Centralized and Decentralized Equilibria in Provider Network Breadth

Natalia Serna*

Stanford University

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Abstract

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

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

JEL codes: I11, I13, I18, L13.

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1 Introduction

The introduction of managed care competition in different countries has been accompanied by increasing differentiation between health insurers. Provider networks are one such dimension of insurer differentiation. Insurers establish networks of preferred providers to limit where their patients can go. In the U.S., for example, hospital network breadth ranged from 40% and 80% across Medicaid managed care plans in New York during 2010 (Wallace, 2023). Other systems like Germany's private health insurance market and Colombia's statutory health system have seen similar trends in insurer differentiation. Recent literature has shown that insurers' choice of network breadth responds to risk selection and cost incentives (Serna, 2024; Shepard, 2022; Ho and Lee, 2017). However, there is limited evidence on whether and how insurer competition impacts provider networks.

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

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

To settle intuition on the effects of interest, I specify a simple theoretical model of insurer competition on provider network breadth. Allowing for adverse selection and moral hazard in network breadth, the model shows that a monopolist insurer chooses a narrow network, while the social planner chooses a broad network. With the option of uninsurance, fewer consumers enroll under a monopoly than under the social planner and these consumers are relatively sicker. The model also shows that in an insurance duopoly, the equilibrium is one where insurers maximally differentiate and coverage is under-provided to relatively unhealthy consumers. To examine the impact of competition on provider network breath more systematically, I move to the empirical model.

My empirical setup builds on the model and estimates from Serna (2024). The main object of interest in this model is insurers' service network breadth, defined as the fraction of providers in a market that deliver a service and are covered by the insurer. On the demand side of the model, new consumers choose their insurer based on out-of-pocket costs and service network breadth. On the supply side, insurers are heterogeneous in their average costs and network formation costs, and compete by choosing their vector of service network breadth to maximize the net present value of their profits.[1]

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

[1] Network formation costs encompass wages to lawyers and employees in charge of contracting with providers as well as rents and public utilities fees for providers that are vertically integrated with the insurer. Network formation costs do not vary with the types of consumers that the insurer enrolls, but vary with the breadth of the network.

networks in unprofitable services and respond to scope economies and network formation cost incentives by offering broad networks.

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

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

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

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

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

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

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

2 Theoretical Framework

To establish intuition on how insurer competition affects hospital networks, I develop a simple model of competition in network breadth. Suppose a consumer is of type $\theta \sim U[\underline{\theta}, \overline{\theta}]$, with $\overline{\theta} > \underline{\theta} \geq 0$. The consumer's type denotes their sickness level, so higher θ means the individual is in worse health. Consumers can choose from a set of insurers $\{1, ..., j, ..., J\}$ that offer network breadth $H_j \in \{0, 1\}$, where 0 denotes a narrow network and 1 denotes a broad network.[2]

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

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

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

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

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

[2]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.

$R(\overline{\theta}) < (1-r)c(0,\overline{\theta})$.

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.

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

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

We can rewrite the previous expression as

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The social planner's objective function is:

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

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

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

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

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

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

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 may generate an equilibrium that is closer to the social planner's solution. To compare how different levels of competition impact network breadth, I proceed to the empirical application.

3 Data and Descriptive Evidence

3.1 Background

My empirical setting is the Colombian health care system. This system is divided into two schemes: contributory and subsidized. The former covers individuals who pay payroll taxes and their families; the latter covers low-income households. Colombia's insurance system is a managed care competition system with near-universal coverage. Private insurers provide one national health insurance plan. Premiums are zero and cost-sharing and benefits are regulated. Individuals in the contributory scheme pay coinsurance rates and copays that are indexed to their monthly income level while health care is free for those in the subsidized scheme (apart from very small copays for doctor visits).[3]

Private insurers are in charge of collecting payroll taxes and sending contributions back to the central government, which then redistributes funds to insurers using a risk adjustment formula. The government's formula compensates insurers ex-ante (before health claims are made) for their enrollees' sex, age and location, but does not compensate for diagnoses. The government has started to provide compensations ex-post for a few chronic diseases, but both risk adjusted payments are imperfect in controlling risk selection incentives.[4]

Although insurers cannot charge premiums or design cost-sharing rules, they compete

[3]In 2011, for individuals with incomes below 2 times the monthly minimum wage (MMW) the coinsurance rate is 11.5% of the health service price, the copay is 1,900 COP, and the out-of-pocket maximum is 57.5% of the MMW. For individuals making between 2 and 5 times MMWs, the coinsurance rate is 17.3%, the copay is 7,600 COP, and the out-of-pocket maximum is 230% of the MMW. Finally, for individuals who earn more than five times the MMW, the coinsurance rate is 23%, the copay is 20,100 COP, and the out-of-pocket maximum is 460% of the MMW.

[4]Using health claims and enrollment data from year $t-2$, the government calculates the ex-ante risk adjustment transfers for year t by computing the average annual health care cost per risk pool. Risk pools are defined by a combination of sex, age group (1-4, 5-14, 15-18, 19-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75+), and municipality of residence (insurers get 6% more for individuals who reside in the main capital cities of the country and 10% more for those who reside in peripheral areas like the amazon). The ex-post risk adjustment mechanism is known as the High-Cost Account. This is a zero-sum mechanism that compensates insurers with an above-average share of enrollees with chronic diseases with funds coming from insurers with a below-average share. The chronic diseases considered in this mechanism are: renal disease (since 2007), HIV-AIDS (since 2016), and certain cancers (since 2010).

for enrollees by choosing which and how many providers to cover for every health service offered in the national insurance plan. For example, insurers can choose to cover cardiac care at a particular provider but not renal care. Insurers also negotiate health service prices with in-network providers. The government has in place a few network adequacy rules that apply to services like primary care, oncology, and urgent care, but they do not span the full range of services covered in the national plan. Health service coverage in Colombia is comprehensive, from basic primary care consultations to complex organ transplants. As of 2010, the national health plan also covered a comprehensive list of prescription medications available to consumers at moderate copays.

Consumers are free to choose any of the insurers that operate in their area of residence. Although there is no designated open enrollment period, consumers are allowed to switch insurers if they have been enrolled with their incumbent insurer for at least 12 months. Insurers make available the list of covered providers for consumers to make informed decisions. However, conditional on staying within the contributory system, only around 6% of individuals switch insurers. In 2011, only 4 out of the 23 insurers in the contributory scheme operated in the subsidized scheme as well.

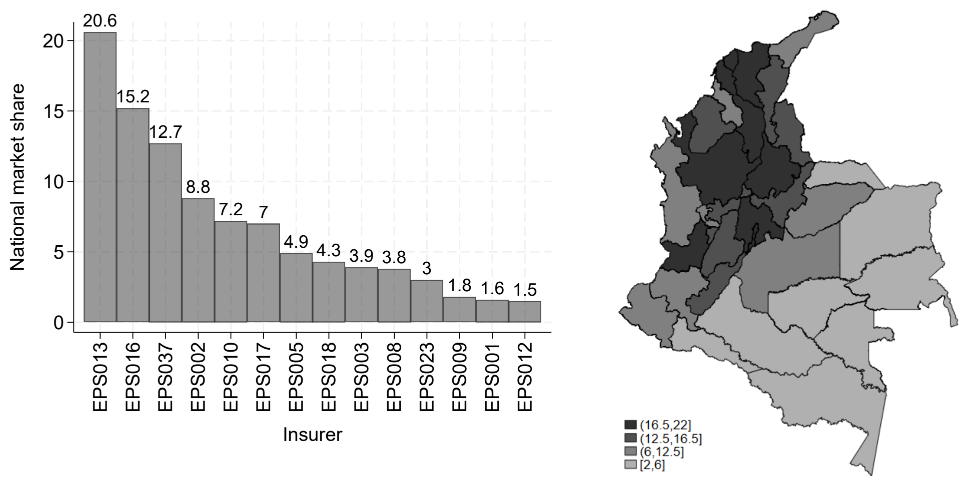
3.2 Data

I use individual-level enrollment and health claims data from everyone enrolled in the contributory scheme in Colombia between 2010 and 2011, which encompass around 24 million enrollees. The enrollment files contain information on the enrollees' sex, age, municipality of residence, insurer, and days enrolled in the year, which allows me to recover the ex-ante risk adjusted transfers that each insurer received for each of its enrollees. The health claims data report date in which the claim was filed, insurer that reimbursed the claim, provider that rendered the claim, associated health service, diagnosis code (following the International Classification of Diseases Code), and negotiated price of the health service. With these data, I can determine the consumers' health status by looking at the list of diagnoses that they received during the year and I can also compute insurers' average cost per consumer type, defining types as combinations of sex, age, and diagnosis (cancer, cardiovascular disease, diabetes, renal disease, pulmonary, other disease, no diseases).

In Figure 1, I provide a description of market structure in the contributory scheme. Panel A shows that this market is highly concentrated with the three largest insurers covering 46% of enrollees during 2011. Panel B also shows that half of the Colombian states had fewer than 7 insurers and about 8 states had an insurance duopoly.

Figure 1: Description of Markets

(a) National Market Shares (b) Number of insurers



Note: Panel A presents the national market share on the full sample of enrollees of the top 14 insurance companies in the contributory system in 2011. Panel B presents the number of active insurers in every state in 2011. Darker colors represent higher numbers.

Market concentration in the contributory scheme raises questions about the efficiency of network coverage through private insurers. The theoretical model indicated, for example, that low levels of competition or high market power in settings where insurers choose provider networks rather than premiums can lead to lower network breadth than is socially desirable. Insurers can have market power in this setting if they are able to screen the most profitable consumers and "lock them in." Table 1 shows evidence of substantial insurer inertia consistent with insurers having market power. The table shows that switching rates are fairly low across insurers. In the full sample of enrollees, between 1 and 6% of consumers

Table 1: Switch-in Rates

Insurer	All enrollees (1)	Continuously enrolled (2)
EPS001	0.032	0.030
EPS002	0.037	0.028
EPS003	0.026	0.016
EPS005	0.046	0.038
EPS008	0.045	0.031
EPS009	0.037	0.026
EPS010	0.056	0.039
EPS012	0.024	0.016
EPS013	0.024	0.014
EPS016	0.025	0.010
EPS017	0.029	0.008
EPS018	0.046	0.018
EPS023	0.028	0.008
EPS037	0.017	0.004

Note: Table shows the fraction of consumers that switch into each insurer in 2011 relative to 2010. Column (1) uses the full sample of enrollees without taking into account their enrollment spells. Column (2) conditions on enrollees with continuous enrollment spells in each year, that is, consumers who are enrolled 365 days.

switch their insurer from 2010 to 2011. Conditional on enrollees with continuous enrollment spells in each year, the switching rates are even smaller, ranging between 0.4 and 3%.

3.3 Service-Level Provider Networks

I summarize insurers' network of covered providers with a measure of service network breadth given by the fraction of providers in a state that deliver a service and are covered by the insurer. To construct this measure, I use the service-level provider directories that insurers reported to the National Health Superintendency in 2010 and 2011. I consider only hospitals, clinics, and physician practices, but exclude stand-alone physicians.[5] Examples of services include cardiac care, renal care, hospital admissions, etc. Appendix Table 1 presents the complete list of services.

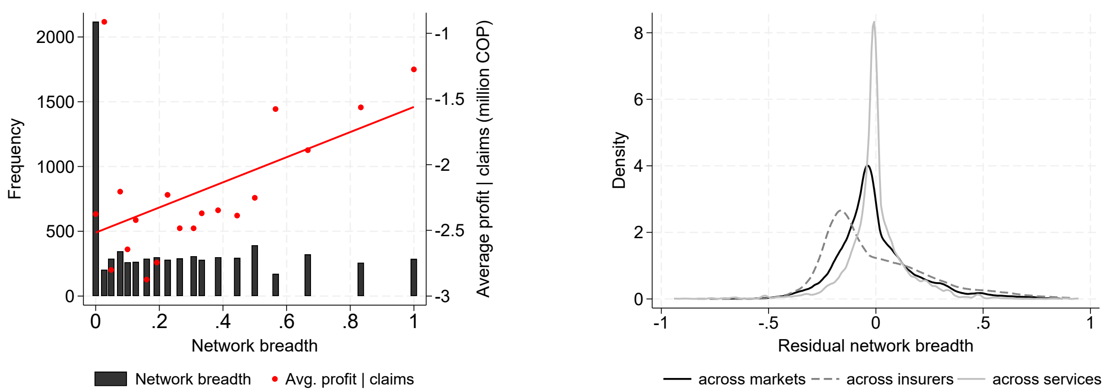
Individuals who enroll with a particular insurer have access to all the providers in its

[5] In the construction of service network breadth, providers that do not deliver a particular service are excluded from the denominator of that service.

network across states. Even when they live in rural or isolated areas with few clinics, consumers typically travel to the capital city of their state to receive care. Enrollment decisions are often made on the basis of service network breadth in the consumer's state of residence, therefore I assume that the relevant market for insurers' network coverage decisions and consumer's enrollment decisions is a Colombian state. Insurers must cover at least one provider for every health service offered in the national insurance plan, but because consumers can access the network in different markets, some insurers can choose not to cover specific services in a given market, perhaps for profit motives.

FIGURE 2: Distribution of (Residual) Network Breadth

(A) Network breadth (B) Residual network breadth



Note: Panel A shows the distribution of service network breadth in 2011 in black (left vertical axis) and the average profit conditional on consumers who make claims for each service in red (right vertical axis). Panel B shows the distribution of residuals from a regression of service network breadth in 2011 on insurer-by-service fixed effects in black, market-by-service fixed effects in dark gray, and market-by-insurer fixed effect in light gray.

Figure 2, Panel A shows that the distribution of service network breadth for 2011 has a mass at zero, indicating that some insurers do not cover certain services in a market. These services tend to be highly unprofitable as seen in the red dots in the figure, which depict the average profit conditional on consumers who make claims for the service.[6] Figure 2, Panel B also shows that most of the variation in service network breadth is across insurers and markets rather than across services. This panel depicts the distribution of

[6] Average profits are all negative because the reported measure does not take into account consumers who do not make claims and who are the most profitable.

residuals from a regression of service network breadth on insurer-by-service ("across markets"), market-by-service ("across insurers"), and market-by-insurer ("across services") fixed effects. With zero premiums and fixed health plan characteristics, this variation in service network breadth across insurers is unusual. Serna (2024) rationalizes these differences with findings of substantial preference and cost heterogeneity across insurers. However, variation across markets, may also result from differences in insurer market structure, provider market structure, and/or market size, the first of which I study in this paper.

Throughout the paper, I assume that service network breadth is the insurer's main choice variable in this health system. This variable represents a lower bound on consumers' expected utility for the network derived from a discrete choice model of providers. Service network breadth characterizes insurers' contracts properly in this setting because quality variation across providers conditional on a service is relatively low (see Appendix Figure 1).[7] This implies that biases arising from collapsing networks to a single index will be fairly small as well.

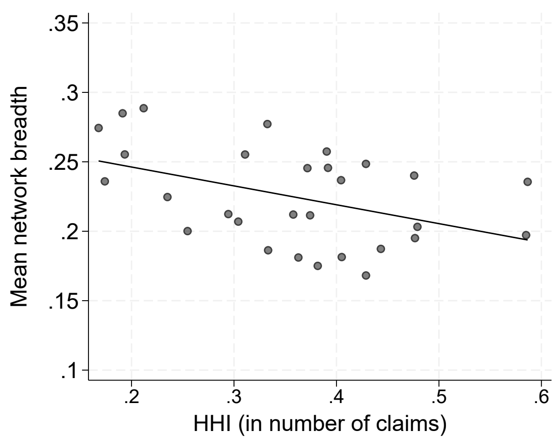
With growing concerns about proliferation of narrow networks in different managed care systems (like Colombia and the U.S.), analyzing the determinants of network breadth in markets where premiums are strictly regulated has become central for the design of health insurance policies such as network adequacy regulations. Literature so far has quantified the impact of insurer competition on premiums and health service prices holding provider networks fixed (e.g., Ho and Lee, 2017). By using service network breadth as the choice variable, I am able to tractably endogenize the size of the network and insurers' costs (which capture their negotiated prices).

[7]If providers differed substantially in quality conditional on the service, as in the U.S., using service network breadth to characterize insurers' contracts would lead to substantial bias in consumer preferences for the network. In that case, we would need to estimate a discrete choice model of providers to obtain consumers' expected utility for the network as in Tilipman (2022) and Ho and Lee (2017).

3.4 Market Structure and Network Breadth

To see how insurer competition might impact service network breadth, Figure 4 presents a scatterplot of average service network breadth (across insurers and services) and Herfindahl-Hirschman Index (HHI) per market. The HHI is calculated from insurer market shares in the total number of claims. The figure shows that markets with relatively high insurer concentration tend to have lower average service network breadth, in line with the theoretical model.

FIGURE 3: HHI and Mean Service Network Breadth



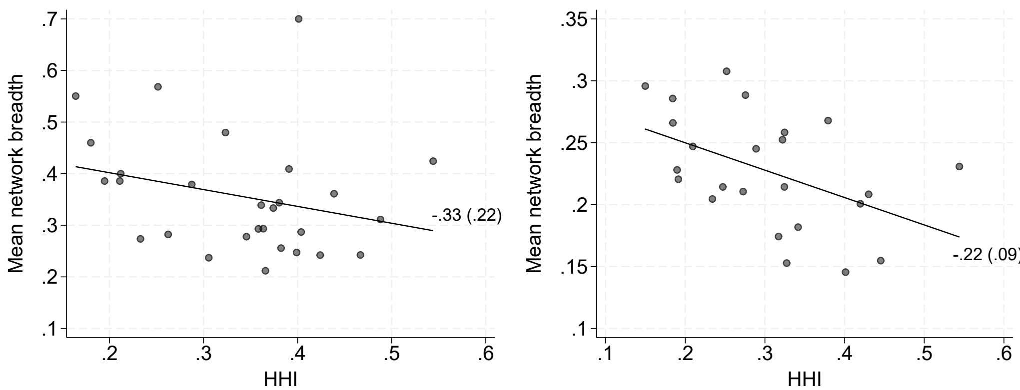
Note: Scatter plot of average service network breadth in a market (across insurers and services) and the Herfindahl-Hirschman Index based on insurer market share in the total number of claims per market. Every dot is a market. The solid line represents a linear fit. I exclude four markets with HHI above 0.6, which cover less than 0.3% of all enrollees in the country.

The market-level correlation also masks an underlying adverse selection effect. Figure 4 shows the same scatter plot separately for general medicine in Panel A and for cardiac care in Panel B. General medicine has a relatively high claim probability among both healthy and sick individuals, while cardiac care services are mostly claimed by patients with chronic conditions. Insurers' risk selection incentives therefore differ across these services.

The figure shows a negative correlation between HHI in the number of claims for each service and average service network breadth. However, the dispersion is much larger for general medicine than for cardiac care services, potentially suggesting that insurer competition can have different effects on network breadth depending on the degree of adverse selection in each service.

FIGURE 4: HHI and Mean Network Breadth for General Medicine and Cardiac Care

(A) General medicine (B) Cardiac care



Note: Scatter plot of average service network breadth in a market (across insurers) and the Herfindahl-Hirschman Index based on insurer market share in the total number of claims per market and service, for general medicine in Panel A and for cardiac care in Panel B. Every dot is a market. The solid line represents a linear fit. Each panel reports the coefficient and standard error in parenthesis of a linear regression of service network breadth on the HHI. In both panels I exclude four markets with HHI above 0.6, which cover less than 0.3% of all enrollees in the country.

4 Empirical Model

In this section, I propose an equilibrium model of insurer competition on service network breadth that allows me to measure the impact of market power on networks. I build on the empirical model and estimates from Serna (2024). That paper presents a detailed description of the model, identification strategy, and estimates that I use here. I summarize these modelling aspects in Appendix 2, but provide below the main empirical micro-foundations for the theoretical model of section 2.

Because the Colombian insurance market is characterized by substantial consumer inertia, insurers compete for new enrollees who are make their first enrollment choice. After consumers are "locked-in," insurers take into account the disease and age progression of their enrollees to choose the vector of service network breadth. Insurers thus make simultaneous choices of service network breadth to maximize the present discounted value of their profits. 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's –unobserved to insurers– sickness level (with higher θs denoting sicker individuals), 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 the network formation cost, which captures administrative costs associated with including additional providers to the network.[8] 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 the risk-adjusted transfer from the government plus revenues from copayments, $AC_{j\theta}$ is insurer j's average cost for a type-θ consumer, r_θ is consumer θ's coinsurance rate, and $s_{j\theta}$ is insurer j's demand from type-θ consumers. Assume that $\frac{\partial AC_{j\theta}}{\partial \theta} > 0$, $\frac{\partial AC_{j\theta}}{\partial H_{jk}} > 0$, $\frac{\partial C_j(\cdot)}{\partial H_{jk}} > 0$, $\frac{\partial^2 C_j(\cdot)}{\partial H_{jk}^2} > 0$, $\frac{\partial s_{j\theta}}{\partial H_{jk}} > 0$, and $\frac{\partial s_{j\theta}}{\partial H_{-jk}} < 0$.

Insurers compete in every market by choosing their service network breadths to maxi-

[8] Network formation costs comprise wages to agents and lawyers that contract with providers and rents and public utilities fees for providers that are vertically integrated with the insurer. These costs vary with the breadth of the network but not with the types of consumers that insurers enroll.

mize profits. The first-order condition (FOC) of the insurer's problem is:

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

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

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

The FOC also provides intuition on how market concentration and perhaps market power may impact service 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 service network breadth weighted across insurers by their market share $s_{j\theta}$. We can rewrite equation (1) as:

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

Equation (2) shows that market concentration reinforces the adverse selection effect when firms have homogeneous cost structures and average costs are increasing in network breadth: in the second term of the equation, HHI has a multiplicative effect on the increase in insurers' average cost following an increase in network breath. Thus, concentrated markets with adverse selection will be characterized by narrower networks than less concentrated markets. However, in a setting with heterogeneous costs and preferences, predictions of how market concentration impacts network breadth can be ambiguous. Moreover, to the extent that market concentration does not reflect market power, we need counterfactual exercises that target market power directly (such as collusion between insurers) to measure its effect on provider networks.

In the profit function, insurer demand is obtained from a random utility model. A new enrollee i of type θ has the following utility from enrolling with insurer j in market m:

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

where $q_{\theta k}$ is the weight that a type-θ consumer places on 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 (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). The coefficients in the utility function are given by $\beta_i = x_i'\beta$, $\alpha_i = x_i'\alpha$. The vector x_i includes dummies for sex, age group, diagnoses, rural, income level, and a dummy for (anecdotally) high-quality insurers (EPS010, EPS016, EPS013).

The dependence of the average out-of-pocket cost to network breadth is captured by the pass-through of insurers' average cost to consumers' out-of-pocket cost via coinsurance rates: $c_{\theta jm} = r_\theta AC_{\theta jm}(H_{jm})$. In turn, insurers' average cost function $AC_{\theta jm}$ is:

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

This cost function can capture whether broad-network insurers negotiate higher prices with in-network provider than narrow-network insurers through the second term to the right side of the equation. It also allows for the possibility that insurers to enjoy economies of scope across services (in the third term), which would be needed to rationalize why some insurers choose broader networks across services that sick individuals tend to claim. In the first term, A_k is the government's reference price for service k that insurers use as starting point in their bilateral negotiations. Furthermore, I assume that $\epsilon_{\theta jm}$ is mean-zero white noise and independent of ε_{ijm}.[9] My specification of insurers' average cost per enrollee is informed by patterns in the raw data presented in Appendix Figure 2, which depicts a positive relation between log average costs with service network breadth and a negative relation with the interaction of network breadth across pairs of services.

Given the distribution of the preference shock, insurer j's demand in market m among type-θ enrollees is

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

where $|J_m|$ is the set of insurers in market m. Finally, I parameterize the network formation cost as:

$$C_{jm}(H_{jm}, \xi_{jm}) \equiv \sum_k \Big(\omega H_{jkm} + \xi_j + \xi_m + \xi_{jkm}\Big)H_{jkm}$$

where ξ_j and ξ_m are insurer- and market-specific cost components and ξ_{jkm} is an unobserved (to the econometrician) cost component. The network formation cost allows me rationalize

[9] The assumption on $\epsilon_{\theta jm}$ means that insurers do not observe it and therefore that in counterfactuals I will consider $\epsilon_{\theta jm}$ as zero.

insurers that choose systematically broader or narrower networks across *all* services. Using data from insurers' 2011 public income statements reported to the National Health Superintendency, I provide evidence of these network formation costs as administrative costs that vary with network breadth in Appendix Figure 3.

4.1 Estimation Results

Demand and cost estimates are provided in Appendix 2.5. Appendix Table 2 shows that consumers prefer broad networks overall and dislike out-of-pocket costs. The preference for network breadth is lower among individuals without diseases, and the disutility for out-of-pocket costs is lower among individuals with chronic diseases. These parameters estimates imply substantial heterogeneity in willingness-to-pay for service network breadth across consumers. For instance, patients with renal disease are willing to pay almost 27 times more for an additional provider in the network for renal care relative to a healthy patient, consistent with adverse selection on networks.

Estimation results for the average cost function are provided in Appendix Table 3. Results show that average costs per enrollee are increasing in service network breadth at a decreasing rate. Thus, broad-network insurers negotiate higher service prices with in-network providers and enjoy substantial scope economies across services. These scope economies might come from price discounts at providers where insurers cover several services. Findings also show substantial heterogeneity in per enrollee average costs across insurers.

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

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

5 Centralized Equilibrium

The first step to understand the impact of insurer competition is to derive a benchmark for service network breadth. My benchmark is the service network breadth 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. In the participation constraints, insurers need to make at least the median total profit in the market, $\overline{\Pi}_m$. My proxy for consumer surplus is the long-run expected utility obtained from the demand model:

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

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

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

The social planner solves the following optimization problem per market:

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

To reduce the computational burden, I solve the social planner's problem only in the market of Bogotá, the capital city of Colombia. Moreover, because this problem involves searching over 240 parameters (20 services for each of 12 insurers), I redefine the optimization routine over 20 parameters, which correspond to network breadth for general medicine and hospitalizations for each insurer, holding network breadth for the rest of services fixed at their values in the observed equilibrium. I focus on general medicine and hospitalizations because they are services commonly used by both healthy and sick individuals.

By redefining the social planner's problem in this way, the solution will reflect a partial equilibrium. Results are presented in Table 2. The table shows the percentage change in several outcomes between the social planner's solution and the observed scenario: insurer long-run total average costs, total network formation cost, long-run consumer surplus for sick and healthy individuals, and average network breadth for general medicine and hospital admissions.

I find that the social planner chooses nearly complete networks for each insurer in these two services. Average network breadth for general medicine increases to 0.92 from 0.45, while average network breadth for hospital admissions increases to 0.85 from 0.38, both corresponding to a 47% increase. In the social planner's solution insurers' participation constraints are binding for those with above-median profits in the observed scenario, but slack for those with below-median profits.

Although complete coverage of general medicine and hospital admissions reduce total average costs by 13%, they also increase network formation costs by 37% per year. The reduction in total average costs is a combination of insurers exploiting their scope economies and of healthy individuals reallocating evenly across insurers. The substantial increase in network formation cost is due to the fact that insurers now need to maintain and negotiate with a broader network. Complete coverage in these two services increases consumer surplus around 14% for both sick and healthy individuals.

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

Variable	Centralized equilibrium
Total average cost	-13.04
Network formation cost per year	37.20
Consumer surplus (sick)	14.07
Consumer surplus (healthy)	14.33
Nework breadth general medicine	47.27
Network breadth hospital admissions	46.77

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

The trade-off between total costs and network breadth highlights a potential reason for why the social planner's solution is not attainable in practice for managed care competition systems. A policy that imposes complete network coverage in some services is costly and may generate incentives for insurers to drop coverage of other services altogether. Although my counterfactual results in Table 2 can not speak to these latter incentives, adverse selection suggests that this is 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 insurer competition affect network breadth relative to the social planner's benchmark ("first best"). If the first-best is not attainable in practice due to administrative costs or other hassle costs, two important questions come to mind: first, can a decentralized equilibrium where insurers compete in service network breadth implement the first-best solution? And second, if it does, what level of competition attains the first-best? To answer these questions, I use the empirical model to simulate a counterfactual scenario where insurers collude. For simplicity, I compute the new market equilibrium assuming that only three insurers maximize joint profits. This counterfactual mirrors the monopolist solution in the theoretical model of section 2.

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

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

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

In the FOC 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 greater 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 power on network coverage will depend on relative magnitudes of preference and cost heterogeneity across insurers and services.

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

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

Table 3: Networks, costs, and welfare under collusion

	Colluding insurers	
	(1)	(2)
	EPS017	EPS013
	EPS008	EPS002
Variable	EPS005	EPS037
A. Overall		
Average network breadth	-5.26	-1.10
Consumer surplus (sick)	-1.83	-0.64
Consumer surplus (healthy)	-1.83	-0.60
B. Service network breadth		
Otorhinolaryngologic care	-5.11	-1.17
Cardiac care	-5.56	-0.97
Gastroenterologic care	-5.97	-1.02
Renal care	-6.56	-1.03
Gynecologic care	-4.68	-1.05
Orthopedic care	-6.15	-0.99
Imaging	-4.24	-1.07
General medicine	-4.55	-1.23
Laboratory	-2.80	-1.16
Hospital admission	-4.71	-0.91

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

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

In each counterfactual, profits for the insurers that collude increase and average network breadth decreases relative to the observed scenario where they act as independent firms. In the case where EPS017, EPS008, and EPS005 maximize joint profits, Table 4 shows that total profits increase around 8.4% for EPS017, 3.7% for EPS008, and 11% for EPS005. Average network breadth also decreases 2, 99, and 6%, respectively, relative the observed equilibrium. The fact that profits for every firm in the collusive agreement increase relative to the observed scenario but network breadth decreases, provide evidence that collusion strengthens risk selection. The exercise of market power in insurance markets is therefore tied to the provision of narrow provider networks.

Table 4: Networks and profits for colluding firms

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

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

7 Network Adequacy Rules

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

Formally, insurer j chooses $H_k = H\ \forall k$ in each market. The FOC of the 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, Panel A shows that forcing insurers to cover all services at a provider increases average network breadth by 78% from a baseline of 0.24. This change in coverage translates into a 14% increase in consumer surplus for both sick and healthy individuals despite having to make higher out-of-pocket payments. Panel B shows that network breadth increases substantially across all services, and percentage changes in network breadth are larger for services that were underprovided in the observed scenario due to risk selection incentives. For instance, average network breadth for renal care increases 78%, while average network breadth for general medicine increases 58%. Prohibiting discrimination of networks across services thus reduces the impact of selection incentives.

Eliminating variation in network breadth across services generates an equilibrium that closely resembles the social planner's solution from Table 2. Consumer surplus for both healthy and sick individuals increase by a similar magnitude across the two scenarios as well. The fact that providing complete networks in general medicine and hospital admissions generates similar welfare effects as an equilibrium where network breadth doubles in every service, suggests that only network breadth in a few services play a major role for access to care. This finding provides an avenue for the design of healthcare policies that target provider 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.

8 Conclusion

Private health insurers in different managed care health systems typically compete on the breadth of their provider networks. These systems have seen a proliferation of narrow-network insurers, which raises the question of whether narrow networks are desirable for

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

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

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

society. To answer this question and to appropriately design policies that target provider networks, we need to understand the trade-offs associated with network breadth, as well as how these trade-offs relate to insurer competition.

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

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

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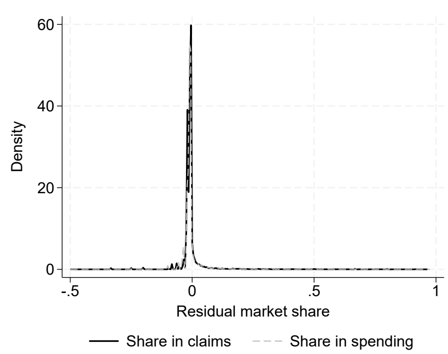
Appendix 1 Additional Descriptives

Appendix Table 1: List of services

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

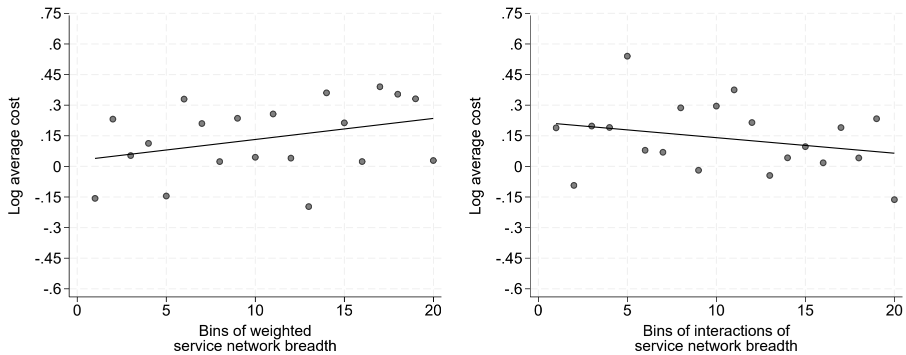
Appendix Figure 1: Residual Provider Market Share



Note: Figure presents the distribution of residuals from a regression of provider market shares in the number of claims (in black) and of provider market share in total health care spending (in gray) on market-by-service fixed effects.

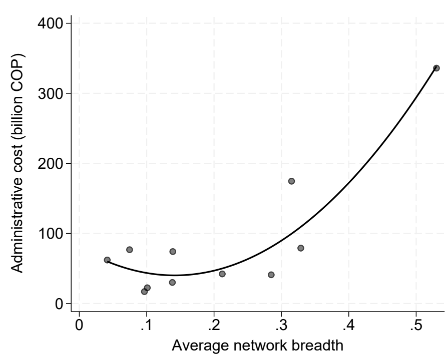
Appendix Figure 2: Empirical Relation of Log Average Cost per Enrollee

(a) Network breadth (b) Network breadth interactions



Note: Panel A presents a scatter plot of log average cost per enrollee averaged within 20 bins of weighted service network breadth, $\sum_k q_{\theta k} H_{jkm}$. Panel B presents a scatter plot of log average cost per enrollee averaged within 20 bins of weighted interactions of network breadth across pairs of services, $\sum_k \sum_l q_{\theta k} q_{\theta l} H_{jkm} H_{jlm}$. The solid line represents a linear fit.

Appendix Figure 3: Empirical Relation of Administrative Costs



Note: Figure presents a scatter plot of insurers' total administrative cost in 2011 against average network breadth across services and markets. The solid line represents a quadratic fit. Administrative costs are obtained from insurers' public income statements reported to the National Health Superintendency, accessed through https://docs.supersalud.gov.co/PortalWeb/SupervisionRiesgos/EstadisticasEPSRegimenContributivo/RC%20Estados%20financieros%20Dic%202011-CT2011.pdf.

Appendix 2 Model Summary

In this Appendix I describe the empirical model of insurer competition in service-level network breadth presented in Serna (2024). Insurers first compete in every market by simultaneously choosing their vector of service network breadths; then observing networks and expected out-of-pocket costs, consumers make enrollment decisions. I estimate the model on the sample of new enrollees with full enrollment spells (continuously enrolled), that is, individuals who I observe in the enrollment data for all of 2011 but not for 2010. New enrollees potentially do not experience inertia when making their first enrollment choice. However, after this first choice, I assume consumers become fully inertial, since the data report switching rates of less than 2% on the sample of the continuously enrolled.

2.1 Insurer Demand

The utility of a myopic 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). H_{jkm} insurer j's network breadth for service k in market m, $q_{\theta k}$ is the weight that a consumer of type θ places on 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 $\beta_i = x_i'\beta$ and $\alpha_i = x_i'\alpha$, where x_i includes sex dummies, age group dummies, diagnoses dummies, dummies for type of municipality (urban, normal, rural), and income level dummies ($<= 2 \times MMW$, $> 2 \times MMW$).

The first term to the right-hand side of equation (4) is a reduced-form representation of the consumer's valuation for the network of covered providers. Service network breadth 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 the 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 expected out-of-pocket cost in the second term on the right-hand side of equation (4) is a function of network breadth across all services, $H_{jm} = \{H_{jkm}\}_{k=1}^{K}$, and is aggregated across services with weights equal to $q_{\theta k}$. The dependence of out-of-pocket costs to service network breadth reflects a cost-coverage trade-off for consumers: broad-network insurers negotiate higher prices with providers in their network, which translates into higher out-of-pocket costs for enrollees. The positive relation between service network breadth and negotiated prices is explained by the insurer's inability to use replacement threats during negotiations with providers 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.

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. 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.

2.2 Insurer Competition

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 network breadths to maximize the net present discounted value of their profits. 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 that 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 service 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. Serna (2024) also shows that these transition probabilities are uncorrelated with service network breadth.

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 service network breadth as seen below

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

This average 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 providers.[10] 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 per enrollee to its choice of service network breadth captures whether broad-network insurers bargain higher prices with providers in their network compared to narrow-network insurers. The model would rationalize this bargaining argument with a positive estimate of τ_1. Moreover, the data 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

[10] 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.

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; they encompass for instance wages to agents in charge of contracting with providers and rents and utilities fees for providers that are vertically integrated with the insurer. The network formation cost is non-linear in service network breadth and heterogeneous across insurers and markets. The parameter ω in equation (5) captures whether network formation costs are convex in service network breadth. Moreover, $\xi_{jkm} = \xi_j + \xi_m + \vartheta_{jkm}$ is a cost shock with an insurer- and market-specific components as well as an unobserved (to the econometrician) cost shock.

2.3 Service Weights

I estimate $q_{\theta k}$ outside of the model. I use data from all enrollees in 2010 and 2011 to estimate the following logistic regression:

$$\text{logit}(\text{any claims})_{ik} = \psi_k + \psi_\theta + \psi_{ik}$$

The dependent variable is an indicator for whether patient i makes a claim for service k, and ψ_k and ψ_θ are service and consumer type fixed effects, respectively. Let $\hat{p}_{\theta k}$ be the prediction from this logistic regression, then $q_{\theta k} = \hat{p}_{\theta k} / \sum_k \hat{p}_{\theta k}$.

2.4 Identification

The main source of variation that identifies the preference for service network breadth in the demand model is the variation in claim probabilities $q_{\theta k}$ across consumer types and markets. 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 service network breadth. Insurer-by-market fixed effects also absorb the endogenous variation in service 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 provider quality. For example, if an insurer covers a high-quality provider, then we would likely see high demand for that insurer (because consumers value having access to high-quality provider) as well as high out-of-pocket costs (because the provider has a relatively high bargaining power), which would bias α_i towards zero. Variation in provider quality introduces endogenous variation in service network breadth across insurers and markets. Thus, the inclusion of insurer-by-market fixed effects help control for this source of endogenous variation. α_i is then identified from exogenous variation in income across consumers within a market, which generates variation in the coinsurance rates.

For 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 systematic variation in marginal variable profits across services within an insurer that is independent of consumer types. For example, if there are two insurers that have identical health risk, but one insurer offers low service network breadth and another offers high service network breadth across all services, then the model would rationalize these choices with high network formation costs for the former and low network formation costs for the latter. To identify ω, I rely on instrumental variables because insurers choose service network breadth with knowledge of their cost shocks ξ_{jkm}. My instrument follows Gowrisankaran et al. (2015) and is given by the predicted demand for each insurer assuming that insurers offer service network breadth equal to the market average.

2.5 Model Estimates

The following tables summarize the model estimates from Serna (2024). Appendix Table 2 shows results of the insurer demand model. I find that consumers have preferences for broad networks and dislike the out-of-pocket costs. The estimates imply that willingness-to-pay for service network breadth defined as $\frac{1}{-\alpha_i}\frac{\partial s_{ijm}}{\partial H_{jkm}}\frac{H_{jkm}}{s_{ijm}}$ is higher for individuals with chronic conditions than for individual without diagnoses, consistent with adverse selection.

Appendix Table 3 shows results of insurers' average cost per consumer type. Average costs are increasing in service network breadth in line with broad-network insurers negotiating higher prices with providers, but at a decreasing rate, in line with insurers enjoying economies of scope across services. Average costs are also heterogeneous across insurers.

Appendix Tables 4 and 5 present summary statistics of dropout and transition probabilities which enter the computation of future profits. These probabilities are estimated outside of the model as follows. For computing both probabilities, I use the enrollment data for all enrollees between 2010 and 2011. The probability that a consumer type θ drops out is the fraction of consumers type θ enrolled in 2010 but not enrolled in 2011. The transition probability is the fraction of consumers type θ in 2010 that turn into θ' in 2011.

Appendix Table 2: Insurer demand

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

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

Appendix Table 3: Insurer average costs per enrollee

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

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

Appendix Table 4: Dropout probabilities

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

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

Appendix Table 5: Transition probabilities

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

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

Using the demand, average costs, and dropout and transition probability estimates, I forward simulate the insurers' profit function and marginal variable profits for 100 periods. I estimate the remaining parameters associated with the network formation cost from insurers' first-order condition below:

$$\mathrm{MVP}_{jkm} = \omega H_{jkm} + \xi_j + \xi_m + \xi_{jkm}$$

where

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

To accommodate the fact that marginal variable profits vary substantially across insurers and some values are relatively large (in the order of billions of COP), I estimate the parameters on the log of MVP_{jkm}. Appendix Table 6 presents the results. I find that network formation costs are increasing ans convex with respect to service network breadth. Network formation costs also vary substantially across insurers.

Appendix Table 6: Model of insurer network formation costs

$\log(MVP_{jmk})$	coef	se
Service network breadth	16.05	(1.75)
<u>Insurer FE</u>		
EPS001	(ref)	(ref)
EPS002	-0.83	(0.45)
EPS003	-0.11	(0.34)
EPS005	-0.82	(0.40)
EPS008	0.41	(0.46)
EPS009	-0.06	(0.64)
EPS010	1.85	(0.32)
EPS012	-1.81	(0.76)
EPS013	-0.44	(0.49)
EPS016	0.23	(0.44)
EPS017	-1.61	(0.58)
EPS018	-3.31	(0.61)
EPS023	0.73	(0.35)
EPS037	-1.94	(0.64)
<u>Market FE</u>		
5	(ref)	(ref)
11	1.08	(0.24)
13	-0.44	(0.26)
25	-0.92	(0.25)
76	0.88	(0.27)
Constant	3.97	(0.47)
N	1,060	
F-statistic	76.4	

Note: Table presents 2SLS regression of the log of marginal variable profit on network breadth, insurer fixed effects, and market fixed effects. An observation is a combination of insurer, service, and market. The instrument for service network breadth is predicted insurer demand assuming that all insurers have service network breadth equal to the market average. Robust standard errors in parenthesis. Table reports F-statistic for the first stage regression.