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: 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 descentralized 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. The health system is divided into a contributory regime and a subsidized regime. The first covers individuals who can pay their taxes, while the second is fully funded by the government from tax contributions.

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. Conditional on mandatory enrollment (as in Colombia) and allowing for adverse selection and moral hazard in insurance choice, the model shows that a monopolist insurer always chooses a narrow network, while the social planner chooses a broad network. An extension of the model that allows consumers to choose uninsurance maintains these predictions under certain conditions of the insurers' cost function. To determine whether insurer competition on hospital network breadth brings the equilibrium closer to the social planner's solution relative to monopoly, I move to the empirical model.

I use the empirical 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 profit function follows a net present value specification to accommodate the future profits that insurers may derive from consumers who do not switch after making their first enrollment decision. The solution concept in this game is a Nash equilibrium.

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 describes the background and data. Section 4 summarizes the empirical model. Section 5 presents the results of a centralized equilibrium where the social planner chooses network breadth. Section 6 derives the equilibrium network breadth when insurers maximize joint profits. Section 7 provides results of an alternative policy where insurers are prohibited from discriminating networks across health services. Section 8 concludes.

2 A Simple Theoretical Model

To establish intuition of 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 sicker. 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 $c_\theta(H_j, \theta) >$

[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.

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 $\beta_j \geq 2$ is a preference parameter that introduces preference heterogeneity across insurers. Suppose there is no outside option, therefore individuals always have to buy health insurance. This assumption is not without loss of generality, but it relates to my empirical setting. In appendix A I extend the model to the case where consumers can choose uninsurance.

Suppose insurers make per-enrollee profits given by $\pi(H_j,\theta) = R(\theta) - (1-r)c(H_j,\theta)$, 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 that $R_\theta(\theta) < c_\theta(H_j,\theta)$. 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. Start with a monopolist insurer. The profit of a monopolist choosing network breadth is:

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

Claim. The monopolist insurer always chooses a narrow network. Note that with fixed total revenues, $\Pi(1) < \Pi(0)$.

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

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

Here we can think of β being 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 always chooses a broad network. The assumption that $c(1,\theta) < 2c(0,\theta)$ implies the following relation

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

This simple model highlights the tension between the social planner's solution and a decentralized equilibrium with a monopolist insurer. With mandatory enrollment, the monopolist is essentially a cost-minimizing firm, while the social planner chooses the most expensive network conditional on every consumer participating. Deriving a decentralized equilibrium with more than one insurer in the market would require stronger assumptions about the insurers' profit function. I therefore proceed to describe the empirical setting and econometric model that I use to compare equilibrium network breadth across different levels of competition.

3 Background and Data

To analyze the impact of insurer competition on hospital networks, I use enrollment and claims data from everyone enrolled in the contributory system in Colombia between 2010 and 2011. There are 22.5 million enrollees in 2010 and 23.1 million in 2011. I limit my sample to consumers who have continuous enrollment spells and are new enrollees in 2011. A new enrollee in this setting is a person who either moves from the subsidized system to the contributory system, turns 18 and can no longer be covered by their parents' insurer, or has been uninsured for at least a year.[2] I focus on new enrollees because they have not had previous interactions with their insurer, so their preferences for hospital network breadth are unaffected by insurer inertia. The enrollment files have information on the enrollees' sex, age, municipality of residence, insurer, and days enrolled in the year. I complement this information with enrollees' diagnoses obtained from grouping their ICD-10 codes from the claims data. The ICD-10 groupings follow Riascos et al. (2014).

During the sample period, the contributory system had 23 private insurers. I limit the sample of insurers to the top 14, that account for approximately 97 percent of enrollees. The Colombian insurance market is highly concentrated: table 1 shows that the three largest insurers covered 46 percent of enrollees in the country during 2011.

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. Cost-sharing rules are indexed to the enrollee's monthly income level

[2] Given that the Colombian health care system has near-universal coverage, a person may be considered uninsured for a certain period of time if they have not completed the enrollment application at any insurer.

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.

in a three-tier system. Individuals are categorized based on whether they make less than two times, between two and five times, or more than five times the monthly minimum wage. Appendix table 1 provides the cost-sharing rules for these three income categories.

Additionally, the government sets insurance premiums to zero. Individuals covered by the contributory system pay 12 percent of their monthly income in taxes to receive access to health, unemployment, and disability insurance. If the individual is employed, they pay 4 percent of this contribution and their employer pays the remaining 8 percent. If the individual is self-employed they contribute the entire 12 percent. Importantly, this tax contribution does not vary across insurers, so it does not generate sorting of consumers into insurers.

Given that premiums are zero, 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 first type of transfer is calculated by the government using claims data from two years prior. This transfer equals roughly the present value of average health care cost per risk pool, where a risk pool is defined by a combination of sex, age, and municipality of residence. The second type of transfer is calculated by the government using same-year claims from individuals who have any of the following health conditions: cervical cancer, breast cancer, stomach cancer, colon cancer, prostate cancer, lymphoid leukemia, myeloid leukemia, Hodgkin lymphoma, non-Hodgkin lymphoma, epilepsy, rheumatoid arthritis, and HIV-AIDS. Insurers with a below-average share of enrollees with any of these diagnoses pay those with an above-average share. This type of transfer is therefore zero-sum across insurers, and equals roughly the average cost of treatment of each disease during a year. The first type of transfer on average accounts for 96 percent of total insurer revenues, while the second accounts for the remaining 4 percent.

3.1 Hospital Networks

Even though cost-sharing and premiums are highly regulated, insurers in the public health system have discretion over which health services to cover at which hospitals. Insurers also negotiate service prices with hospitals when determining network inclusions. Although the government does stipulate 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 comprehensive list of around 7 thousand services, procedures, and devices, and around 700 medications as of 2011. The government categorizes these services based on their main anatomical purpose. Insurers and hospitals follow this categorization when negotiating prices and network inclusions. I use this categorization to construct 58 service groups over which hospital networks are defined. A service in my data describes procedures in certain parts of the body, for example, procedures in cardiac vessels, procedures in stomach, procedure in intestines, hospitalizations, consultations, etc. The complete list of services is provided in appendix table 2.

With these services, I infer insurers' network of hospitals per service using the claims data. These data report date in which the claim was filed, insurer that reimbursed the claim, provider that rendered the claim, associated health service, negotiated price of the health service, and contract under which the claim was reimbursed (capitation, fee-for-service, fee-for-package, or fee-for-diagnosis). To recover insurers' networks I use only a sample of large hospitals and clinics for which there are enough claims per service to infer them as being part of the network. I refer to this sample of providers as "hospitals" from now on. Appendix figure 1 shows the distribution of number of claims among in-network hospitals and services in the final dataset. This sample restriction avoids measurement errors in network breadth coming from small providers that might be in-network but do not provide claims during the sample period. The final sample of hospitals accounts for a third of total health care costs and claims in the contributory system.

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 how many hospitals the insurer covers 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. Colombian states are similar in size to Metropolitan Statistical Areas in the US. I have data on 32 out of the 33 states in the country after imposing sample restrictions.

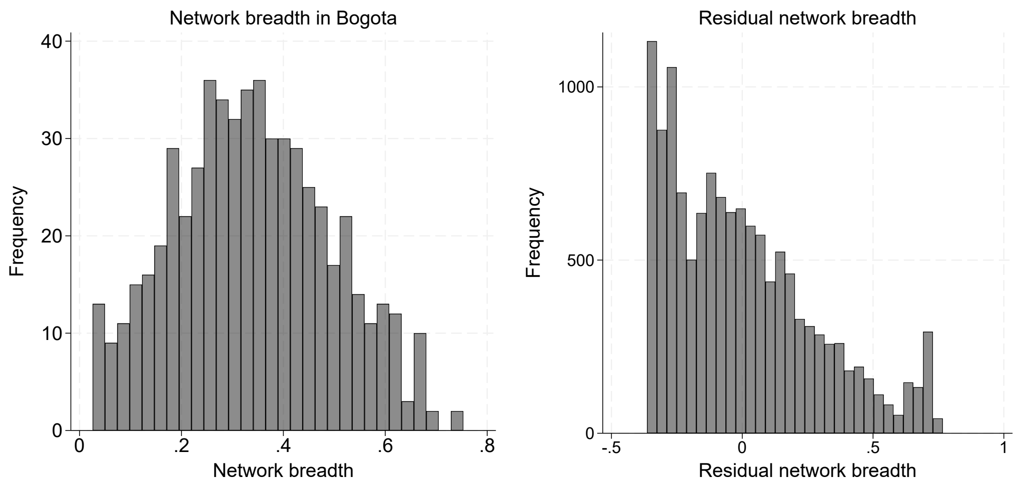

Figure 1: Distribution of (residual) network breadth

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.

For simplicity in the empirical model of the next section, I collapse the information contained in the service-level hospital networks to a measure of hospital network breadth. 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.

The left-hand panel of figure 1 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 (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 1. 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. I focus on the impact of insurer market structure taking other aspects as given in the next subsections.

3.2 Market Structure

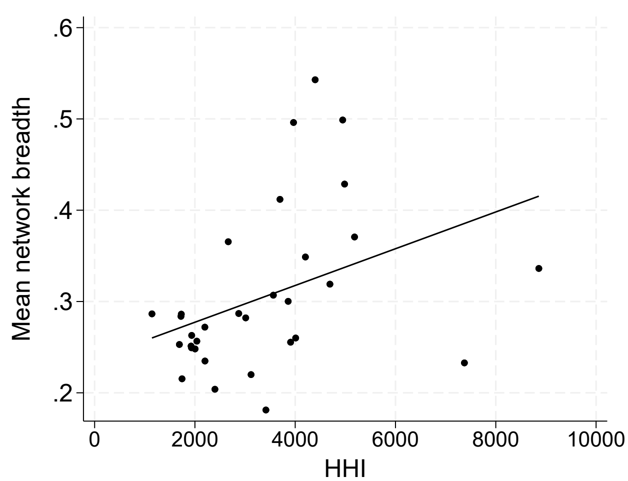

Figure 2: HHI and mean network breadth

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.

Figure 3 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.

This correlation however masks an underlying adverse selection effect. Figure 3 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.

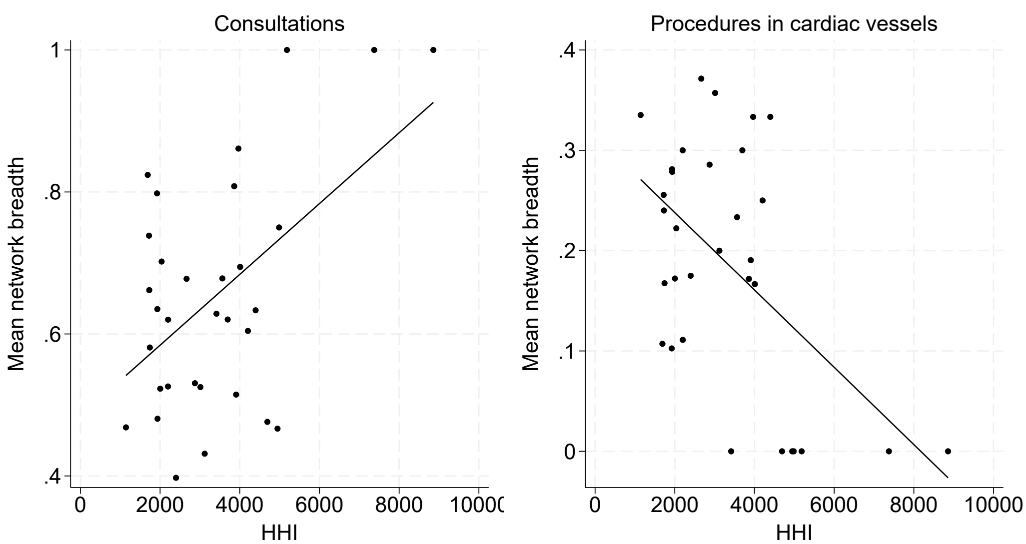

Figure 3: HHI and mean network breadth for consultations and cardiac vessels

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

4 Empirical Model

In this section I describe the empirical model of insurer competition in service-level network breadth.[3] 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.

4.1 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:

$$u_{ijm} = \beta_i \sum_k q_{\theta k} H_{jkm} - \alpha_i c_{\theta jm}(H_{jm}) + \phi_{jm} + \varepsilon_{ijm} \tag{1}$$

[3]For a more detailed discussion the reader can refer to Serna (2023).

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 (1) 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 (1) 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.

4.2 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:

$$\Pi_{jm}(H_m) = \sum_{\theta} \Big(\underbrace{\pi_{ijm}(H_m, \theta) N_{\theta m}}_{\text{current profit}} + \underbrace{\sum_{s=t+1}^{T} \zeta^s \sum_{\theta'} (1 - \rho_{\theta' m}) \mathcal{P}(\theta' | \theta) \pi_{ijm}(H_m, \theta') N_{\theta' m} \Big)}_{\text{future profit}}$$
$$- \underbrace{\sum_k \Big(\omega H_{jkm} + \xi_{jkm} \Big) H_{jkm}}_{\text{network formation cost}} \tag{2}$$

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

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

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.[4] 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

[4]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.

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 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 (2) 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}.

4.3 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.

4.4 Estimation

Demand and cost estimates are provided in appendix C. Appendix table 3 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. In particular, consumers with chronic diseases have a higher willingness-to-pay for network breadth in services that their disease requires for treatment compared to healthy individuals. 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 4 shows that broad-network insurers have higher average cost 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 before. 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 5 and 6 present estimates of dropout and transition probabilities, which are computed non-parametrically outside of the model. Appendix table 7 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 8. 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.

5 Centralized Equilibrium

To understand how insurer competition affects coverage decisions, the first step is to derive a benchmark of network breadth. The benchmark that I focus on in this section is 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 4.

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 $H_m = \{H_{jkm}\}_{j=1,k=1}^{J,K}$, and following McFadden (1996) the short-run expected utility 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 separately for every market:

$$\max_{H_m} \; CS_m(H_m)$$
$$\text{s.t} \;\; \Pi_{jm}(H_m) \geq 0 \; \forall j$$

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. This partial equilibrium is sufficient for the purpose of providing a benchmark for network breadth. Results are presented in table 2. The table shows the percentage change in overall median network breadth, average costs per enrollee, insurer total average costs, consumer surplus for sick and healthy individuals, and median network breadth per service, between the social planner's solution and the observed scenario.

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 as seen in panel B of the table. The social planner's solution is to provide complete coverage in these services because insurers make substantial profits in the observed scenario. Therefore, even with complete networks, insurers' participation constraints are not binding.

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

	Variable	% change
A. 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
B. Service network breadth	Skull, spine, nerves, glands	0.0
	Eyes, ears, nose, mouth	0.0
	Pharynx, lungs	0.0
	Heart and cardiac vessels	0.0
	Lymph nodes, bone marrow	0.0
	Esophagus, stomach and intestines	0.0
	Liver, biliary tract	0.0
	Abdominal wall	0.0
	Urinary system	0.0
	Reproductive system	0.0
	Bones and facial joints	0.0
	Joints, bones, muscles, tendons	0.0
	Skin	0.0
	Imaging, lab, consultation	2.1
	Hospital admission	74.8

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 social planner's solution 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. The counterfactual is calculated with data from Bogotá only.

Complete coverage of consultations and hospitalizations more than doubles the system's health care costs as seen in panel A. This effect is a combination of these services 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, the welfare gains from having broader networks overcompensates the welfare losses from higher out-of-pocket payments. Panel A of 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.

6 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.

In this counterfactual scenario, the two colluding firms j and g solve the following maximization problem:

$$\max_{H_{jm}, H_{gm}} \ \Pi_{jm}(H_{jm}, H_{gm}) + \Pi_{gm}(H_{jm}, H_{gm})$$

Relative to the observed scenario, each colluding firm now internalizes the effect of its network breadth choices on the other colluding firm's demand. In the first order condition with respect to H_{jkm}, the derivative of the per-enrollee profit for firm g is:

$$\frac{\partial \pi_{igm}}{\partial H_{jkm}} = -\beta_i q_{\theta k}(R_{\theta m} - (1 - r_i)AC_{\theta jm}(H_{jm}))s_{igm}s_{ijm}$$

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 without an outside option for consumers, 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. The counterfactual is calculated with data from Bogotá only.

Focusing on column (1) where EPS013 and EPS037 collude – 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 due to reductions in network breadth across services. The exercise of market power in insurance markets is therefore tied to the provision of narrow hospital networks.

7 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 it 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 $H_k = H \ \forall k$ separately in each market. The first order condition of its profit maximization problem is:

$$\frac{1}{K}\sum_k \sum_i \left(\frac{\partial \pi_{ijm}}{\partial H_{jkm}} N_{\theta m} + \sum_{s=t+1}^{T} \zeta^s \sum_{\theta'} (1-\rho_{\theta' m}) \mathcal{P}(\theta'|\theta) \frac{\partial \pi'_{ijm}}{\partial H_{jkm}} N_{\theta' m} \right)$$
$$= \frac{1}{K}\sum_k \left(2\omega H_{jkm} + \xi_{jkm} \right)$$

Table 5 shows the results. I find that forcing insurers to cover all services at a hospital doubles the median network breadth from a baseline of 0.36 as seen in panel A. Note that in this counterfactual scenario (and 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 underprovided 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. However, 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 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.

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. The counterfactual is calculated with data from Bogotá only.

8 Conclusion

Private health insurers that operate in different health systems (such as Medicare Advantage in the US, Colombia, and the Netherlands, etc.) increasingly use hospital networks as a dimension of differentiation. The design of these hospital networks typically 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 the provision of a broad or a narrow network and how these relate to competition between private insurers is important for the design of 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. In Colombia, private insurers can choose hospital networks separately for each health service, but all other aspects of the insurance contract are regulated by the government including premiums, cost-sharing, and benefits.

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 approximately 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.

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Appendix A Model Extension

Suppose consumers from the toy model of section 2 can choose an alternative of uninsurance. Let the utility of uninsurance be equal to zero. In this case consumers enroll if:

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

Monopoly. The monopolist's problem is to choose network breadth to maximize profits given by:

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

Claim. The monopolist chooses a narrow network. Note that this implies that

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

We can rewrite the previous expression as

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

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

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

This expression holds under the assumptions that $R(\underline{\theta}) > (1-r)c(1,\underline{\theta})$ and $R(\overline{\theta}) < (1-r)c(0,\overline{\theta})$.

Social planner. For the social planner, the objective function becomes:

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

Comparing total welfare under a broad and a narrow network yields:

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

which holds under the assumption that $c(1,\theta) < 2c(0,\theta)$, since:

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

Therefore, the social planner chooses a broad network.

Appendix B Additional Descriptives

Table 1: Cost-sharing rules

Income level	Copay (COP)	Coinsurance rate	Out-of-Pocket maximum	
		Per claim	Per claim	Per year
$< 2 \times MMW$	2,100	11.5%	28.7%	57.5%
$[2,5] \times MMW$	8,000	17.3%	115%	230%
$> 5 \times MMW$	20,900	23.0%	230%	460%

Note: The MMW in 2011 equals 535,600 COP or roughly 282 USD. The coinsurance rates are percentages of claims cost, whereas the maximum OOP expenditures are percentages of the MMW

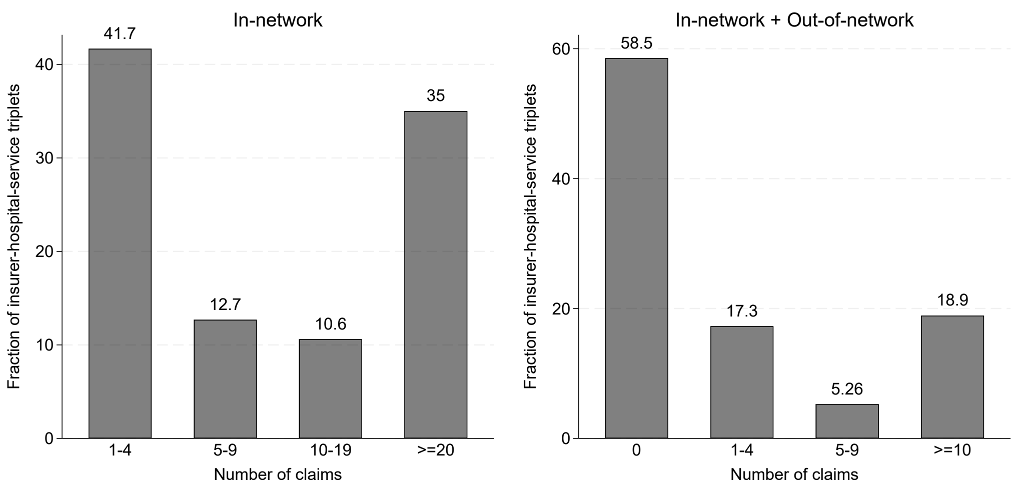

Figure 1: Distribution of number of claims for in-network hospitals and services

Note: Figure shows the distribution of number of claims across insurer-hospital-service triplets. The left-hand panel shows the distribution conditional on hospital-services considered in-network. The right-hand panel shows the distribution across all hospital-services (in-network with non-zero claims and out-of-network with zero claims).

Table 2: 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 Estimates

This appendix summarizes the model estimates from Serna (2023).

Table 3: 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 4: 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 5: 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 6: 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 7: 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)
Service		
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 8: Model of insurer network formation costs

asinh(MVP$_{jmk}$)	coef	se
Network breadth	6.86	(0.16)
Service		
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 4.3. Robust standard errors in parenthesis and first-stage F-statistic for the endogenous variable, network breadth reported.