sick)	-9.9	-9.3	-9.3
	Consumer surplus (healthy)	-7.2	-6.5	-6.5
B. Service network breadth	Skull, spine, nerves, glands	-6.2	-4.7	-3.7
	Eyes, ears, nose, mouth	-7.7	-8.1	-9.0
	Pharynx, lungs	-6.3	-8.1	-2.7
	Heart and cardiac vessels	-12.8	-5.0	-3.0
	Lymph nodes, bone marrow	-11.1	-2.0	-1.9
	Esophagus, stomach and intestines	-8.7	-5.1	-4.5
	Liver, biliary tract	-5.3	-4.0	-1.5
	Abdominal wall	-8.3	-2.4	-2.3
	Urinary system	-7.7	-9.4	-4.9
	Reproductive system	-8.6	-4.4	-3.2
	Bones and facial joints	-1.0	-6.0	-6.0
	Joints, bones, muscles, tendons	-8.2	-8.5	-9.0
	Skin	-1.3	-6.4	-4.4
	Imaging, lab, consultation	-5.3	-2.4	-0.6
	Hospital admission	-4.7	-4.6	-1.3

Note: Panel A presents the percentage change in median network breadth across insurers, insurer total average costs, short-run average cost per enrollee, and short-run consumer welfare for the healthy and sick, between the collusive scenario and the observed scenario. Column (1) presents results when EPS013 and EPS037 collude, column (2) when EPS002 and EPS016 collude, and column (3) when EPS001 and EPS003 collude. Panel B presents the percentage change of median network breadth by service category. I collapse the 58 original categories into 15 broader groups for exposition. The counterfactual is calculated with data from Bogotá.

Focusing on column (1) where EPS013 and EPS037 maximize joint profits – the ex-ante two largest insurers–, I find that median network breadth falls by 7.0 percent. The reduction in coverage generates a 9.9 percent reduction in surplus for consumers with diseases and a 7.2 percent reduction in surplus for healthy consumers. Consumer surplus falls by a greater magnitude for those with chronic diseases because network breadth in services that these individuals are more likely to claim decreases substantially as seen in panel B of the table. For example, network breadth falls 12.8 percent for procedures in heart and cardiac vessels, but falls only 5.3 percent for imaging, lab, and consultations. This means that collusion exacerbates risk selection incentives. Serna (2023) shows that insurers engage in risk selection by offering narrow networks in unprofitable services. The fact that network breadth decreases substantially in expensive 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 consultations and hospitalizations (holding other services fixed), while table 3 indicates that network breadth for these two services would be 43 percent farther from the first-best if two firms collude.

Table 4: Networks and profits for colluding firms

Variable	EPS013	EPS037	EPS002	EPS016	EPS001	EPS003
Median network breadth	-22.6	-10.3	-6.5	-11.7	-13.9	-9.9
Total revenues	-25.5	-13.8	-12.8	-17.9	-12.7	-12.9
Total avg. cost	-30.7	-17.1	-14.0	-21.1	-16.2	-14.5
Avg. cost per enrollee	-6.9	-3.8	-2.0	-4.3	-4.7	-2.5

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

In each counterfactual, profits for the two insurers that collude increase and median network breadth decreases relative to the observed scenario where they act as independent firms. In the case where EPS013 and EPS037 maximize joint profits, table 4 shows that total average costs for EPS013 fall by a greater magnitude than total revenues, so variable profits increase around 5 percent. Median network breadth for this insurer also decreases 22.6 percent relative the observed equilibrium. Percentage changes in total revenues, costs, and median network breadth are smaller for EPS037, but provide similar suggestive evidence: collusion generates cost efficiencies and higher profits for each of the two firms. The exercise of market power in insurance markets is therefore tied to the provision of narrow hospital networks.

6 Prohibiting Service Discrimination

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. The most widely used policy to this end is risk adjustment, by which the government compensates insurers for their enrollees' health risk. This policy has been evaluated extensively in settings like the US (e.g., Geruso and Layton, 2017; Brown et al., 2014) and more recently in Colombia (e.g., Serna, 2023). In the context of the Colombian health system, where insurers can discriminate networks by health service, prohibiting their leverage across services can also limit risk selection incentives.

In this section I study the effect of prohibiting service-level discrimination of networks and how closely this type of policy can approximate the social planner's solution. In practice, this policy forces insurers to cover all the services a hospital can provide if the hospital is in-network, so network breadth must the same across services. While insurers still have discretion on whether to cover the hospital 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:

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

Table 5 shows the results. I find that forcing insurers to cover all services at a hospital doubles median network breadth from a baseline of 0.36 as seen in panel A. Note that in this counterfactual scenario (as well as in the previous ones) government spending is fixed, therefore increased coverage comes at the expense of insurer profits. Insurers' total average cost increases 23.3 percent relative to the observed scenario. Lost profits to insurers are transferred to consumers, for whom surplus increases 37.0 percent for those with chronic conditions and 36.5 percent for those without diseases.

Panel B of the table shows that network breadth increases substantially across all services. But the percentage changes are larger for services that were under-provided in the observed scenario due to risk selection incentives. For instance, network breadth for procedures in heart and cardiac vessels increase 85.4 percent, while network breadth for hospital admissions increases 73.7 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 consultations and hospitalizations 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, healthcare costs, and social welfare. 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

Table 5: Networks, costs, and welfare under no risk adjustment

	Variable	% change
A. Overall	Median network breadth	99.6
	Avg. cost per enrollee	18.9
	Total avg. cost	23.3
	Consumer surplus (sick)	37.0
	Consumer surplus (healthy)	36.5
B. Service network breadth	Skull, spine, nerves, glands	108.6
	Eyes, ears, nose, mouth	84.6
	Pharynx, lungs	86.2
	Heart and cardiac vessels	85.4
	Lymph nodes, bone marrow	122.5
	Esophagus, stomach and intestines	117.4
	Liver, biliary tract	109.0
	Abdominal wall	73.1
	Urinary system	109.0
	Reproductive system	125.5
	Bones and facial joints	189.0
	Joints, bones, muscles, tendons	109.6
	Skin	76.2
	Imaging, lab, consultation	95.6
	Hospital admission	73.7

Note: Panel A presents the percentage change in median network breadth across insurers, insurer total average costs, short-run average cost per enrollee, and short-run consumer welfare for the healthy and sick, between the scenario prohibiting service heterogeneity and the observed scenario. Panel B presents the percentage change of median network breadth by service category. I collapse the 58 original categories into 15 broader groups for exposition. The counterfactual is calculated with data from Bogotá.

appropriate access to care in key services, patients can be made better off. But the impact on healthcare costs should also be taken into consideration when evaluating such policies.

7 Conclusion

Private health insurers that operate in different health systems (such as Medicare Advantage in the US, Colombia, and the Netherlands) typically differentiate in their hospital networks. The design of these 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 healthcare policies such as network adequacy rules.

In this paper I study the effect of insurer competition on hospital 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 like consultations and hospitalizations. The social planner's solution increases consumer surplus by 38 percent, but also increases the system's healthcare costs by 53 percent.

Simulations of the model allowing two insurers to collude show that network breadth is an increasing function of the degree of competition between private insurers. While policies that promote competition may be difficult to implement, I find that a simple network adequacy rule prohibiting 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 healthcare costs.

References

Atwood, A. and Sasso, A. T. L. (2016). The Effect of Narrow Provider Networks on Health Care Use. *Journal of Health Economics*, 50:86–98.

Bailey, M. J. and Goodman-Bacon, A. (2015). The War on Poverty's Experiment in Public Medicine: Community Health Centers and the Mortality of Older Americans. *American Economic Review*, 105(3):1067–1104.

Brown, J., Duggan, M., Kuziemko, I., and Woolston, W. (2014). How Does Risk

Selection Respond to Risk Adjustment? New Evidence from the Medicare Advantage Program. *American Economic Review*, 104(10):3335–3364.

Dafny, L. (2010). Are Health Insurance Markets Competitive? *American Economic Review*, 100(4):1399–1431.

Dafny, L., Gruber, J., and Ody, C. (2015a). More Insurers Lower Premiums: Evidence from Initial Pricing in the Health Insurance Marketplaces. *American Journal of Health Economics*, 1(1):53–81.

Dafny, L., Hendel, I., and Wilson, N. (2015b). Narrow Networks on the Health Insurance Exchanges: What do they Look Like and How do they Affect Pricing? A Case Study of Texas. *American Economic Review*, 105(5):110–14.

Finkelstein, A., Hendren, N., and Shepard, M. (2019). Subsidizing Health Insurance for Low-Income Adults: Evidence from Massachusetts. *American Economic Review*, 109(4):1530–1567.

Geruso, M. and Layton, T. (2017). Selection in Health Insurance Markets and Its Policy Remedies. *Journal of Economic Perspectives*, 31(4):23–50.

Ghili, S. (2022). Network Formation and Bargaining in Vertical Markets: The Case of Narrow Networks in Health Insurance. *Marketing Science*, 41(3):501–527.

Ho, K. and Lee, R. (2017). Insurer Competition in Health Care Markets. *Econometrica*, 85(2):379–417.

Ho, K. and Lee, R. (2019). Equilibrium Provider Networks: Bargaining and Exclusion in Health Care Markets. *American Economic Review*, 109(2):473–522.

Kreider, A., Layton, T., Shepard, M., and Wallace, J. (2022). Adverse Selection and Network Design Under Regulated Plan Prices: Evidence from Medicaid.

Liebman, E. (2018). Bargaining in Markets with Exclusion: An Analysis of Health Insurance Networks.

Liebman, E. and Panhans, M. T. (2021). Why Do Narrow Network Plans Cost Less? *Health Economics*, 30(10):2437–2451.

Mahoney, N. and Weyl, G. (2017). Imperfect Competition in Selection Markets. *The Review of Economics and Statistics*, 99(4):637–651.

McFadden, D. (1996). Computing willingness-to-pay in random utility models. *University of California at Berkeley, Econometrics Laboratory Software Archive, Working Papers*.

Rothschild, M. and Stiglitz, J. (1976). Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information*. *The Quarterly Journal of Economics*, 90(4):629–649.

Serna, N. (2023). Non-Price Competition and Risk Selection Through Hospital Networks.

Shepard, M. (2022). Hospital Network Competition and Adverse Selection: Evidence from the Massachusetts Health Insurance Exchange. *American Economic Review*, 112(2):578–615.

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: Service list

Service code	Description
01	Procedures in skull, brain, and cerebral meninges
03	Procedures in spinal cord and structures of spine
04	Procedures in peripheral and skull nerves
05	Procedures in nerves or sympathetic ganglia
06	Procedures in thyroid and parathyroid gland
08	Procedures in eyelids and lacrimal apparatus
10	Procedures in conjunctive, cornea, iris, retina, orbit
18	Procedures in ear
21	Procedures in nose and paranasal sinuses
23	Procedures in teeth, tongue, salivary glands
27	Procedures and interventions in mouth and face
28	Procedures in tonsils and adenoids
29	Procedures in pharynx, larynx, trachea
32	Procedures in lung and bronchus
34	Procedures in thoracic wall, pleura, mediastinum, diaphragm
35	Procedures in heart valves
36	Procedures in cardiac vessels
37	Procedures in heart and pericardium
38	Procedures in blood vessels
40	Procedures in lymphatic system
41	Procedures bone marrow and spleen
42	Procedures in esophagus
43	Procedures in stomach
45	Procedures in intestines
47	Procedures in appendix
48	Procedures in rectum, rectosigmoid, perirectal tissue
50	Procedures in liver
51	Procedures in gallbladder and biliary tract
52	Procedures in pancreas
53	Procedures in abdominal wall
55	Procedures in kidney
56	Procedures in ureter
57	Procedures in bladder
58	Procedures in urethra and urinary tract
60	Procedures in prostate, seminal vesicles, scrotum, testicles, penis
65	Procedures in ovaries, fallopian tubes, cervix, uterus
70	Procedures in vagina and cul-de-sac
72	Procedures and interventions in vaginal delivery
76	Procedures in bones and facial joints
79	Reduction of fracture and dislocation
80	Procedures in joint structures
81	Repair procedures and plasties in joint structures
82	Procedures in tendons, muscles, and hand fascia
83	Procedures in muscle, tendon, fascia, bursa except hand
85	Procedures in breast
86	Diagnostic procedures in skin and subcutaneous cellular tissue
87	Radiology and non-radiology imaging
89	Consultation, anatomic measures, physiology, manual tests, and pathology
90	Laboratory
91	Blood bank and transfusion medicine
92	Nuclear medicine and radiotherapy
93	Procedures and interventions in functional development and rehabilitation
94	Procedures related to mental health
95	Non-surgical procedures and interventions related to eye and ear
97	Substitution and extraction of therapeutic devices
98	Non-surgical extraction of kidney stones
99	Prophylactic and therapeutic procedures
S1	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 (2023). 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:

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

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 co-payments, 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

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

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.[3] 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

[3]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.

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 component 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 (2023).

Table 2: Insurer demand

Variable		Network breadth	OOP spending (million)
Mean		2.26 (0.19)	-11.5 (0.26)
Interactions			
Demographics	Male	0.37 (0.02)	0.83 (0.13)
	Age 19-24	1.81 (0.06)	-0.24 (0.47)
	Age 25-29	2.58 (0.07)	2.46 (0.26)
	Age 30-34	2.17 (0.06)	1.59 (0.31)
	Age 35-39	1.78 (0.06)	0.43 (0.41)
	Age 40-44	1.58 (0.06)	1.49 (0.37)
	Age 45-49	1.30 (0.06)	1.14 (0.30)
	Age 50-54	0.99 (0.06)	1.29 (0.32)
	Age 55-59	0.94 (0.07)	1.50 (0.30)
	Age 60-64	0.66 (0.07)	1.01 (0.29)
	Age 65-69	0.56 (0.07)	0.55 (0.29)
	Age 70-74	0.47 (0.07)	0.93 (0.29)
	Age 75 or more	(ref)	(ref)
Diagnoses	Cancer	0.08 (0.07)	5.85 (0.25)
	Cardiovascular	-0.25 (0.05)	4.79 (0.23)
	Diabetes	-0.11 (0.12)	5.60 (0.43)
	Renal	0.24 (0.27)	8.28 (0.17)
	Pulmonary	-0.27 (0.18)	7.63 (0.33)
	Arthritis	-0.13 (0.12)	7.79 (0.28)
	Asthma	-0.16 (0.24)	8.61 (0.50)
	Other	-0.81 (0.15)	7.26 (0.25)
	Healthy	(ref)	(ref)
Location	Normal	3.70 (0.04)	1.99 (0.16)
	Special	5.47 (0.08)	0.94 (0.32)
	Urban	(ref)	(ref)
Income	Low	0.30 (0.03)	-1.13 (0.22)
	High	(ref)	(ref)
N		5,852,405	
N enrollees		500,000	
Pseudo-R^2		0.23	

Note: Conditional logit for the insurer choice model estimated 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	1.81	(0.21)
Scope economies	-134.3	(24.9)
Reference price	20.5	(6.43)
Insurer		
EPS001	0.11	(0.04)
EPS002	-0.29	(0.02)
EPS003	-0.22	(0.02)
EPS005	-0.08	(0.02)
EPS008	0.02	(0.06)
EPS009	0.06	(0.05)
EPS010	-0.08	(0.03)
EPS012	-0.70	(0.13)
EPS013	-0.07	(0.02)
EPS016	-0.12	(0.02)
EPS017	-0.25	(0.03)
EPS018	-0.18	(0.04)
EPS023	-0.45	(0.03)
EPS037	(ref)	(ref)
N	40,989	
R^2	0.39	

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

Table 4: Dropout probabilities

	mean	sd
Diagnosis		
Cancer	4.9	(3.2)
Cardio	3.1	(1.7)
Diabetes	3.1	(1.4)
Renal	4.7	(2.8)
Pulmonary	4.5	(2.9)
Arthritis	2.6	(1.4)
Asthma	3.3	(1.9)
Other	3.5	(2.1)
Healthy	46.1	(7.7)
Age		
19-24	10.8	(16.5)
25-29	7.6	(12.0)
30-34	7.0	(12.1)
35-39	7.2	(12.6)
40-44	7.2	(13.1)
45-49	7.2	(13.5)
50-54	7.6	(14.1)
55-59	7.6	(14.6)
60-64	7.7	(14.7)
65-69	8.0	(14.8)
70-74	8.6	(14.7)
75 or more	14.5	(14.4)
Sex		
Female	7.5	(12.1)
Male	9.3	(15.2)

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	Lung	Arthritis	Asthma	Other	Healthy
Cancer	30.0	13.3	1.7	0.7	1.4	2.6	0.4	1.4	48.6
	(7.4)	(8.5)	(1.5)	(0.6)	(1.3)	(1.9)	(0.2)	(0.5)	(17.9)
Cardio	4.1	53.8	2.7	1.1	1.4	1.7	0.4	1.1	33.8
	(3.4)	(20.9)	(1.7)	(0.9)	(1.4)	(0.9)	(0.3)	(0.5)	(23.3)
Diabetes	2.9	17.0	54.1	1.2	0.9	0.9	0.2	0.8	22.0
	(2.4)	(10.3)	(8.3)	(1.0)	(1.1)	(0.6)	(0.3)	(0.5)	(14.9)
Renal	4.7	21.9	3.7	27.2	1.3	2.0	0.3	2.9	36.1
	(3.6)	(13.3)	(3.0)	(4.4)	(1.3)	(1.7)	(0.4)	(2.0)	(17.8)
Lung	5.4	17.9	1.7	0.6	22.7	2.6	2.8	1.8	44.4
	(4.4)	(8.9)	(1.2)	(0.7)	(15.5)	(1.7)	(1.5)	(1.0)	(23.9)
Arthritis	5.8	15.8	1.5	0.6	1.6	23.6	0.5	2.1	48.6
	(4.4)	(10.5)	(1.2)	(0.4)	(1.6)	(5.7)	(0.3)	(1.1)	(16.4)
Asthma	4.5	13.4	1.2	0.4	8.9	2.4	28.5	1.2	39.4
	(3.9)	(9.5)	(1.3)	(0.6)	(8.3)	(2.0)	(9.2)	(1.0)	(16.2)
Other	5.4	15.2	1.6	1.0	2.5	3.6	0.4	33.3	37.1
	(3.6)	(11.7)	(1.5)	(0.7)	(3.2)	(2.8)	(0.3)	(11.8)	(8.9)
Healthy	5.5	12.8	1.5	0.6	1.6	2.9	0.4	1.0	73.6
	(4.1)	(9.4)	(1.3)	(0.7)	(1.8)	(2.0)	(0.2)	(0.2)	(14.5)

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: First stage regression of network breadth

H_{jkm}	coef	se
H^{t-1}_{jkm}	0.85	(0.01)
$H^{t-1}_{jkm} \times \overline{q}_{\text{age 19-24, k}}$	-10.43	(10.01)
$H^{t-1}_{jkm} \times \overline{q}_{\text{age 25-29, k}}$	16.21	(37.19)
$H^{t-1}_{jkm} \times \overline{q}_{\text{age 30-34, k}}$	-5.19	(31.74)
<u>Service</u>		
Cardiac vessels	0.00	(0.02)
Stomach	0.02	(0.02)
Intestines	0.06	(0.02)
Imaging	-0.01	(0.02)
Consultation	-0.03	(0.05)
Laboratory	-0.01	(0.02)
Nuclear Medicine	0.03	(0.01)
Hospital Admission	0.06	(0.02)
F-statistic	1,718.5	
N	2,262	

Note: First stage of the GMM estimation of the insurer's first -order condition. H^{t-1}_{jkm} is network breadth in 2010. $\overline{q}_{i,k}$ is the average probability that a consumer with characteristic i makes a claim for service k. The specification includes service fixed effects. Robust standard errors in parenthesis and first-stage F-statistic reported.

Table 7: Model of insurer network formation costs

asinh(MVP$_{jmk}$)	coef	se
Network breadth	6.86	(0.16)
<u>Service</u>		
Cardiac Vessels	1.47	(0.20)
Stomach	1.25	(0.20)
Intestines	4.77	(0.20)
Imaging	6.64	(0.20)
Consultation	6.37	(0.21)
Laboratory	7.35	(0.20)
Nuclear Medicine	4.67	(0.20)
Hospital Admission	4.90	(0.20)
First stage F-stat	1,718.5	
N	2,262	
R^2	0.76	

Note: 2-step GMM estimation of the first-order condition of insurers' profit maximization problem on the subsample of markets 05, 08, 11, 76, and the subsample of the 10 largest insurers in these markets. Excluded instruments are described in section **??**. Robust standard errors in parenthesis and first-stage F-statistic for the endogenous variable, network breadth reported.