Payment Contracts in Healthcare and Their Impact on C-section Rates*

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May 9, 2024

Abstract

A fundamental question in health economics is how financial incentives affect medical treatment decisions. We study this question in the context of delivery procedure choice in Colombia where payment contracts vary across insurer-hospital pairs. Using a dynamic differences-in-differences design, we show that transitioning to a fee-for-service contract generates a 22 percentage point (p.p) increase in c-section rates. We use a structural model to evaluate two counterfactual payment contract regulations: full capitation and a c-section price ceiling. Both regulations reduce delivery costs, but there is a trade-off between the two with respect to reducing c-section rates and consumer surplus.

Keywords: Moral hazard, Cesarean section, Fee-for-service, Provider treatment decisions

JEL codes: I11, I13, I18.

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1 Introduction

A fundamental question in health economics is how treatment choices for medical conditions are made. Research into this question comes to bear when public health professionals warn of an imbalance between medical need for a treatment and its provision. Such warnings have been raised with respect to opioid prescriptions (Barnett et al., 2017), oral rehydration salts (Wagner et al., 2024), cesarean sections (c-section) (WHO, 2021, 2018), among others. Well-designed non-clinical interventions may reduce this imbalance, thereby improving public health and potentially reducing healthcare spending if the alignment of need and use prevents costly adverse health events.

In this paper, we study how payment contracts between health insurers and providers affect treatment decisions and other market outcomes of interest. The most common types of payment contracts in several health systems are fee-for-service (FFS) and capitation, which present starkly different incentives to contracting parties (Di Guida et al., 2019; Zuvekas and Cohen, 2016; Hennig-Schmidt et al., 2011). In the fragmented insurance landscape of the U.S., payment contracts are typically uniform across all services within an insurer-hospital pair. Studies examining the effect of payment contracts on treatment choices have therefore leveraged variation in these contracts over time (e.g., Kuziemko et al., 2018; Gruber et al., 1999), which may provide partial insight into the impact of regulating how insurers reimburse providers for an individual treatment.

We study this question in the context of delivery procedure choice in the Colombian health care system. This setting is ideal for our purposes, as insurers and hospitals in Colombia negotiate payment contracts and prices separately for each service included in the national insurance plan, while other plan features are strictly regulated by the government (including premiums, cost-sharing, and benefits). Our data are comprised of enrollment and health claims made between 2010 and 2011 by all pregnant women covered in Colombia's contributory healthcare system. With a national c-section rate of 53 percent during our sample period, Colombia is considered to be at the center of what has been termed a "c-section epidemic," making it particularly suitable for our study of how payment contracts impact treatment choice.[1] In doing so, we complement prior work studying the determinants of c-section rates and their variation across geographies (Robinson et al., 2024; Fischer et al., 2023).

We start by developing reduced-form evidence of the effect of payment contracts on several outcomes. We exploit changes in payment contracts within insurer-hospital pair over time using a dynamic differences-in-differences approach. For insurer-hospital pairs that switch the payment contract for c-sections from capitation to FFS, we find a 22 percentage point (p.p) increase in the c-section rate. C-section prices and hospital market shares also increase 31 percent and 10 p.p, respectively. In contrast, we find that pairs switching from FFS to capitation experience a 25 p.p reduction in c-section rates and a 13 percent decrease in c-section prices. Effects on c-section rates are larger for women whose diagnoses indicate that their pregnancies are "low risk" and for whom c-section is unlikely to be medically indicated. We refer to this responsiveness of hospitals to payment contracts as "hospital moral hazard." Our results indicate that changes to payment contracts in the presence of hospital moral hazard have the potential to affect treatment decisions as well as hospital choice and negotiated prices. Understanding the mechanisms by which changes in payment contracts affect these market outcomes will help us characterize the trade-off between changing treatment choices and healthcare costs.

To that end, we develop a structural model that endogenizes hospital responses to payment contracts. In the model, insurers and hospitals first negotiate prices for vaginal delivery and c-section according to a Nash-in-Nash protocol. Then, women make their insurance enrollment decisions. Conditional on enrollment, women choose an in-network hospital for their childbirth. Finally, hospitals and patients jointly choose the delivery procedure. Estimation of the delivery choice model shows that women are 18 percent more likely to receive

[1] See https://www.eltiempo.com/salud/el-abuso-de-las-cesareas-en-colombia-juan-gossain-497792.

a c-section if the FFS c-section price increases by 40 percent, consistent with our reduced-form evidence of hospital moral hazard. Hospital demand estimates show that women are sensitive to out-of-pocket prices, but that hospitals reimbursed under FFS face a more inelastic demand: the c-section price elasticity equals -0.26 under capitation and -0.10 under FFS. While we cannot say definitively where the preference for FFS hospitals comes from, we find a strong correlation between the use of FFS and treatment of high risk pregnancies, which may suggest that hospitals under FFS have higher clinical expertise. In line with this result, our bargaining model shows that the price-cost margin is higher for c-sections than for vaginal deliveries for every insurer-hospital pair and payment contract.

We use the structural model estimates to simulate outcomes under alternative payment contracts. Our first counterfactual sets the payment contract for all insurer-hospital pairs and for both delivery procedures to capitation. The results of this counterfactual both corroborate and add nuance to our differences-in-differences results. We find that under full capitation the c-section rate decreases 10 p.p. on average. Total spending in deliveries decreases 9 percent, which is a combination of c-sections becoming cheaper but vaginal deliveries becoming more expensive. Importantly, declines in c-section rates are concentrated among low-risk women for whom c-section is unlikely to be medically required. In a second counterfactual, we examine the impact of imposing a price ceiling on c-sections. We find that this policy has virtually no effect on the c-section rate but that it reduces total delivery spending by a similar magnitude as our previous counterfactual. Together, our results highlight the potential for payment contract regulations to meaningfully impact c-section rates and the costs of delivery.[2]

Related literature. We contribute to a large literature on the response of healthcare providers to financial incentives, of which Chandra et al. (2011) provides a review. A sizable portion of this literature is devoted to the impact of prices and payment contracts on obstet-

[2]Examples of other policies for decreasing c-section rates might include a cap on c-section rates such as the one implemented in California as part of the Maternity Care Honor Roll program; see https://hcai.ca.gov/visualizations/maternity-care-honor-roll-2023/.

ric care. For example, Kuziemko et al. (2018) and Aizer et al. (2007) find reductions in the quality of maternal health care after a transition from FFS to managed care in Medicaid. Other papers document how payment contracts influence delivery choice. For instance Johnson and Rehavi (2016) and Alexander (2017) show that FFS regimes and higher FFS prices result in more c-sections, respectively. Relative to these papers, where changes in payment contracts apply to all services, we evaluate payment contract variation across services within an insurer-hospital pair in a similar style as Foo et al. (2017). Our results highlight the importance of payment contracts for the choice of a delivery procedure that can have downstream effects on health outcomes (Haas et al., 1993; Card et al., 2023; Kallianidis et al., 2018).

We also contribute to the literature on payment contracts in healthcare by modeling price negotiations and characterizing hospital incentives under multiple contracts. Empirical studies in this literature include Gaynor et al. (2023) who derive the optimal nonlinear payment contract for an expensive anemia treatment, and Ho and Lee (2023) who examine multidimensional contracts in the context of pharmacy benefit managers. Our contribution is in embedding variation in payment contracts into a structural model that endogenizes treatment decisions, complementing theoretical work on provider moral hazard as in Acquatella (2022) and structural work on insurer responses to financial incentives as in Ho and Pakes (2014).

The remainder of this paper is as follows. Section 2 describes the Colombian healthcare system. Section 3 introduces our data. Section 4 presents our *did* analysis. Section 5 presents our structural model. Section 6 discusses parameter identification. Section 7 presents estimation results. Section 8 simulates policy counterfactuals. Section 9 concludes.

2 Background

Colombia's statutory healthcare system is divided into a contributory regime and a subsidized regime. The contributory regime covers the 51 percent of the population that are above a monthly income threshold and are able to pay the required tax contributions to the system. The remaining 49 percent of the population who are below the income threshold are covered by the subsidized regime, which is fully funded by the government. The healthcare system has near-universal coverage and provides access to a national health insurance plan through private insurers.

The national plan covers a comprehensive list of more than 7 thousand services and procedures and more than 700 prescription medications as of 2011. Cost-sharing rules are specified by the government based on whether the enrollee makes less than 2, between 2 and 5, or 5 than five times the monthly minimum wage. Coinsurance rates, copays, and maximum out-of-pocket expenditures within each income group are standardized across insurers and hospitals.

In addition to regulating cost-sharing rules, the government sets insurance premiums to zero. Instead, private insurers receive two types of transfers from the government. At the beginning of each year, the government makes per-enrollee transfers that are risk-adjusted for the enrollee's sex, age, and municipality of residence. At the end of every year, the government also compensates insurers for a non-exhaustive list of diseases.

Insurers have discretion over which hospitals to cover for each service in the national plan. Insurers bargain prices and payment contracts for each service with hospitals in their network. The government allows insurers and hospitals to choose from among the following set of payment contracts: fee-for-service (FFS), capitation, fee-for-package, and fee-for-diagnosis. The most common payment contracts under which services are reimbursed in our data are capitation and FFS. Almost 51 percent of all claims filed during 2011 were reimbursed under capitation and another 43 percent under FFS.

When a service is reimbursed under FFS, the insurer and the hospital negotiate a price that is paid by the insurer each time the service is provided. For example, if the price of a primary care visit is \$10 and the price of a blood test is \$20, then the insurer of a patient who visits the primary care physician and receives two blood tests will pay \$50 (=\$10+\$20+\$20) to the hospital that provided those services. Payments under FFS contracts are thus retrospective and hospital revenue is proportional to the number of services provided. FFS incentivizes hospitals to over-provide services or to provide relatively more expensive services.

Under a capitation contract, insurers and hospitals decide on a set of services that will be covered and bargain over the unit price of each service in this set. The capitation payment equals the sum of unit prices across services in the capitated set and it is made for each enrollee. This payment is made once in every contracting period (typically a calendar year) and does not vary with the number of services provided. For example, if the unit price of a primary care visit is \$10 and of a blood test is \$20, then the insurer of the patient from our previous example pays \$30 to the hospital regardless of whether the patient claims those services or how many they claim.[3] In our claims data we observe FFS prices and unit capitation prices per service, hence they have the same unit of measurement.

3 Data

Our data are comprised of enrollment and claims from 256,707 unique women who have a first childbirth at a hospital that performed at least 10 childbirths under either capitation or FFS. We exclude women who have breech pregnancies (identified with ICD-10 code O32) and keep those with singleton pregnancies (identified with the procedure code in the national plan). Appendix table 1 shows the number of observations after imposing these sample restrictions.

In the claims data, we observe the date on which each claim was provided, the provider

[3] Insurers and hospitals in our setting do not negotiate "shared risk agreements" wherein costs over and above the capitation payment are split between the insurer and the hospital.

that rendered the claim, the insurer that reimbursed it, and the associated ICD-10 diagnosis code. We observe demographic information such as age, income group, and municipality of residence. Using this information, we can recover each enrollee's level of cost sharing and the risk adjustment payments that the government made to insurers for each of their enrollees. We create patient-level diagnosis indicators by grouping ICD-10 codes recorded before the delivery date in the categories created by Riascos et al. (2014).[4]

We also use ICD-10 codes to classify women with a "high-risk" pregnancy. These are women who receive an ICD-10 diagnosis code for supervision of high-risk pregnancies (O09), infections of genitourinary tract in pregnancy (O23), pregnancy-induced hypertension or pre-eclampsia (O10-O16), hemorrhage due to threatened abortion (O20), excessive vomitting during pregnancy (O21), venous complications and hemorrhoids in pregnancy (O22), diabetes mellitus in pregnancy, childbirth, and the puerperium (O24), malnutrition in pregnancy, childbirth and the puerperium (O25), abnormal findings on antenatal screening of mother (O28), and complications of anesthesia during pregnancy (O29).[5] We do not observe the woman's residential address to measure distance to hospitals in her municipality; however, later in our model we indirectly capture the impact of distance by controlling for past hospital choices. We also do not have information on whether a c-section is scheduled.

Importantly, we observe whether each claim was reimbursed under a FFS or a capitation contract and its price. In the case of FFS, the reported price is the negotiated price for that service. Patients' OOP costs for services covered under FFS equals the coinsurance rate times this reported price. For capitated claims, the reported price is the negotiated unit price of the service as explained in the previous section.Patients' OOP costs in this case equal the coinsurance rate times this reported unit price. In our pricing model of section 5, insurers and hospitals bargain over these FFS and unit capitation prices.

[4]The grouping of ICD-10 codes to diagnoses can be accessed through https://www.alvaroriascos.com/researchDocuments/healthEconomics/CLD_xCIE10.tab.

[5]While papers in the medical literature discuss how to measure pregnancy risk and other maternal and infant outcomes using multiple ICD-10 codes per claim (e.g., Handley et al., 2023), our definition of pregnancy risk is the most accurate given our data.

In some cases, prices reported in the claims data may differ from negotiated prices based on patient characteristics that are unobserved at the time of negotiations. The data excerpt in appendix table 2 shows an example of how prices can vary within insurer-hospital-service-contract. To obtain negotiated prices for vaginal delivery and c-section that do not vary within insurer-hospital pair we use Gowrisankaran et al. (2015)'s methodology. Negotiated prices equal the average prediction of linear regressions of reported prices on patient characteristics, an indicator for FFS, an indicator for c-section, and hospital fixed effects, estimated separately for each insurer. We describe this methodology in more detail in appendix B. We recover each insurer's network of delivery hospitals in every market (defined as a municipality) from observed claims, since all claims in our data correspond to in-network providers.[6]

The claims data does not report the individual obstetrician that performs deliveries in each hospital. Hence, we assume that doctors are perfect agents for hospitals and that doctors' and hospitals' incentives are perfectly aligned. This is a reasonable assumption for our analysis because the agency problem arises between the insurer and the hospital not between the hospital and the physician. The insurer wants to induce a treatment intensity, which is unobserved, by designing a contract profile which the hospital can accept or reject. The contract profile involves prices and degree of payment retrospectiveness for vaginal deliveries and c-sections.

[6]There are 1,123 municipalities in Colombia.

Table 1: Summary statistics

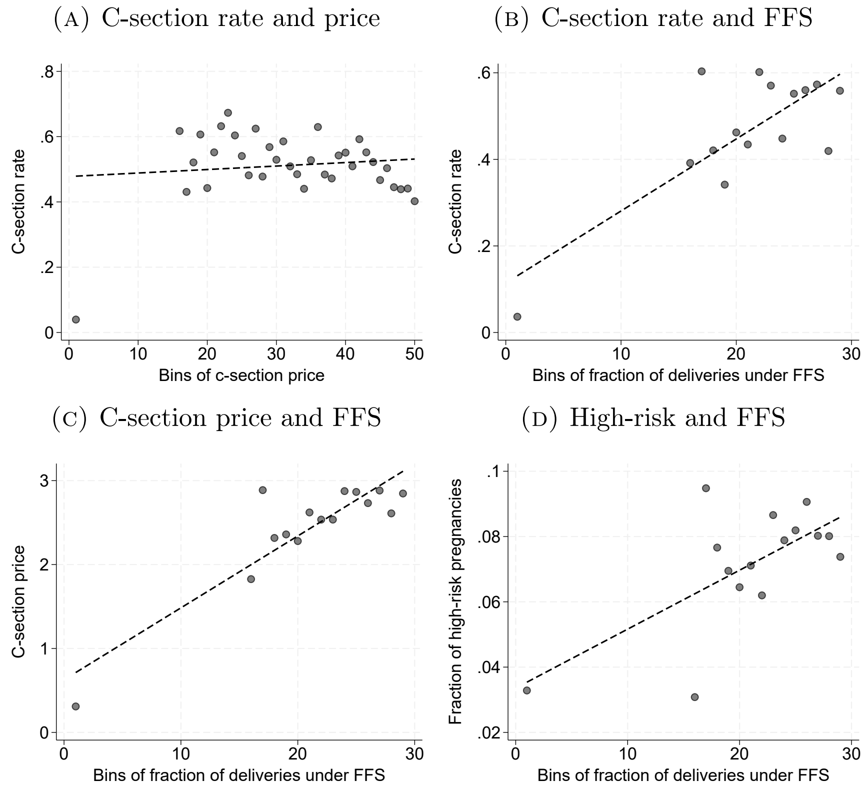
		All (1)	Vaginal (2)	C-section (3)
Contracts	Price	2.27 (1.30)	1.91 (1.29)	2.64 (1.20)
	FFS	0.82 (0.38)	0.78 (0.41)	0.86 (0.34)
	C-section	0.49 (0.50)	—	—
Demographics	Age 18-24	0.34 (0.47)	0.38 (0.48)	0.29 (0.46)
	Age 25-29	0.30 (0.46)	0.30 (0.46)	0.29 (0.46)
	Age 30-34	0.23 (0.42)	0.21 (0.41)	0.25 (0.43)
	Age 35 or more	0.14 (0.35)	0.12 (0.32)	0.17 (0.37)
	Low income	0.78 (0.42)	0.77 (0.42)	0.78 (0.41)
	Medium income	0.17 (0.38)	0.17 (0.38)	0.18 (0.38)
	High income	0.05 (0.21)	0.05 (0.23)	0.04 (0.2)
	Rural municipality	0.01 (0.10)	0.01 (0.12)	0.01 (0.08)
Health	Cancer	0.02 (0.15)	0.02 (0.14)	0.03 (0.16)
	Cardiovascular	0.01 (0.11)	0.01 (0.09)	0.02 (0.13)
	Diabetes	0.002 (0.04)	0.001 (0.03)	0.003 (0.05)
	High-risk pregnancy	0.08 (0.28)	0.07 (0.25)	0.10 (0.30)
	Cost up to delivery	1.94 (4.42)	1.58 (3.36)	2.32 (5.28)
	Length-of-stay	0.90 (1.62)	0.80 (1.52)	1.01 (1.77)
Provider characteristics	Adverse health outcome	0.02 (0.04)	0.02 (0.04)	0.02 (0.04)
	Maternal mortality	0.0005 (0.003)	0.0003 (0.001)	0.0006 (0.004)
Providers		663	655	469
Insurers		14	14	14
N		254,421	130,662	123,759

Note: Table shows mean and standard deviation in parentheses of main variables in the full sample of deliveries in column (1), conditional on vaginal deliveries in column (2), and conditional on c-sections in column (3). Prices and costs up to delivery are measured in 100s of dollars. We drop women with lengths-of-stay greater than 30 days.

Summary statistics for our sample are provided in table 1. An observation in this table is a delivery. Column (1) uses the full sample of deliveries, column (2) the sample of vaginal deliveries, and column (3) the sample of c-sections. The average price of a delivery is $226, with c-sections being $73 more expensive than vaginal deliveries. C-sections are also more likely to be covered under FFS. Women who receive a c-section are on average older and in worse health than those who receive a vaginal delivery as measured by comorbidity incidence and pregnancy risk. The average hospital in our data has a maternal mortality rate equal to 50 per 100,000 live births, which is very similar to the national rate in 2011.[7] We construct the rate of adverse health outcomes at each hospital as the fraction of all deliveries that are associated with women that have hospitalizations and ICD10 codes for puerperal sepsis (O85), infection of obstetric surgical wound (O86), and abnormal findings in abdominal cavity (R85) between one week and one month after childbirth. The average hospital in our data has a rate of adverse health outcomes equal to 1 percent.

[7] See https://data.worldbank.org/indicator/SH.STA.MMRT?locations=CO.

Figure 1: Correlations between prices, c-section rates, and payment contracts



(a) C-section rate and price

(b) C-section rate and FFS

(c) C-section price and FFS

(d) High-risk and FFS

Note: To construct this figure we collapse our data to the hospital level and compute the c-section rate, average c-section price, fraction of c-sections covered under FFS, and fraction of deliveries that correspond to high-risk women. Panel (A) shows a scatter plot of the c-section rate against bins of the average c-section price. Panel (B) shows a scatter plot of the c-section rate against bins of the fraction of c-sections covered under FFS. Panel (C) shows a scatter plot of the c-section price against bins of the fraction of c-sections covered under FFS. Panel (D) shows a scatter plot of the fraction of high-risk deliveries against bins of the fraction of c-sections covered under FFS. The dashed line in each panel corresponds to a linear fit.

To see whether payment contracts in our setting are related to the over-provision incentives that have been documented in prior literature (e.g., Adida et al., 2017; Hennig-Schmidt et al., 2011), in figure 1 we report the association between c-section prices, fraction of c-sections covered under FFS, fraction of high-risk deliveries, and c-section rates. Panel (A) shows that c-section prices are uncorrelated with the c-section rate at each hospital. Instead, panel (B) shows a steep gradient in the c-section rate by whether the procedure is covered under FFS. These correlations suggest that prices are not the main driver of over-provision incentives but rather the interaction of prices and their degree of retrospectiveness. In fact, panel (C) shows that c-section prices tend to be higher at hospitals with a higher fraction of deliveries covered under FFS. Hospitals that cover c-sections under FFS also tend to treat a higher fraction of women with high-risk pregnancies as seen in panel (D), which indicates that FFS is potentially correlated with the hospital's clinical expertise.

4 Reduced-Form Evidence

Summary statistics in section 3 indicate that there is a strong correlation between payment contracts and delivery outcomes. This correlation may be driven by selection into payment contracts or by endogenous responses of insurers and hospitals to payment contracts. In this section, we establish evidence that these correlations are a result of the causal effect of payment contracts on insurer and hospital behavior and we estimate the resulting impact on c-section rates, negotiated prices, and quality of care.

Our empirical approach exploits changes in the payment contracts established between insurer-hospital pairs at some point during the years 2010 and 2011. Insurers and hospitals in Colombia typically negotiate payment contracts annually, but the timing of such negotiations may vary across pairs. Our empirical model is therefore one of differences-in-differences (*did*) with variation in treatment timing. Treatment is defined as a change in the payment contract for c-section either from FFS to capitation or vice versa. Our estimating equation is

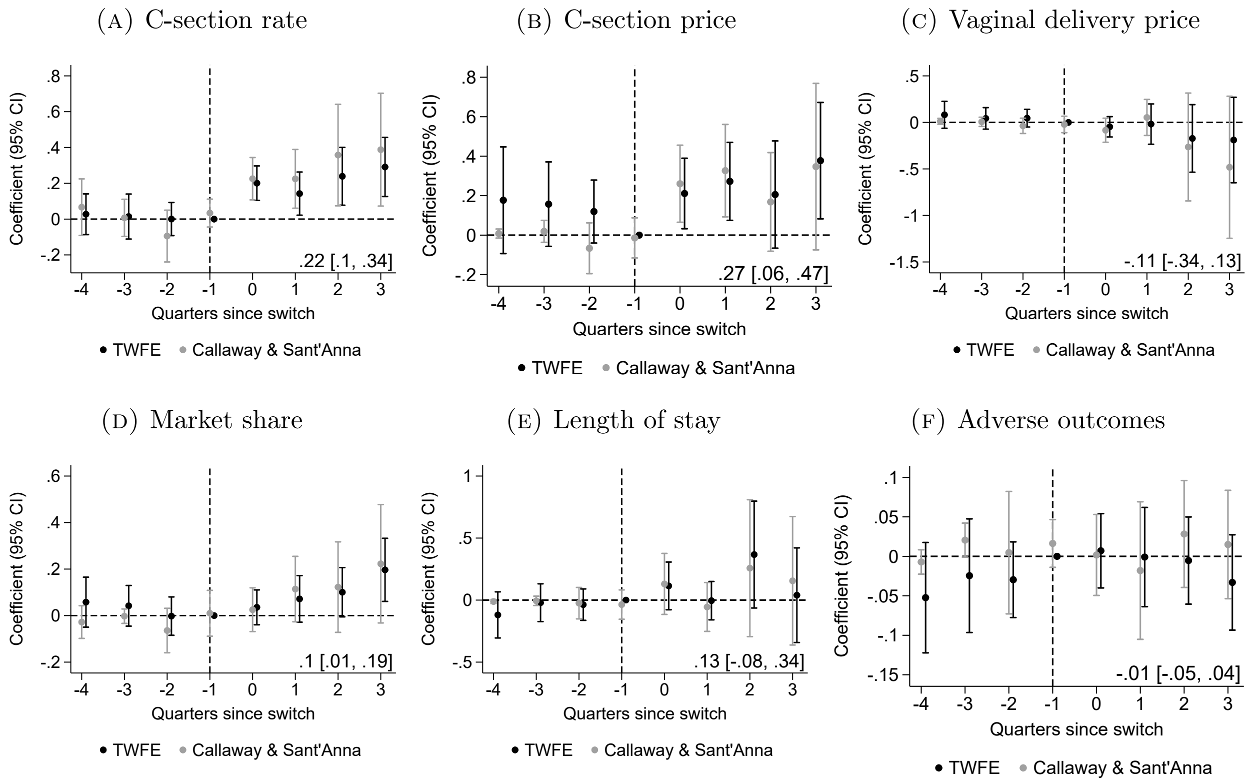
$$y_{jht} = \sum_{\substack{k=-4 \\ k\neq -1}}^{3} \beta_k 1\{t - t^* = k\} \times T_{jh} + x'_{jht}\alpha + \gamma_{jh} + \gamma_t + \varepsilon_{jht} \tag{1}$$

where y_{jht} is an outcome for insurer-hospital pair jh in quarter t, t^* is the quarter in which jh switched payment contracts for c-sections, T_{jh} is an indicator for insurer-hospital pairs that ever switch payment contracts, x_{jht} is a vector containing the time-varying fraction of women with high-risk pregnancies and of women with at least one chronic condition, γ_{jh} is an insurer-hospital fixed effect, and γ_t is a quarter fixed effect. Given that treatment is defined at the jh level, we cluster our standard errors accordingly.

We estimate two specifications of equation (1). The first restricts the treated group to insurer-hospital pairs that switch c-sections from capitation to FFS. The control group for this specification is all pairs for which c-section remains covered under capitation for the duration of the sample period. The second specification restricts the treated group to pairs that switch from FFS to capitation and defines the control group as pairs that are always covered under FFS. Appendix table 3 provides summary statistics for each of these treated and control groups.

Identification of the treatment effect β_k is threatened by the possibility that insurers and hospitals select into FFS contracts based on time-varying factors within pair. For example, changes in women's health status that are contemporaneous with the change in payment contracts will bias our estimate of the average treatment effect. We address this issue by controlling for the time-varying fraction of women who have a high-risk pregnancy and who have at least one chronic condition. Another potential bias in our empirical approach is the confounding effect of physician surgical skill. However, changes in physician skill over time are likely to be gradual and unlikely to generate immediate changes in outcomes following a payment contract change.

Figure 2: Dynamic effects of switch to FFS contract



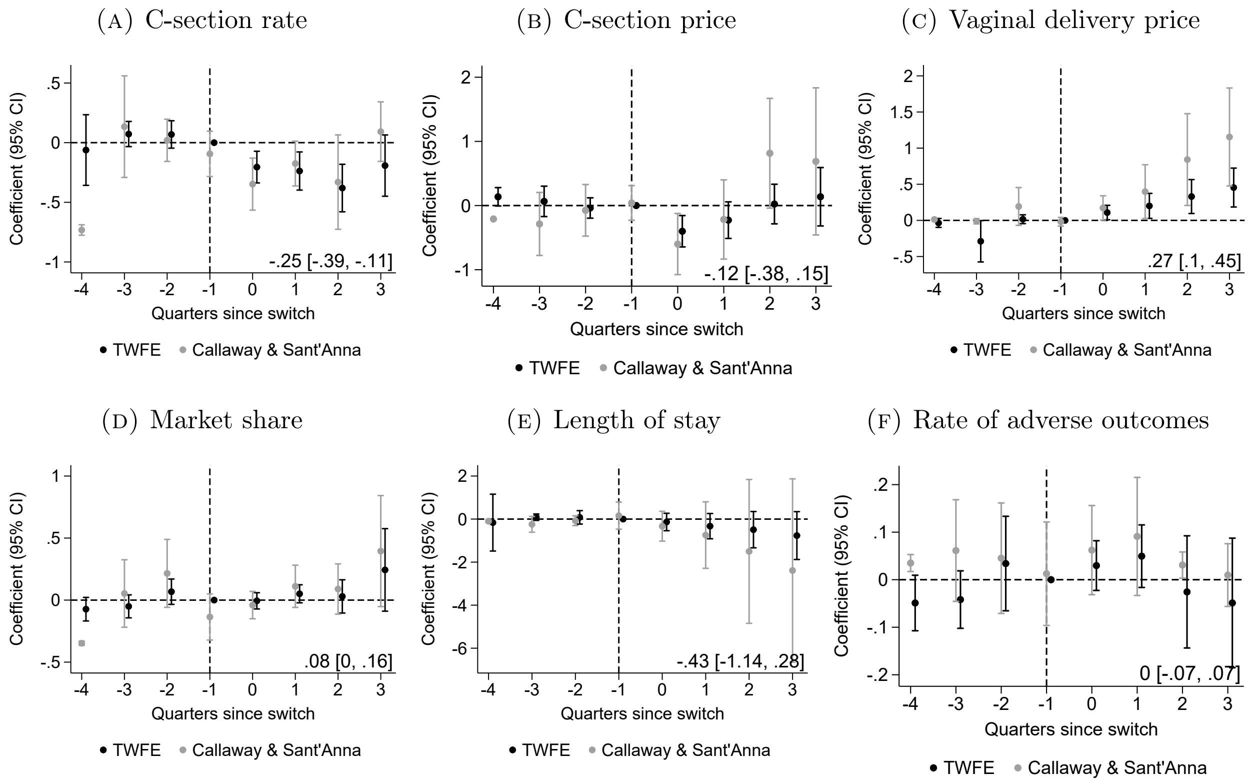
Note: Figure shows coefficients and 95 percent confidence intervals of difference-in-differences event study regressions. All specifications compare (control) insurer-hospital pairs that always cover c-sections under capitation to (treated) pairs that switch their payment contract for c-sections from capitation to FFS. Black markers denote two-way fixed effects estimates and gray markers denote the Callaway and Sant'Anna (2021) estimates. Panel (A) uses as outcome the fraction of deliveries performed by c-section at each insurer-hospital pair. Panels (B) and (C) use the log of c-section and vaginal delivery prices, respectively. Panel (D) uses the hospital's market share on the number of deliveries per insurer. Panel (E) uses the average length of stay at each insurer-hospital pair, and panel (F) uses the rate of adverse outcomes. Included in the bottom right of each panel is the average post-period TWFE estimate and its corresponding 95 percent confidence interval. All specifications include insurer-hospital pair and quarter fixed effects, and control for the fraction of high risk women, and the fraction of women with at least one chronic condition. Standard errors are clustered at the insurer-hospital level.

Results of estimating equation (1) for the effect of switching to a FFS contract using both two-way fixed effects (TWFE) and Callaway and Sant'Anna (2021)'s estimator are presented in figure 2. Focusing on the TWFE estimates, in panel (A) we find a 22 p.p increase in c-section rates on average in the post-period. Panel (B) shows that c-section prices increase approximately 31 percent, while panel (C) shows no statistically significant effects on vaginal delivery prices. This net increase in prices coupled with 10 p.p. increase in the hospital's market share in panel (D) suggests that quality of care is changing as a result of changes in payment contracts.

Motivated by this finding as well as by the correlation between FFS and pregnancy risk (in figure 1), we explore impacts on different measures of quality of care, such as the average length of stay and rate of adverse health outcomes. These results are presented in panels (E) and (F) of figure 2. We find no evidence that the switch to FFS has any effect on these measures, suggesting that whatever drives the increase in hospital demand is not directly related to the quality of care provided. Moreover, we observe parallel outcome trends prior to the switch, which we take as evidence of non-differential selection into FFS based on these outcomes.

Results of estimating equation (1) for the effect of switching to a capitation contract are presented in figure 3. We focus on the TWFE estimates. We find a 25 p.p. decline in c-section rates and a 31 percent increase in vaginal delivery prices on average after the switch. There are no statistically significant effects for hospital market shares, c-section prices, or quality of care measures. These results are consistent with our conceptualization of hospital moral hazard in this setting: hospitals have greater incentive to provide the most profitable service –c-section– when reimbursed under FFS and to provide the lower cost service –vaginal delivery – when reimbursed under capitation.

Figure 3: Dynamic effects of switch to capitation contract

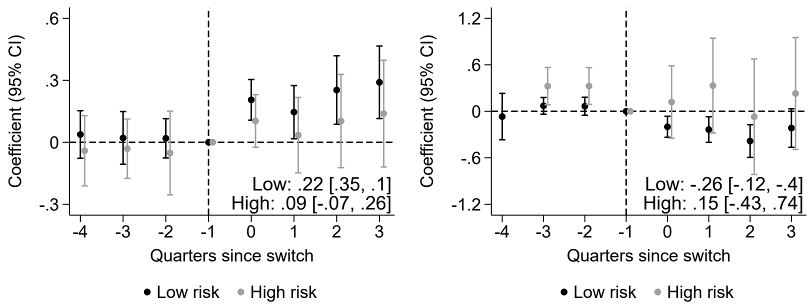


Note: Figure shows coefficients and 95 percent confidence intervals of difference-in-differences event study regressions. All specifications compare (control) insurer-hospital pairs that always cover c-sections under FFS to (treated) pairs that switch their payment contract for c-sections to from FFS to capitation. Black markers denote two-way fixed effects estimates and gray markers denote the Callaway and Sant'Anna (2021) estimates. Panel (A) uses as outcome the fraction of deliveries performed by c-section at each insurer-hospital pair. Panels (B) and (C) use the log of c-section and vaginal delivery prices, respectively. Panel (D) uses the hospital's market share on the number of deliveries per insurer. Panel (E) uses the average length of stay at each insurer-hospital pair, and panel (F) uses the rate of adverse outcomes. Included in the bottom right of each panel is the average post-period TWFE estimate and its corresponding 95 percent confidence interval. All specifications include insurer-hospital pair and quarter fixed effects, and control for the fraction of high risk women, and the fraction of women with at least one chronic condition. Standard errors are clustered at the insurer-hospital level.

Providers are likely somewhat altruistic in their delivery procedure choice, taking into account both the patient's suitability for each procedure as well as the relative profitability of the procedures. If this is true, then hospitals should be less responsive to payment contract changes as it pertains to high-risk women who are particularly suitable for c-sections. We test this by estimating our *did* model using as outcomes the c-section rate among the subset of high- and low-risk pregnancies, respectively. Results are presented in figure 4. Findings show that hospitals are less responsive to changes in payment contracts for high-risk pregnancies than they are for low-risk pregnancies. To simulate equilibria under different counterfactual policies and to assess the trade-offs presented by each, we move to specifying a structural model of this market.

FIGURE 4: Dynamic effects on c-section rates by pregnancy risk

(A) Switch to FFS (B) Switch to capitation



Note: Figure shows coefficients and 95 percent confidence intervals of difference-in-differences event study regressions. The switch to FFS specification in panel (A) specifications compares (control) insurer-hospital pairs that always cover c-sections under capitation to (treated) pairs that switch their payment contract for c-sections to from capitation to FFS. The switch to capitation specification in panel (B) specifications compares (control) insurer-hospital pairs that always cover c-sections under FFS to (treated) pairs that switch their payment contract for c-sections to from FFS to capitation. Black markers denote TWFE estimates for the c-section rate among low-risk pregnancies and gray markets denote TWFE estimates for the c-section rate among for high-risk pregnancies. C-section rates are the insurer-hospital pair's fraction of deliveries performed by c-sections. All specifications include insurer-hospital pair and quarter fixed effects, the share of high risk women, and the share of women with at least one chronic condition. Standard errors are clustered at the insurer-hospital level.

5 Model

To study equilibrium impacts of payment contracts on c-section rates and delivery costs, we develop a model of hospital, insurer, and delivery choice. Throughout the model we take payment contracts and hospital networks as given. The timing of the model is as follows: (1) insurers and hospitals negotiate delivery prices, conditional on payment contracts; (2) observing prices and networks, women make enrollment decisions; (3) conditional on enrollment, women choose a hospital in the network of their insurer at which to have a childbirth; (4) observing prices and payment contracts, the woman and the hospital jointly decide whether to deliver the child by vaginal delivery or c-section. We describe our model starting from the choice of delivery procedure and drop market subscripts throughout for ease of notation, but each element of our model (hospital demand, insurer demand, and prices) is conditional on a market.

5.1 Delivery choice

Let d_{ijh} be an indicator for whether woman i enrolled with insurer j receives a c-section at in-network hospital h, p^f_{jhl} the negotiated FFS price of procedure l, and p^c_{jhl} the negotiated capitation price of procedure l, where $l \in \{\text{C-section} = 1, \text{Vaginal delivery} = 2\}$. Also, let f_{jhl} be a binary indicator for whether procedure l is reimbursed under FFS. We model the choice of a c-section as:

$$d_{ijh} = \theta_{1,i} f_{jhl=1} p^f_{jh,l=1} + x_i' \theta_2 + \epsilon_{ijh}$$

where x_i is a vector of the woman's characteristics including costs up to delivery, and dummies for age group, having a chronic disease, being a high-risk pregnancy, and living in a rural municipality. The coefficient $\theta_{1,i} = (1 \quad x_i)'\theta_1$ captures the responsiveness of c-section choice to the financial characteristics of FFS contracts relative to capitation and thus reflects hospital moral hazard. Our specification follows from the descriptive patterns in figure

1 showing that c-section prices alone are uncorrelated with c-section rates, but their interaction with the degree of retrospectiveness does matter for the decision to provide a c-section. We allow the responsiveness to FFS to vary with the woman's characteristics to capture the heterogeneous effects of FFS on c-section rates as presented in our *did* analysis. Let ϕ_{ijhl} be the predicted probability of procedure l from this model, where $\sum_l \phi_{ijhl} = 1$.

5.2 Hospital demand

We model a woman's choice over in-network hospitals as a function of her expected out-of-pocket (OOP) price, with expectations taken over the delivery procedure. The probability distribution over delivery procedures is endogenous and comes from our model of delivery choice. Define the expected delivery price as $\hat{p}_{ijh} = \sum_l \phi_{ijhl}(f_{jhl}p^f_{jhl} + (1 - f_{jhl})p^c_{jhl})$, and the expected delivery price under FFS as $\hat{r}_{ijh} = \sum_l \phi_{ijhl} f_{jhl} p^f_{jhl}$. Pregnant woman i enrolled with insurer j has the following utility from choosing hospital h for delivery:

$$u_{ijh} = \underbrace{\alpha\kappa_i\hat{p}_{ijh} + \lambda\kappa_i\hat{r}_{ijh} + \delta_i y_{ih} + x'_{ih}\beta + \xi_h}_{\psi_{ijh}} + \varepsilon_{ijh} \tag{2}$$

where κ_i is the patient's coinsurance rate, y_{ih} is an indicator for whether the woman went to hospital h in the year prior to her childbirth for health care that may be unrelated to obstetric care, x_{ih} is a vector of observable patient characteristics interacted with hospital characteristics (number of beds, rate of adverse outcomes, and rate of maternal mortality), and ξ_h is a hospital fixed effect. We normalize the fixed effect for the largest hospital (in terms of the number of women who choose it) in each choice set to zero following Ho and Pakes (2014). Finally, ε_{ijh} is a preference shock assumed to follow a type-I extreme value distribution.

The first term on the right-hand side of equation (2) is the patient's expected OOP price. Women pay their share of delivery prices regardless of the payment contract, but contracts affect OOP payments directly through delivery prices and indirectly through the probability of having a c-section. The second term in the equation is the price sensitivity due to FFS contracts, which might arise if FFS is correlated with unobserved hospital quality such as its clinical expertise. This type of heterogeneity in delivery prices allows us to characterize the *did* result showing that FFS induces both an increase in c-section prices and in hospital demand.

The third term represents provider inertia. There is substantial evidence that patients are more likely to choose a hospital or a provider if they have had previous healthcare encounters at it (Drake et al., 2022; Saltzman et al., 2022).[8] This is especially true in the case of pregnancy, where women tend to choose the same hospital to have their baby delivered as the hospital that provided their prenatal care.[9]

From this model, woman i's likelihood of choosing hospital h is

$$s_{ijh}(\mathbf{p}, \mathbf{f}, H_j) = \frac{\exp(\psi_{ijh})}{\sum_{k \in H_j} \exp(\psi_{ijk})}$$

where H_j is the set of hospitals in insurer j's network. Following McFadden (1996), the woman's expected utility for insurer j's network of hospitals is

$$EU_{ij}(\mathbf{p}, \mathbf{f}, H_j) = \log\Big(\sum_{h \in H_j} \exp(\psi_{ijh})\Big)$$

How do payment contracts affect demand? To see how FFS contracts impact hospital choice, consider the sensitivity of hospital h's demand to prices when both procedures

[8] While we cannot distinguish between state dependence and unobserved changes in preferences as the cause of provider inertia, this distinction is not needed for conducting our counterfactual analyses.

[9] Although we do not observe distance from the woman to each hospital in her choice set, inclusion of past hospital choices allows us to indirectly control for this predictor.

are covered under FFS:

$$\frac{\partial s_{ijh}}{\partial p^f_{jhl}} = s_{ijh}(1-s_{ijh})\Big[\overbrace{\alpha\kappa_i\Big(\sum_l \phi_{ijhl} + p^f_{jhl}\phi_{ijhl}(1-\phi_{ijhl})\theta_{1,i})\Big)}^{\text{Direct price effect}} + \\ + \underbrace{\lambda\kappa_i\Big(\sum_l(\phi_{ijhl} + p^f_{jhl}\phi_{ijhl}(1-\phi_{ijhl})\theta_{1,i})\Big)}_{\text{Hospital moral hazard}}\Big]$$

If $\lambda = 0$ and the decision to perform a c-section depended only on women's health and not on the financial characteristics of payments contracts (i.e. if $\theta_{1,i} = 0$), then demand would respond to prices only to the extent that women do. Instead, if c-sections are more likely the higher the c-section price (i.e. if $\theta_{1,i} > 0$) and hospital demand increases with FFS contracts as seen in the *did* results (i.e. if $\lambda > 0$), then hospital moral hazard induces a lower price sensitivity of demand, allowing them to charge higher prices and drive-up demand as seen in section 4.

5.3 Insurer demand

We model the indirect utility of woman i from enrolling with insurer j as:

$$\tilde{u}_{ij} = \gamma_i EU_{ij} + \nu_j + \omega_{ij}.$$

where $\gamma_i = x_i'\gamma$, x_i is the same as before, ν_j are insurer fixed effects capturing unobserved insurer quality that does not vary across markets, and ω_{ij} is a type-I extreme value shock. Let J be the set of insurers available to woman i, the likelihood that woman i chooses insurer j is:

$$\sigma_{ij}(\mathbf{p}, \mathbf{f}, H_j) = \frac{\exp(\gamma_i EU_{ij} + \nu_j)}{\sum_{k\in J}\exp(\gamma_i EU_{ik} + \nu_k)}$$

Because the woman's expected utility for insurer j's network of hospitals is increasing in hospital demand, FFS contracts will have the same impact on insurer demand as they have on hospital demand.

5.4 Prices

Although capitation prices are paid per enrollee and FFS prices are paid per procedure, our setting is one where the predicted number of enrollees equals the predicted number of procedures: our focus is on deliveries and women who have a baby for the first time. This setting simplifies the problem of having to specify four pricing functions (one for each delivery procedure and payment contract combination) to specifying only two of them (one for each delivery procedure).

Insurers and hospitals negotiate delivery prices conditional on payment contracts and hospital networks. We assume that the bargaining protocol is Nash-in-Nash. Let r_i be the risk-adjusted transfer from the government (recall that insurers in our setting do not charge premiums), J_h the set of insurers that include hospital h in their networks, and m_{jhl} the marginal cost of procedure l between insurer j and hospital h. The insurer profit function is given by:

$$\pi^j(\mathbf{p}, \mathbf{f}, H_j) = \sum_i r_i \sigma_{ij} - \sum_i \sum_{h \in H_j} \sum_l (1 - \kappa_i)(f_{jhl} p^f_{jhl} + (1 - f_{hjl}) p^c_{jhl}) D_{ijhl}$$

and the hospital profit function by:

$$\pi^h(\mathbf{p}, \mathbf{f}, J_h) = \sum_{j \in J_h} \sum_i \sum_l (f_{jhl}(p^f_{jhl} - m_{jhl}) + (1 - f_{hjl})(p^c_{jhl} - m_{jhl})) D_{ijhl}$$

where $D_{ijhl} = \phi_{ijhl} s_{ijh} \sigma_{ij}$.[10] Insurer j and hospital h choose delivery prices to maximize their Nash surplus conditional on equilibrium prices among the rest of insurer-hospital pairs (Horn and Wolinsky, 1988). The Nash surplus function is:

$$S_{jh} = \Big(\pi^j(\mathbf{p}, \mathbf{f}, H_j) - \underbrace{\pi^j(\mathbf{p}, \mathbf{f}, H_{j \setminus h})}_{t^j_h}\Big)^{\beta} \times \Big(\pi^h(\mathbf{p}, \mathbf{f}, J_h) - \underbrace{\pi^h(\mathbf{p}, \mathbf{f}, J_{h \setminus j})}_{t^h_j}\Big)^{1-\beta}$$

[10] The corresponding per-enrollee payment under capitation in the insurer profit function would be equal to $p^c_{jhl} \phi_{ijhl} s_{ijh}$.

where β is the insurer's bargaining power. The disagreement payoff to the insurer (hospital) is assumed to be the profit it would enjoy from dropping the hospital (insurer) from its network. The maximization problem with respect to the prices of c-sections and vaginal deliveries yields a system with two equations and two unknowns (the marginal cost of each procedure). The equilibrium pricing function for procedure $l \neq l'$ is:

$$\mathbf{p}_l = \mathbf{m}_l - (\mathbf{\Lambda}_l^l - \mathbf{\Lambda}_{l'}^l(\mathbf{\Lambda}_{l'}^{l'})^{-1}\mathbf{\Lambda}_l^{l'})^{-1}(\mathbf{D}_l - \mathbf{\Lambda}_{l'}^l(\mathbf{\Lambda}_{l'}^{l'})^{-1}\mathbf{D}_{l'})$$

where $\mathbf{\Lambda}_l^l$ is a matrix whose (h,k) element is given by $\sum_i \frac{\beta}{1-\beta}\frac{\partial\pi^j/\partial p_{jhl}}{\pi^j - t_h^j}\Delta D_{ijkl} + \sum_i \frac{\partial D_{ijkl}}{\partial p_{jhl}}$, $\mathbf{\Lambda}_{l'}^l$ is a matrix whose (h,k) element is given by $\sum_i \frac{\beta}{1-\beta}\frac{\partial\pi^j/\partial p_{jhl}}{\pi^j - t_h^j}\Delta D_{ijkl'} + \sum_i \frac{\partial D_{ijkl}}{\partial p_{jhl'}}$, $\mathbf{D}_l = \sum_i D_{ijhl}$, and $\Delta D_{ijhl} = \sum_i \left(\sum_{h\in H_j} D_{ijhl} - \sum_{k\in H_j\backslash h} D_{ijkl}\right)$. Note that the price of procedure l is increasing in its demand and decreasing in the demand for procedure l'. Appendix E shows a complete derivation of these pricing functions.

Using the equilibrium pricing functions for c-sections and vaginal deliveries, we can recover the marginal cost of each delivery procedure and specify our econometric error as:

$$\mu(\mathbf{p}, \mathbf{f}, H_j, J_h) = -\tau\mathbf{v} + \mathbf{m}(\mathbf{p}, \mathbf{f}, H_j, J_h) \tag{3}$$

where $\mathbf{m}$ is the stacked vector of marginal costs for c-sections and vaginal deliveries and $\mathbf{v}$ is a matrix of hospital fixed effects.

6 Identification

Delivery choice. We exploit the quasi-random variation in prices introduced by changes in payment contracts over time to identify the parameters of our delivery choice model. *did* results in section 4 showed evidence of non-differential selection of insurer-hospital pairs into capitation and FFS contracts based on c-section rates. Results there also showed that when insurer-hospital pairs switch their payment contracts, there is a discontinuous change in negotiated prices. We corroborate the exogeneity of these price changes in appendix table 5 by re-estimating our delivery choice function including insurer fixed effects noting that estimates are robust across the different specifications. We estimate the delivery choice logistic function using maximum likelihood on the full sample of deliveries between 2010 and 2011.

Hospital demand. The coefficients of our hospital demand model are identified from price variation within hospital and variation in hospital choice sets across patients. Identification is threatened by women non-randomly choosing their insurer. For example, a woman may choose her insurer because it has negotiated low delivery prices with her preferred hospitals, which would bias our price coefficient to zero. We follow Prager (2020) and Abaluck et al. (2018) to correct for this source of bias leveraging inertia in insurer choice. Our estimation sample is the set of women who are enrolled with the same insurer between 2010 and 2011. Assuming that inertia plays a major role in the decision (or lack thereof) to switch insurers in this setting, within-patient changes in prices and payment contracts after the period of initial choice will be quasi-random.

Conditional on the sample of inertial women, we identify α from price variation across insurers within hospital and from variation in women's observable characteristics which exogenously shift the probability of getting a c-section. λ is identified from variation in payment contracts across insurers within hospital, which we know from the dynamic *did* results to be associated with parallel hospital demand trends prior to a switch in payment contracts. Finally, the coefficient on provider inertia, δ_i, is identified from women who have their baby delivered at a different hospital from the set that they visited in 2010. The demand model in equation (2) is a conditional logit, which we estimate by maximum likelihood. Appendix table 4 presents summary statistics of our estimation sample which conditions on inertial women.

Insurer demand. Because our insurer demand model includes insurer fixed effects, the parameters on network valuation are identified from variation in women's observable characteristics and hospital choice sets across markets. We assume that these insurer fixed effects absorb any unobserved insurer quality that might be correlated with prices. Given that these are the only two choice variables for insurers, fixed effects in our model allow us to isolate the exogenous variation in network valuation. The insurer demand model is a conditional logit, estimated by maximum likelihood.

Bargaining. To estimate the bargaining parameter of the Nash surplus function between insurers and hospitals we use our econometric error in equation (3). This error is correlated with demand and prices, which is why we need instruments that shift the marginal cost independently from demand unobservables. Our instrument set denoted by $\mathbf{z}$ is comprised of: hospital fixed effects $\mathbf{v}$ and predicted hospital demand evaluated at the government's references prices and at the average payment contract in the spirit of Gowrisankaran et al. (2015); Ho and Lee (2017). Reference prices were created in 2005 by the government and a group of physicians to reimburse hospitals in the event of natural disasters, car accidents, and terrorist attacks.[11] Studies from the Ministry of Health and interviews with experts suggest that these reference prices are used as starting points in the bilateral negotiations between insurers and hospitals and thus are exogenous. We estimate the bargaining parameter using generalized method of moments (GMM) under the condition that $\mathbf{E}[\mu(\mathbf{p}, \mathbf{f}, H_j, J_h)\mathbf{z}] = 0$.

7 Estimation results

Delivery choice. Table 2 reports results of our delivery choice model. We find that payment contracts between insurers and hospitals significantly affect delivery choice. The likelihood of a c-section increases by 18 percent when the average FFS price of a c-section increases by \$100 or by 40 percent. The responsiveness of c-section choice to financial characteristics is less pronounced among older women and is similar in magnitude between high-risk and low-risk pregnancies. Variation in c-section rates that is attributable to delivery procedure

[11] See Decree 2423 of 1996 by the Ministry of Health and Social Protection.

prices and payment contracts is suggestive of hospital moral hazard. Qualitatively similar results have been reported in Foo et al. (2017); Shafrin (2010); Gruber et al. (1999). We also find that the probability of a c-section is higher among women aged 35 or older, women with chronic diseases, and women with high-risk pregnancies, than among their counterparts, in line with prior work (e.g., Currie and MacLeod, 2017).

Table 2: Delivery choice model estimates

		Estimates	
		coef	se
C-section Contracts	$f_{jh}p_{jh}^{f}$	0.181	(0.037)
	× High-risk pregnancy	-0.065	(0.032)
	× Age 18-24	-0.034	(0.031)
	× Age 25-29	-0.023	(0.025)
	× Age 30-34	-0.026	(0.013)
	× Rural	0.412	(0.112)
Health	Costs up to delivery	0.045	(0.008)
	High-risk pregnancy	0.345	(0.092)
	Chronic disease	0.192	(0.034)
Demographics	Age 24 or less	(ref)	(ref)
	Age 25-29	0.188	(0.037)
	Age 30-34	0.394	(0.076)
	Age 35 or more	0.516	(0.113)
	Low income	(ref)	(ref)
	Middle income	-0.110	(0.028)
	High income	-0.192	(0.020)
	Rural	-1.930	(0.469)
Pseudo R^2		0.03	
N		254,421	

Note: Maximum likelihood estimation of delivery choice model. We replace missing prices and missing payment contracts with zeros. Standard errors in parenthesis are clustered at the municipality level.

Hospital demand. Table 3 presents results of our hospital demand model. We find that women are approximately 21 percent less likely to choose a hospital if its expected OOP delivery price increases by $10. The average elasticity of hospital demand equals -0.10 with respect to c-section prices and -0.07 with respect to vaginal delivery prices. FFS contracts reduce demand sensitivity to expected OOP prices as seen in the positive estimate for λ. This explains our *did* finding that a switch from capitation to FFS increases both c-section prices and hospital demand. We also find evidence of substantial hospital inertia, as women are nearly 6 times more likely to visit a hospital they had been to in the previous year. Interactions of hospital and patient characteristics show that women with chronic diseases prefer larger hospitals and tend to visit hospitals with lower maternal mortality rates relative to women without diagnoses.

Table 3: Hospital demand model estimates

		Estimates	
		coef	se
Expected OOP ($100)		-2.055	(0.210)
Expected OOP x FFS ($100)		1.733	(0.185)
Previous visit		1.438	(0.113)
Interactions			
Previous visit	Age 25-29	-0.223	(0.102)
	Age 30-34	-0.297	(0.102)
	Age 35 or older	-0.225	(0.107)
	Cost up to delivery	-0.007	(0.005)
	High-risk pregnancy	-0.052	(0.060)
	Chronic disease	-0.065	(0.065)
	Low income	-0.148	(0.067)
Beds	Age 25-29	-0.161	(0.018)
	Age 30-34	-0.174	(0.019)
	Age 35 or older	-0.170	(0.022)
	Cost up to delivery	0.006	(0.001)
	High-risk pregnancy	-0.015	(0.022)
	Chronic disease	0.053	(0.028)
	Low income	-0.173	(0.015)
Maternal mortality	Age 25-29	73.14	(15.19)
	Age 30-34	56.80	(16.36)
	Age 35 or older	59.17	(19.22)
	Cost up to delivery	0.809	(0.886)
	High-risk pregnancy	85.41	(18.06)
	Chronic disease	-63.95	(21.77)
	Low income	85.87	(13.40)
Pseudo R^2		0.35	
N		403,138	

Note: Maximum likelihood estimation of hospital demand model. Specification includes hospital fixed effects. Estimation uses the sample of women who have a baby in 2011 and did not switch their insurer from 2010. Expected OOP prices are measured in $100s.

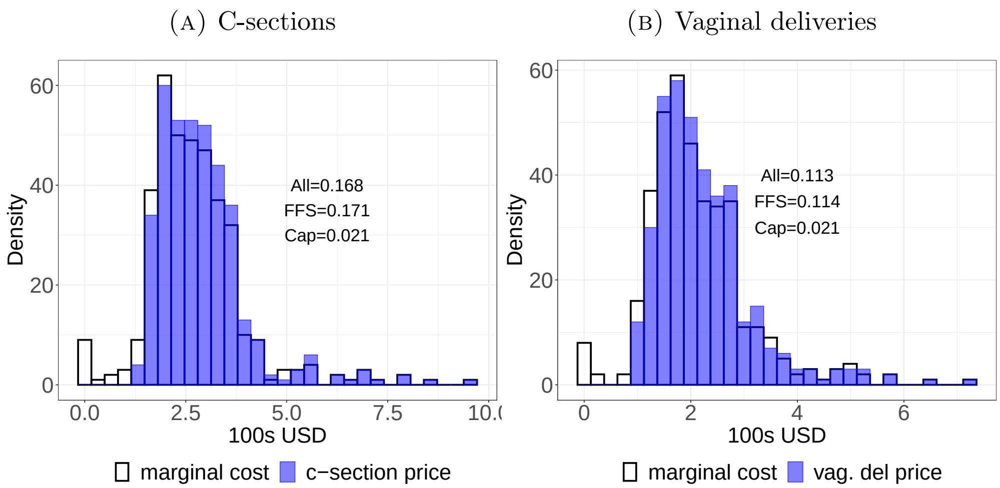
Insurer demand. Estimates of our insurer demand model are presented in table 4. The specification includes insurer fixed effects which are not reported for ease of exposition. We find that on average women have strong preferences for broader networks, since network valuation is increasing in the number of covered hospitals. Preferences for insurers' networks are constant across age groups, but are increasing in the woman's pregnancy risk. Our estimates imply that the c-section price elasticity of insurer demand equals -0.06 and the vaginal delivery price elasticity is -0.04.

Table 4: Insurer demand model estimates

	Estimates	
	coef	se
Network valuation	0.582	(0.028)
× Age 18-24	-0.073	(0.028)
× Age 25-29	-0.007	(0.026)
× Age 30-34	0.000	(0.027)
× Cost up to delivery	-0.014	(0.002)
× High-risk pregnancy	0.242	(0.023)
× Chronic disease	0.069	(0.031)
× Low income	-0.077	(0.021)
Pseudo R^2	0.18	
Observations	321,569	

Note: Maximum likelihood estimation of insurer demand model. Specification includes insurer-by-market fixed effects.

Figure 5: Distribution of prices and marginal costs



Note: Figure shows the distribution of prices in blue and of marginal costs in white implied by our bargaining model. Panel (A) depicts the distribution of these variables for c-sections and panel (B) for vaginal deliveries. Legends in each graph show the markup in $100s for the procedure across all insurer-hospital pairs, across insurer-hospital pairs that use a FFS contract, and across insurer-hospital pairs that use a capitation contract.

Bargaining. Our bargaining parameter estimate is $\hat{\beta} = 0.892$ (0.316), that is, hospitals extract only 11 percent of the surplus generated in their interaction with insurers. This result is consistent with anecdotal evidence that insurers tend to impose the reference prices in their negotiations and with the fact that the insurance side of the market is highly concentrated while the provider side is highly competitive. Figure 5 presents the implied distribution of marginal costs and observed prices for each delivery procedure. In estimation we impose that marginal costs are non-negative, a restriction that is binding for only 3 percent of insurer-hospital pairs. We find that the average marginal cost across insurer-hospital pairs equals \$273 for c-sections and \$212 for vaginal deliveries. The estimated price-cost margin is also higher for c-sections than for vaginal deliveries across all pairs. For each procedure, markups are higher under FFS than capitation contracts. Our model thus provides two plausible explanations for the agency problem under FFS: first, hospital demand is relatively inelastic under FFS compared to capitation; second, hospital markups are greater for c-sections than for vaginal deliveries under every payment contract.

8 Equilibrium Effects of Contract Regulation

The increase in c-section rates and the variation in delivery prices across hospitals may be problematic for maternal health outcomes and health care costs (Card et al., 2023). While policies that cap the number of c-sections directly may halt this increase (such as the one implemented by the California Health Care Foundation, 2022), they may not be efficient at eliminating price variation across hospitals or at concentrating c-section reductions among low-risk pregnancies. In this section we use our model estimates to assess the impact of regulating payment contracts in ways that can help achieve these goals.

We conduct two counterfactual exercises to this end. In the first counterfactual, we set the payment contract for both c-sections and vaginal deliveries to capitation across all insurer-hospital pairs. This exercise mirrors the reduced-form evidence in section 4 which exploited a switch in payment contracts from FFS to capitation. Unlike the reduced-form evidence, our analysis here delivers counterfactual outcomes for the entire set of insurer-hospital pairs taking into account equilibrium responses of competitors. We think of this counterfactual as a government mandate over the types of services can be covered under each payment contract, reflecting the impact of a full transition to prospective reimbursements.

In the second counterfactual, we explore the equilibrium effects of imposing a price ceiling on c-sections. We set the price ceiling equal to the average c-section price in each market in the observed equilibrium. This counterfactual therefore holds fixed the observed selection into contracts while restricting the margin earned on each c-section. In other words, we impose a constraint on the marginal effect of negotiated prices on retrospective reimbursements.

For each counterfactual, we summarize the effect on predicted c-section rates $\left(\frac{\sum_i \sum_{j\in J} \sum_{h\in H_j} \phi_{ijh} s_{ijh} \sigma_{ij}}{\sum_i \sum_{j\in J} \sum_{h\in H_j} s_{ijh} \sigma_{ij}}\right)$, total spending $\left(\sum_i \sum_{j\in J} \sum_{h\in H_j} \sum_l \phi_{ijhl}(f_{jhl} p^f_{jhl} + (1-f_{jhl}) p^c_{jhl}) s_{ijh} \sigma_{ij}\right)$, consumer surplus $\left(\sum_j \sum_i \alpha^{-1} \sigma_{ij} \log(\sum_{h\in H_j} \exp(\psi_{ijh}))\right)$, and equilibrium prices.

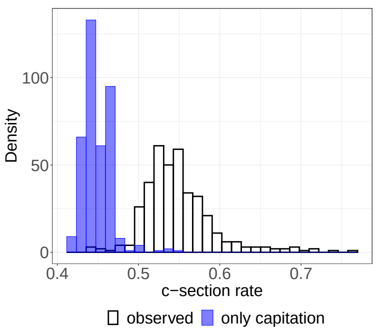
8.1 Results

Figure 6 presents the distribution of c-section rates across insurer-hospital pairs for the full capitation counterfactual in section (I) and for the price ceiling counterfactual in section (II). Each section shows the distribution for the full sample of women in panel (A), the sample of women with high-risk pregnancies in panel (B), and the sample of women with low-risk pregnancies in panel (C). Our results indicate that a move toward full capitation results in a reduction in the c-section rate for the average insurer-hospital pair of 10 p.p. This result is about half as large as the average treatment effect on the treated estimated in section 4. Both women with high- and -low-risk pregnancies experience reductions in the use of c-sections, but effects are larger among the latter. The reduction in c-section rates at the average insurer-hospital pair equals 11 p.p for low-risk pregnancies and 6 p.p for high-risk pregnancies. The figure also shows that under full capitation there is a reduction in c-section rate dispersion.

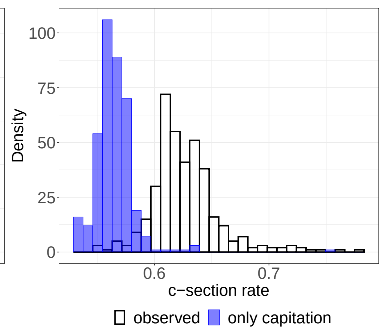
Figure 6: Distribution of c-section rates under counterfactual payment contract regimes

(i) Full capitation counterfactual

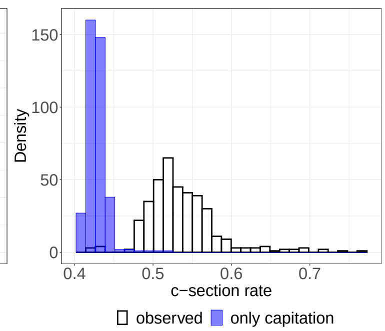
(a) Full sample



(b) High-risk

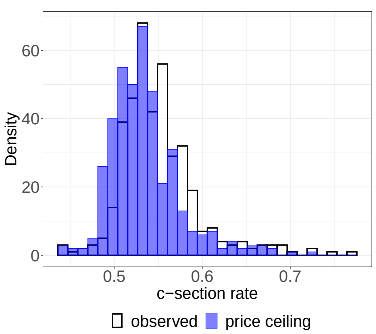


(c) Low-risk

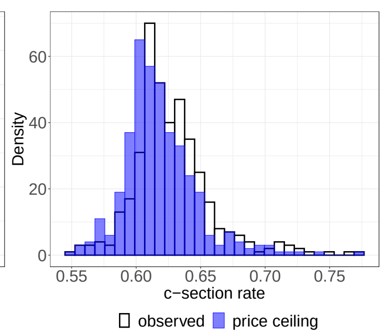


(ii) C-section price ceiling counterfactual

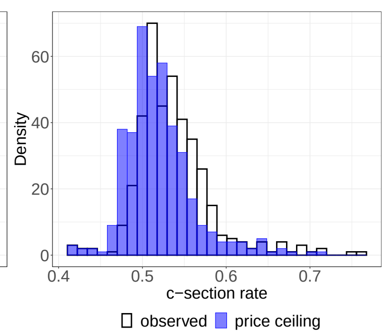
(a) Full sample



(b) High-risk



(c) Low-risk



Note: Figure shows the distribution of counterfactual c-section rates in blue and of observed c-section rates in white. Section (I) provides distributions for the full capitation counterfactual. Section (II) provides distributions for the counterfactual in which a ceiling is placed on c-section prices equal to the observed market average. For each counterfactual, distributions are provided for the full sample of women in panel (A), the subsample of high-risk women in panel (B), and the subsample of low-risk women in panel (C).

In section (II) of figure 6 we find that a price ceiling policy has negligible effects on c-section rates among most insurer-hospital pairs. Low- and high-risk pregnancies see an average reduction of 2 p.p and 1 p.p in the c-section rate, respectively, although differences across groups are not significant. These results show that the impact of constraining retrospective prices is substantially smaller than the impact of imposing prospective payments. Hence, the hospital moral hazard problem stems mostly from how prices are paid rather than the price level itself.

Table 5 provides the remainder of results for our two counterfactuals. A switch to a fully capitated system reduces c-section prices by 4 percent but increases vaginal delivery prices by 6 percent as seen in column (2). This is because demand for vaginal deliveries becomes relatively more inelastic than demand for c-sections. In equilibrium, c-sections are still more expensive but their markups fall relative to those for vaginal deliveries. Despite the increase in the price and number of vaginal deliveries, we estimate that total spending decreases 9 percent under the full capitation counterfactual relative to the observed scenario. Although results suggest that payment contract regulation can achieve the goals of reducing c-section rates and delivery costs, we also estimate a 4-fold reduction in consumer surplus. Recall that women derive utility from visiting hospitals covered under FFS potentially because of an underlying correlation between clinical expertise and FFS.

Table 5: Other counterfactual outcomes

	Observed (1)	Full capitation (2)	C-section price ceiling (3)
C-section price	2.92 (1.14)	2.81 (1.25)	2.54 (0.63)
Vaginal delivery price	2.26 (0.92)	2.39 (1.55)	2.43 (1.93)
Total spending	130,859	118,968	119,782
Consumer surplus	16,821	4,917	17,012

Note: Table presents the average and standard deviation of c-section prices and vaginal delivery prices, as well as total healthcare spending in deliveries, and total consumer surplus in the observed scenario in column (1), the full capitation counterfactual in column (2), and the price ceiling counterfactual in column (3). Total spending and consumer surplus are measured in $100s.

Column (3) of table 5 shows that the c-section price ceiling also results in lower c-section prices and higher vaginal delivery prices, but effects are larger than in column (2). The average c-section price falls by 13 percent and vaginal delivery price increases by 8 percent. The reduction in c-section prices coupled with a mostly unchanged c-section rate reduces total spending on deliveries by 8 percent, an effect that is similar in size to the impact of moving towards a fully capitated system. Consumer surplus also increases by 1 percent under the price ceiling as c-section prices fall and consumers maintain access to FFS hospitals, which they value. Our counterfactuals highlight that there is a trade-off between reducing c-section rates and reducing consumer surplus. Evaluating this trade-off would require information on the impacts of c-section use on maternal and fetal health outcomes as well as on what dimensions of hospital quality pregnant women value. Ultimately, our results indicate that if medical risk from unnecessary c-sections is particularly high, then regulation payment contracts is superior to price regulation.

9 Conclusions

In this paper we consider the role of payment contracts in contributing to c-section rates and costs of childbirth. Using data from the Colombian health care system, we show using a *did* approach that insurer-hospital pairs that switch their payment contract from capitation to FFS see a 22 p.p increase in the c-section rate, as well as an increase in c-section prices and hospital demand. Instead, a switch from FFS to capitation has opposite effects on c-section rates and prices. The impacts of FFS are heterogeneous across pregnancy risk, suggestive of hospital moral hazard under each payment contract.

To simulate counterfactual policies that can address the hospital moral hazard problem, we develop a structural model of delivery choice, hospital and insurer demand, and delivery procedure pricing. Estimates show that hospitals are 18 percent more likely to provide a c-section when c-section prices increase by 40 percent, and that FFS contracts reduce the price-elasticity of hospital demand. Our pricing model suggests that price-cost margins for c-sections are higher than margins for vaginal deliveries at every insurer-hospital pair and every payment contract. Together these results suggest a substantial impact of hospital moral hazard on maternal health care.

In our counterfactual simulations we study the equilibrium effects of forcing all insurer-hospital pairs to cover c-sections and vaginal deliveries under capitation. Corroborating the *did* results, we find that a fully capitated system reduces the c-section rate by 10 p.p, with effects stemming from low-risk pregnancies. Total delivery spending decrease 9 percent despite increases in vaginal delivery prices. A policy that targets prices rather than payment contracts by imposing a price ceiling on c-sections, generates on average a 2 p.p reduction in c-section rates, but an 8 percent reduction in total delivery spending.

The findings of our paper speak to treatment decisions where hospitals may have an incentive to over-provide care. We show that capitation is successful at reducing c-section rates at the cost of reduced quality of care, while direct regulation of prices has little effect on treatment decisions. Work on the impacts of c-section on maternal and fetal health outcomes coupled with evidence of hospital investments in quality of care under different payment contracts can help policymakers evaluate this trade-off.

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Appendix A Sample restrictions

Table 1 presents the number of observations that result after imposing each sample restriction step. In step (1) we drop deliveries that are reimbursed under different types of payment contracts. These are deliveries that were authorized but not paid, deliveries covered under fee-for-diagnosis, and deliveries covered under fee-for-package. We exclude these deliveries because we do not observe important terms for these payment contracts such as which services were included in the diagnosis or the package. In step (2) we keep providers that render more than 10 deliveries in the year. This is a usual restriction when trying to define which hospitals are in-network for a given consumer. In step (3) after obtaining negotiated prices using Gowrisankaran et al. (2015)'s methodology, we winsorize prices.

Appendix Table 1: Number of observations

	2010	2011
Number of deliveries	241,775	225,133
(1) Keep capitation and fee-for-service	158,233	158,256
(2) Keep provider with at least 10 deliveries	134,250	150,295
(3) Winsorize prices	121,737	134,938
(4) Exclude breech, keep singleton	120,825	133,596
Final number of observations	254,421	

Note: Table shows number of observations that result after imposing sample restrictions.

Appendix B Obtaining Negotiated Prices

The raw data shows that prices vary within insurer-hospital-service-contract tuple in ways that are correlated with women's characteristics. The data excerpt in appendix table 2 below shows an example of price variation that is correlated with the woman's age.

We use Gowrisankaran et al. (2015)'s methodology to average-out this type of price variation. We estimate the following linear regression separately for every insurer j:

$$\tilde{p}_{ijh} = x_i'\beta_1 + \beta_2 f_{ijh} + \beta_3 l_{ijh} + \gamma_h + \epsilon_{ijhs}$$

Appendix Table 2: Data excerpt

id	year	service	contract	price	provider	insurer	age
1	2010	740100	FFS	382.6037	X	A	21
2	2010	740100	FFS	384.9969	X	A	19
3	2010	740100	FFS	384.9969	X	A	18
4	2010	740100	FFS	382.6037	X	A	37
5	2010	740100	FFS	478.1738	X	A	36
6	2010	740100	FFS	478.1738	X	A	40
7	2010	740100	FFS	480.2584	X	A	26
8	2010	740100	FFS	479.0149	X	A	33
9	2010	740100	FFS	384.9969	X	A	32
10	2010	740100	FFS	382.6037	X	A	23
11	2010	740100	FFS	480.2584	X	A	31

Note: Data excerpt to show price variation within insurer, provider, service, and contract. We anonymized the provider and the insurer to produce this table.

where $\tilde{p}_{ijh}$ is the reported price for delivery i covered by insurer j and performed by hospital h, x_i are delivery characteristics including dummies for age group, dummies for length-of-stay, and an indicator for whether the woman has a chronic disease; f_{ijh} is an indicator for whether delivery i is covered under FFS between insurer j and hospital h; l_{ijh} is an indicator for whether the delivery is a c-section; and γ_h is a hospital fixed effect.

Denote by $\hat{E}[\tilde{p}_{ijh}|x_i, f_{ijh}, l_{ijh}]$ the predictions from these linear regressions. The negotiated price for each insurer-hospital pair under contract $k \in \{\text{FFS}, \text{Cap}\}$ and for procedure $l \in \{\text{C-section, Vaginal delivery}\}$ is:

$$p_{jhl}^k = \frac{1}{N_{jhl}} \sum_{jhl} \hat{E}[\tilde{p}_{ijh}|x_i, f_{ijh} = k, l_{ijh} = l]$$

where N_{jhl} is the number of deliveries by procedure l at insurer j and hospital h. We use this predicted price as the negotiated price throughout our analysis.

Appendix C Other results

This appendix presents summary statistics of treated and control insurer-hospital pairs for our analysis in section 4 and summary statistics of the sample on which we apply or structural model.

Appendix Table 3: Balance table for differences-in-differences estimation

	(1) Switch to FFS			(2) Switch to capitation		
	Treated	Control	p-value	Treated	Control	p-value
Age 18-24	0.370 (0.307)	0.318 (0.271)	0.004	0.363 (0.337)	0.367 (0.319)	0.88
Age 25-29	0.281 (0.277)	0.264 (0.255)	0.29	0.265 (0.286)	0.246 (0.240)	0.46
Age 30-34	0.208 (0.249)	0.256 (0.260)	0.001	0.218 (0.266)	0.243 (0.260)	0.32
Age 35 or more	0.141 (0.214)	0.162 (0.214)	0.091	0.154 (0.230)	0.144 (0.195)	0.64
Low income	0.796 (0.256)	0.799 (0.218)	0.82	0.776 (0.273)	0.779 (0.249)	0.90
Middle income	0.151 (0.226)	0.157 (0.198)	0.62	0.166 (0.237)	0.174 (0.231)	0.69
High income	0.054 (0.144)	0.044 (0.099)	0.23	0.058 (0.162)	0.047 (0.127)	0.43
Chronic disease	0.038 (0.103)	0.036 (0.104)	0.78	0.027 (0.105)	0.019 (0.061)	0.41
High-risk pregnancy	0.066 (0.144)	0.061 (0.127)	0.56	0.038 (0.128)	0.033 (0.077)	0.66
Observations	6,862	298	1,790	126		

Note: Table shows mean and standard deviation in parenthesis of the mean values of characteristics per insurer-hospital for the treated and control groups used in estimating equation 1. In column (1) treated units are those that switch the contract for c-section from capitation to FFS, and control units are those that always cover c-sections under capitation. In column (2) treated units are those that switch the contract for c-section from FFS to capitation, and control units are those that always cover c-sections under FFS. Reported p-values are for the difference between treated and control group means.

Appendix Table 4: Summary statistics of model sample

		All	Vaginal	C-section
		(1)	(2)	(3)
Contracts	Price	2.35 (1.16)	2.04 (1.10)	2.62 (1.13)
	FFS	0.89 (0.31)	0.88 (0.32)	0.89 (0.31)
	C-section	0.54 (0.50)	—	—
Demographics	Age 18-24	0.28 (0.45)	0.33 (0.47)	0.25 (0.43)
	Age 25-29	0.31 (0.46)	0.32 (0.47)	0.30 (0.46)
	Age 30-34	0.25 (0.44)	0.23 (0.42)	0.27 (0.45)
	Age 35 or more	0.15 (0.36)	0.12 (0.33)	0.18 (0.39)
	Low income	0.78 (0.41)	0.78 (0.41)	0.79 (0.41)
	Medium income	0.18 (0.38)	0.17 (0.38)	0.18 (0.39)
	High income	0.04 (0.19)	0.05 (0.21)	0.03 (0.18)
	Rural municipality	0.01 (0.11)	0.02 (0.12)	0.01 (0.09)
Health	Cancer	0.05 (0.22)	0.04 (0.20)	0.06 (0.23)
	Cardiovascular	0.02 (0.15)	0.02 (0.13)	0.03 (0.17)
	Diabetes	0.003 (0.06)	0.002 (0.04)	0.004 (0.07)
	High-risk pregnancy	0.14 (0.35)	0.12 (0.32)	0.16 (0.37)
	Cost up to delivery	3.62 (5.6)	3.16 (4.22)	4.03 (6.54)
	Length-of-stay	1.12 (2.11)	1.00 (2.00)	1.22 (2.19)
Provider characteristics	Adverse health outcome	0.03 (0.05)	0.03 (0.05)	0.03 (0.05)
	Maternal mortality	0.0005 (0.003)	0.0004 (0.002)	0.0007 (0.004)
Providers		465	451	395
Insurers		11	11	11
N		96,957	45,029	51,928

Note: Table shows mean and standard deviation in parentheses of main variables in the full sample of deliveries in column (1), conditional on vaginal deliveries in column (2), and conditional on c-sections in column (3). Prices and costs up to delivery are measured in 100s of dollars. We drop women with lengths-of-stay greater than 30 days.

Appendix D Robustness Checks

Appendix Table 5: Robustness of Delivery Choice Model Estimates

		(1) Main model		(2) Insurer FEs	
		coef	se	coef	se
C-section contracts	$f_{jh}p_{jh}^{f}$	0.181	(0.037)	0.195	(0.034)
	$\times$ High-risk pregnancy	-0.065	(0.032)	-0.071	(0.020)
	$\times$ Age 18-24	-0.034	(0.031)	-0.042	(0.027)
	$\times$ Age 25-29	-0.023	(0.025)	-0.026	(0.018)
	$\times$ Age 30-34	-0.026	(0.013)	-0.023	(0.013)
	$\times$ Rural	0.412	(0.112)	0.414	(0.113)
Health	Costs up to delivery	0.045	(0.008)	0.039	(0.005)
	High-risk pregnancy	0.345	(0.092)	0.368	(0.062)
	Chronic disease	0.192	(0.034)	0.164	(0.032)
Demographics	Age 24 or less	(ref)	(ref)	(ref)	(ref)
	Age 25-29	0.188	(0.037)	0.179	(0.037)
	Age 30-34	0.394	(0.076)	0.364	(0.060)
	Age 35 or more	0.516	(0.113)	0.486	(0.090)
	Low income	(ref)	(ref)	(ref)	(ref)
	Middle income	-0.110	(0.028)	-0.086	(0.021)
	High income	-0.192	(0.020)	-0.180	(0.023)
	Rural	-1.930	(0.469)	-2.026	(0.467)
Pseudo R^2		0.03		0.04	
N		254,421		254,421	

Note: Maximum likelihood estimation of delivery choice model. Our main specification is reported in column (1). Column (2) includes insurer fixed effects. We replace missing prices and missing payment contracts with zeros. Standard errors in parenthesis are clustered at the municipality level.

Appendix E Derivation of Pricing Functions

Consider a logarithmic transformation of the Nash surplus function:

$$\log S_{jh} = \beta \log(\pi^j(\mathbf{p}, \mathbf{f}, H_j) - t_h^j) + (1-\beta)\log(\pi^h(\mathbf{p}, \mathbf{f}, J_h) - t_j^h)$$

The FOC with respect to the c-section price is:

$$-\underbrace{\frac{\beta}{1-\beta}\frac{\partial \pi^j/\partial p_{jh,l=1}}{\pi^j - t_h^j}(\pi^h - t_j^h)}_{\mathbf{\Gamma}^1} = \frac{\partial \pi^h}{\partial p_{jh,l=1}}$$

which in matrix form is equivalent to:

$$-\mathbf{\Gamma}_1^1(\mathbf{p}_1-\mathbf{m}_1)-\mathbf{\Gamma}_2^1(\mathbf{p}_2-\mathbf{m}_2)=\mathbf{\Omega}_1^1(\mathbf{p}_1-\mathbf{m}_1)+\mathbf{D}_1+\mathbf{\Omega}_2^1(\mathbf{p}_2-\mathbf{m}_2)$$

where $D_{ijhl}=\phi_{ijhl}s_{ijh}\sigma_{ij}$, $\mathbf{D}_1=\sum_i D_{ijh,l=1}$, $\mathbf{\Gamma}_1^1=\mathbf{\Gamma}^1\mathbf{\Delta}\mathbf{D}_1$, $\mathbf{\Gamma}_2^1=\mathbf{\Gamma}^1\mathbf{\Delta}\mathbf{D}_2$; $\mathbf{\Delta}\mathbf{D}_1$ and $\mathbf{\Delta}\mathbf{D}_2$ are the change in demand for c-sections $\sum_i D_{ijh,l=1}$ and vaginal deliveries $\sum_i D_{ijh,l=2}$, respectively, between the observed scenario and the scenario where hospital h is dropped from the network; $\mathbf{\Omega}_1^1$ is a matrix whose (h,k) element is given by $\sum_i \frac{\partial D_{ijk,l=1}}{\partial p_{jh,l=1}}$, and $\mathbf{\Omega}_2^1$ is a matrix whose (h,k) element is given by $\sum_i \frac{\partial D_{ijk,l=2}}{\partial p_{jh,l=1}}$. Solving for the c-section price yields:

$$\mathbf{p}_1=\mathbf{m}_1-(\mathbf{\Gamma}_1^1+\mathbf{\Omega}_1^1)^{-1}(\mathbf{D}_1+(\mathbf{\Gamma}_2^1+\mathbf{\Omega}_2^1)(\mathbf{p}_2-\mathbf{m}_2)) \tag{4}$$

The FOC with respect to the vaginal delivery price is:

$$-\underbrace{\frac{\beta}{1-\beta}\frac{\partial\pi^j/\partial p_{jh,l=2}}{\pi^j-t_h^j}}_{\mathbf{\Gamma}^2}(\pi^h-t_j^h)=\frac{\partial\pi^h}{\partial p_{jh,l=2}}$$

which in matrix form becomes:

$$-\mathbf{\Gamma}_1^2(\mathbf{p}_1-\mathbf{m}_1)-\mathbf{\Gamma}_2^2(\mathbf{p}_2-\mathbf{m}_2)=\mathbf{\Omega}_1^2(\mathbf{p}_1-\mathbf{m}_1)+\mathbf{\Omega}_2^2(\mathbf{p}_2-\mathbf{m}_2)+\mathbf{D}_2$$

or:

$$-(\mathbf{\Gamma}_2^2+\mathbf{\Omega}_2^2)(\mathbf{p}_2-\mathbf{m}_2)=(\mathbf{\Gamma}_1^2+\mathbf{\Omega}_1^2)(\mathbf{p}_1-\mathbf{m}_1)+\mathbf{D}_2 \tag{5}$$

where $\mathbf{D}_2=\sum_i D_{ijh,l=2}$ and the rest of matrices are defined analogously to the FOC for c-sections. Replacing (4) in (5) obtains:

$$-(\mathbf{\Gamma}_2^2+\mathbf{\Omega}_2^2)(\mathbf{p}_2-\mathbf{m}_2)=-(\mathbf{\Gamma}_1^2+\mathbf{\Omega}_1^2)(\mathbf{\Gamma}_1^1+\mathbf{\Omega}_1^1)^{-1}(\mathbf{D}_1+(\mathbf{\Gamma}_2^1+\mathbf{\Omega}_2^1)(\mathbf{p}_2-\mathbf{m}_2))+\mathbf{D}_2$$

$$\mathbf{p}_2=\mathbf{m}_2-((\mathbf{\Gamma}_2^2+\mathbf{\Omega}_2^2)-(\mathbf{\Gamma}_1^2+\mathbf{\Omega}_1^2)(\mathbf{\Gamma}_1^1+\mathbf{\Omega}_1^1)^{-1}(\mathbf{\Gamma}_2^1+\mathbf{\Omega}_2^1))^{-1}(\mathbf{D}_2-(\mathbf{\Gamma}_1^2+\mathbf{\Omega}_1^2)(\mathbf{\Gamma}_1^1+\mathbf{\Omega}_1^1)^{-1}\mathbf{D}_1)$$

Hence, the equilibrium pricing function for vaginal deliveries is:

$$\mathbf{p}_2=\mathbf{m}_2-(\mathbf{\Lambda}_2^2-(\mathbf{\Lambda}_1^2(\mathbf{\Lambda}_1^1)^{-1}\mathbf{\Lambda}_2^1))^{-1}(\mathbf{D}_2-\mathbf{\Lambda}_1^2(\mathbf{\Lambda}_1^1)^{-1}\mathbf{D}_1)$$

where $\mathbf{\Lambda}_l^{l'}=\mathbf{\Gamma}_l^{l'}+\mathbf{\Omega}_l^{l'}$. The pricing function for c-sections can be obtained by symmetry.