Determinants of Provider Networks: Risk Selection vs. Fixed Costs

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Abstract

Health insurers typically negotiate with healthcare providers over network inclusions. Negotiations result in substantial variation in network breadth across insurers even when premiums are regulated. This paper shows that insurers' decision to offer network breadth depends on two opposing factors: risk selection and fixed cost structure. To decompose the relative importance of these factors, I estimate a structural model of insurer competition in networks applied to data from Colombia. I find that insurers risk-select by providing narrow networks in services that unprofitable patients require. Despite selection incentives, some insurers choose to offer broad networks because of heterogeneity in their cost structure. These results have implications for the design of risk adjustment and network adequacy rules.

Keywords: Health Insurance; Provider networks; Risk selection; Fixed Cost Structure.

JEL codes: I11, I13, I18, L13.

1 Introduction

In health systems with managed care competition such as those of the U.S., Israel, Netherlands, Germany, Switzerland, and Colombia, health insurers typically negotiate with healthcare providers over network inclusions. These negotiations result in substantial variation in network breadth across insurers. For example, Dafny et al. (2017) report that physician network breadth ranges from 23% to 34% and hospital network breadth from 75% to 86% across insurance plans in the U.S. Marketplaces.[1] Why does network breadth vary across insurers despite the strong regulation of other plan characteristics (such as premiums, deductibles, and cost-sharing)? And does this variation matter for policy-making?

In answering these questions recent literature (e.g., Shepard, 2022) has focused on the role of risk selection as the main driver of insurers' incentives to offer narrow networks.[2] In this paper, I discuss and document a novel dimension that co-determines the formation of provider networks in a health insurance market: insurers' heterogeneous cost structures. If insurers enjoy economies of scale or scope in the number of covered providers, they may have incentives to offer broad networks, counterbalancing the effect of risk selection.

My setting to study the determinants of provider network breadth is the Colombian healthcare system. In this system, private insurers provide one contract that is closely regulated along most dimensions (such as premiums, cost-sharing, and benefits). However, provider networks and provider prices are unregulated. Insurers in Colombia can choose their provider networks separately for every health service covered in the contract. This makes for a convenient empirical setting to isolate and highlight the main determinants of networks and prices.

In terms of service-level risk selection, I start by documenting that the coarseness of the government's risk adjustment formula leaves significant variation in expected patient profitability depending on the types of services the patient is likely to need. Then, I give evidence that provider networks tend to be narrower for less profitable services. Finally, I

[1]The authors measure physician network breadth as the fraction of physicians in a rating area who are included in a plan's network, and hospital network breadth as the fraction of hospital discharges that are represented by a plan's network.

[2]Under risk selection, insurers may attempt to disproportionately enroll healthy (profitable) patients rather than sick (unprofitable) patients by providing networks that appeal the most to the former, which are narrow networks.

show that patients tend to select insurers that have broad networks in services they are likely to need. For example, patients with cardiovascular disease are more likely to choose insurers with broad networks for cardiac care services.

In terms of costs, I document that insurers' administrative costs are increasing in the breadth of their provider network. But, after accounting for differences in network breadth, administrative costs are uncorrelated with insurers' average profit per enrollee. These correlations suggest that fixed costs are increasing in the number of covered providers but do not depend on enrollee characteristics that determine healthcare costs beyond network breadth.

Motivated by these descriptive facts, I develop and estimate a model of insurer competition in service-level provider network breadth. This model builds on prior empirical work that uses Horn and Wolinsky (1988)'s Nash-in-Nash bargaining solution to endogenize negotiated prices between buyers and suppliers holding networks fixed (e.g., Grennan, 2013; Gowrisankaran et al., 2015; Ho and Lee, 2017). In my model, however, networks are also determined endogenously. Jointly modelling network and price setting can be excessively complex, if not infeasible.[3] In my analysis, I circumvent this obstacle by redefining the problem as one in which insurers choose, rather than a network, the fraction of providers in a market that deliver a specific service. This ensures tractability while allowing for endogenous networks and insurer costs.[4]

I assume that insurers make a one-time choice of service network breadth, recognizing that this choice will affect both current and future profits as patients age and transition between diagnoses. Expected profits combine a random utility model of demand in which individuals select insurers based on service-level provider network breadth and out-of-pocket costs, and cost functions that allow for heterogeneity in expected costs not only across individuals (risk selection), but also across insurers with varying provider network breadths (fixed costs).

To estimate the model, I use a novel administrative dataset that encompasses all enrollees

[3] Lee and Fong (2013) is one exception. Their empirical approach, nonetheless, is only showcased with simulations, and the dimensions of the problem become quickly intractable in full scale empirical applications as the one I consider here.

[4] A shortcoming of this approach is that I cannot model provider heterogeneity beyond what is captured by the composition of services that they offer. In the literature, Dafny et al. (2015), Ericson and Starc (2015), Polsky et al. (2016), Dafny et al. (2017), and Starc and Swanson (2021) use similar approximations to describe the correlation between network breadth and premiums.

to the contributory healthcare system in Colombia during 2010 and 2011, which represents nearly half of the population in the country (25 million individuals) and their medical claims (650 million). My data also contain the set of providers that insurers cover for every service. Demand estimates show that, conditional on sex and age, willingness-to-pay for service network breadth varies substantially across diagnoses and services, consistent with adverse selection. Insurers' average cost function exhibits economies of scope, and both average and fixed costs are heterogeneous across insurers.

To quantify the relative importance of risk selection and insurers' cost structure for equilibrium service network breadth, I conduct two sets of counterfactual exercises. To get at risk selection, I examine whether service coverage decisions respond to changes in the government's risk adjustment formula. Without any risk adjustment, I find that average service network breadth would fall 5.3% (dropping around 4 providers). In contrast, if risk adjustment were made more granular by compensating for diagnoses, average service network breadth would increase 7.6% with effects being larger among services that sick individuals tend to claim. To get at the importance of insurers' cost structure, I examine whether the heterogeneity in costs can explain why some insurers choose to offer broad service networks despite risk selection. My main finding is that with homogeneous fixed costs, average service network breadth decreases 9.8% and the decline is larger in services that sick individuals tend to claim.

Taken together, the magnitude of these results indicate that risk selection and fixed costs weigh equally in the decision to offer network breadth. Risk selection drives the choice of narrow networks while heterogeneous fixed costs drive the choice of broad networks. In this setting, risk adjustment is an effective policy to achieve broad network coverage beyond what markets alone can produce in equilibrium with sufficient insurer heterogeneity in costs. My findings also suggest that the efficacy of network adequacy rules forcing insurers to cover specific providers will depend on the relative magnitudes of risk selection and insurers' fixed costs.[5]

Contributions and literature. This paper makes three contributions to the litera-

[5]These types of network adequacy rules are widely used in Medicare Advantage, the federal Marketplaces, and Medicaid Managed Care. See https://www.kff.org/health-reform/issue-brief/network-adequacy-standards-and-enforcement/.

ture: first, it shows that insurers' cost structure may have an opposite effect relative to risk selection on the decision to offer service-level provider network breadth. To do this, I build on insights from Shepard (2022) who first explicitly modelled selection through star hospital coverage, and from Decarolis and Guglielmo (2017); Geruso et al. (2019); Aizawa and Kim (2018); Shapiro (2020) who study alternative selection mechanisms such as insurance generosity, drug formulary design, and advertising. Second, it develops a new model of insurer competition that endogenizes network breadth across several insurers and services in a tractable way, while maintaining a relation with the underlying bargaining game. Prior work has focused on endogenizing prices holding networks fixed (Gowrisankaran et al., 2015; Ho and Lee, 2017). More recently, Ho and Lee (2019) endogenize prices and networks in the context of a monopolist insurer, while Fleitas et al. (2024) extend their theoretical framework to an empirical application with several insurers and providers. Ghili (2022) and Liebman (2022) provide alternative approximations to endogenous networks. The third contribution is in quantifying the relative importance of risk selection and costs for equilibrium network breadth and showing how this trade-off impacts policy design. Existing literature has studied the relation between network breadth and premiums (Dafny et al., 2017; Polsky et al., 2016; Dafny et al., 2015), while others have focused on the impact of risk adjustment on selection efforts (Brown et al., 2014; McWilliams et al., 2012; Nicholson et al., 2004) and on other elements of the insurance contract (Cabral et al., 2018; McGuire et al., 2013; Pauly and Herring, 2007).

The remainder of this paper is structured as follows: section 2 describes the institutional background and data, section 3 provides descriptive evidence of risk selection and cost variation, section 4 presents the structural model, section 5 shows estimation results, section 6 studies the impact of risk adjustment and insurers' cost structure, and section 7 concludes.

2 Institutional Background and Data

Background. The Colombian healthcare system was established in 1993 and it is divided into a "contributory" and a "subsidized" regime. The first covers formal employees and independent workers who pay monthly payroll taxes (nearly 51% of the population). The second covers individuals who are poor enough to qualify and are unable to contribute (the remaining 49%). The national healthcare system has near-universal coverage, which implies that insurer competition for enrollees is zero-sum.

In this system, private insurers provide one national insurance plan. The plan covers a comprehensive list of more than 7,000 services or procedures and 673 medications as of 2010. Several aspects of this plan are strictly regulated by the government, for example, insurance premiums are zero and cost-sharing rules are a function of the enrollee's monthly income level, but they are standardized across insurers and providers.[6]

Instead, the government reimburses insurers at the beginning of every year (ex-ante) with capitated risk-adjusted transfers, and at the end of every year (ex-post) with the High-Cost Account. The ex-ante risk adjustment formula controls for sex, age group, and municipality of residence, but it does not include diagnoses. Appendix 1 describes how this risk-adjusted transfer is calculated. Because of the coarsely defined risk pools, the ex-ante formula poorly fits realized healthcare costs. For example, Riascos et al. (2014, 2017) find that the R^2 of the government's formula is only 0.017. The High-Cost Account compensates insurers that enroll an above-average share of people with certain diagnoses, and reimbursements come from insurers that enroll a below-average share.[7] These ex-post transfers typically represent only 0.4% of total ex-ante transfers per insurer, suggesting these ex-post transfers do not provide much risk adjustment.

Provider networks and negotiated prices are the only dimensions in which insurers can differentiate. Insurers form provider networks separately for each health service offered in the national plan and negotiate prices with in-network providers. Service level negotiations

[6] Cost-sharing in the national insurance plan follows a three-tiered system. As of 2010, for individuals earning less than 2 times the monthly minimum wage (MMW) the coinsurance rate equals 11.5%, the copay equals 2,100 pesos, and the maximum out-of-pocket amount in a year equals 57.5% times the MMW. This corresponds to an actuarial value of 92%. For those with incomes between 2 and 5 times the MMW, the coinsurance rate is 17.3%, the copay is 8,000 pesos, and the maximum out-of-pocket amount is 230% times the MMW. The associated actuarial value is 84%. Finally, for people with incomes above 5 times the MMW, the coinsurance rate equals 23%, the copay 20,900 pesos, and the maximum out-of-pocket amount is 460% times the MMW, corresponding to an actuarial value of 78%. The average exchange rate during 2011 was $1,847 COP/USD.

[7] Diseases compensated by the High-Cost Account include: 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. See Resolution 0248 of 2014 from the Ministry of Health.

imply, for example, that insurers can choose to offer a broad network for orthopedic care but a narrow network for cardiology.[8]

Enrollees can access their insurer's network in any state of the country (states are similar in size to Metropolitan Statistical Areas in the U.S.). Those who reside in peripheral municipalities (similar to counties in the U.S.) tend to travel to the main capital city of their state to receive care. While consumers can visit out-of-network providers, the insurer does not cover any of the healthcare costs associated with these visits.[9] Hence, individuals' enrollment and healthcare consumption decisions depend on the provider network that their insurer offers in their state of residence. During 2011, there were 23 private insurers participating in the contributory healthcare system across the 33 states of the country. 10 of these insurers covered 95% of enrollees. Participation in the subsidized system is not required for insurers participating in the contributory system.

Data. At the end of every year, insurers report to the government all the health claims made through the national insurance plan that they reimbursed providers in their network for. The data for this paper are: enrollment files of all enrollees to the contributory system during 2010 and 2011 ($\sim$25 million), insurers' claims reports to the government ($\sim$650 million), and insurers' provider network data per healthcare specialty between 2010 and 2011.

The enrollment files have basic demographic characteristics like sex, age, municipality of residence, and enrollment spell length in the year. Although I do not observe individual income per month, using publicly available, aggregate income data from enrollees to the contributory system I assign to each individual the average income of his or her municipality, sex, and age cell. The health claims data report date of provision, procedure code, procedure price, provider, insurer, and ICD-10 diagnosis code.

Every claim is associated to a 6-digit procedure code from the national health insurance plan. These codes can be mapped to the healthcare specialties that insurers and providers

[8] Although the government does stipulate a set of network adequacy rules to guarantee appropriate access to health services, these rules are very coarse and apply only to the provision of primary care, urgent care, and oncology. These rules are described in https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/VS/PSA/Redes-Integrales-prestadores-servicios-salud.pdf

[9] In fact, anecdotal evidence suggests that providers deter consumers for which they are not in-network by denying care at their door.

bargain over, contained in the provider network data. These data report 150 unique specialties, which I aggregate up to 20 "services," corroborating and complementing with network inclusions inferred from claims. Some examples of specialties in the data are cardiology, pediatric cardiology, and cardiovascular surgery, which I aggregate to cardiac care services. Other specialties are intensive care unit, intermediate care unit, neonatal intensive care unit, and hospitalization, which I aggregate to hospital admission services. Appendix 2 provides the final list of services and an excerpt from the provider network data.[10]

Sample restrictions. I focus on the sample of individuals aged 19 or older enrolled with one of the 10 largest insurers. Of these individuals, 2/3 have continuous enrollment spells or no gaps in enrollment. Of the continuously enrolled, 2/3 are *current enrollees*, that is, individuals who are enrolled throughout 2010 and 2011. The remaining 1/3 are *new enrollees* or individuals who enroll for the first time in 2011. Because there is near universal coverage, new enrollees to the contributory system can be individuals who move from the subsidized system after they find a job, turn 18 and choose a different insurer from their parents', or for some reason were uninsured for 12 continuous months.[11] Appendix Table 5 shows that new enrollees are relatively healthier and have lower healthcare costs than the continuously enrolled, but have prevalence of the same diagnoses.

Switching rates. Insurers compete mainly on attracting these new enrollees because consumer inertia in this system is substantial. Conditional on staying in the contributory system, less than 6% of all enrollees switch their insurer from 2010 to 2011. Moreover, of those who have continuous enrollment spells, less than 2% switch their insurer. When making their network coverage decisions, insurers thus take into account the fact that individuals

[10] Service level negotiations could generate clinical chaos if, for example, a patient with diabetes is admitted to a hospital for a cardiac episode but the insurer does not cover diabetes care at that hospital. This kind of care fragmentation has received substantial media attention for an issue that came to be called "the rounds of death," where patients would have to go from clinic to clinic to be treated and died in the process. To avoid these issues and based on conversations with experts, insurers tend to cover all the services at large clinics and hospitals where inpatient admissions occur. But service coverage varies at smaller providers where outpatient care is delivered. Appendix Figure 2 corroborates this fact.

[11] Even if new enrollees in 2011 had enrollment before the start of my sample period in 2010, decree 806 of 1998 and decree 1703 of 2002 established that after three continuous months of non-payment of tax contributions, a person would be disenrolled and lose any information so far reported to the system. Enrollment after non-payment is therefore a "fresh-start" in the contributory system. Moreover, in 2011 only around 500 thousand enrollees switched from an insurer in the subsidized system that also had presence in the contributory system.

who enroll today, will stay with the same insurer tomorrow.

3 Descriptive Evidence

Using the demographic information contained in the enrollment files, I can recover the ex-ante risk-adjusted transfers that each insurer received for each of its enrollees. Ex-ante reimbursements range from 162.2 thousand pesos ($87) (for males aged 15-18) to 2.2 million pesos ($1,191) (for females aged 75 or older), while realized costs range from 0 to over 300 million pesos ($162K). The enormous variation in healthcare costs across patients suggests that there may be risk selection incentives and possibly heterogeneous costs across insurers.

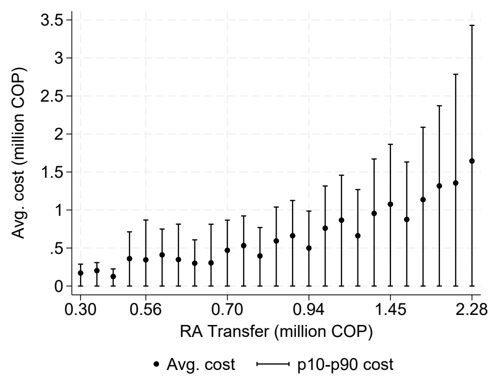


Figure 1: Healthcare cost by risk-adjusted transfer

Note: Figure presents mean and 10th and 90th percentiles of annual healthcare cost across all individuals enrolled in the contributory system, conditional on the government's ex-ante risk-adjusted transfer. Healthcare costs and risk-adjusted transfers are measured in millions of COP. The average exchange rate in 2011 was 1,847 COP/USD.

Figure 1 shows that this variation in healthcare costs holds even after controlling for the risk-adjusted transfers. The figure shows that the mean and the variance (as reflected in the difference between 10th and 90th percentiles) of healthcare costs increase with the government's reimbursement. The rising trend in average costs indicates that insurers can have incentives to enroll costly individuals because they can receive higher government reimbursements. The rising trend in variance indicates that there is scope to select consumers in the upper tail of the distribution who are more likely to be overcompensated by the risk adjustment formula (as in Brown et al., 2014).

3.1 Measuring Network Breadth

If insurers respond to selection incentives using their provider networks, then differences in healthcare costs should appear as differences in service network breadth. I define service network breadth as the fraction of providers in a market offering a particular service that are covered by the insurer. A provider is either a hospital, a clinic, or a physician practice. I exclude stand-alone physicians.[12] Table 1 shows that there is substantial variation in this measure of coverage across insurers. Even with poor risk adjustment some insurers like EPS013 and EPS037 choose to offer broad service networks, while others like EPS001 and EPS002 choose narrow networks.[13]

Table 1: Distribution of service network breadth per insurer in 2011

Insurer	mean	p25	p75
EPS001	0.14	0.03	0.21
EPS002	0.29	0.00	0.45
EPS003	0.15	0.00	0.25
EPS005	0.33	0.18	0.43
EPS008	0.04	0.00	0.04
EPS009	0.10	0.00	0.12
EPS010	0.07	0.00	0.13
EPS012	0.10	0.01	0.11
EPS013	0.51	0.33	0.70
EPS016	0.32	0.15	0.49
EPS017	0.14	0.00	0.20
EPS018	0.21	0.04	0.31
EPS023	0.04	0.00	0.04
EPS037	0.52	0.34	0.73

Note: Table presents mean and 25th and 75th percentiles of service network breadth per insurer during 2011. An observation to construct this table is a combination of insurer, service, and market.

[12] Although it is mandatory that insurers cover at least one provider for every service in the national insurance plan, coverage choices can be determined by the type of consumers that insurers want to risk select upon.

[13] Although by U.S. standards some of these insurers would have ultra-narrow networks, these standards are based on the coverage of large hospitals (see https://www.mckinsey.com/industries/healthcare/our-insights/hospital-networks-updated-national-view-of-configurations-on-the-exchanges/). My measure of service network breadth is instead defined over all types of provider organizations. As long as a provider is certified by the Ministry of Health, this provider will be included in my measure. Dafny et al. (2017) report that provider networks in the U.S. based on a similar definition also tend to be much narrower than hospital networks.

3.2 Network Breadth as a Means of Risk Selection

Variation in service network breadth is consistent with differences in selection efforts and costs *across insurers*. In this subsection I characterize selection incentives *across services* by replicating figures in Geruso et al. (2019) with data from *all* enrollees in the contributory health system.

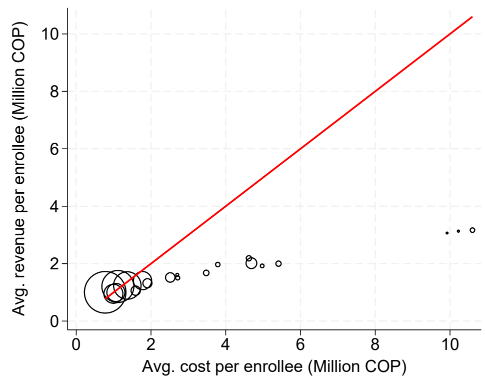


Figure 2: Service-level selection incentives after risk adjustment

Note: Figure presents a scatter plot of average annual revenue and average annual cost per enrollee across all individuals in the contributory system. Each dot is a service weighted by the number of individuals who make claims for the service. Revenues are calculated as the government ex-ante plus ex-post risk-adjusted transfers, plus revenues from copayments and coinsurance rates. The red line is a 45 degree line. One enrollee can be represented in several dots if they make claims for different services. Enrollees who make zero claims are not represented in this figure.

Figure 2 shows whether the current risk adjustment systems are effective at neutralizing service-level risk selection. The figure plots the average cost per enrollee against the average revenue per enrollee conditional on patients who make claims for each service. Every circle represents a service weighted by the number of patients who make claims for it. Patients who make claims for several services will be represented in several circles, while patients who make zero claims (and are the most profitable) are not represented in this figure. The red line is the 45 degree line, which splits the space into services that are overcompensated by the risk-adjusted transfers (above the line) and those that are undercompensated (below the line). The main takeaway is that patients who make any claim are likely to be unprofitable; but this is especially true for patients who have claims in certain services such as cardiac care, renal care, and hospital admissions, which are located toward the right of this figure.

The existence of services that are outliers in terms of profits per enrollee suggests a scope for insurers to engage in service-level risk selection through their choice of provider networks.

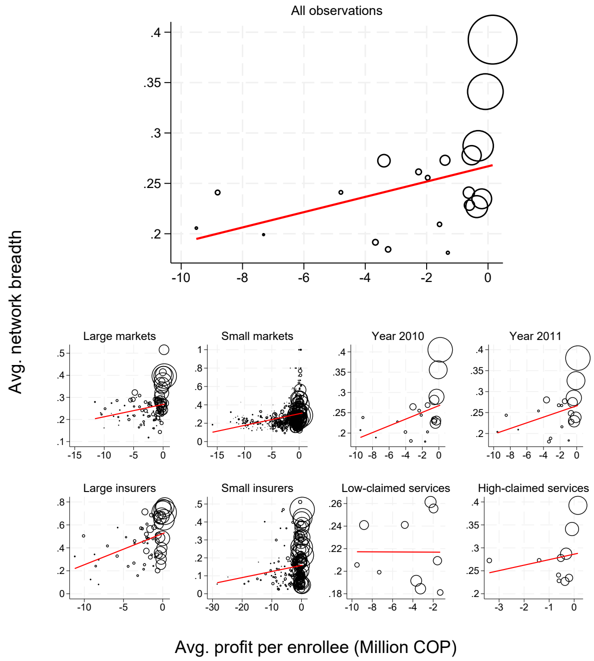


Figure 3: Correlation between network breadth and service profitability

Note: The top panel of the figure presents a scatter plot of average service network breadth and average profit per enrollee across all individuals in the contributory system. Each dot is a service weighted by the number of individuals who make claims for the service. Profits per enrollee are calculated as government's ex-ante plus ex-post risk-adjusted transfers, plus revenues from copayments and coinsurance rates, minus total healthcare costs. The red line corresponds to a linear fit. One enrollee can be represented in several dots if they make claims for different services. Enrollees who make zero claims are not represented in this figure. The bottom panel of the figure present a scatter plot of average service network breadth and average profit per enrollee conditional on the set of 5 largest markets (states 25, 11, 76, 05, and 13) and the rest of markets, conditional on 2010 and 2011, conditional on the three largest insurers (EPS016, EPS013, EPS037) and the rest of insurers, and conditional on services with below- and above-median number of enrollees who make claims for the service (the median equals 550,000 enrollees).

One way to test whether the data are consistent with selection at the service level is to show whether service network breadth covaries with the profitability of a service, a version of the positive correlation test in Chiappori and Salanie (2000).

Figure 3 plots the average profit per enrollee against average service network breadth across insurers and markets. Average profits are calculated conditional on patients who make claims for each service. The red line corresponds to a linear fit and shows that relatively profitable services, such as general medicine and laboratory, tend to have broader networks than relatively unprofitable services, such as cardiac care and renal care. This correlation holds along several dimensions considered in the bottom panels of the figure and is not necessarily driven by services with few claims. Appendix Figures 4 and 5 unpack some of the variation in network breadth per service to give an example of those that are likely to be under-covered across markets.

Another explanation for why complex services tend to be under-covered is that total demand for those services is relatively low. This explanation would rule out risk selection as a driver of insurers' network breadth choices. To separate the importance of risk selection, I estimate the correlation between insurer market shares in the number of new enrollees with chronic diseases and network breadth for the services those patients are most likely to need. Table 2 shows that market shares in initial choices are positively correlated with service network breadth, suggestive of adverse selection. For example, insurers with relatively broad networks for renal care tend to have a higher share of new enrollees with renal disease.

Table 2: Market share in initial choices and network breadth

	(1) Healthy	(2) Cancer	(3) Diabetes	(4) Cardio	(5) Renal
Network breadth	0.411 (0.022)	0.332 (0.042)	0.409 (0.022)	0.297 (0.046)	0.327 (0.064)
Observations	312	312	312	312	312

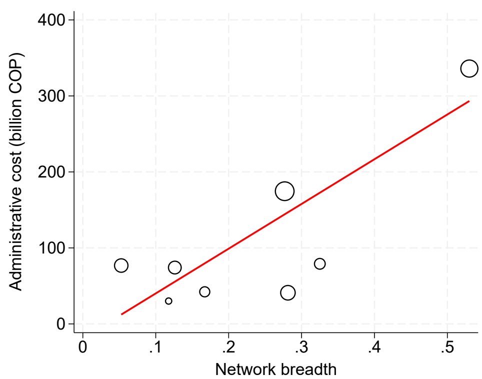
Note: Table presents OLS regressions of insurer market share on service network breadth. Column (1) uses the sub-sample of individuals without diagnoses and network breadth for general medicine. Column (2) uses the sub-sample of individuals with cancer and network breadth for chemotherapy. Column (3) uses the sub-sample of individuals with diabetes and network breadth for laboratory. Column (4) uses the sub-sample of individuals with cardiovascular disease and network breadth for cardiac care services. Column (4) uses the sub-sample of individuals with renal disease and network breadth for renal care services. All specifications include market fixed effects. An observation in this table is an insurer-market for 2011. Standard errors in parenthesis are clustered at the market level.

Switching decisions. Prior papers on selection in health insurance markets leverage enrollees' switching decisions to test for adverse selection (e.g., Shepard, 2022; Gruber and McKnight, 2016; Newhouse et al., 2015; Brown et al., 2014; Einav et al., 2013). Although this type of analysis would be under-powered in my setting (since, conditional on staying in the contributory system, only 6% of all enrollees switch their insurer between 2010 and 2011), I find evidence consistent with selection on switching decisions in Appendix Table 6. For instance, findings show that healthy enrollees are more likely to switch out of insurers with broad networks for primary care, while patients with cardiovascular disease are more likely to switch out of insurers with narrow networks for cardiac care.

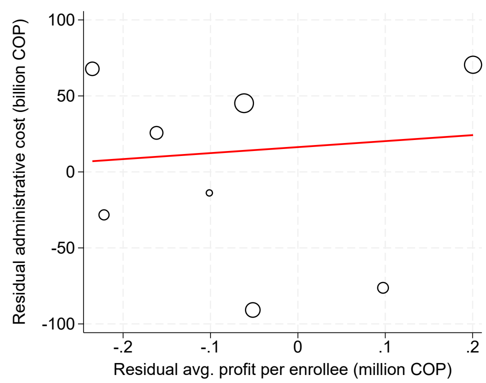
3.3 Fixed Costs in Network Breadth

In addition to the evidence on risk selection in network breadth, in this subsection I show that network breadth is also related to heterogeneous fixed costs across insurers. Fixed costs are administrative costs associated with the provision of the national health insurance plan through a network of providers, that do not vary with the number of enrollees or with enrollee characteristics but may vary with provider network breadth.

I provide evidence on these two fronts using aggregate, publicly available data from insurers' public income statements in 2011, which report their total administrative costs associated with the provision of the national health insurance plan.[14] These costs range from 30 to 336 billion pesos across insurers.



(a) Network breadth



(b) Average profits per enrollee

Figure 4: Correlates of insurers' administrative costs

Note: Panel A presents a scatter plot of total administrative costs against average network breadth across services and markets in 2011. Panel B presents a scatter plot of residual total administrative costs against residual average profits per enrollee, residualized by network breadth in 2011. In each panel, a dot is an insurer weighted by its number of enrollees, and the red line corresponds to a linear fit. Total administrative costs are obtained from insurers' public income statements submitted to the National Health Superintendency in 2011.

Panel A of Figure 4 shows that insurers' total administrative costs are positively correlated with their average network breadth across services and markets. Panel B shows that administrative costs are uncorrelated with average profits per enrollee after residualizing both measures by network breadth. This suggests that the fixed cost of providing health insurance is increasing in the fraction of covered providers, but does not vary with enrollee

[14]Insurers' public income statements are publicly available at the National Health Superintendency's website https://www.supersalud.gov.co/es-co/Paginas/Delegada%20Supervision%20de%20Riesgos/informacion-financiera-EPS-EMP-SAP-regimenes-de-excepcion-y-especiales.aspx.

characteristics that determine their healthcare costs beyond network breadth.

4 Model

Motivated by the descriptive evidence, in this section I develop a model of the Colombian insurance market to decompose risk selection and insurers' cost structure as potential mechanisms for service network breadth. I limit my analysis sample moving forward to individuals who have continuous enrollment spells and reside in the main capital cities of the country. This distinguishes consumers whose choices are not conflated by variation in income, job loss, or informality and distinguishes markets with enough variation in service network breadth. Appendix 4 shows some summary statistics and replicates all the descriptive evidence presented earlier for this sample.

4.1 Foundations and Relation to Prior Work

My model is specified over insurers' decision to offer service network breadth. Although substantial research in the U.S. suggests that patients care strongly about whether their preferred provider is included in the network (e.g., Ho, 2006; Shepard, 2022), my model loses the identities of specific providers up to the composition of services that they offer in an effort to circumvent tractability issues that arise when jointly modelling network and price setting.

Following McFadden (1996), most of the literature to date uses random utility models that allow for preference heterogeneity across providers to derive patients' expected utility for their insurer's network. This expected utility is fed into models of insurer and provider Nash bargaining with the goal of endogenizing negotiated prices (Gowrisankaran et al., 2015; Ho and Lee, 2017). The structural unobservable of the Nash-in-Nash surplus function is typically the provider's marginal cost, but off-equilibrium prices in the event that the insurer and the provider disagree are assumed to be fixed at their equilibrium values (Horn and Wolinsky, 1988).

When trying to endogenize insurers' decision of which providers to include in its network in addition to negotiated prices, the assumption that disagreement payoff prices are fixed is too strong. Nash-in-Nash proves to be infeasible in this case because both the provider's marginal cost and the off-equilibrium price are unobserved, resulting in a system with more unknowns than equations.[15] Ho and Lee (2019) and Lee and Fong (2013) provide some solutions to this problem. However, the first group of authors apply their model to a setting with a monopolist insurer and the second group of authors showcase their model through simulations. Here I derive an alternative solution by redefining the problem of *which* providers to include in the network and at what *price* as a problem of *how* many providers to include and at what *cost*.

Appendix 5 shows that this model can be micro-founded with models of provider choice and Nash-in-Nash bargaining. My model is an exact representation of markets where providers are homogeneous *conditional on the service*. When providers are heterogeneous, it provides a lower bound on consumer surplus. I discuss the implications of this in my counterfactual exercises in section 6. The model allows me to quantify by how much would service network breadth and insurer average costs change under counterfactual policies, which are both objects of interest for policymakers.[16] I move now to describing my econometric implementation.

4.2 Insurer Demand

I model insurer demand in the sample of new enrollees in 2011, who do not experience inertia when making their first enrollment choice. Assume that a new enrollee i living in market m is of type θ. With probability $q_{\theta k}$, such that $\sum_k q_{\theta k} = 1$, the consumer will need each of the $k = \{1, ..., K\}$ services. An individual's type is given by a 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), and diagnosis $d \in D = \{$cancer, diabetes, cardiovascular disease, pulmonary disease, renal disease, other chronic disease, no diseases$\}$. Diagnoses in the list are groupings of ICD-10

[15] Crawford and Yurukoglu (2012) discuss some of the limitations of allowing for endogenous networks in Nash-in-Nash in the context of television markets.

[16] Estimating a richer model of provider choice and Nash-in-Nash bargaining is also infeasible in my setting as the size of consumer choice sets for relatively common services such as general medicine equals 179 in the largest market. This choice set would imply solving $179 \times |J_m|$ bilateral negotiations in this market and for general medicine alone.

codes following Riascos et al. (2014).[17]

I assume that the individual knows his or her diagnoses before making the first enrollment choice. This could be either because of medical family history or because, prior to enrolling in the contributory system, they went to the doctor and received a diagnosis. Private information on their diagnosis, which I observe in the data, implies that selection in my model will occur on observable, un-reimbursed (or poorly reimbursed) characteristics such as those associated with health status.[18]

Denote by u_{ijm} the indirect utility of a new enrollee i in market m for insurer j, which takes the following form:

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

where $\beta_{ij} = (x_i \;\; x_j)'\beta$ and $\alpha_i = x_i'\alpha$. The vector x_i includes consumer characteristics such as dummies for sex, age category, diagnosis, living in a rural market, and having low income. x_j is an indicator for relatively large, high-quality insurers based on quality rankings constructed by the Ministry of Health for 2013. The average out-of-pocket cost of consumer type θ at insurer j is given by $c_{\theta jm}$ and depends on the insurer's vector of service network breadth $H_{jm} = \{H_{jkm}\}_{k=1}^{K_m}$. The coefficient ϕ_{jm} is an insurer-by-market fixed effect that captures unobserved insurer quality that varies across markets. Finally, ε_{ijm} is an *iid* unobserved shock to preferences assumed to be distributed type-I extreme value.

Average out-of-pocket costs are the sum of coinsurance payments, copays, and tax contributions to the system:

$$c_{\theta jm} \equiv \text{Coins}_{\theta jm} + \text{Copay}_{\theta jm} + \text{Tax}_{\theta} = r_\theta AC_{\theta jm}(H_{jm})$$

Coinsurance payments and copays are indexed by j because they are a function of the insurer's negotiated service prices with in-network providers. These prices may be correlated

[17] These diagnoses were chosen for being the most expensive in Colombia and thus the most likely to be undercompensated by the current risk adjustment formula. For example, the most expensive patients with renal disease had annual healthcare cost of over 55 million pesos in 2011, more than 100 times the monthly minimum wage. For individuals with several comorbidities, I assign the most expensive disease.

[18] Results are also robust to a version of the model where individuals are uncertain about their diagnoses (see Appendix Table 16).

with service network breadth because an insurer's bargaining position depends on how many providers it has included in the network. Appendix Table 8 shows that negotiated prices and healthcare costs per service are positively correlated with service network breadth. I capture this correlation by noting the pass-through of insurers' costs to consumers' out-of-pocket costs via cost-sharing. Out-of-pocket costs equal the individual's coinsurance rate times the insurers' average cost per enrollee, which in turn depends on service network breadth. This dependence is needed to rationalize the existence of narrow network insurers in equilibrium since myopic, healthy new enrollees will disproportionately choose narrow-network insurers with lower implied out-of-pocket costs.[19]

The probability of making a claim, $q_{\theta k}$, is calculated outside of the model as the average prediction of a logistic regression. Appendix 6.1 explains this procedure. Given the distribution of the preference shock, the probability that consumer i in market m enrolls with insurer j is:

$$s_{ijm}(H_m) = \frac{\exp\left(\beta_{ij} \sum_k q_{\theta k} H_{jkm} - \alpha_i c_{\theta jm}(H_{jm}) + \phi_{jm}\right)}{\sum_{j' \in \mathcal{J}_m} \exp\left(\beta_{ij} \sum_k q_{\theta k} H_{j'km} - \alpha_i c_{\theta j'm}(H_{j'm}) + \phi_{j'm}\right)}$$

Identification. To identify the parameters associated with service network breadth, I rely on variation in market demographics across markets, which generates exogenous variation in the claim probabilities. For example, if an insurer offers the same network breadth for cardiac care in two different markets, but one of these markets has a higher prevalence of cardiovascular conditions, then we should observe higher insurer demand in the market where people are relatively sicker. Appendix Table 9 shows that service network breadth is uncorrelated with the claim probabilities, providing suggestive evidence of the exogeneity of market demographics and of the absence of moral hazard (consumers are not more likely to make claims the broader is the network).

Identification is threatened if service network breadth is correlated with unobserved insurer quality or unobserved consumer characteristics, such as their valuation for specific providers. Service network breadth could also be correlated with how good the insurer is in

[19] My specification for out-of-pocket costs per consumer type and insurer is equivalent to aggregating service-level out-of-pocket costs with weights given by the claim probabilities.

processing health claims. These types of unobserved insurer characteristics potentially do not vary across markets conditional on the consumer type. Therefore, inclusion of insurer-by-market fixed effects allows me to identify preferences for network breadth off of exogenous variation in market demographics.

To identify the parameters associated with the out-of-pocket cost, I use variation in income within market, which generates exogenous variation in coinsurance rates. This variation may not be sufficient for identification if negotiated service prices are correlated with unobserved provider quality. For example, if an insurer covers a star hospital, demand and negotiated prices for that insurer will be relatively high across all income groups, and my model would interpret consumers as having low sensitivity to out-of-pocket costs. This endogenous variation is specific to an insurer-market combination, hence the inclusion of insurer-by-market fixed effects help isolate the variation in out-of-pocket costs that is exogenous. I also conduct robustness checks in section 5 to verify that differences in provider quality conditional on the service are not significant.

4.3 Insurer Average Costs per Enrollee

I approximate the expected cost of type-θ individuals as the average cost across all consumers i that are of type θ. Then, I model the logarithm of average cost per consumer type as a quadratic function of service network breadth:

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

where K_m is the number of services available in market m; A_k is the government's reference price for service k which guides service-level negotiations (explained in more detail in Appendix 7); λ_θ, η_m, and δ_j are consumer type, market, and insurer fixed effects, respectively; and $\varepsilon_{\theta jm}$ is white noise. Equation (2) captures the fact that consumers of different types will imply different average costs to the insurer conditional on service network breadth. This reduced-form approach is very much in the spirit of Tebaldi (2024) who also models insurers' expected costs as an exponential function of consumer characteristics and generosity of coverage. My choice of functional form is supported by the underlying bargaining game as seen in Appendix 5 and by the empirical relationship between log average costs with service network breadth and with the interaction of network breadth across pairs of services as seen in Appendix Figure 10.[20]

The coefficient τ_0 captures whether insurers bargain higher or lower prices than the reference price with the average provider in their network. τ_1 represents the direct effect of network breadth for service k on average costs. τ_2 captures the average degree of complementarity between pairs of services. If $\tau_2 < 0$, insurers have economies of scope across services, thus greater coverage for service $l \neq k$ makes it more attractive to provide higher coverage for service k. This measure of scope economies helps rationalize the fact that insurers with broad networks in one service, tend to offer broad networks in other services as well (see Appendix Figure 11).

Identification. The parameters of equation (2) are identified from variation in average costs within consumer types and across insurers that are identical except for their service network breadth. My source of identification does not rely on different consumers implying different costs for similar insurers as in Tebaldi (2024) but, *conditional* on the composition of enrollee pools, for different service coverage levels to imply different costs to the insurer. In this case, variation in service network breadth across insurers is exogenous conditional on the rich set of fixed effects. However, one worry is that consumers may select into insurers based on their unobservables. One way to check this is to test whether estimates are robust to more granular definitions of consumer types. I conduct a robustness checks of this style in Appendix Table 18.

4.4 Competition in Network Breadth

Insurers compete separately in every market choosing their service network breadths taking expectations of demand and costs. Let $\pi_{ijm}(H_m, \theta)$ be insurer j's annual per-enrollee profit in market m, which depends on j's service network breadth and its rivals' $-j$, all collected

[20] The micro-foundation in Appendix 5 shows that the average cost has insurer-specific slopes with respect to service network breadth. Equation (2) has one slope for all insurers, which is less demanding of the data.

in the vector $H_m = \{H_{jm}, H_{-jm}\}$. The annual per-enrollee profit is given by:

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

where $R_{\theta m}$ is the per-capita revenue (including ex-ante and ex-post risk-adjusted transfers plus average copayments), $AC_{\theta jm}$ is the average cost of a type-θ consumer net of patients' coinsurance payments with r_θ denoting the coinsurance rate, and s_{ijm} is consumer i's choice probability for insurer j in market m from the demand model.

I focus on a Nash equilibrium in which insurers choose service network breadth simultaneously to maximize the sum of current and future discounted profits minus fixed costs:

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

Insurers take into account the future profits associated with each enrollee since, after making their first enrollment choice, individuals do not switch (see section 2). Insurers therefore maximize the net present value of their profits. $N_{\theta m}$ is the fixed market size of consumers type θ. In the expression for future profits, $\rho_{\theta m}$ represents the probability that a type-θ consumer drops out of the contributory system. This probability is exogenous to the choice of network breadth as it is mostly governed by the event of being unemployed. $\mathcal{P}(\theta'|\theta)$ is the transition probability from type θ in period t to type θ' in period $t + 1$. Appendix Table 10 provides evidence of the exogeneity of transition probabilities by showing that, conditional on not having a diagnosis in 2010, the likelihood of being diagnosed in 2011 is uncorrelated with service network breadth. Future profits at year t are discounted by a factor of ζ^t, which I set to 0.95 and forward simulate this profit function for 100 periods.[21]

In addition to its indirect effect on insurer profits through expected costs and demand,

[21]In the formulation of insurer profits, I use θ to denote sex-age-diagnosis combinations as opposed to sex-age group-diagnosis, for simplicity in notation.

I assume service network breadth involves a direct "fixed" cost to the insurer, that is, an administrative cost that does not vary with the number of enrollees but varies with the fraction of covered providers. The fixed cost is non-linear in service network breadth and heterogeneous across insurers and markets with $\xi_{jkm} = \xi_j + \xi_m + \vartheta_{jkm}$. In this specification, ξ_j represents the insurer-specific cost component, ξ_m the market-specific cost component, and ϑ_{jkm} the idiosyncratic cost shock that is observed by insurance companies but unobserved to the econometrician. The multiplicative structure of the unobserved cost is needed to obtain a first-order condition that is linear in ϑ_{jkm}.

Profit maximization involves a set of $|J| \times |K|$ FOCs in each market which, assuming an interior solution in service network breadth, is given by:

$$\sum_i \left(\frac{\partial \pi_{ijm}}{\partial H_{jkm}} N_{\theta m} + \sum_{s=t+1}^{T} \zeta^s \sum_{\theta'} (1 - \rho_{\theta' m}) \mathcal{P}(\theta' | \theta) \frac{\partial \pi'_{ijm}}{\partial H_{jkm}} N_{\theta' m} \right) = \omega H_{jkm} + \xi_{jkm} \tag{3}$$

The left-hand side of equation (3) represents the marginal variable profit MVP_{jkm}, and the right-hand side is the marginal cost of network formation. The derivative of the short-run per enrollee profit, which enters the MVP_{jkm}, is:

$$\begin{aligned} \frac{\partial \pi_{ijm}}{\partial H_{jkm}} = & \underbrace{\overbrace{R_{\theta m} \frac{\partial s_{ijm}}{\partial H_{jkm}}}^{\substack{\text{Selection} \\ \text{incentives}}} + \overbrace{R_{\theta m} \frac{\partial s_{ijm}}{\partial AC_{\theta jm}} \frac{\partial AC_{\theta jm}}{\partial H_{jkm}}}^{\text{Cost incentives}}}_{\text{Marginal revenue}} \\ & - \underbrace{(1 - r_\theta) \Big(\overbrace{AC_{\theta jm} \frac{\partial s_{ijm}}{\partial H_{jkm}} + s_{ijm} \frac{\partial AC_{\theta jm}}{\partial H_{jkm}}}^{\text{Selection incentives}} + \overbrace{AC_{\theta jm} \frac{\partial s_{ijm}}{\partial AC_{\theta jm}} \frac{\partial AC_{\theta jm}}{\partial H_{jkm}}}^{\text{Cost incentives}} \Big)}_{\text{Marginal cost}} \end{aligned} \tag{4}$$

Equation (4) shows how selection and cost incentives affect insurers' service network breadth choices. If an insurer unilaterally increases its network breadth for a particular service, marginal revenues will increase because demand from individuals with high willingness-to-pay for that service is higher (selection effect). Marginal costs also increase because patients with high willingness-to-pay for the service are the most expensive in that service, and because changes in service network breadth increase the cost of the marginal consumer (selection effect). Cost incentives have opposite effects on marginal revenues and marginal costs. Increasing network breadth for a particular service raises consumers' out-of-pocket costs and puts a downward pressure on demand and marginal revenues. An increase in service network breadth also reduces marginal costs because if relatively sicker consumers disenroll due to higher out-of-pocket payments, then the marginal consumer is cheaper.

Identification. Rewriting the FOC as

$$\text{MVP}_{jkm}(H_{jkm}) = \omega H_{jmk} + \xi_j + \xi_m + \vartheta_{jkm}, \quad \forall\ H_{jkm} \in (0,1) \tag{5}$$

makes explicit the endogeneity problem between H_{jkm} and the fixed cost shocks, ϑ_{jkm}. Insurers observe ϑ_{jkm} before or at the same time as they are deciding on their service network breadths. For instance, if an insurer hires a highly trained manager to bargain with providers or if an insurance company is vertically integrated with its network, then $E[\vartheta_{jkm}|H_{jkm}] < 0$.[22] Identification of fixed cost parameters thus relies on instrumental variables. In the style of Gowrisankaran et al. (2015), I use the insurer's predicted demand in every market assuming that all insurers have service network breadth equal to the market average. I estimate the FOC via 2SLS since only 1% of observations correspond to corner solutions in H_{jkm} in my estimation sample.[23]

5 Estimation

5.1 Insurer Demand

The insurer demand model is a conditional logit estimated by maximum likelihood. To reduce the computational burden, I estimate equation (1) on a random sample of 500,000 new enrollees. Results in Table 3 show that insurer demand is decreasing in out-of-pocket costs and increasing in service network breadth. A 10 thousand pesos increase in out-of-pocket costs reduces the choice probability by 24%, corresponding to an average elasticity

[22] Vertical integration is restricted by the Colombian government to up to 30% of an insurance company's assets. So, endogeneity stemming from vertical integration is unlikely.

[23] Alternatively, the parameters of the network formation cost can be estimated using moment inequalities (as in Pakes et al., 2015).

of -0.26.[24] A ten percentage point increase in network breadth across all services increases the choice probability by 23%.[25] These results suggest not only that there is sorting based on service network breadth but also that consumers prefer broad service networks overall.

Interactions between consumer and insurer characteristics matter for enrollment decisions. Sensitivity to out-of-pocket costs is decreasing with income. Patients aged 65 or older are both more likely to enroll in broad-network insurers and more sensitive to out-of-pocket costs compared to younger patients. One explanation for this result is that old individuals need more expensive care. Individuals with cancer and renal disease have stronger preferences for broader networks than their healthy peers. Consumers with chronic conditions are also significantly less responsive to out-of-pocket costs. Appendix 6.2 presents some measures of in-sample model fit.

With my estimates of the preference for service network breadth and out-of-pocket costs, I calculate patient willingness-to-pay (wtp) for an additional percentage point of network breadth in each service as $\frac{1}{-\alpha_i}\frac{\partial s_{ijm}}{\partial H_{jkm}}$. Differences in wtp across consumer types will be suggestive of patient sorting based on service network breadth. Table 4 presents the average wtp for some services among patients with chronic diseases, normalizing healthy individuals to 1. Patients with chronic conditions have a significantly higher wtp for network breadth across all services compared to individuals without diagnoses. For example, patients with renal disease are willing to pay 27 times more than a healthy individual for an additional provider in the network for renal care services.[26] This variation in wtp implies that, in principle, insurers can avoid unprofitable patients by offering narrow networks in the services they require, and that for some services insurers can find it profitable to offer broad networks.

Alternative specifications. I estimate several alternative demand specifications to provide encouraging evidence of my identification arguments and modelling choices. Appendix Table 13 presents a demand function that includes an indicator of star hospital coverage,

[24]The elasticity with respect to out-of-pocket costs is $\frac{\partial s_{ijm}}{\partial c_{\theta jm}}\frac{c_{\theta jm}}{s_{ijm}}$, which is averaged across consumers and insurers.

[25]Calculated as $\beta_{ij}\sum_k q_{\theta k}$ and averaged across consumers and insurers.

[26]The measure of willingness-to-pay can also be interpreted in terms of travel times to the nearest provider as seen in Appendix Figure 3. For example, the estimates imply that patients with renal disease are willing to pay 27 times more than a healthy individual for a reduction of approximately 10 minutes in travel time per visit to the nearest provider that offers renal care services.

Table 3: 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.

Table 4: Average willingness-to-pay per service and diagnosis

Diagnosis	Cardiac care	Renal care	Imaging	General medicine	Laboratory	Hospital admissions
Cancer	3.78	3.78	2.20	1.16	1.80	3.50
Diabetes	3.93	3.93	2.41	1.33	2.00	3.67
Cardio	2.85	2.85	1.77	0.98	1.47	2.67
Pulmonary	6.20	6.20	3.21	1.60	2.57	5.62
Renal	27.24	27.25	12.46	5.83	9.72	24.04
Other disease	6.15	6.15	3.55	1.87	2.90	5.69
Healthy	1.00	1.00	1.00	1.00	1.00	1.00

Note: Table presents average willingness-to-pay for a percentage point increase in network breadth for the service in the column. Willingness-to-pay is calculated as $\frac{1}{-\alpha_i}\frac{\partial s_{ijm}}{\partial H_{jkm}}$, averaged across all consumers with the diagnosis in the row, and normalized to 1 for healthy individuals.

showing that this indicator is insignificant conditional on service network breadth. Thus, variation in provider quality does not bias my main estimates. Because requiring that new enrollees know their diagnoses before enrolling can create mechanical bias, in Appendix Table 14 I identify new enrollees' diagnoses using only the information from claims made in January 2011. Interactions with service network breadth are robust, and although mean effects decrease in magnitude with respect to my main specification, they do not change results qualitatively. Appendix Table 15 presents a demand model where service network breadth is weighted by each provider's number of beds. This specification shows that my estimates are robust to accounting for provider size. Finally, Appendix Table 16 shows a version of demand where consumers are uncertain about their diagnoses. The coefficients in this table are larger in magnitude than in my main specification (but produce the same qualitative results) for two reasons: first, the specification does not include interactions of service network breadth and out-of-pocket costs with diagnoses; and second, out-of-pocket costs are weighted by the diagnosis probabilities and summed across diagnoses for every individual, resulting in smaller magnitudes of the out-of-pocket cost relative to the main specification.

5.2 Insurer Average Costs Per Enrollee

I estimate equation (2) in the sample of new and current enrollees, conditional on observed choices in 2010 and 2011. Table 5 shows the results and appendix figure 12 presents the estimated consumer type fixed effects with their corresponding 95% confidence intervals. Average costs are increasing in service network breadth and decreasing in the interaction between network breadth for different pairs of services. Insurer coverage decisions are thus characterized by economies of scope: a 1% increase in network breadth for service k reduces the average cost of providing service $l \neq k$ by 4.8% per enrollee.[27] Moreover, the estimate for τ_1 indicates that a 1% increase in service network breadth raises average costs by 2.2% per enrollee.[28]

A potential mechanism for why insurers enjoy economies of scope from a bargaining perspective is that insurers enjoy price discounts at provider h when they cover this provider for several services and when network breadth for other services is high. For example, if provider h is dropped from the network of laboratory testing, then demand for other diagnostic services like imaging is more likely to increase at lower-priced providers the broader is the network for imaging. This implies that the equilibrium price that provider h can charge to the insurer for laboratory testing is lower than it would be without the interaction with imaging providers. Appendix Table 17 provides evidence of this mechanism by showing that negotiated prices for service k between insurer j and provider h are negatively correlated with the fraction of other services $l \neq k$ for which the provider is in network and with average network breadth across all other services $l \neq k$.

Table 5 also shows substantial heterogeneity across insurers. EPS008, EPS009, and EPS018, have average costs per enrollee that are between 6% and 20% higher than the average cost of EPS037. My estimates fit the data for observed log average costs as seen in Appendix Figure 13. Appendix Tables 18 and 19 also show that my model is robust to more granular definitions of consumer type and to explicitly modelling hospital quality with inclusion of a star hospital indicator. These exercises provide evidence of no relevant unobserved cost heterogeneity within consumer types and of no relevant variation in provider quality.

Table 5: 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 FE		
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 the log of average costs per consumer type on network breadth, economies of scope, and service reference prices. An observation is a combination of insurer, consumer type, market and year. Estimation uses data from all continuously enrolled individuals in 2010 and 2011, averaged per consumer type. Specification includes insurer, market, and consumer type fixed effects. Robust standard errors in parenthesis.

5.3 Competition in Network Breadth

The third piece of the insurers' profit function left to estimate is the fixed cost, for which I use insurers' FOCs. Demand and average cost estimates allow me to compute MVPs in the left-hand side of equation (3). Dropout and transition probabilities are calculated off-line non-parametrically from the data. Appendices 9 and 10 present summary statistics of these probabilities and of MVPs, respectively. The fact that MVPs are positive for all insurer-market-services suggests a role for fixed costs in explaining the profit maximizing choices of service network breadth.

Table 6 presents the results of equation (5) for the log of marginal variable profits and Appendix Table 23 presents first stage results instrumenting service network breadth with the average claim probability for individuals without diagnoses. I find that fixed costs are

[27] Calculated as the average of $100 \times \frac{1}{2K_m} \hat{\tau}_2 \sum_{l \neq k} q_{\theta k} q_{\theta l} H_{jlm}$

[28] Calculated as the average of $100 \times \hat{\tau}_1 q_{\theta k}$

Table 6: Model of insurer fixed costs

$\log(MVP_{jmk})$	coef	se
Service network breadth	16.05	(1.75)
Insurer FE		
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)
Market FE		
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	
R^2	0.94	

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.

increasing in service network breadth and are substantially heterogeneous across insurers and markets. The unobserved cost component explains 6% of the variation in MVPs. The first-stage F-statistic suggests that my instrument is relevant. Without the instrument, the coefficient on service network breadth is one order of magnitude smaller, consistent with the direction of the bias discussed in section 4.4. Appendix Figure 14 shows that my model of fixed costs fits untargeted moments such as the ratio of administrative costs to total variable profits coming from insurers' public income statements.

6 Risk Selection vs. Cost Structure

In this section I use my model estimates to assess the magnitude of risk selection and insurers' cost structure for determining service network breadth. This exercise is important to inform about the best policies to increase network coverage for patients most in need. For example, if risk selection is the main driver of service network breadth decisions, then using network adequacy rules that force the inclusion of certain providers would be ineffective because insurers would respond by avoiding the enrollees who need those providers. In this case a policy like risk adjustment would be better suited for incentivizing insurers to offer broad networks. If cost incentives (economies of scale or scope) are the main driver of service network breadth decisions, then forcing insurers to include certain providers would be effective in achieving broad coverage.

For risk selection I conduct two counterfactual simulations: first, I eliminate risk adjustment by imposing the same transfer across all consumer types. Second, I improve the government's risk adjustment formula by compensating for a list of 14 health conditions listed in Appendix Table 24. In these analyses I hold long-run government spending fixed across all markets, so that changes in service network breadth are determined only by changes in how resources are redistributed across insurers, but not by the level of the transfer itself. For cost incentives I conduct two additional counterfactuals: I eliminate average cost and fixed cost heterogeneity by imposing the fixed effect for the reference insurer, $\delta_j = 0$ and $\xi_j = 0$ $\forall j$, respectively.

One concern in the counterfactual analyses is that the model may admit multiple equilibria. For instance, my measure of scope economies can make it such that every firm choosing complete networks or no coverage at all are both feasible equilibria. While a direct proof of uniqueness is challenging, in Appendix 11 I provide suggestive evidence of uniqueness by computing the second partial derivative of the insurers' profit function with respect to service network breadth, all else equal. The rich preference and cost heterogeneity prevent multiple equilibria from arising. In computing the counterfactual analyses, I also use several different starting values for the vector of service network breadth to confirm that they all converge to the same equilibrium. For tractability, I conduct all my counterfactuals with data from the largest market, Bogotá, where 29% of all continuously enrolled individuals reside and where all private insurers compete.

Table 7 presents the results. Panel A shows the percentage change in average network breadth, average costs per enrollee, total average costs, and long-run consumer surplus for sick and healthy individuals. Panel B shows the percentage change in network breadth for specific services. Columns (1) and (2) show results under no risk adjustment and with improved risk adjustment, respectively. Columns (3) and (4) show results of imposing homogeneity in average costs and fixed costs, respectively.

Table 7: Networks, costs, and welfare after changes in risk adjustment and cost structures

	Risk adjustment		Cost structure	
Variable	No RA (1)	RA (2)	Avg cost (3)	Fixed cost (4)
Panel A. Overall				
Avg. network breadth	-5.29	7.63	-0.06	-9.80
Avg. cost per enrollee	1.21	-0.03	5.52	1.83
Total avg. cost	1.08	-0.05	6.33	4.54
Consumer surplus (sick)	0.08	-0.40	0.16	-1.13
Consumer surplus (healthy)	-0.21	-0.50	0.10	-1.32
Panel B. Service network breadth				
Otorhinolaryngologic care	-5.38	8.02	-0.05	-11.23
Cardiac care	-5.75	7.92	-0.04	-11.02
Gastroenterologic care	-5.66	7.95	-0.04	-10.75
Renal care	-6.09	8.39	-0.05	-11.59
Gynecologic care	-5.83	8.19	-0.04	-10.08
Orthopedic care	-5.79	8.00	-0.05	-11.00
Imaging	-3.07	5.25	-0.07	-7.01
General medicine	-1.31	3.05	-0.11	-7.39
Laboratory	-2.49	4.64	-0.10	-7.47
Hospital admission	-4.88	6.92	-0.04	-8.42

Note: Panel A presents the percentage change in average network breadth, average cost per enrollee, total average cost, and long-run consumer surplus for sick and healthy individuals, in the scenario without risk adjustment in column (1), the scenario with improved risk adjustment in column (2), the scenario with homogeneous average costs in column (3), and the scenario with homogeneous fixed costs in column (4). Panel B presents the percentage change in average network breadth for a few service categories, for exposition. Simulations use data from Bogotá where the 10 largest insurers compete.

Without risk adjustment, average network breadth falls 5.3%, a reduction of at most 4 providers in the network. The reduction in service network breadth generates negligible welfare effects because the current risk adjustment formula is already very coarse. Panel B shows that insurers reduce coverage of relatively expensive services by a greater magnitude than coverage of relatively cheap services. For instance, average network breadth for hospital admissions decreases approximately 4.9% relative to the observed scenario, while average network breadth for general medicine decreases 1.3%.

Column (2) shows qualitatively opposite results. With improved risk adjustment, average network breadth increases 7.6%, which corresponds roughly to adding at most 6 providers to the network. Effects are larger for services that mostly sick patients claim, consistent with weakened selection incentives and with risk selection being a determinant of narrow networks. Panel B shows that average network breadth for cardiac care increases 7.9%, while average network breadth for general medicine increases nearly 3.1%. Despite the substantial changes in network coverage, I find essentially no variation in consumer surplus. However, this finding would be a lower bound on welfare effects measured with a more flexible model that takes into account heterogeneous preferences over providers. The small variation in surplus is due to the higher out-of-pocket payments that consumers make in this counterfactual relative to the observed scenario, which compensate the welfare gains from having greater coverage.

In relation to insurers' cost structure, findings show that absent fixed cost heterogeneity, service network breadth decreases as seen in column (4), but average cost heterogeneity has very little impact on service network breadth as seen in column (3). Focusing on column (4), Panel A shows that if insurers had homogeneous fixed costs, average service network breadth would decrease 9.8% relative to the observed scenario. Insurers' total average cost would increase 4.5% because they can no longer take advantage of scope economies. Consumer surplus for individuals with and without diagnoses would decrease by a moderate amount, suggesting that welfare losses due to lower network coverage slightly overcompensate welfare gains from lower out-of-pocket costs. Panel B shows that the reduction in network breadth is larger for services that mostly sick individuals tend to claim. For instance, network breadth for general medicine decreases approximately 7.4%, while network breadth for renal care falls around 11.6% relative to the observed scenario.

Taken together, counterfactual results indicate that risk selection and insurers' fixed cost structure weigh equally in the decision to offer service network breadth. Risk selection drives the choice of narrow networks, while fixed cost heterogeneity drives the choice of broad networks. Thus, policies like risk adjustment improve coverage for individuals with and without chronic conditions beyond what markets alone can produce given insurers' heterogeneity in costs. Moreover, the efficacy of network adequacy rules either forcing insurers to cover specific providers or establishing minimum provider-to-enrollee ratios –which have become popular in health systems around the world– will depend on the relative magnitude of risk selection and fixed costs.

7 Conclusions

Private health insurers respond to different incentives when crafting the various elements of their insurance contracts. This paper shows that risk selection and insurers' cost structure are the main drivers of the decision to offer provider network breadth. Risk selection induces insurers to offer narrow networks, while fixed cost heterogeneity induces insurers to offer broad networks despite selection incentives. I use a structural model of insurer competition in service network breadth to decompose the relative importance of these factors in counterfactuals. The empirical setting is Colombia, where the government regulates premiums and cost-sharing (similar to Medicaid Managed Care and the Exchanges in the U.S.), and allows insurers to choose only which and how many providers to cover for each health service.

To quantify the equilibrium impact of risk selection on service network breadth I modify the risk adjustment formula. Without risk adjustment, average service network breadth would decrease 5.3%, consistent with increased selection incentives. Instead, improving the risk adjustment formula by compensating for a granular list of diagnoses would increase average service network breadth by 7.6%. To quantify the equilibrium impact of insurers' cost structure, I force fixed costs to be homogeneous across insurers. Results show that average service network breadth would decrease 9.8%, with reductions being larger in services that sick individuals require the most.

The findings of this paper provide new evidence of selection on provider networks and speak to the increasing use of network adequacy rules in markets where narrow-network plans have proliferated. A direct implication of my results is that when risk selection weighs more than insurers' cost structure in the decision to offer provider networks, there is little scope for the use of network adequacy rules, and instead markets should adopt more granular risk adjustment formulae to increase coverage for those most in need.

Acknowledgements. I am deeply grateful to Alan Sorensen, Ken Hendricks, Corina Mommaerts, JF Houde, and Dan Quint, as well as Naoki Aizawa, Lorenzo Magnolfi, Christopher Sullivan, and Ashley Swanson for their mentorship and thoughtful advice. This research has benefited substantially from discussions with Ignacio Cuesta, Kate Ho, Maria Polyakova, Mark Shepard, and Pietro Tebaldi; as well as from comments from participants at BFI's 2024 Women in Empirical Microeconomics, NBER IO 2023 Summer Institute, 2022 Stanford's SITE, IO Workshop at UW-Madison, ASHEcon 2022, IIOC 2023, MEA 2022, Central Bank of Colombia Workshop 2023, and the seminars at Boston University, California Institute of Technology, Kelley School of Business, London School of Economics and Political Science, Ohio State University, Olin School of Business, Quantil Colombia, Ross School of Business, Stanford Health Policy, University of Toronto, University College London, and University of Pennsylvania. I want to thank the Colombian Ministry of Health for providing the data for this research. Findings do not represent the views of any institution involved. All errors are my own.

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Online Appendix

Appendix 1 Current risk adjustment system

For year t, the base un-adjusted capitated transfer is calculated using the claims data from year $t-2$. The per-enrollee transfer is roughly equal to the average annual healthcare cost in the population multiplied by a risk adjustment factor that is specific to a combination of sex, age group, and municipality. Appendix table 1 shows the national un-adjusted transfer and appendix table 2 shows the risk adjustment multipliers.

Appendix Table 1: Base capitated transfer for the Contributory System during 2011

Department/city		Transfer
National (pesos)		525,492
Market multiplier a_m	Amazonas	$\times$ 1.10
	Arauca, Arauca	$\times$ 1.10
	Yopal, Casanare	$\times$ 1.10
	Florencia, Caquetá	$\times$ 1.10
	Chocó	$\times$ 1.10
	Riohacha, Guajira	$\times$ 1.10
	Guainía	$\times$ 1.10
	Guaviare	$\times$ 1.10
	Villavicencio, Meta	$\times$ 1.10
	Putumayo	$\times$ 1.10
	San Andrés y Providencia	$\times$ 1.10
	Sucre, Sincelejo	$\times$ 1.10
	Vaupés	$\times$ 1.10
	Vichada	$\times$ 1.10
	Soacha, Cundinamarca	$\times$ 1.06
	Bello, Antioquia	$\times$ 1.06
	Itaguí, Antioquia	$\times$ 1.06
	Envigado, Antioquia	$\times$ 1.06
	Sabaneta, Antioquia	$\times$ 1.06
	Soledad, Antioquia	$\times$ 1.06
	Bogotá	$\times$ 1.06
	Medellín, Antioquia	$\times$ 1.06
	Barranquilla, Atlántico	$\times$ 1.06

Note: Table reports national base risk-adjusted transfer which includes payments for promotion and prevention programs. Table also reports risk-adjustment multipliers for each market.

Appendix Table 2: Risk Adjustment Factors in the Contributory System during 2011

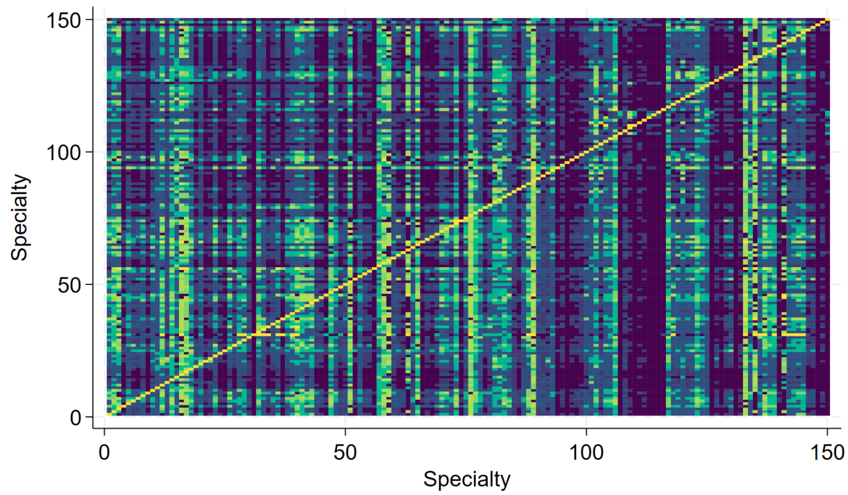
Age group	Sex	Multiplier
Less than 1	—	3.0000
1-4	—	0.9633
5-14	—	0.3365
15-18	M	0.3207
15-18	F	0.5068
19-44	M	0.5707
19-44	F	1.0588
45-49	—	1.0473
50-54	—	1.3358
55-59	—	1.6329
60-64	—	2.1015
65-69	—	2.6141
70-74	—	3.1369
More than 74	—	3.9419

Note: Table reports government risk-adjustment multipliers by sex and age group.

Appendix 2 Service categories

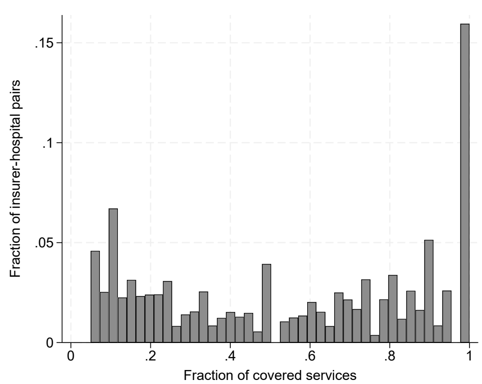
The service-level provider network data reports 150 unique specialities over which insurers and providers bargain. Some of these specialties are highly correlated in the sense that insurers tend to include them together at a particular provider. Appendix figure 1 presents a heatmap of the fraction of insurer-provider pairs that include the specialty in the horizontal axis, and also include the specialty in the vertical axis. Light colors represent higher fractions. The heatmap shows that (i) there are very common specialties such as general medicine and internal medicine seen in the vertical light-colored lines, and (ii) some specialties are correlated along the diagonal.

Appendix figure 2 shows that most insurers cover all the services at a particular provider, but there is still substantial variation in service coverage within insurer-provider pair. I group the different specialties of the network data into a final list 20 service categories, which can be mapped to the claims data based on the 6-digit service code reported for each claim. Appendix table 3 provides the final list of services and appendix table 4 provides a data excerpt of insurer's network inclusions for three hospitals and three services.



Appendix Figure 1: Heatmap of specialty pairs network inclusions

Note: Figure presents a heatmap of the fraction of insurer-hospital pairs in the network data that include the specialty in the horizontal axis and the specialty in the vertical axis. Lighter colors represent higher fractions.



Appendix Figure 2: Service inclusions within hospital

Note: Figure presents the distribution of the fraction of services that the provider can deliver which are covered by the insurer.

Appendix Table 3: 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

Note: Table presents the final list of 20 services and their description.

Appendix Table 4: Service coverage at hospitals

	Cardiac care			Renal care			Hospital admissions		
Insurer	Valle del Lili	Santa Fe	Pablo Tobón	Valle del Lili	Santa Fe	Pablo Tobón	Valle del Lili	Santa Fe	Pablo Tobón
EPS001	1	0	0	1	0	0	1	1	1
EPS002	1	0	1	1	0	1	1	1	1
EPS003	1	0	0	0	0	0	1	1	1
EPS005	1	1	1	1	1	1	1	1	1
EPS008	1	1	0	1	1	0	1	1	0
EPS009	0	0	1	0	0	1	0	0	1
EPS010	1	1	1	1	1	1	1	1	1
EPS012	1	1	0	1	1	0	1	1	0
EPS013	1	0	1	1	0	1	1	1	1
EPS016	1	1	1	1	1	1	1	1	1
EPS017	0	1	0	0	1	0	1	1	1
EPS018	1	1	1	1	1	1	1	1	1
EPS023	0	0	0	0	0	0	1	1	1
EPS037	1	1	1	1	1	1	1	1	1

Note: Table presents service coverage per insurer at three hospitals in the country and for three services. Data comes from the National Health Superintendency.

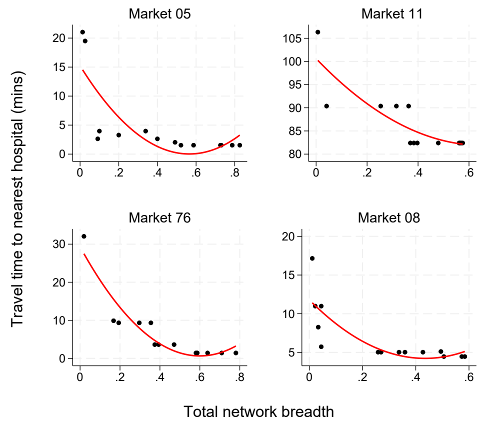
Appendix 3 Additional descriptives

This appendix presents additional descriptive evidence. Appendix table 5 presents summary statistics of all new enrollees and all the continuously enrolled. Appendix figure 3 presents the correlation between travel times and network breadth across all services for the four largest markets. Appendix figure 4 shows the distribution of network breadth during 2011 for general medicine, laboratory testing, hospital admissions, neurological care, cardiac care, and renal care. Appendix figure 5 presents these distributions conditional on the 5 largest markets and the rest of markets. Appendix table 6 shows OLS regressions of an indicator for switching out of an insurer on that insurer's service network breadth conditional on patients with different health conditions. The estimation uses the full sample of individuals.

Appendix Table 5: Summary statistics of new and continuous enrollees

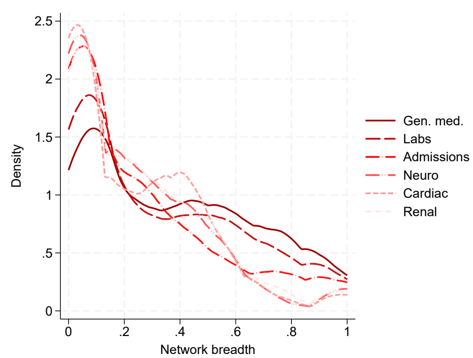
	New (1)	Continuous (2)
Male	0.508 (0.500)	0.447 (0.497)
Age	41.79 (15.34)	45.53 (15.96)
Cancer	0.058 (0.233)	0.088 (0.283)
Diabetes	0.018 (0.135)	0.042 (0.200)
Cardiovascular disease	0.099 (0.299)	0.194 (0.396)
Pulmonary disease	0.010 (0.099)	0.021 (0.142)
Renal disease	0.007 (0.081)	0.018 (0.133)
Other disease	0.039 (0.193)	0.071 (0.257)
Low income	0.374 (0.484)	0.345 (0.475)
Medium income	0.621 (0.485)	0.649 (0.477)
High income	0.005 (0.070)	0.006 (0.076)
Total healthcare cost	0.358 (3.708)	0.591 (3.623)
Individuals	3,101,064	7,675,021

Note: Table presents mean and standard deviation in parenthesis of demographic and health characteristics of new enrollees in column (1) and the continuously enrolled in column (2) during 2011.



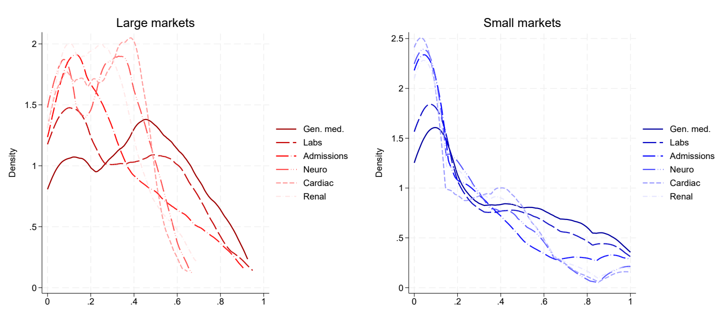
Appendix Figure 3: Average network breadth and travel times

Note: Figure presents a scatter plot of network breadth and travel time from the municipality centroid to the nearest in-network provider in minutes. The red line represents a quadratic fit.



Appendix Figure 4: Distribution of network breadth per service

Note: Figure presents epanechnikov kernel density estimates for the distribution of network breadth conditional on six services: general medicine, laboratory testing, hospital admissions, neurological care, cardiac care, and renal care. An observation to construct these distribution is a combination of insurer, market, and year.



Appendix Figure 5: Distribution of service network breadth per market

Note: Figure presents kernel density estimates of the distribution of network breadth for general medicine, laboratory testing, hospital admissions, neurological care, cardiac care, and renal care in the 5 largest markets in the left panel and in the rest of markets in the right panel.

Appendix Table 6: Determinants of switching

	(1)	(2)	(3)	(4)
Sample:	Healthy	Cancer	Diabetes	Cardio
Service:	General medicine	Therapy	Laboratory	Cardiac care
Network breadth	7.21	-4.79	-1.34	-2.62
	(0.11)	(0.23)	(0.25)	(0.19)
Controls				
Demographics	x	x	x	x
Days enrolled	x	x	x	x
Market FE	x	x	x	x
N	10,703,261	771,447	346,022	1,723,168

Note: Table presents OLS regression of a switching indicator on service network breadth for the 2010 insurer. Column (1) uses the sub-sample of individuals without diagnoses and network breadth for general medicine. Column (2) uses the sub-sample of individuals with cancer and network breadth for chemotherapy. Column (3) uses the sub-sample of individuals with diabetes and network breadth for laboratory. Column (4) uses the sub-sample of individuals with cardiovascular disease and network breadth for cardiac care services. All specifications control for enrollees' demographic characteristics, days enrolled, and market fixed effects. Robust standard errors in parenthesis.

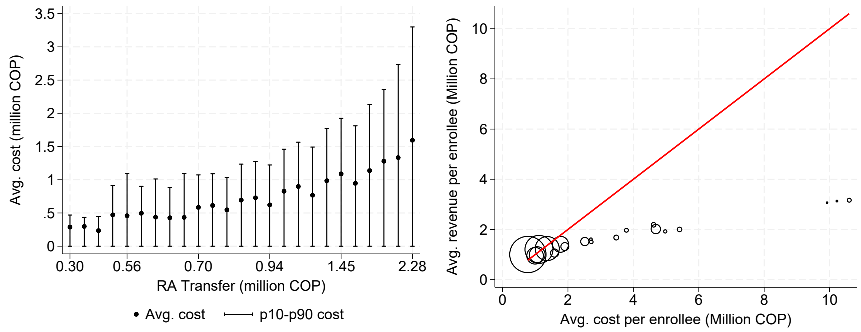
Appendix 4 Descriptives in subsample

This appendix replicates the descriptive evidence in the main text on the sample for model estimation which comprises individuals who have continuous enrollment spells.

Appendix Table 7: Summary statistics in estimation sample

	mean	sd
Demographics		
Male	50.85	(49.99)
Age	41.70	(15.29)
Low income (%)	28.52	(45.15)
Rural (%)	24.73	(43.14)
Diagnoses (%)		
Cancer	5.55	(22.90)
Diabetes	1.77	(13.17)
Cardiovascular disease	9.55	(29.40)
Long-term pulmonary disease	0.99	(9.92)
Renal disease	0.64	(7.99)
Other disease	3.77	(19.04)
Healthcare utilization		
OOP spending	0.14	(0.12)
Weighted network breadth	0.51	(0.15)
Risk-adjusted transfer	0.67	(0.42)
Total healthcare cost	0.36	(2.26)

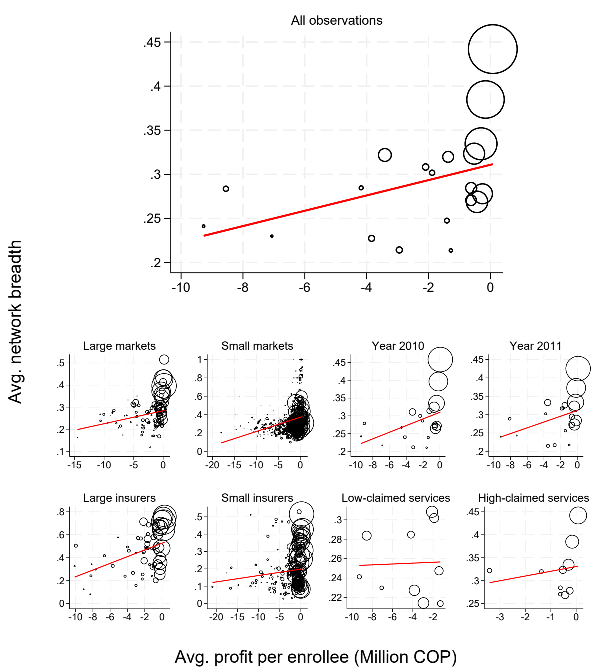
Note: Table presents mean and standard deviations in parenthesis of main analysis variables conditional on observed choices. OOP spending, risk-adjusted transfer, and total healthcare cost are measured in millions of COP.



(a) Cost by risk-adjusted transfer (b) Service-level selection incentives

Appendix Figure 6: Costs and selection incentives in the continuously enrolled

Note: Panel (a) of the figure presents mean, and 10th and 90th percentiles of annual healthcare cost by ex-ante government's risk-adjusted transfer in the sample of continuously enrolled. Panel (b) presents a scatter plot of average cost per enrollee against average revenue per enrollee in the sample of continuously enrolled. Each dot is a service weighted by the number of individuals who make claims for the service. The red line is a 45 degree line. One enrollee can be represented in several dots if she makes claims for different services. Enrollees who make zero claims are not represented in this figure.



Appendix Figure 7: Network breadth and service profitability in the continuously enrolled

Note: Figure presents a scatter plot of average service network breadth against average profit per enrollee in the sample of continuously enrolled. Each dot is a service weighted by the number of individuals who make claims for the service. Profits are calculated as government ex-ante and ex-post transfers, plus revenues from copays and coinsurance rates, minus total healthcare costs. The red line corresponds to a linear fit. One enrollee can be represented in several dots if she makes claims for different services. Enrollees who make zero claims are not represented in this figure.

Appendix 5 Micro-foundation

Insurer demand. For the demand side, take one market and consider a simple model of provider choice where individual i's indirect utility from choosing provider h for service k in the network of insurer j is:

$$u_{ijkh} = \overline{\xi_k} H_{jk} + \nu_{ijkh}$$

This model assumes that providers have identical quality *conditional on the service* which is equal to $\overline{\xi}_k$ weighted by the fraction of covered providers H_{jk}. Moreover, ν_{ijkh} is a preference shock distributed T1EV. Following McFadden (1996), individual i's value for insurer j's network of providers in service k, G_{jk}, is:

$$w_{ijk} = \log\Big(\sum_{h \in G_{jk}} \exp(\overline{\xi}_k H_{jk})\Big)$$

which simplifies to:

$$w_{ijk} = \log\Big(\sum_{h \in G_{jk}} \exp(\overline{\xi}_k H_{jk})\Big) = \log(|G_{jk}| \exp(\overline{\xi}_k H_{jk})) = \log(|G_{jk}|) + \overline{\xi}_k H_{jk} = \phi_{jk} + \overline{\xi}_k H_{jk}$$

where $|G_{jk}|$ is the number of providers in insurer j's network for service k and $\log(|G_{jk}|) = \phi_{jk}$. Summing across services yields:

$$\sum_k w_{ijk} = \phi_j + \sum_k \overline{\xi}_k H_{jk}$$

where $\phi_j = \sum_k \phi_{jk}$. This shows that insurer demand can be modelled as a function of $\sum_k \overline{\xi}_k H_{jk}$ and insurer fixed effects ϕ_j. It also shows that an approximation with network breadth is exact when providers are homogeneous *conditional on the service.*

The relation between network valuation and network breadth can be extended to a model where providers differ in quality and where consumers have heterogeneous preferences as follows. Suppose the utility function is:

$$u_{ijkh} = x_{\theta(i)} \xi_{hk} + \varepsilon_{ijkh}$$

where $x_{\theta(i)}$ is a vector of observed consumer characteristics describing a consumer type θ. Let γ_θ be the fraction of consumers type θ in the population and $|G_k|$ the total number of providers that deliver service k. Then:

$$\begin{aligned}
\sum_\theta \gamma_\theta w_{\theta(i)jk} &= \sum_\theta \gamma_\theta \log\Big(\sum_{h\in G_{jk}} \exp(x_{\theta(i)}\xi_{hk})\Big) \geq \sum_\theta \gamma_\theta \log\Big(\frac{1}{|G_k|}\sum_{h\in G_{jk}} \exp(x_{\theta(i)}\xi_{hk})\Big) \\
&\geq \sum_\theta \gamma_\theta \frac{1}{|G_k|}\sum_{h\in G_{jk}} \log(\exp(x_{\theta(i)}\xi_{hk})) = \sum_\theta \gamma_\theta \frac{1}{|G_k|}\sum_{h\in G_{jk}} x_{\theta(i)}\xi_{hk} \\
&= \sum_\theta \gamma_\theta \frac{|G_{jk}|}{|G_k|}\sum_{h\in G_{jk}} \frac{1}{|G_{jk}|} x_{\theta(i)}\xi_{hk} = \sum_\theta \gamma_\theta x_{\theta(i)}\bar{\xi}_{jk} H_{jk}
\end{aligned}$$

where the second inequality follows from Jensen's inequality and $\bar{\xi}_{jk} = \frac{1}{|G_{jk}|}\sum_{h\in G_{jk}} \xi_{hk}$ is the average quality of providers in insurer j's network. This derivation suggests that when providers differ in quality conditional on the service and when consumers have heterogeneous preferences, a model of insurer demand defined over $\gamma_\theta x_{\theta(i)}\bar{\xi}_{jk}H_{jk}$ and resulting welfare measures will be a lower bound of a demand function and welfare measures defined over $\gamma_\theta w_{\theta(i)jk}$.

Insurer costs. Moving to the supply side, suppose that insurer j and provider h engage in bilateral negotiations over service prices. Let $D_j(\cdot)$ be insurer j's demand, R the per-capita risk-adjusted transfer, $D_{jhk}(\cdot)$ provider h's demand for service k from j's enrollees, p_{jhk} the negotiated price, m_{hk} provider h's marginal cost of providing service k, H_{jk} the set of providers in insurer j's network for service k, and J_{hk} the set of insurers that cover provider h for service k. Insurer profits can be written as $\pi^j = D_j(\cdot)R - \sum_k \sum_{h\in H_{jk}} D_{jhk}(\cdot)p_{jhk}$ and provider profits as $\pi^h = \sum_k \sum_{j\in J_{hk}} D_{jhk}(\cdot)(p_{jhk} - m_{hk})$. For simplicity, suppose that $D_{jhk}(\cdot)$ does not depend on prices as in Ho and Lee (2017).

The log Nash surplus function is:

$$S_{jhk} = \beta \log(\pi_j - t_h^j) + (1-\beta)\log(\pi_h - t_j^h)$$

where β is the bargaining power of the insurer, and t_h^j and t_j^h are the insurer and provider disagreement payoffs, respectively. The insurer disagreement payoff is defined as the profit it would enjoy if it excludes provider h from the network, while reimbursing the rest of providers at their equilibrium prices. Provider disagreement payoffs are defined analogously.

The FOC of the log Nash surplus function with respect to the negotiated price is:

$$
\begin{aligned}
\sum_k D_{jhk} p_{jhk} = \beta \Big(\sum_k D_{jhk} m_{hk} - \sum_k \sum_{n \in J_h \setminus j} \Delta D_{nhk}(\cdot)(p_{nhk} - m_{hk}) \Big) \\
+ (1-\beta) \Big(\Delta D_j(\cdot) R - \sum_k \sum_{l \in H_j \setminus h} \Delta D_{jlk}(\cdot) p_{jlk} \Big)
\end{aligned}
$$

Adding these FOCs across all providers in the market for service k, imposing symmetry across providers, and dividing on both sides by insurer j's demand, yields the following expression for the insurer's average cost per enrollee:

$$
\begin{aligned}
AC_j &= \frac{1}{D_j} \beta \Big(\sum_k \overline{D}_{jk}(\cdot) \overline{m}_k \; H_{jk} - \sum_k \Delta \overline{D}_{nk}(\cdot)(\overline{p}_{nk} - \overline{m}_k) \; (|J_k| - 1) \; H_{jk} \Big) \\
&+ \frac{1}{D_j} (1-\beta) \Big(\frac{\Delta D_j(\cdot)}{|G_{jk}|} R \; H_{jk} - \sum_k \Delta \overline{D}_{jk}(\cdot) \overline{p}_{jk} \; (|G_{jk}| - 1) \; H_{jk} \Big) \\
&= \frac{1}{D_j} \sum_k \Big(\beta \overline{D}_{jk}(\cdot) \overline{m}_k - \beta \Delta \overline{D}_{nk}(\cdot)(\overline{p}_{nk} - \overline{m}_k)(|J_k| - 1) \Big) H_{jk} \\
&+ \Big(\frac{1}{D_j} (1-\beta) \frac{\Delta D_j(\cdot)}{|G_{jk}|} R \Big) H_{jk} + \frac{1}{D_j} (1-\beta) \sum_k \Big(\Delta \overline{D}_{jk}(\cdot) \overline{p}_{jk} \Big) H_{jk} \\
&- \frac{1}{D_j} (1-\beta) \sum_k \Big(\Delta \overline{D}_{jk}(\cdot) \overline{p}_{jk} \; |G_k| \Big) H_{jk}^2 \\
&= f(H_{jk}, H_{jk}^2)
\end{aligned}
$$

Here variables with over-lines denote the value for the average provider in service k. This derivation shows that an average cost function that is quadratic in network breadth is a correct simplification when providers are homogeneous conditional on the service. Together with results on demand, this shows that my proposed model is internally consistent.

Appendix 6 Model inputs

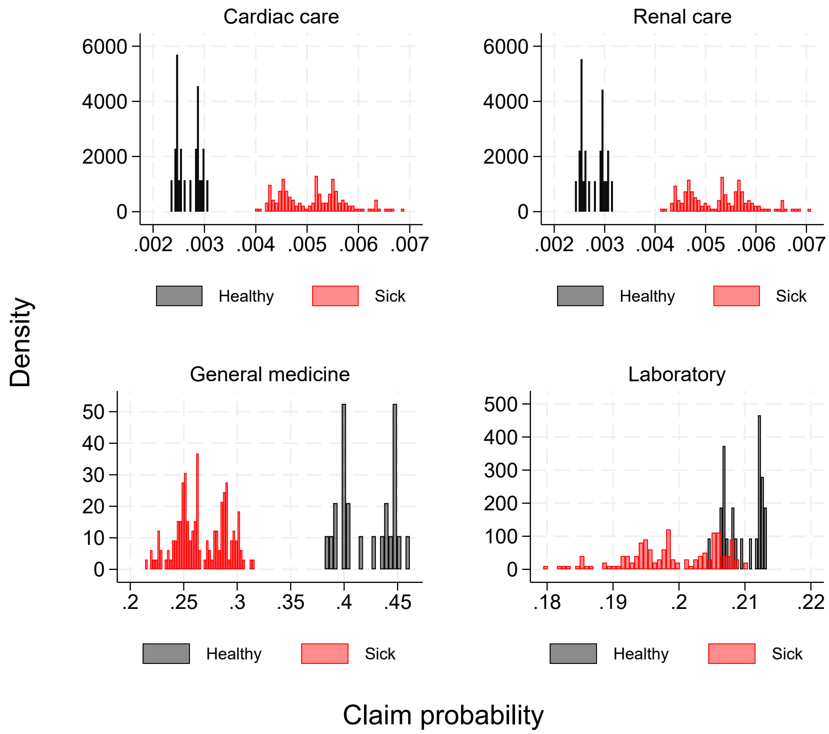
6.1 Estimating claim probabilities

I estimate the claim probabilities using the following logistic regression:

$$\text{logit}(\text{any claims})_{ik} = \psi_k + \psi_\theta + \psi_{ik} \tag{6}$$

The dependent variable is an indicator for whether patient i makes a claim for service k. On the right side, ψ_k and ψ_θ are service and consumer type fixed effects, respectively. ψ_{ikm} is a mean zero shock to the claim probability that is independent of network breadth conditional on consumer observables. I assume that new enrollees' expectations over the services they will need are correct on average, and that these expectations do not depend on the insurer they enroll with. I estimate equation (6) on data from both current and new enrollees in 2010 and 2011. Appendix figure 8 presents the resulting distribution of $q_{\theta k}$ for a few services such as cardiac care, renal care, general medicine, and laboratory.

Appendix tables 8 to 10 present supporting evidence for model assumptions. First, they show that negotiated service prices and total service healthcare costs are higher the broader is the network. Hence, consumers who enroll broad networks make higher out-of-pocket payments. Second, they show that service claim probabilities are uncorrelated with service network breadth, providing suggestive evidence for using variation in claim probabilities to identify the parameter on network breadth in the demand model. Third, they show that the probability of receiving a chronic disease diagnosis in 2011 conditional on not having one in 2010 is uncorrelated with network breadth. Thus, transition probabilities in insurers' profit function are orthogonal to network breadth.



Appendix Figure 8: Distribution of service claim probability

Note: Figure presents the distribution of the probability of making a claim in a sample of service categories separately for sick and healthy individuals. Services reported in the figure include cardiac care, renal care, general medicine, and laboratory.

Appendix Table 8: Correlation between negotiated prices and network breadth

	Log negotiated price (1)	Log total cost (2)
Network breadth	0.423	3.793
	(0.154)	(0.195)
Controls		
Fraction of enrollees with diseases	Y	Y
Fraction male	Y	Y
Log average income	Y	Y
Number of enrollees	Y	Y
Market-service-year fixed effects	Y	Y
Observations	7,014	7,014

Note: Table presents an OLS regression of the log of negotiated service prices on network breadth in column (1) and of the log of total healthcare costs per service on network breadth in column (2). An observation is an insurer-service-market-year. Negotiated prices are calculated as the average price across providers weighted by number of claims. Specifications control for the fraction of males; fraction of enrollees with cancer, diabetes, cardiovascular disease, pulmonary disease, renal disease, and other other diseases; log of average income; and number of enrollees. Specifications include market-service-year fixed effects.

Appendix Table 9: Correlation between claim probabilities and network breadth

	Claim probability	
	Full sample (1)	Estimation sample (2)
Network breadth	-0.00021 (0.00017)	-0.00002 (0.00010)
Fixed effects		
Consumer type	Y	Y
Service	Y	Y
Market	Y	Y
Individuals x Services	18,727,206	10,000,000

Note: Table presents an OLS regression of the claim probability on network breadth. An observation is an individual-service. Column (1) uses a random sample of 1 million continuously enrolled individuals. Column (2) uses the subsample of new enrollees for model estimation. Every specification includes consumer type, service, and market fixed effects. Standard errors are clustered at the consumer type level.

Appendix Table 10: Correlation between diagnosis probability and network breadth

	Any diagnosis in 2011
Weighted network breadth	-0.00003 (0.00109)
Controls	
Claim probabilities	Y
Market fixed effects	Y
Individuals	2,783,735

Note: Table presents an OLS regression of an indicator of being diagnosed with any chronic condition in 2011 on network breadth weighted by the claim probabilities. Estimation uses the subsample of continuously enrolled individuals who did not have a diagnosis in 2010. Specification controls for the service claim probabilities and includes market fixed effects. Standard errors are clustered at the market level.

6.2 In-sample demand model fit

This appendix shows the observed and predicted market shares in the country and in the three largest markets for every insurer, as a measure of the in-sample demand model fit.

Appendix Table 11: National market shares

Insurer	Observed	Predicted
EPS001	2.42	2.42
EPS002	7.50	7.45
EPS003	4.69	4.70
EPS005	6.19	6.23
EPS008	6.56	6.59
EPS009	2.42	2.45
EPS010	9.48	9.55
EPS012	2.12	2.09
EPS013	10.62	10.66
EPS016	15.23	15.19
EPS017	9.58	9.53
EPS018	4.66	4.65
EPS023	3.97	3.96
EPS037	14.57	14.54

Note: Table presents observed and model-predicted national market shares using the demand model.

Appendix Table 12: Market shares in three largest markets

	Market 05		Market 11		Market 76	
Insurer	Obs	Pred	Obs	Pred	Obs	Pred
EPS001	0.81	0.82	4.29	4.28	1.14	1.12
EPS002	5.25	5.20	9.46	9.45	2.91	2.99
EPS003	3.21	3.22	8.18	8.16	0.82	0.82
EPS005	1.37	1.39	11.29	11.37	2.62	2.64
EPS008	—	—	14.72	14.78	—	—
EPS009	9.44	9.55	—	—	—	—
EPS010	26.79	27.06	3.26	3.23	4.39	4.43
EPS012	—	—	—	—	10.83	10.67
EPS013	11.51	11.48	9.15	9.21	7.58	7.68
EPS016	24.91	24.72	3.79	3.77	27.57	27.65
EPS017	—	—	16.72	16.64	—	—
EPS018	—	—	0.15	0.16	23.45	23.40
EPS023	2.29	2.31	6.63	6.59	1.85	1.81
EPS037	14.42	14.26	12.36	12.38	16.83	16.79

Note: Table presents observed and model-predicted market shares in the three largest markets using the demand model.

6.3 Alternative specifications

This appendix presents alternative demand specifications to provide suggestive evidence of my identification arguments and modelling choices.

Appendix Table 13: Insurer demand with star hospital indicator

Variable		Network Breadth	OOP spending	Star hospital
Mean		2.32 (0.42)	-2.42 (0.11)	0.67 (0.45)
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)	0.31 (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	-0.42 (0.06)	0.16 (0.14)	
	Age 65 or more	(ref)	(ref)	
Diagnoses	Cancer	0.54 (0.05)	0.46 (0.09)	
	Diabetes	-0.11 (0.08)	0.41 (0.12)	
	Cardio	-0.51 (0.04)	0.19 (0.08)	
	Pulmonary	-0.61 (0.11)	1.11 (0.14)	
	Renal	1.87 (0.14)	1.53 (0.08)	
	Other	-0.44 (0.06)	0.88 (0.09)	
	Healthy	(ref)	(ref)	
Insurer	High-quality	1.08 (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 insurer choice model including a measure of star hospital coverage equal to $\sum_k q_{\theta k} Star_{jkm}$, where $Star_{jkm}$ is an indicator for insurer j covering a star hospital in market m for service k. Specification includes insurer-by-market fixed effects. Robust standard errors in parenthesis.

Appendix Table 14: Insurer demand with diagnosis in January

Variable		Network Breadth	OOP spending
Mean		1.67 (0.41)	-1.44 (0.1)
Interactions			
Demographics	Male	0.11 (0.02)	0.06 (0.07)
	Age 19-24	-0.52 (0.05)	1.63 (0.12)
	Age 25-29	-1.12 (0.05)	0.56 (0.14)
	Age 30-34	-1.38 (0.05)	0.46 (0.15)
	Age 35-39	-1.43 (0.05)	0.30 (0.19)
	Age 40-44	-1.24 (0.05)	0.64 (0.18)
	Age 45-49	-1.11 (0.05)	0.64 (0.16)
	Age 50-54	-0.92 (0.05)	0.81 (0.14)
	Age 55-59	-0.87 (0.06)	0.46 (0.15)
	Age 60-64	-0.43 (0.06)	0.01 (0.15)
	Age 65 or more	(ref)	(ref)
Diagnoses	Cancer	0.32 (0.13)	0.07 (0.23)
	Diabetes	-0.02 (0.16)	0.94 (0.24)
	Cardio	0.09 (0.07)	0.32 (0.16)
	Pulmonary	-1.31 (0.28)	1.52 (0.24)
	Renal	0.97 (0.39)	1.29 (0.11)
	Other	0.00 (0.14)	0.46 (0.19)
	Healthy	(ref)	(ref)
Insurer	High-quality	1.23 (0.31)	—
Location	Rural	4.08 (0.04)	-0.02 (0.1)
	Urban	(ref)	(ref)
Income	Low	0.26 (0.03)	-1.83 (0.16)
	High	(ref)	(ref)
N		5,544,805	
N enrollees		500,000	
Pseudo-R^2		0.15	

Note: Table presents insurer choice model obtaining diagnoses from claims made in January 2011. Specification includes insurer-by-market fixed effects. Robust standard errors in parenthesis.

Appendix Table 15: Insurer demand with network breadth weighted by provider size

Variable		Network Breadth	OOP spending
Mean		2.10 (0.39)	-2.32 (0.11)
Interactions			
Demographics	Male	0.28 (0.03)	-0.08 (0.07)
	Age 19-24	-1.00 (0.07)	1.66 (0.12)
	Age 25-29	-1.91 (0.07)	0.83 (0.12)
	Age 30-34	-2.20 (0.07)	0.76 (0.14)
	Age 35-39	-2.30 (0.07)	0.57 (0.17)
	Age 40-44	-2.02 (0.07)	0.70 (0.16)
	Age 45-49	-1.71 (0.07)	0.74 (0.14)
	Age 50-54	-1.40 (0.07)	0.83 (0.12)
	Age 55-59	-1.20 (0.08)	0.59 (0.14)
	Age 60-64	-0.59 (0.09)	0.24 (0.14)
	Age 65 or more	(ref)	(ref)
Diagnoses	Cancer	1.61 (0.07)	0.56 (0.09)
	Diabetes	-0.16 (0.11)	0.39 (0.12)
	Cardio	-0.50 (0.05)	0.29 (0.08)
	Pulmonary	-0.87 (0.13)	1.07 (0.14)
	Renal	2.00 (0.22)	1.42 (0.08)
	Other	-0.53 (0.07)	0.83 (0.09)
	Healthy	(ref)	(ref)
Insurer	High-quality	0.96 (0.27)	—
Location	Rural	5.63 (0.06)	-0.39 (0.1)
	Urban	(ref)	(ref)
Income	Low	0.75 (0.05)	-1.83 (0.15)
	High	(ref)	(ref)
N		5,544,805	
N enrollees		500,000	
Pseudo-R^2		0.15	

Note: Table presents insurer choice model with network breadth weighted by each provider's number of beds. The denominator in network breadth is the total number of beds in the market and the numerator is the number of beds included in the insurer's network. Specification includes insurer-by-market fixed effects. Robust standard errors in parenthesis.

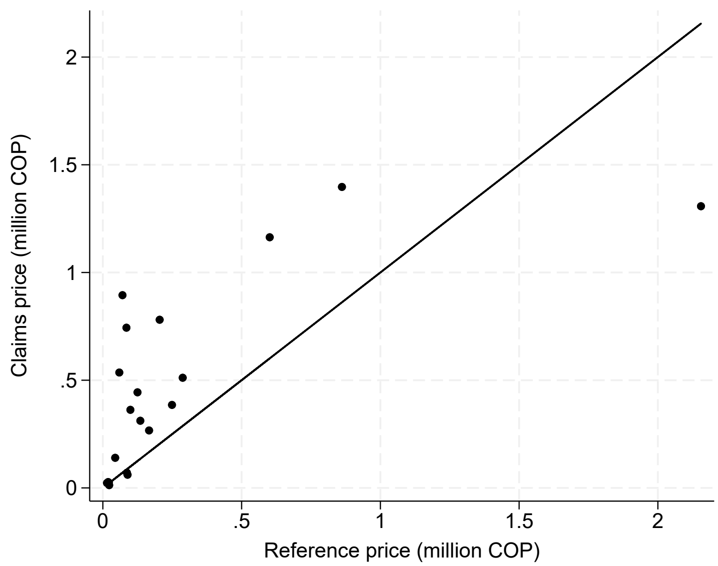
Appendix Table 16: Insurer demand with expectations over diagnoses

Variable		Network Breadth	OOP spending
Mean		27.11 (0.73)	-5.12 (0.18)
Interactions			
Demographics	Male	0.54 (0.02)	-0.11 (0.17)
	Age 19-24	0.53 (0.05)	10.43 (0.32)
	Age 25-29	-0.23 (0.05)	0.79 (0.24)
	Age 30-34	-0.53 (0.05)	-0.96 (0.32)
	Age 35-39	-0.59 (0.05)	-1.38 (0.41)
	Age 40-44	-0.49 (0.05)	-0.68 (0.46)
	Age 45-49	-0.49 (0.05)	1.99 (0.36)
	Age 50-54	-0.36 (0.05)	2.68 (0.32)
	Age 55-59	-0.5 (0.06)	0.75 (0.3)
	Age 60-64	-0.24 (0.06)	0.02 (0.24)
	Age 65 or more	(ref)	(ref)
Insurer	High-quality	-6.97 (0.52)	—
Location	Rural	4.06 (0.04)	-1.45 (0.24)
	Urban	(ref)	(ref)
Income	Low	0.17 (0.03)	-6.13 (0.24)
	High	(ref)	(ref)
N		5,544,805	
N enrollees		500,000	
Pseudo-R^2		0.15	

Note: Table presents insurer choice model where consumers have expectations over diagnoses and services. Let $\tilde{\theta}$ be a combination of sex and age group. Network breadth is calculated as $\sum_d \sum_k \gamma_{d\tilde{\theta}} q_{\theta k} H_{jkm}$ and out-of-pocket costs are calculated as $\sum_d \gamma_{d\tilde{\theta}} c_{\theta jm}$, where $\gamma_{d\tilde{\theta}}$ is the probability of having diagnosis d conditional on $\tilde{\theta}$. Specification includes insurer-by-market fixed effects. Robust standard errors in parenthesis.

Appendix 7 Service reference prices

In 2005, the Colombian government published a list of reference prices for all the services included in the national health insurance plan. The list was created by a group of government officials and medical experts with the purpose of reimbursing healthcare providers in the event of terrorist attacks, natural disasters, and car accidents (Decree 2423 of 1996). Although they were not meant to guide price negotiations between insurers and providers, there is evidence that insurers use these reference prices as starting points in their negotiations with providers (Ruiz et al., 2008). Appendix figure 9 shows that references prices are highly correlated with negotiated prices from the claims data.

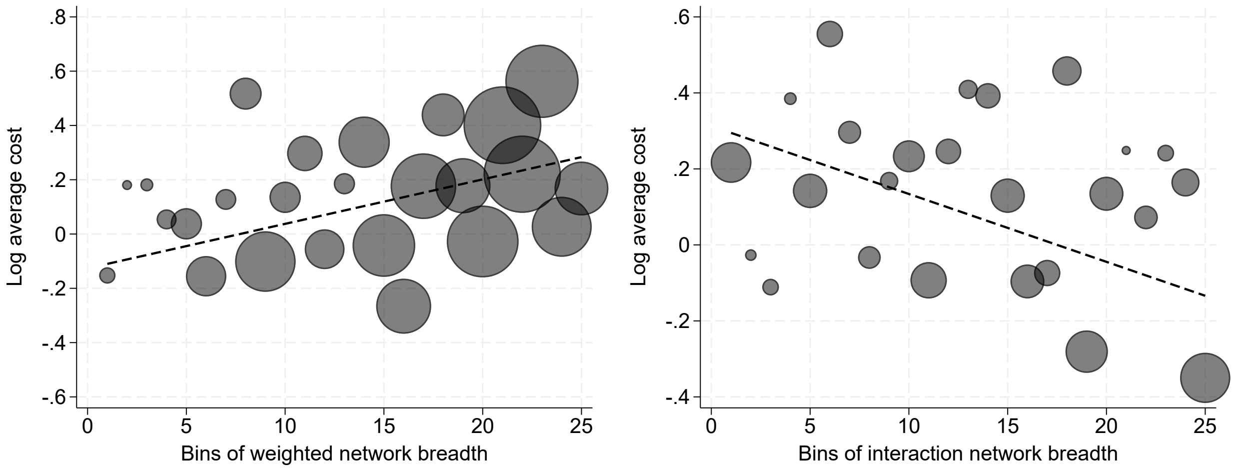


Appendix Figure 9: Negotiated prices and reference prices

Note: Figure presents a scatter plot of average negotiated price obtained from the claims data and average reference price per service. The black line is a 45 degree line.

Appendix 8 Additional average cost results

This appendix presents additional descriptive evidence and robustness checks to support my identification and functional form assumption for the average cost model.

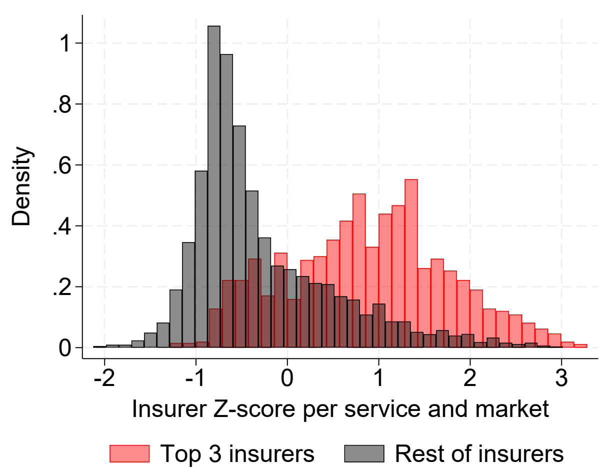


(a) Service network breadth

(b) Service network breadth interactions

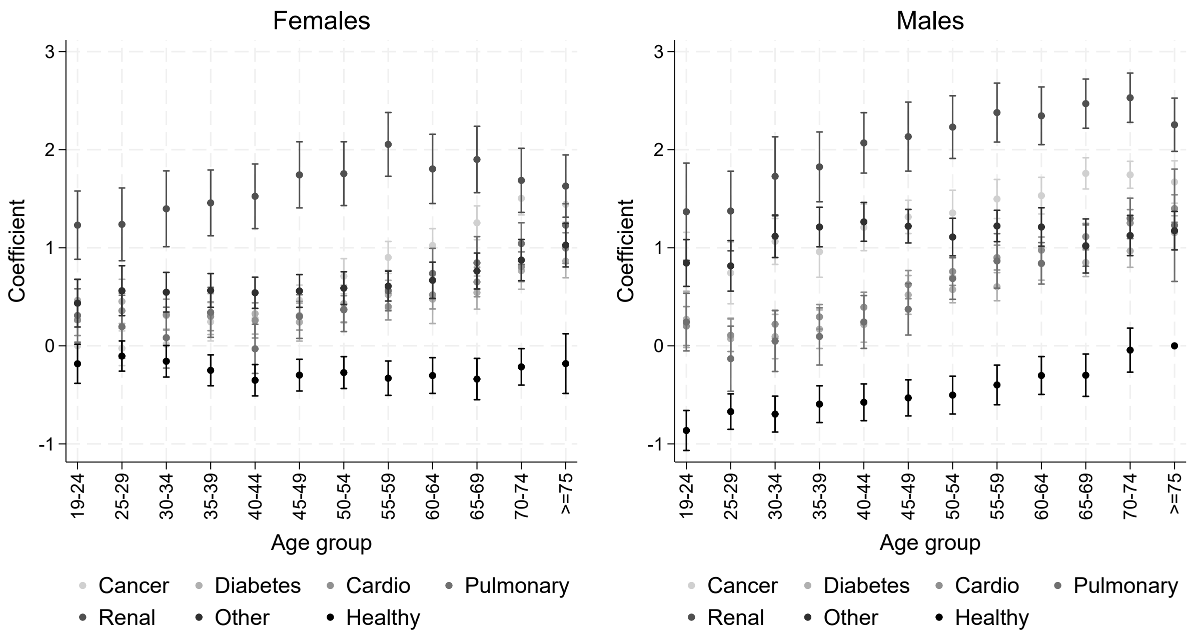
Appendix Figure 10: Empirical relation between average costs and networks

Note: Panel A of the figure presents a scatter plot of the log of average costs per enrollee by 25 bins of network breadth weighted by the claim probability across services ($\sum_k q_{\theta k} H_{jkm}$). Panel B presents a scatter plot of the log of average costs per enrollee by 50 bins of the interaction between weighted network breadth across pairs of services. Dots are weighted by the number of enrollees. Dashed lines correspond to linear fits.



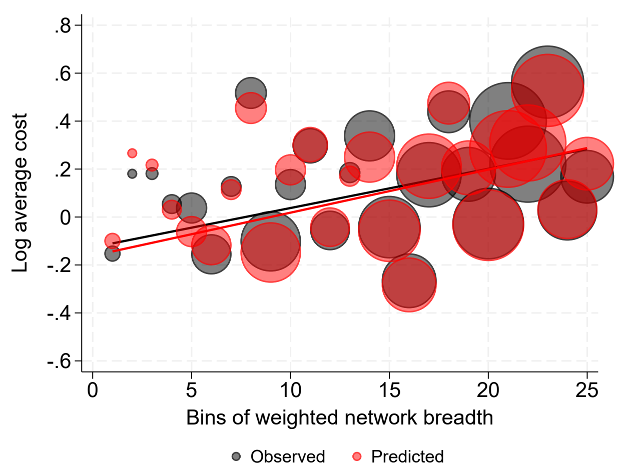
Appendix Figure 11: Standardized network breadth per service and market

Note: Figure presents distribution of network breadth standardized within service and market. The red histogram corresponds to the three largest insurers (EPS013, EPS016, and EPS037). The black histogram corresponds to the rest of insurers. Standardized values of network breadth are obtained by subtracting the service-market mean and dividing by the service-market standard deviation. The top 3 insurers have consistently broad networks across services, while the rest tend to have narrow networks across services.

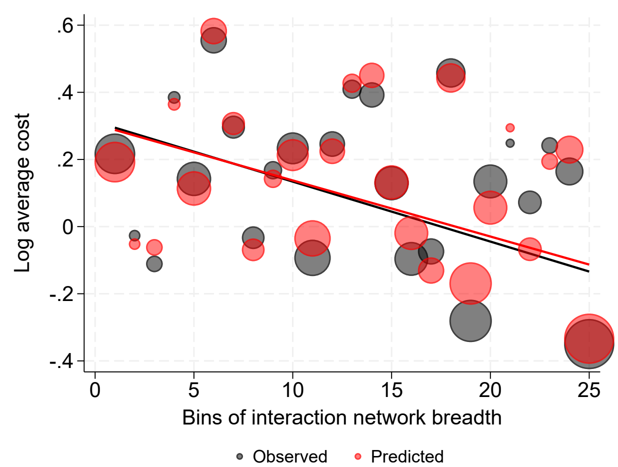


Appendix Figure 12: Consumer type fixed effects

Note: Figure presents point estimate and 95 percent confidence interval of the consumer type fixed effects in the average cost function. The left panel presents fixed effects for females separately by disease category and age group. The right panel presents fixed effects for males separately by disease category and age group.



(a) Service network breadth



(b) Service network breadth interactions

Appendix Figure 13: Average cost model fit

Note: Panel A of the figure presents a scatter plot of observed and predicted log average cost by 25 bins of service network breadth weighted by the claim probabilities ($\sum_k q_{\theta k} H_{jkm}$). Panel D presents a scatter plot of observed and predicted log average cost by 25 bins of service network breadth interactions weighted by the claim probabilities ($\sum_k^{K_m} \sum_{l \neq k}^{K_m} q_{\theta k} q_{\theta l} H_{jkm} H_{jlm}$). Dots are weighted by the number of enrollees.

Appendix Table 17: Price mechanism for economies of scope

	Log negotiated price	
	(1)	(2)
Fraction of other services where the provider is in network	-0.086 (0.002)	—
Avg. network breadth for other services	—	-1.531 (0.027)
Controls		
Fraction of enrollees with diseases	Y	Y
Fraction male	Y	Y
Log average income	Y	Y
Number of enrollees	Y	Y
Market-service-year fixed effects	Y	Y
Observations	76,843	80,129

Note: Table presents OLS regression of the log of the negotiated price for service k between insurer j and provider h on the fraction of other services $l \neq k$ for which the provider is in network in column (1) and on average network breadth across all other services $l \neq k$ in column (2). An observation in this table is a combination of insurer, provider, service, market, year. Specifications control for the fraction of males; fraction of enrollees with cancer, diabetes, cardiovascular disease, pulmonary disease, renal disease, and other other diseases; log of average income; and number of enrollees for the insurer. Specifications include market-service-year fixed effects. Estimation is conditional on the provider being in-network for service k. The reduction in the number of observations in column (1) is due to providers that are in-network for service k only and for which the fraction is indeterminate because it is divided by zero. Robust standard errors in parenthesis.

Appendix Table 18: Patient-level estimates of average cost

log(cost+1)	coef	se
Network breadth	2.63	(0.06)
Scope economies	-146.53	(2.76)
Reference price	—	—
Insurer		
EPS001	-1.65	(0.01)
EPS002	0.50	(0.01)
EPS003	0.82	(0.01)
EPS005	2.06	(0.01)
EPS008	1.83	(0.01)
EPS009	0.98	(0.01)
EPS010	0.81	(0.01)
EPS012	1.31	(0.01)
EPS013	1.37	(0.01)
EPS016	0.21	(0.01)
EPS017	1.41	(0.01)
EPS018	1.32	(0.01)
EPS023	1.70	(0.01)
EPS037	(ref)	(ref)
N	9,976,897	
R^2	0.24	

Note: Table presents OLS regression of log healthcare cost (plus 1) per patient on network breadth, economies of scope, and service reference price. Uses a random sample of 500,000 patients. Includes insurer, market, and consumer type fixed effects. Reference price is omitted due to multicollinearity. Robust standard errors in parenthesis.

Appendix Table 19: Average cost with star hospitals

Variable	coef	se
Network breadth	0.39	(0.09)
Star hospital	0.39	(0.19)
Scope economies	-105.52	(45.49)
Reference price	41.01	(6.64)
Insurer		
EPS001	-0.04	(0.05)
EPS002	-0.18	(0.04)
EPS003	-0.12	(0.04)
EPS005	-0.25	(0.04)
EPS008	0.15	(0.05)
EPS009	0.20	(0.04)
EPS010	-0.08	(0.06)
EPS012	-0.04	(0.04)
EPS013	-0.13	(0.03)
EPS016	-0.02	(0.03)
EPS017	-0.11	(0.04)
EPS018	0.05	(0.06)
EPS023	-0.16	(0.04)
EPS037	(ref)	(ref)
N	8,662	
R^2	0.66	

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

Appendix 9 Dropout and transition probabilities

To estimate the marginal cost of network formation in the third step of my model, I first need to compute the probability that consumer type θ drops out of the contributory system and the probability that consumer type θ in period t transitions into θ' in period $t+1$. I use the data from *all* enrollees to the contributory system in 2010 and 2011, regardless of their enrollment spell length, to compute dropout probabilities. For each consumer type θ, I calculate the probability that she drops out of the system non-parametrically as 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 20 presents the mean and standard deviation of the dropout probability conditional on diagnoses, sex, and age.

I use a non-parametric approach to compute transition probabilities as well, 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. Appendix table 21 presents the mean and standard deviation in parenthesis of transition probabilities from having cancer, cardiovascular disease, diabetes, renal disease, other diseases, 2 or more diseases, and no diseases in period t to having each of these 9 diagnoses in period $t+1$.

Appendix Table 20: Dropout probability

	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: Mean and standard deviation in parenthesis of dropout probabilities conditional on diagnosis in the first panel. age group in the second panel, and sex in the third panel.

Appendix Table 21: 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 presents mean and standard deviation in parenthesis of transition probabilities across diagnoses. Summary statistics are calculated across sex-age combinations in each cell.

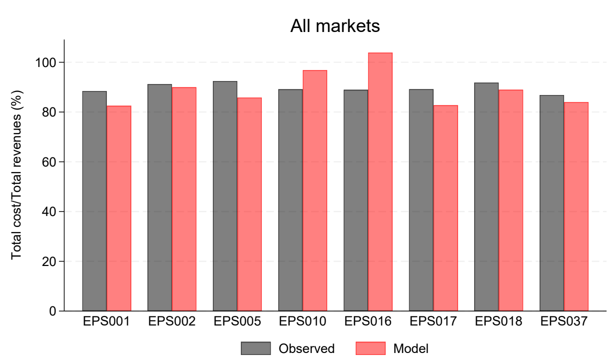
Appendix 10 Additional fixed cost results

This appendix presents additional descriptive evidence for marginal variable profits and measures of out-of-sample model fit.

Appendix Table 22: Summary statistics of marginal variable profits

Insurer	mean	sd
EPS001	10,040	32,640
EPS002	49,683	119,549
EPS003	31,825	103,891
EPS005	38,409	128,447
EPS008	65,442	163,999
EPS010	55,998	164,682
EPS013	97,856	204,481
EPS016	121,612	271,489
EPS017	99,873	260,659
EPS018	86,641	218,653
EPS023	31,752	94,038
EPS037	102,637	191,252

Note: Table presents mean and standard deviation of marginal variable profits per insurer. Measured in millions of Colombian pesos per service.



Appendix Figure 14: Out-of-sample model fit

Note: Figure presents the model-predicted ratio of total costs (total average costs plus fixed costs) to total revenues and the observed ratio from insurers' public income statements. Public income statements are obtained from https://docs.supersalud.gov.co/PortalWeb/SupervisionRiesgos/EstadisticasEPSRegimenContributivo/RC%20Estados%20financieros%20Dic%202011-CT2011.pdf. Because my model is estimated on the sample of new enrollees with continuous enrollment and public income statements correspond to all enrollees, I scale up estimated insurer revenues and costs by multiplying by the total number of enrollees in the country and dividing by the number of new enrollees.

Appendix Table 23: First-stage regression for fixed cost estimation

	Service network breadth	
Demand at avg network	0.80	(0.09)
Insurer FE		
EPS001	(ref)	(ref)
EPS002	0.14	(0.02)
EPS003	0.06	(0.02)
EPS005	0.12	(0.02)
EPS008	0.01	(0.03)
EPS009	0.10	(0.04)
EPS010	-0.12	(0.02)
EPS012	0.23	(0.04)
EPS013	0.17	(0.02)
EPS016	0.09	(0.02)
EPS017	0.19	(0.03)
EPS018	0.21	(0.03)
EPS023	0.01	(0.02)
EPS037	0.28	(0.02)
Market FE		
05	(ref)	(ref)
11	-0.01	(0.02)
13	-0.05	(0.02)
25	-0.04	(0.02)
76	-0.07	(0.02)
Constant	0.18	(0.02)
N	1060	
F-statistic	76.4	

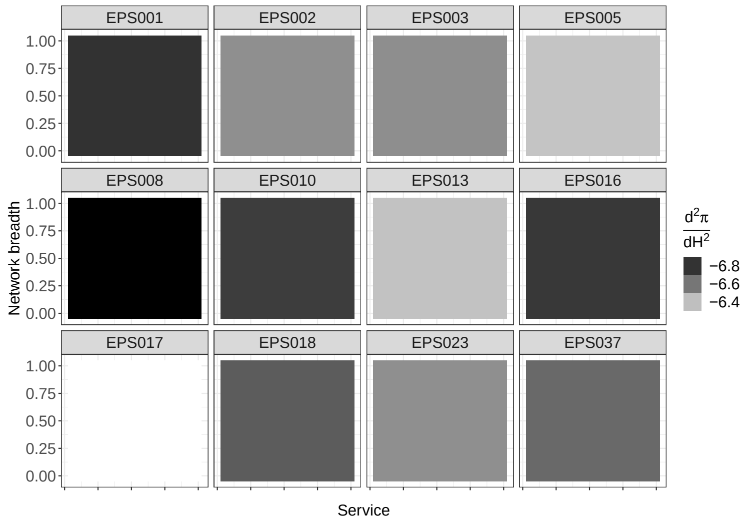
Note: Table presents first stage regression of service network breadth on insurer fixed effects, market fixed effects, and the instrument which is predicted insurer demand assuming that all insurers have service network breadth equal to the market average. Robust standard errors in parenthesis. Table reports the F-statistics associated with the instrument.

Appendix 11 Concavity of the profit function

The second partial derivative of the short-run profit function with respect to network breadth for service k is:

$$\frac{\partial^2 \Pi_{jm}}{\partial H_{jkm}^2} = \sum_i \left((R_{\theta m} - (1-r_i)AC_{\theta jm}) \frac{\partial^2 s_{ijm}}{\partial H_{jkm}^2} - 2(1-r_i)\frac{\partial s_{ijm}}{\partial H_{jkm}} \frac{\partial AC_{\theta jm}}{\partial H_{jkm}} - (1-r_i) s_{ijm} \frac{\partial^2 AC_{\theta jm}}{\partial H_{jkm}^2} \right) - 2\omega$$

To check whether this derivative is negative at all values of network breadth, I conduct a partial equilibrium exercise where each insurer is allowed to deviate and set $H_{jkm} = \{0, 0.1, 0.2, 0.3, ..., 1\}$ for each service k, holding its rivals' choices fixed at observed levels. I compute this exercise with data from Bogotá as in my counterfactuals. Appendix figure 15 presents the results. Each panel corresponds to the deviating insurer, and displays the value of the second partial derivative for each service in the horizontal axis and for each value of network breadth in the vertical axis. Results show that the second partial derivative of the short-run profit function is negative for all insurers and services.



Appendix Figure 15: Second partial derivative of short-run profit function

Note: Figure presents the second partial derivative of insurers' short-run profit function for every service. Each panel corresponds to an insurer, the horizontal axis is a service, and the vertical axis is the value of service network breadth.

Appendix 12 Additional counterfactual results

Appendix Table 24: Insurer demand

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

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

Appendix Table 25: Networks, costs, and welfare under homogeneous costs

Variable	(1) Avg cost	(2) Fixed cost
Panel A. Overall		
Mean network breadth	0.24	-7.56
Avg. cost per enrollee	0.73	-0.08
Total avg. cost	1.37	2.07
Consumer surplus (sick)	0.95	1.67
Consumer surplus (healthy)	0.62	1.35
Panel B. Service network breadth		
Otorhinolaryngologic care	0.27	-9.45
Cardiac care	0.25	-8.30
Gastroenterologic care	0.26	-8.68
Renal care	0.26	-9.94
Gynecologic care	0.26	-8.60
Orthopedic care	0.25	-9.10
Imaging	0.15	-5.02
General medicine	0.15	-7.17
Laboratory	0.09	-5.16
Hospital admission	0.22	-6.52

Note: Panel A presents the percentage change in mean network breadth, insurer total average costs, short-run average cost per enrollee, and long-run consumer welfare for sick and healthy individuals, in the scenario with homogeneous average costs in column (1), and the scenario with homogeneous average and network formation costs in column (2). Insurer fixed effects in average costs and network formation costs are set to the average fixed effect. Panel B presents the percentage change in mean network breadth by service category.