Payment Contracts for Delivery Procedures: Addressing the C-section Epidemic*

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Abstract

C-section overuse may lead to poor maternal health outcomes and contribute to rising health care costs. In this paper, we speak to the ongoing policy debate on using reimbursement mechanisms to impact delivery procedure choice. We estimate the effect of two payment contracts –fee-for-service and capitation– on c-section rates, health care costs, and health outcomes. We develop a structural model of delivery choice, hospital demand, and prices to quantify hospital and insurer responses to financial incentives. We find that hospitals are more likely to provide a c-section when it is reimbursed under fee-for-service, while demand estimates are consistent with insurers steering patients toward capitated hospitals. We use our model estimates to compute market outcomes under counterfactual contract regulations and find lower health care costs, c-section rates, and rates of negative maternal health outcomes when delivery procedures are capitated.

Keywords: Delivery, Health Insurance, Fee-for-service, Capitation

JEL codes: I11, I13, I18.

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1 Introduction

Several countries in Latin America, including Brazil, Colombia, and Chile, have experienced a rapid increase in cesarean section (c-section) rates in recent decades, a phenomenon some call the "c-section epidemic."[1] In Colombia, c-sections accounted for 61 percent of all deliveries in the statutory health system in 2013 (Ministerio de Salud, 2015). This c-section rate exceeds recommendations from the World Health Organization and is well above the rate in OECD countries (WHO, 2018). C-sections are the leading cause of hospitalization among women, are more expensive than vaginal deliveries, and are more commonly associated with bad maternal health outcomes (AHRQ, 2018b,a; Rizo Gil, 2009). It is therefore of policy interest to design mechanisms that help reduce unnecessary c-sections. In this paper we focus on how the regulation of payment contracts between health insurers and hospitals impacts delivery procedure choice, health care costs, and maternal health outcomes in the Colombian healthcare system.

The most common types of payment contracts between insurers and hospitals are capitation and fee-for-service (FFS). While use of capitation grew in many countries with the rise of managed care, FFS remains the dominant way by which insurers reimburse providers (Zuvekas and Cohen, 2016). These contracts generate starkly opposing incentives for insurers and providers. Under capitation, hospitals have incentives to under-provide care because they are exposed to higher financial risk (Aizer, Currie, and Moretti, 2007; Kuziemko, Meckel, and Rossin-Slater, 2018). Under FFS, hospitals have incentives to over-provide services because their revenues are proportional to the number of services provided (Hennig-Schmidt, Selten, and Wiesen, 2011;

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

Helmchen and Lo Sasso, 2010). At the same time, different payment contracts may incentivize insurers to steer patients towards cheaper hospitals or higher-value care. In Colombia and other settings, such as Medicaid Managed Care in the U.S., these payment contracts are used simultaneously (KFF, 2022).

Insurers and hospitals in Colombia negotiate payment contracts and prices separately for each health service. First, they determine which services will be reimbursed under FFS and which under capitation. Then, they negotiate prices based on expected demand and costs. After contracts are signed, patients choose a hospital based on their unobserved health risk, which cannot be fully priced into contracts ex-ante. Insurers and hospitals may therefore have incentives to influence procedure and hospital choices ex-post. For example, insurers can steer patients towards cheaper hospitals and hospitals can promote more expensive treatments. Payment contracts in part determine the extent to which insurers and providers can respond to this type of asymmetric information.

We start by providing descriptive evidence of substantial adverse selection in hospital choice, consistent with insurers' inability to fully price in health risk during negotiations with hospitals. We then document that hospitals are more likely to provide c-sections if they are reimbursed on a FFS basis. This is suggestive of hospitals responding to financial incentives in their treatment choices, which we refer to as hospital moral hazard. We also show that, conditional on delivery procedure, negotiated delivery prices are higher at hospitals with capitation contracts than at hospitals with FFS contracts. This price difference stems from larger, higher-quality hospitals selecting into capitation contracts.

The descriptive evidence suggests that incentives differ for insurers and hospitals based on their payment contracts, consistent with economic intuition. To quantify the effect of such incentives under counterfactual payment contract regulations, we develop and estimate an equilibrium model of delivery procedure prices, hospital demand, and delivery choice. In our model, insurers and hospitals first negotiate prices for vaginal delivery and c-section, taking observed payment contracts and health insurance enrollment decisions as given. Then, women choose an in-network hospital for their childbirth. Finally, hospitals and patients jointly choose the delivery procedure.

We solve the model backwards, starting with the choice of delivery procedure. We model the likelihood of having a c-section as a flexible function of delivery procedure prices, payment contracts, and patient characteristics. Each woman takes into account the likelihood of receiving a c-section when making her hospital choice. Hospital demand is a function of the woman's expected out-of-pocket (OOP) price and payment contracts for c-sections and vaginal deliveries. Conditional on hospital demand, we derive reduced-form equations for the price of a delivery procedure under both FFS and capitation from a Nash-in-Nash bargaining model. To estimate our model, we use claims and enrollment data for all women who gave birth in the Colombian healthcare system during 2010 and 2011. These data contain information on the payment contract under which each claim was reimbursed and negotiated prices.

Estimation of our delivery choice model shows that, conditional on the woman's health status, hospitals are more likely to perform c-sections the higher is the relative price of a c-section. Hospitals are also 2 percentage points (p.p.) more likely to offer a c-section if it is reimbursed under FFS. Our demand estimates show that women are approximately 65 percent less likely to choose a hospital if the expected OOP delivery price increases by $10 (4 percent of the monthly minimum wage). All else equal, hospital demand is 68 percent lower if the expected payment contract under which the delivery is covered is FFS. The negative effect of payment contracts on hospital demand is consistent with insurers steering patients towards hospitals where delivery is capitated and the insurer's marginal cost is zero.

We estimate four reduced-form pricing functions, one for each payment contract-delivery procedure pair. For both payment contracts, we find that hospital markups are significantly greater for c-sections than for vaginal deliveries. Under FFS, for example, the average c-section markup is 14 percent of the average price while the average vaginal delivery markup is 8 percent. We predict that the marginal cost of a c-section reimbursed under FFS at the average hospital equals \$290, while that of a vaginal delivery equals \$220. Predictions of our capitation pricing functions also show that the base capitation transfer at the average hospital is \$295 for a c-section and \$283 for a vaginal delivery.

We use our equilibrium model of delivery choice and hospital demand to simulate the expected number of c-sections, delivery costs, and maternal health outcomes under alternative payment contracts. We find that moving to a fully capitated system, in which both c-sections and vaginal deliveries are covered under capitation for every insurer-hospital pair, results in a 6 percent decrease in the expected number of c-sections per hospital and a 16 percent decrease in delivery costs per hospital. Importantly, the reduction in the number of c-sections stems from low-risk pregnancies. We also find that the share of women with bad health outcomes after childbirth falls 9 percent under full capitation. These results show that prospective payment structures can reduce usage of medically unnecessary c-sections and may generate improvements in women's health.

This paper contributes to the literature on payment contracts between insurers and hospitals. Perhaps the paper that is most similar to ours is Ho and Pakes (2014). The authors analyze referral decisions made by physician groups whose compensation is capitated. We complement their work by focusing on the interplay of payment contracts with hospital and procedure choice in the presence of negotiated prices. Our paper is also related to Acquatella (2022) in considering the effects of payment contracts on health care costs and providers' treatment decisions.

Our counterfactual results speak to the potential of payment contracts to influence treatment decisions and costs. These outcomes are important and topical in the context of childbirth for several reasons. First, c-section rates have been shown to vary considerably across hospitals even among low-risk women (Baiker, Buckles, and Chandra, 2006). Second, unnecessary c-sections contribute to rising health care costs (Sakala, Delbanco, and Miller, 2013). Third, there is recent policy interest in reducing c-section rates (see e.g, California Health Care Foundation, 2022). The relevance of payment contracts in addressing these issues has sparked research on their impact on c-section rates (Alexander, 2017; Johnson and Rehavi, 2016). Our paper contributes to this literature by providing a unified framework of delivery procedure pricing, treatment decisions, and hospital choice. This paper also contributes to the emerging literature on the negotiation of multidimensional contracts in healthcare settings (e.g. Ho and Lee, 2023).

The remainder of this paper is structured as follows. Section 2 provides a description of the Colombian healthcare system. Section 3 introduces our data. Section 4 provides descriptive analyses. Section 5 presents our structural model. Section 6 discusses parameter identification. Section 7 presents our estimation results. Section 8 provides our 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 nearly 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. Cost-sharing rules are specified by the government based on whether the enrollee makes less than two times, between two and five times, or more than five times the monthly minimum wage. Coinsurance rates, copays, and maximum out-of-pocket expenditures within each group are standardized across insurers and hospitals.

In addition to regulating cost-sharing rules, the government sets insurance premiums to zero. Private insurers instead 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 with a below-average share of patients with diseases in this list make payments to those with an above-average share. Both risk adjustment mechanisms have been insufficient to control risk selection incentives in this healthcare system (Serna, 2023; Riascos, 2013).

Insurers have discretion over which hospitals to cover for each service in the national plan. Insurers bargain over 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 to negotiate their terms: fee-for-service, 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 on a capitated basis and another 43 percent on a FFS basis.

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 FFS 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. This payment contract incentivizes hospitals to over-provide services, or to provide relatively more expensive services. Because insurers bear the financial risk of this over-provision of care, they may have incentives to steer patients away from hospitals with a high share of services reimbursed on a FFS basis.

Under a capitation contract, insurers and hospitals bargain over the unit price of each service in the set of capitated services. The capitation payment made for each enrollee equals the sum over all unit prices. 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 that for a blood test is \$20, then 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.[2]

3 Data

We use enrollment and claims data for all individuals enrolled in the Colombian contributory regime in 2010 and 2011. Our data are comprised of 187,389 unique women who have a first childbirth in 2011 at a hospital that performed at least

[2]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.

10 childbirths. Our analysis uses the subsample of women who do not switch to the subsidized system or switch their insurer between 2010 and 2011 (N=135,791). Further sample restrictions, such as dropping women with missing values for observed characteristics, reduce the number of observations for our analysis sample to 109,821.

In the claims data, we observe the date on which each claim was provided, the provider that rendered the claim, the insurer that reimbursed it, and the associated ICD-10 diagnosis code. We observe basic 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 would have made to insurers for each of their enrollees. We create patient-level diagnosis indicators by grouping ICD-10 codes recorded before the delivery date according to the methodology in Riascos, Alfonso, and Romero (2014). We also use ICD-10 codes to classify women as having either high- or low-risk pregnancies.[3] We do not observe the woman's residential address and so cannot measure distance to hospitals in her municipality.

Importantly, we observe whether each claim was reimbursed under a FFS or a capitation contract and its price. We consider claims reimbursed under fee-for-package and fee-for-diagnosis to be forms of capitation.[4] 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 product of their coinsurance rate and this reported price. For capitated claims, the reported price is the negotiated unit price of the service in the

[3]Women with high-risk pregnancies are those who receive an ICD-10 diagnosis code of O09, V23, O10-O16, O20-O29, or O25.

[4]Fee-for-diagnosis and fee-for-package make up less than 6 percent of claims. Fee-for-diagnosis payments are per-enrollee payments made only for patients with specific health conditions; e.g. a fixed payment for diabetes will be made by the insurer for all diabetic patients. Fee-for-package payments are per-enrollee payments made only for patients that have specific healthcare episodes; e.g. a fixed payment for childbirth will be made by the insurer for all patients who are pregnant.

set of capitated services.[5] Patients' OOP costs in this case equal the product of their coinsurance rate and this reported unit price. In our pricing model in section 5, we assume that insurers and hospitals bargain over these FFS and unit capitation prices.

In some cases, reported prices may differ from negotiated prices based on encounter characteristics that are unobserved at the time of negotiations, such as length-of-stay. We therefore obtain negotiated prices for vaginal deliveries and c-sections in the style of Gowrisankaran, Nevo, and Town (2015). Negotiated prices are the average predictions of linear regressions of reported prices on patient characteristics, an indicator for payment contract type, and hospital fixed effects, estimated separately for each insurer and delivery procedure. We describe this procedure in more detail in appendix B. We refer to the predictions obtained from this methodology as "prices."

We recover each insurer's network of delivery hospitals in each market from observed claims, since all claims in our data correspond to in-network providers. We define a market as a municipality, of which there are 1,123 in Colombia. We assume that women have their baby delivered at a hospital covered by their insurer in their municipality of residence, as women typically do not travel far to receive obstetric care (Minion, Krans, Brooks, Mendez, and Haggerty, 2022). In the claims data we do not observe the individual obstetrician at each hospital that performs deliveries. We therefore assume that doctors are perfect agents for the hospital and that doctors' and hospitals' incentives are perfectly aligned.

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) uses the sample of vaginal deliveries, and column (3) uses the sample of c-sections. The average price of a delivery is $277, and c-sections are on average $25 more expensive

[5] We describe how unit capitation prices are calculated and how they are reported in the claims data in appendix A.

Table 1: Summary statistics

		All (1)	Vaginal (2)	C-section (3)
Contracts	Price	277 (131.9)	264 (134.8)	289 (127.7)
	FFS	0.78 (0.42)	0.74 (0.44)	0.81 (0.39)
	C-section	0.50 (0.50)	—	—
Demographics	Age 18-24	0.28 (0.45)	0.31 (0.46)	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)	0.24 (0.43)	0.27 (0.44)
	Age 35 or more	0.15 (0.36)	0.13 (0.33)	0.18 (0.38)
	Low income	0.77 (0.42)	0.77 (0.42)	0.78 (0.42)
	Medium income	0.19 (0.39)	0.19 (0.39)	0.19 (0.39)
	High income	0.04 (0.19)	0.04 (0.20)	0.03 (0.18)
	Urban municipality	0.51 (0.50)	0.58 (0.49)	0.44 (0.50)
	Rural municipality	0.49 (0.50)	0.42 (0.49)	0.56 (0.50)
Health	Cancer	0.05 (0.22)	0.04 (0.20)	0.06 (0.23)
	Cardiovascular	0.02 (0.15)	0.02 (0.14)	0.03 (0.17)
	Diabetes	0.00 (0.06)	0.00 (0.05)	0.00 (0.06)
	High-risk pregnancy	0.15 (0.36)	0.14 (0.34)	0.17 (0.37)
	Cost up to delivery	377 (558.9)	333 (419.6)	417 (667.7)
	Bad health outcome	0.15 (0.16)	0.15 (0.16)	0.15 (0.16)
	Maternal mortality	0.003 (0.05)	0.003 (0.04)	0.002 (0.05)
Providers		411	392	399
Insurers		14	14	14
N		109,651	54,988	54,663

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 are measured in dollars.

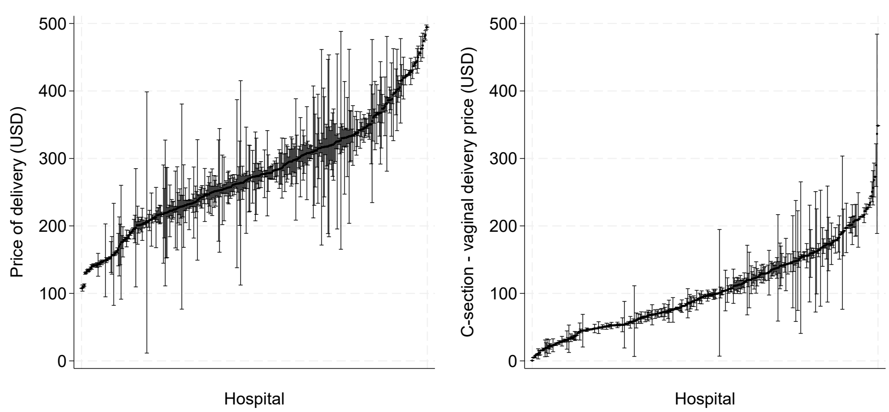
than vaginal deliveries. 81 percent of c-sections are covered under FFS, while only 74 percent of vaginal deliveries are covered under this payment contract. Women who receive a c-section are on average older and in worse health than those who receive a vaginal delivery as measured by comorbidity incidence and pregnancy risk. We also find that 0.3 percent of women on average die during childbirth at the hospitals in our sample, and that 15 percent of hospitals are associated with women who have a bad health outcome in the month after giving birth.[6]

[6]The variable "Bad health outcome" is an indicator variable for hospitals where women have the following ICD10 codes in the three months after childbirth: R85, O85, O86. Mortality rates come from the National Administrative Department of Statistics.

4 Descriptive analysis

In this section, we summarize price variation across hospitals and delivery procedures, and provide descriptive evidence of responses to this variation in the form of adverse selection and hospital moral hazard. Prices for delivery procedures in our data vary significantly across and within hospitals. Figure 1 summarizes each of these sources of variation. The left-hand panel presents the mean and 95 percent confidence interval of delivery prices for each hospital on the horizontal axis. The right-hand panel presents the same statistics for the difference between the price of a c-section and the price of a vaginal delivery. The average price of a delivery ranges from \$106 to \$493. The average standard deviation of delivery prices within a hospital is \$67.

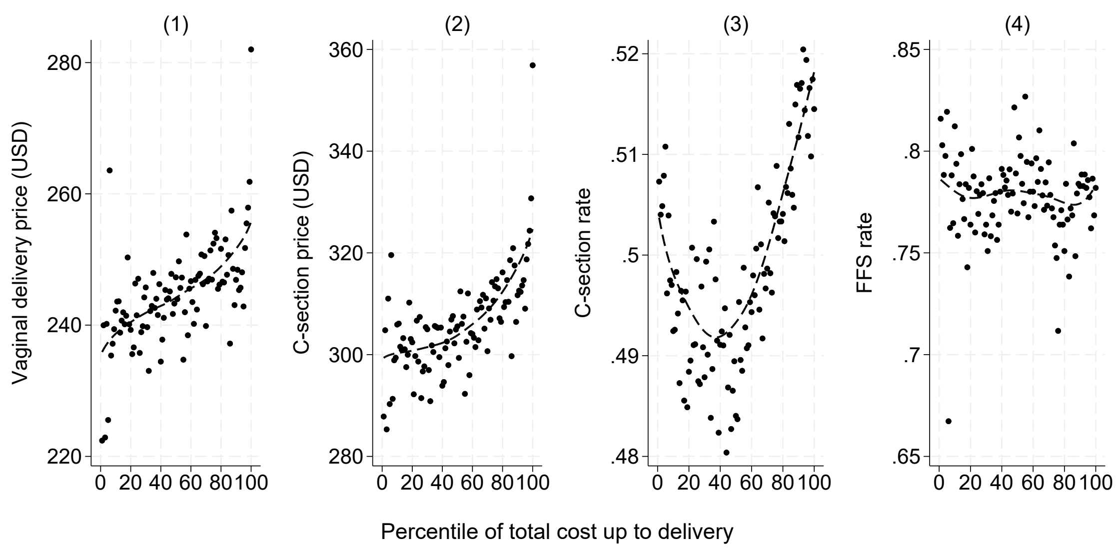
FIGURE 1: Variation in Delivery Prices



Note: Figure shows the average and 95 percent confidence interval of delivery prices in the left-hand panel and the difference between c-section and vaginal delivery prices in the right-hand panel. An observation on the horizontal axis is a hospital. Hospital are arranged in ascending order of delivery prices or their difference.

Variation in delivery prices within hospitals may be the result of differences in bargaining power relative to insurers or of adverse selection in hospital demand. If patients sort non-randomly into hospitals, then we should see a correlation between underlying patient health and hospital characteristics. To check this in the data, we stratify patients into percentiles of health care costs up to but not including the delivery, which we use as proxy for the woman's underlying health status. Figure 2 shows the correlation of this measure of underlying health with hospital delivery prices in panels (1) and (2), with hospital c-section rates in panel (3), and with hospital FFS rates in panel (4). In each panel, dots represent the average value of the outcome variable across hospitals chosen by women in the corresponding percentile of costs-up-to-delivery.

FIGURE 2: Patient sorting on prices, c-section rates, and payment contracts



Note: Figure shows the average of vaginal delivery prices (panel 1), c-section prices (panel 2), c-section rate (panel 3), and FFS rate (panel 4) across delivery hospitals chosen by patients in the percentile of costs up to the time of delivery indicated on the horizontal axis.

Consistent with adverse selection, we see that women who are costlier prior to childbirth choose more expensive hospitals for delivery, and tend to visit hospitals with higher c-section rates. We find however no correlation between the hospital's FFS rate and woman's underlying health. Only by estimating a structural model of the market for deliveries can we determine the extent to which this zero correlation is the result of potentially opposing incentives of insurers, hospitals, and patients under different payment contracts.

Turning to moral hazard, in table 2 we see that c-sections are more common when they are reimbursed on a FFS basis conditional on womens' age and health status. Table 2 also shows that conditional on the delivery procedure, capitation prices are higher than FFS prices, a pattern that may be the result of (i) insurers anticipating hospital moral hazard under FFS when negotiating prices with hospitals, (ii) hospitals anticipating their increased financial risk under capitation, or (iii) hospitals under capitation having greater dispersion in patient health risk (as in Acquatella (2022)).

Table 2: Variation in c-section rates across patients and contracts

	Capitation			FFS		
	C-section rate	C-section price	Vaginal del. price	C-section rate	C-section price	Vaginal del. price
Age<30, Healthy	0.40	431.1	383.3	0.48	271.6	202.8
Age<30, Unhealthy	0.48	434.2	378.7	0.53	276.5	207.1
Age>=30, Healthy	0.50	402.3	361.9	0.55	281.2	212.6
Age>=30, Unhealthy	0.52	424.6	377.7	0.64	276.5	204.7

Note: Table shows mean of c-section rates, c-section prices, and vaginal delivery prices conditional on the woman's observable characteristics (age and having a chronic disease) and whether c-sections are covered under FFS.

Which hospitals negotiate which contracts? Price variation across payment contracts conditional on delivery procedure raises questions about selection of hospitals into payment contracts. Although we do not explicitly model how these payment contracts emerge in equilibrium, knowing which type of hospitals negotiate which payment contracts is important for understanding the welfare implications of counterfactual payment contract regulations. Table 3 presents average characteristics of the hospitals that negotiate each contract type. We see that hospitals that negotiate capitation contracts are on average larger but treat relative sicker women than those that negotiate FFS contracts. Larger hospitals are potentially better able to pool risks across patients compared to smaller hospitals when reimbursed under a capitation contract. The table also shows that hospitals that negotiate FFS are located in more concentrated hospital markets than those that negotiate capitation contracts.

TABLE 3: Hospital and market characteristics by payment contract

	Cap	FFS
C-section rate	0.42 (0.49)	0.52 (0.50)
Beds	110.6 (98.0)	106.9 (94.7)
Maternal mortality	0.007 (0.08)	0.001 (0.03)
Bad outcome	0.17 (0.13)	0.14 (0.17)
Hospital HHI	0.20 (0.21)	0.34 (0.28)
Insurer HHI	0.24 (0.16)	0.32 (0.22)

Note: Table shows average hospital and market characteristics by type of payment contract across all deliveries. Hospital HHI is computed using delivery shares. Insurer HHI is computed using enrollee shares.

5 Model

To study the impact of payment contracts on c-section rates and delivery costs, we develop a model of hospital and delivery choice. Throughout the model we take enrollment decisions, payment contracts, and hospital networks as given. The timing is as follows: (1) insurers and hospitals negotiate delivery prices, conditional on payment contracts; (2) after observing prices, women choose a hospital in the network of their insurer at which to have a childbirth; (3) observing prices and payment contracts, the patient and the hospital jointly decide whether to deliver the child by vaginal delivery or c-section. We lay out our model starting from the choice of delivery procedure.

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. Let p_{jh} be the negotiated price of a c-section, and q_{jh} the negotiated price of a vaginal delivery between insurer j and hospital h. Also, let f_{jh} and g_{jh} be indicators for whether c-sections and vaginal deliveries are covered under FFS, respectively. We model the probability of a c-section as a linear function of negotiated prices and contracts:

$$d_{ijh} = \theta_1 p_{jh} + \theta_2 q_{jh} + \theta_{3,i} f_{jh} + \theta_{4,i} g_{jh} + x_i' \theta_5 + \varphi_j + \delta_{t(h)} + \varepsilon_{ijh}$$

Here, $(\theta_{3,i} \quad \theta_{4,i}) = x_i'(\theta_3 \quad \theta_4)$, x_i is a vector of the woman's observable characteristics including indicators for age group, having a chronic disease, being a high-risk pregnancy, delivery weekday, and municipality of residence. The coefficients φ_j are insurer fixed effects and $\delta_{t(h)}$ are municipality fixed effects. The predicted likelihood of a c-section is $\hat{\phi}_{ijh} = \hat{E}[d_{ijh} | p_{jh}, q_{jh}, f_{jh}, g_{jh}, x_i; \hat{\theta}]$.

The responsiveness of c-section choice to financial characteristics conditional on patient characteristics, measured by θ_1 through θ_4, captures hospital moral hazard. We allow hospitals to be less responsive to payment contracts among high-risk women, by interacting the FFS indicator for c-sections with patient characteristics.

The literature that studies provider moral hazard typically models physicians as altruistic agents that make treatment decisions taking into account their patient's utility (e.g, Godager and Wiesen, 2013). Providers may weigh patient's OOP costs against their own reimbursements when responding to financial incentives. A relatively higher weight on own reimbursements would bias providers in favor of the procedure with the higher markup. By including negotiated prices rather than OOP costs and hospital reimbursements separately, our estimates represent the net effect of provider altruism and moral hazard.

5.2 Hospital demand

We model a woman's choice over in-network hospitals as a function of her expected OOP price and expected payment contract, with expectations taken over the delivery procedure. The probability distribution over delivery procedures is endogenous and comes from our model of delivery choice. In particular, define the expected delivery price as $\hat{p}_{ijh} = \hat{\phi}_{ijh} p_{jh} + (1 - \hat{\phi}_{ijh}) q_{jh}$, and the expected payment contract as $\hat{f}_{ijh} = \hat{\phi}_{ijh} f_{jh} + (1 - \hat{\phi}_{ijh}) g_{jh}$. Pregnant woman i enrolled with insurer j has the following utility from choosing hospital h for delivery:

$$u_{ijh} = \alpha_i c_i \hat{p}_{ijh} + \lambda_i \hat{f}_{ijh} + \gamma_i \hat{\phi}_{ijh} + \delta_i y_i + x'_{ih}\beta + \eta_h + \varepsilon_{ijh} \tag{1}$$

where $(\alpha_i \;\; \lambda_i \;\; \gamma_i \;\; \delta_i) = x'_i(\alpha \;\; \lambda \;\; \gamma \;\; \delta)$. The variable c_i is the patient's coinsurance rate, and y_i 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. We include a vector x_{ih} of observable hospital characteristics interacted with patient characteristics. We also include a hospital fixed effect η_h to capture hospital quality. 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). 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 (1) is the patient's expected OOP price. Contracts affect this payment both through their effect on delivery choice and on delivery prices. Observed heterogeneity across women in their sensitivity to OOP prices is captured through interactions of α with x_i, which includes indicators for age group, having a chronic disease, having a high-risk pregnancy, costs up to delivery, and zone of residence (urban or rural).

The second term in equation (1) captures differences in demand across hospitals reimbursed under FFS relative to those reimbursed under capitation. In addition to women's characteristics, we interact λ with an indicator for whether the woman is enrolled with any of three largest insurers in the country to capture the possibility that large insurers may be better able to steer their patients. Since capitation payments are sunk, the insurer's marginal cost of deliveries at capitated hospitals is zero, which may motivate insurers to steer patients toward capitated hospitals. In the third term, we include the probability of receiving a c-section, $\hat{\phi}_{ijh}$, to capture women's preferences for each delivery procedure (Currie and MacLeod, 2017).

The fourth term in equation (1) represents provider inertia. There is substantial evidence in the literature that patients are more likely to choose a hospital or a provider if they have had previous healthcare encounters at it (Drake, Ryan, and Dowd, 2022; Saltzman, Swanson, and Polsky, 2022).[7] Inclusion of past choices in the utility function helps correct for the potential bias in price sensitivity arising from provider inertia. Lastly, we include interactions between hospital and patient characteristics, x_{ih}, to capture preference heterogeneity over number of beds, the hospital's rate of bad post-delivery outcomes, and the hospitals' rate of maternal mortality. This source of preference heterogeneity accounts for the fact that sicker patients may have stronger preferences for larger or higher-quality hospitals.

Woman i's likelihood of choosing hospital h is

$$s_{ijh}(f_{jh}, g_{jh}, \cdot) = \frac{\exp(\psi_{ijh})}{\sum_{k \in H_j} \exp(\psi_{ijk})}$$

where $\psi_{ijh} = \alpha_i c_i \hat{p}_{ijh} + \lambda_j \hat{f}_{ijh} + \gamma_i \hat{\phi}_{ijh} + \delta_i y_i + x'_{ih}\beta + \eta_h$ and H_j is the set of hospitals in insurer j's network. Following McFadden (1996), the woman's (dollarized) expected utility for insurer j's network is

$$W_{ij}(f_{jh}, g_{jh}, \cdot) = \frac{1}{-\alpha_i} \log \left(\sum_{h \in H_j} \exp(\psi_{ijh}) \right)$$

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

We use this expected utility in our derivation of procedure pricing functions in the next subsection.

Why do payment contracts affect demand? Although contracts are not observed by patients when making enrollment or hospital choices, there are several reasons why they may influence hospital demand directly. First, hospitals reimbursed under FFS have an incentive to increase patient volume, as their profits are proportional to the number of deliveries provided. We consider this incentive as hospital moral hazard on the extensive margin, rather than on the intensive treatment margin. Second, payment contracts may be correlated with unobserved hospital quality. Third, insurers have incentives to steer patients away from hospitals reimbursed on a FFS basis toward those where delivery procedures are capitated. The inclusion of the expected payment contract in our structural model allows us to identify the net effect of these forces (namely hospital moral hazard and insurer steering) from the effect of prices and resulting women sorting on hospital demand.

More explicitly, consider the sensitivity of hospital demand to c-section prices derived in the equation below. If the decision to perform a c-section depended only on women's health and not on prices nor payment contracts (i.e. if $\frac{\partial \hat{\phi}_{ijh}}{\partial p_{jh}} = 0$), then the effects of hospital moral hazard and insurer steering on demand would be zero. In that case, demand responds to price only through patient sensitivity to OOP costs. If c-sections are instead more likely with higher prices (i.e. if $\frac{\partial \hat{\phi}_{ijh}}{\partial p_{jh}} > 0$), then demand would be less elastic if hospital moral hazard overcompensates insurer steering ($\lambda_i > 0$), but would be more elastic in the opposite case ($\lambda_i < 0$). Overall, our model allows us to assess the relative importance of hospital moral hazard and insurer steering for hospital choice with the sign of λ_i, and to assess direct price effects with α_i.

$$\frac{\partial s_{ijh}}{\partial p_{jh}} = s_{ijh}(1 - s_{ijh})\Big[\underbrace{c_i \alpha_i \hat{\phi}_{ijh}}_{\text{Direct price effect}} + \underbrace{\Big(\alpha_i(p_{jh} - q_{jh}) + \lambda_i(f_{jh} - g_{jh}) + \gamma_i\Big)\frac{\partial \hat{\phi}_{ijh}}{\partial p_{jh}}}_{\text{Hospital moral hazard + Insurer steering}} \Big]$$

5.3 Pricing functions

Insurers and hospitals in Colombia bargain over prices and payment contracts for each delivery procedure. We model these interactions with a Nash-in-Nash bargaining framework taking payment contracts as given. In appendix C, we derive a reduced-form expression for FFS and unit capitation prices. Relative to prior work that uses Nash-in-Nash, we do not define the insurer's disagreement payoff as the profit it would enjoy from dropping the hospital from the network. We instead define the insurer's disagreement payoff when negotiating FFS prices as the profit it would enjoy from capitating the hospital but keeping it in the network. Similarly, for a capitation contract, the insurer's disagreement payoff is the profit it would enjoy from covering the hospital under FFS. This definition of disagreement payoffs assumes that insurers are committed to covering hospitals that they have included in their delivery networks under at least one payment contract.

Denote by $s_{jh}(f_{jh}, g_{jh}, \cdot) = \sum_i s_{ijh}(f_{jh}, g_{jh}, \cdot)$ the demand for hospital h in the network of insurer j. Our reduced-form expression of the FFS pricing function for c-sections is

$$p^1_{jh} = \underbrace{\mu^1_j + \mu^1_{t(h)}}_{\text{Marginal cost}} - \underbrace{\Big(\frac{\partial s_{jh}}{\partial p^1_{jh}} + \sum_{\substack{k \in F_j \\ k \neq h}} \Big(\frac{\partial W_j}{\partial p^1_{jh}} - \frac{\partial TC_j}{\partial p^1_{jh}}\Big) s_{jk}\Big)^{-1} \Big(\omega^1 s_{jh} + \tau^1 \overline{p}^0_j\Big)}_{\text{Markup}} + \epsilon^1_{jh} \qquad (2)$$

and the expression of the capitation pricing function for c-sections is

$$p^0_{jh} = \underbrace{\kappa^0 \frac{\overline{s}_{jh}}{\hat{\sigma}_j} - \delta^0 \sum_{j \in F_h} \frac{s_{jh} p^1_{jh}}{\hat{\sigma}_j} + \mu^0_{t(h)}}_{\text{Base transfer}} \underbrace{- \Big(\hat{\sigma}_j \sum_{h \in K_j} \Big(\frac{\partial W_j}{\partial p^0_{jh}} - \frac{\partial TC_j}{\partial p^0_{jh}}\Big)\Big)^{-1} \Big(\tau^0 \hat{\sigma}_j - \omega^0 \sum_{h \in K_j} \frac{\partial s_{jh}}{\partial p^0_{jh}}\Big) + \mu^0_j}_{\text{Markup}} + \epsilon^0_{jh} \tag{3}$$

Analogous expressions can be written for vaginal deliveries with FFS prices and unit capitation prices given by q^1_{jh} and q^0_{jh}, respectively. In these equations, $\hat{\sigma}_j$ is our proxy for insurer demand (described in appendix C), μ_j is an insurer fixed effect, $\mu_{t(h)}$ is a municipality fixed effect, $\overline{s}_{jh}$ is demand for insurer-hospital pair jh evaluated at average market prices, and κ, ω, δ, and τ are parameters to be estimated. The value of insurer j's network, $W_j(f_{jh}, g_{jh}, \cdot) = \sum_i W_{ij}(f_{jh}, g_{jh}, \cdot)$, is our measure of insurer revenues. Insurer j's total cost is given by $TC_j = \sum_{h \in F_j} \sum_i (1 - c_i) p^1_{jh} s_{ijh}(p^1_{jh}, p^0_{jh}) + \sum_{h \in K_j} p^0_{jh} \hat{\sigma_j}$, where F_j is the set of hospitals covered under FFS and K_j is the set of hospitals covered under capitation, and where $F_j \cap K_j = \oslash$.[8]

The first two terms on the right-hand side of equation (2) capture the fixed marginal cost of providing a c-section. The third term is our reduced-form approximation to hospital markups under FFS. The FFS markup is a function of hospital demand s_{jh} and its derivatives, average capitation transfers $\overline{p}^0_j$ that approximate disagreement payoffs, and derivatives of insurer profits given by $\frac{\partial W_j}{\partial p^1_{jh}} - \frac{\partial TC_j}{\partial p^1_{jh}}$. Finally, ϵ^1_{jh} is our FFS structural unobservable. Whether FFS and capitation contracts are strategic complements or strategic substitutes will depend on the sign of τ^1. In absence of capitation contracts, our expression for hospital FFS prices would be the same as in Gowrisankaran et al. (2015).

The first four terms on the right-hand side of equation (3) represent the base capitation transfer. This transfer is increasing in the fraction of insurer j's enrollees that visit capitated

[8] Here and in equations (2) and (3), we have not indexed the sets F_j and K_j to the delivery procedure for ease of exposition, though these sets may in fact differ across procedures.

hospitals in its network and decreasing in the hospital's FFS revenues. The remaining terms in equation (3) are our approximation to markups in a capitation contract. The markup is a function of hospital demand and its derivatives, insurer demand $\hat{\sigma}_j$, and derivatives of insurer profits $\frac{\partial W_j}{\partial p^0_{jh}} - \frac{\partial TC_j}{\partial p^0_{jh}}$. The capitation structural unobservable is given by ϵ^0_{jh}.

6 Identification and estimation

Delivery choice. Our delivery choice model includes insurer and municipality fixed effects. We thus rely on variation in prices and payment contracts across the hospitals in an insurer's network in a given market to identify the parameters in θ. This type of variation is likely correlated with unobserved hospital quality or the patient's unobserved health status. For example, if unobservably high-risk women who need c-sections are more likely to visit higher priced hospitals, then our estimates of responsiveness to prices will be biased upwards. To correct for this type of endogeneity, we instrument prices and payment contracts with their lagged values, average prices in other markets, and hospital characteristics. We estimate the delivery choice function using 2SLS.

Hospital demand. Enrollee's choice of insurer is one source of selection bias that threatens identification of parameters in our demand model. An enrollee may choose her insurer because it has negotiated low delivery prices with her preferred hospitals. This selection would bias our price coefficient to zero. We follow Prager (2020) and Abaluck, Gruber, and Swanson (2018) to correct for this source of bias leveraging inertia in insurer choice. Our main estimation sample is the set of women who were 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, the sorting of patients into prices and payment contracts after the period of initial choice will be quasi-random. This allows us to use a control function for the woman's OOP price following Petrin and Train (2010). In the first stage, we regress the woman's OOP price on patient characteristics, hospital fixed effects, and an instrument, namely c-section and vaginal delivery prices in other markets. In the second stage, we estimate our demand model, including the residuals from the first-stage interacted with patient characteristics.[9]

The coefficient on the OOP price, α_i, is then identified from price variation across hospitals in an insurer's network and variation in choice sets across patients in the same cost-sharing tier. We also use variation in cost-sharing generated by whether women have reached their OOP maximum by the time of delivery, in which case their coinsurance rate is zero. The coefficient λ_i is identified from variation in payment contracts across hospitals in an insurer's network and from variation in the likelihood of receiving a c-section, $\hat{\phi}_{ijh}$.

Finally, the coefficient on provider inertia, γ_i, is identified from variation in whether women have their childbirth at the same hospitals they visited in 2010 for health care that may be unrelated to their pregnancy. The demand model in equation (1) is a conditional logit, which we estimate by maximum likelihood. We compute standard errors with 100 bootstrap resamples.

Pricing functions. Our pricing functions are reduced-form representations of the equilibrium prices that would result from bilateral bargains between insurers and hospitals, taking payment contracts as given. OLS estimation of equation (2) would thus suffer from the standard simultaneity bias in linear supply models. We use instrumental variables to address this simultaneity issue. In the case of the FFS pricing function for c-sections, our instrument for hospital demand (an its derivatives) is the log FFS price for vaginal deliveries. In the case of the FFS pricing function for vaginal deliveries, our instruments are the

[9] More formally, in the first stage we estimate the following linear regression:

$$c_i\hat{p}_{jh} = \tau_1 p'_{jh} + \tau_2 q'_{jh} + \tau_3\hat{f}_{jh} + \tau_4\hat{\phi}_{ijh} + \tau_5 y_i + x'_i\beta + \eta_h + \nu_{ijh}$$

where p'_{jh} and q'_{jh} denote the prices in other markets for c-sections and vaginal deliveries, respectively. From this regression, we obtain the residuals $\hat{\nu}_{ijh}$. Under the assumption that $E[\hat{\nu}_{ijh}\varepsilon_{ijh}] \neq 0$ and that $E[c_i\hat{p}_{jh}\varepsilon_{ijh}|\hat{\nu}_{ijh}] = 0$, we incorporate these residuals into demand estimation as:

$$u_{ijh} = \alpha_i c_i\hat{p}_{jh} + \lambda_i\hat{f}_{jh} + \gamma_i\hat{\phi}_{ijh} + \delta_i y_i + x'_{ih}\beta + \eta_h + \rho x'_i\hat{\nu}_{ijh} + \varepsilon_{ijh}.$$

lagged vaginal delivery price interacted with the c-section FFS indicator. We estimate the FFS delivery pricing functions separately for each delivery procedure using GMM. Because hospital revenues under capitation are independent of consumers' price sensitivity, there is no simultaneity bias in our capitation pricing functions. We thus estimate equation (3) for each procedure using OLS.

7 Estimation results

Delivery choice. Table 4 reports estimation results for our delivery choice model and appendix table 1 presents first-stage regression results of prices on instruments and exogenous variables. Consistent with the previous literature (e.g, Currie and MacLeod, 2017), we find that the probability of a c-section for women aged 35 or older, women with chronic diseases, and women with high-risk pregnancies, is significantly higher than for women under 35, healthy women, and women with low-risk pregnancies, respectively. C-sections are less common during the weekends, when doctors are less available and staffing numbers are low.

Our findings show that the financial characteristics of payment contracts between insurers and hospitals significantly affect delivery choice. First, we find that the likelihood of a c-section increases by 2 p.p. when the price of a c-section increases by \$100. This effect represents a 4 percent increase over the baseline fraction of c-sections. Second, we find that the likelihood of a c-section is 2 p.p higher if c-sections are covered under FFS. Responsiveness to payment contracts is not more pronounced among high-risk pregnancies than among low-risk pregnancies. The medical literature has documented that physicians may prefer c-sections to vaginal deliveries because they are better able to control scheduling times (e.g, Spetz, Smith, and Ennis, 2001). Consistent with this hypothesis, weekday fixed effects estimates show that c-sections are less likely to be provided over the weekend when staff numbers at hospitals are low.

Because our model includes insurer and municipality fixed effects, the impact of prices on delivery choice is identified from comparisons of c-section rates across hospitals conditional on women's observable characteristics. The fact that c-sections rates vary significantly across hospitals based on delivery procedure prices is suggestive of hospitals responding to financial incentives in their treatment decisions. This finding is not unprecedented; qualitatively similar results are reported in Foo, Lee, and Fong (2017); Shafrin (2010); Gruber, Kim, and Mayzlin (1999).

TABLE 4: Delivery Choice Model Estimates

		Estimates	
		coef	se
C-section	Price	1.94	(0.28)
	FFS	1.87	(0.62)
	FFS x High risk pregnancy	1.93	(1.68)
Vaginal delivery	Price	-3.34	(0.36)
	FFS	5.23	(0.62)
	FFS x High risk pregnancy	-0.27	(1.65)
Demographics and health	Age 25-29	4.47	(0.23)
	Age 30-34	8.39	(0.25)
	Age 35 or more	13.9	(0.30)
	High risk pregnancy	3.42	(0.74)
	Chronic disease	2.71	(0.46)
Day of week	Monday	8.25	(0.39)
	Tuesday	9.04	(0.39)
	Wednesday	9.25	(0.39)
	Thursday	9.23	(0.39)
	Friday	9.46	(0.39)
	Saturday	5.35	(0.41)
	Sunday	(ref)	(ref)
R^2		0.13	
N		256,231	

Note: Maximum likelihood estimation of delivery choice model. Specification includes insurer and municipality fixed effects. Bootstrap standard error in parenthesis based on 100 resamples. Coefficients and standard errors are multiplied by 100.

Hospital demand. Table 5 presents results of our hospital demand model and appendix table 2 presents first-stage results of our control function. We find that women are approximately 65 percent less likely to choose a hospital if its expected out-of-pocket delivery price increases by $10. The average elasticity of hospital demand with respect to the expected OOP FFS price equals -1.8 and with respect to the expected OOP capitation price equals -0.31.[10] Hospital demand is around 68 percent lower if the expected payment contract under which the procedure is reimbursed is FFS. This estimate indicates that insurer steering overcompensates hospital moral hazard in our context. The negative effect of FFS contracts is lower for large insurers, suggesting that this type of insurer has fewer incentives to steer patients away from expensive hospitals.

Table 5: Hospital Demand Model Estimates

		Estimates	
		coef	se
Expected OOP ($100)		-10.6	(0.74)
Expected FFS contract		-1.15	(0.05)
Expected C-section		-11.0	(0.64)
Previous visit		1.44	(0.04)
Missing C-section FFS		-1.04	(0.02)
Missing Vaginal delivery FFS		-1.16	(0.02)
Interactions			
Expected OOP ($100)	Age 30 or more	1.44	(0.14)
	Chronic disease	1.24	(0.27)
	High-risk pregnancy	-0.75	(0.23)
	Cost up to delivery	0.92	(0.14)
	Rural	-6.96	(0.95)
	Low income	0.07	(0.14)
Expected FFS contract	Age 30 or more	0.23	(0.05)
	Chronic disease	0.12	(0.10)
	High-risk pregnancy	0.53	(0.08)
	Cost up to delivery	0.47	(0.05)
	Large insurer	1.16	(0.06)
Expected C-section	Age 30 or more	0.62	(0.59)
	Chronic disease	0.28	(1.07)
	High-risk pregnancy	-0.22	(0.84)
	Cost up to delivery	-1.78	(0.53)
Previous visit	Age 30 or more	-0.06	(0.05)
	Chronic disease	-0.24	(0.06)
	High-risk pregnancy	-0.28	(0.05)
	Cost up to delivery	0.03	(0.05)
Pseudo-R^2		0.38	
N		763,213	

Note: Maximum likelihood estimation of hospital demand model. Specification includes interactions between hospital characteristics including number of beds, the rate of bad maternal health outcomes after delivery, and maternal mortality rate for each hospital and patient characteristics including dummies for age group, having a chronic disease, having a high-risk pregnancy, and zone of residence. Specification also includes hospital fixed effects. Bootstrap standard errors in parenthesis based on 100 resamples.

We find that women generally dislike visiting hospitals with high c-section rates. Results

[10] Elasticities of hospital demand with respect of expected OOP FFS prices and capitation prices are given by $\frac{p^1_{jh}}{s_{jh}} \sum_i \frac{\partial s_{ijh}}{\partial \hat{p}_{jh}}$ and $\frac{p^0_{jh}}{s_{jh}} \sum_i \frac{\partial s_{ijh}}{\partial \hat{p}_{jh}}$, respectively.

also provide 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 expected out-of-pocket prices with patient characteristics show that women aged 30 or more are less price sensitive than women under 30, and that price sensitivity is decreasing in the woman's costs up to delivery.

Pricing functions. We present the results of our reduced-form pricing functions for c-sections and vaginal deliveries in table 6. The tables report our main estimates as well as the predicted mean marginal cost under FFS, mean base capitation transfer, mean markup, and first-stage F statistics. Appendix table 3 reports first-stage regressions for the endogenous variables associated with ω^1 and ω^0.

TABLE 6: Pricing Function Estimates

	(1) C-section		(2) Vaginal	
	FFS	Cap	FFS	Cap
ω^1/ω^0	-0.39	0.18	-0.06	8.01
	(0.15)	(0.21)	(0.03)	(5.77)
τ^1/τ^0	0.24	0.04	-0.003	0.08
	(0.09)	(0.07)	(0.002)	(0.06)
δ^0	—	-0.02	—	0.02
		(0.12)		(0.01)
κ^0	—	22.3	—	22.8
		(8.22)		(5.31)
Marginal cost/Base transfer	289.9	294.8	219.5	283.2
Predicted mean markup	46.8	85.1	19.0	57.9
N	565	154	576	131

Note: Instrumental variable regressions of the c-section and vaginal delivery pricing functions under FFS and capitation. Specifications include insurer and municipality fixed effects. Table reports the predicted mean marginal cost under FFS, mean base transfer under capitation, and mean markup. Coefficients and standard errors for capitation are multiplied by 100 for exposition. Robust standard errors in parenthesis.

We find that FFS prices for c-sections and vaginal deliveries are a non-decreasing function of average unit capitation prices, suggesting that FFS and capitation contracts are strategic complements. We predict that the mean marginal cost under FFS equals \$290 for a c-section and \$220 for a vaginal delivery, while the mean base capitation transfer is \$295 for a c-section and \$283 for a vaginal delivery. We also find that hospital markups are greater for c-sections under each payment contract. C-section markups represent 14 and 22 percent of the average price under FFS and capitation, respectively. For vaginal deliveries markups are 8 and 17 percent of average prices under each payment contract, respectively. Conditional on procedure, capitation markups are on average larger than FFS ones. This is likely reflective of higher quality hospitals sorting into capitation as is shown in table 3.

Why are there so many c-sections? Our model estimates provide several explanations for the "c-section epidemic." The pricing functions show that c-sections are relatively more profitable than vaginal deliveries across both payment contracts. C-sections are also more likely to be covered under FFS than under capitation. Together, these results show that hospital moral hazard incentives exist and that hospitals act on them in their delivery procedure choices. Hospital moral hazard is exacerbated by the fact that women enrolled with large insurers are less likely to be steered away from hospitals covered under FFS, as suggested by our hospital demand estimates.

Hospital selection into payment contracts. While throughout our model we take payment contracts as given, here we explain how the fact that large, high-quality hospitals select into capitation contracts may affect our estimates. If hospitals were to randomly sort into FFS contracts, then there would be a greater share of high-quality hospitals reimbursed under FFS relative to what we observe in our data. This would result in higher average FFS markups, which may exacerbate existing moral hazard. Our estimates therefore provide lower bounds of the true effects of retrospective payment structures on delivery and patient choices. For example, underestimation of hospital moral hazard implies that in a counterfactual where all insurer-hospital pairs cover delivery procedures under capitation, we would estimate smaller changes in c-section rates relative to random assignment to payment contracts.

If hospitals were to randomly sort into capitation contracts, then there would be a higher share of low-quality hospitals reimbursed under capitation relative to what we observe in the data. As a result, we would estimate smaller capitation markups for two reasons. First, lower-quality hospitals will likely have lower bargaining power relative to the insurer.

Second, there would be a more even distribution of patient health risk across hospitals, which reduces the minimum per-enrollee transfer needed to have a non-negative Nash surplus. This implies that in a counterfactual scenario where all insurer-hospital pairs negotiate FFS contracts, we would predict smaller changes in c-section rates relative to random assignment to payment contracts. Results from such a counterfactual can therefore be thought of as a lower bound on the true effect of full capitation.

8 Equilibrium Effects of Contract Regulation

The rapid increase in c-section rates and the large variation in delivery prices across hospitals are problematic for maternal health outcomes and health care costs. While policies that cap the number of c-sections directly may halt this increase, they may not be efficient at eliminating price variation across hospitals nor at concentrating c-section reductions among low-risk pregnancies. In this section we use our model estimates to assess the impact of payment contract regulation on equilibrium market outcomes.

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 FFS across all insurer-hospital pairs. In the second counterfactual, we set all payment contracts to capitation. For simplicity, we conduct our counterfactual simulations with data from Bogotá only, which is the capital city of Colombia and where 43 percent of all deliveries are performed. Even though payment contracts are endogenous, we think of these counterfactuals as government mandates over which types of services can be covered under which payment contracts.

Because each payment contract is associated with a different pricing function, our counterfactuals potentially involve changing the pricing function for each insurer-hospital pair in the data. We thus need to predict the structural error term for unobserved payment contracts. Along the lines of Berry, Levinsohn, and Pakes (2004), we predict the unobserved error for the FFS pricing function as hospital h's average error term for the delivery procedure across all other insurers $-j$ in its network that reimburse the service under FFS. In the special case where there are no insurers in hospital h's network with a FFS contract for the delivery procedure, we use insurer j's average error term for that service across all other hospitals $-h$ that it reimburses on a FFS basis. We predict the structural error for our second counterfactual analogously. We fix the average unit capitation price and demand at average prices, $\overline{p}_j^0$ and $\overline{s}_{jh}$, to their respective values in the observed equilibrium. Moreover, in the full capitation counterfactual the term $\sum_{j \in F_h} \frac{s_{jh} p_{jh}^1}{\hat{\sigma}_j}$ collapses to zero.

8.1 Prices and Delivery Choice

Table 7 shows the distribution of counterfactual and observed delivery prices for c-sections in panel A and for vaginal deliveries in panel B. Price statistics in the table are weighted by demand and are calculated conditional on payment contracts in the observed scenario. This allows for an apples-to-apples comparison of prices across the two scenarios.

TABLE 7: Counterfactual Price Distribution

	Mean	SD	Q1	Q3
Panel A. C-section				
$f_{jh} = 1$: Full FFS	345.7	148.2	237.0	476.0
$f_{jh} = 1$: Observed FFS	372.1	132.6	241.4	506.4
$f_{jh} = 0$: Full Cap	406.9	94.3	333.8	488.7
$f_{jh} = 0$: Observed Cap	367.8	109.1	327.5	433.9
Panel B. Vaginal delivery				
$g_{jh} = 1$: Full FFS	319.6	124.9	207.2	437.8
$g_{jh} = 1$: Observed FFS	329.2	126.8	205.2	444.7
$g_{jh} = 0$: Full Cap	401.0	94.6	349.1	460.5
$g_{jh} = 0$: Observed Cap	369.9	101.0	345.4	421.2

Note: Table shows mean, standard deviation, and 1st and 3rd quantiles of the distribution of c-section prices and vaginal delivery prices for the observed scenario and two counterfactuals: both procedures covered under FFS ("Full FFS") and both procedures covered under capitation ("Full Cap").

Consistent with increased hospital competition under FFS, we find that a full FFS contract regime decreases average c-section prices by 7 percent and average vaginal delivery prices by 3 percent. For both procedures, however, the price distribution becomes more dispersed compared to the observed scenario. In the second counterfactual, we find qualitatively opposite results. Imposing a fully capitated regime generates an 11 percent increase in average c-section prices and an 8 percent increase in average vaginal delivery prices. The capitation price increase is explained by the fact that hospital revenues are not decreasing in consumer price sensitivity under capitation contracts but hospital costs are. This can be seen from the hospitals' profit function specification in appendix C.

Table 8 shows the distribution of observed and counterfactual expected number of c-sections per hospital, $\sum_{ij} \phi_{ijh} s_{ijh}$. The table also reports the average c-section likelihood $\sum_{ij} \phi_{ijh} / \sum_{ij} s_{ijh}$, and the expected number of c-sections among high-risk and low-risk pregnancies, $\sum_{ijh} \mathbf{1}\{\text{high risk}\}_i \phi_{ijh} s_{ijh}$ and $\sum_{ijh} (1 - \mathbf{1}\{\text{high risk}\}_i) \phi_{ijh} s_{ijh}$, respectively. We find that relative to the observed equilibrium, imposing a full FFS regime results in more c-sections and greater variation in the number of c-sections across hospitals. The likelihood of a c-section increases 3.1 p.p. under full FFS, a finding that stems from hospital moral hazard under retrospective payment structures.

TABLE 8: Counterfactual Distribution of Expected Number of C-sections per Hospital

	Number of c-sections						
	Mean	SD	Q1	Q3	C-section Likelihood	Total High Risk	Total Low Risk
Full FFS	289.9	372.9	9.1	588.8	0.445	2,141.6	10,903.9
Full Cap	247.3	311.4	11.0	403.6	0.385	1,789.7	9,338.0
Observed	263.4	315.9	6.8	496.1	0.414	1,924.4	9,930.0

Note: Table shows mean, standard deviation, and 1st and 3rd quantiles of the distribution of expected number of c-sections per hospital for the observed scenario and two counterfactuals: both c-sections and vaginal deliveries covered under FFS ("Full FFS") and both c-sections and vaginal deliveries covered under capitation ("Full Cap"). Table also reports average c-section likelihood and total number of c-sections among high-risk and low-risk pregnancies.

Imposing a full capitation regime results in a 6 percent reduction in the average number of c-sections per hospital and a less dispersed distribution across hospitals. We find that the likelihood of a c-section decreases by 2.9 p.p. relative to the observed scenario. With prospective payment structures, hospitals shift towards vaginal deliveries, which are relatively cheaper to provide as suggested by our pricing function estimates.

In the last two columns of table 8, we see that the increase in the number of c-sections under full FFS occurs among both high-risk and low-risk pregnancies. In particular, the number of c-sections increases by a greater magnitude among the latter (11.2 percent) than among the former (9.8 percent). This finding suggests that while a fully retrospective payment regime is detrimental for the purpose of reducing the number of c-sections, increases in the likelihood of a c-section are somewhat concentrated among pregnancies for which they may be medically necessary. In the case of full capitation, we find substantial declines in the total number of c-sections among both high-risk and low-risk pregnancies. This raises the question of whether reductions in c-section use lower costs at the expense of maternal health. We examine whether this is the case in the next section.

Our results shed light on the type of regulation that can more effectively tackle the "c-section epidemic." The California Health Care Foundation, for example, found that introducing reforms to payment incentives, data transparency, and patient engagement, could reduce the fraction of deliveries performed by c-section (c-section rate) in the state of California by 3 p.p.[11] We find that regulation of payment contracts between insurers and hospitals, and in particular implementation of bundled payments such as capitation, can generate reductions in the c-section rate of as large as 2.6 p.p.

Table 9: Counterfactual Distribution of Delivery Healthcare Expenditure

	Delivery costs			
	Mean	SD	Q1	Q3
Full FFS	2,564.4	3,668.2	58.3	4,657.1
Full Cap	2,166.0	2,827.6	64.2	3,775.3
Observed	2,585.9	3,696.6	50.5	4,742.8

Note: Table shows mean, standard deviation, and 1st and 3rd quantiles of the distribution of expected delivery expenditure per hospital for the observed scenario and two counterfactuals: both c-sections and vaginal deliveries covered under FFS ("Full FFS"), and both c-sections and vaginal deliveries covered under capitation ("Full Cap").

In table 9 we turn to the effect of payment contracts on total delivery spending per hospital given by $\sum_{ij} \phi_{ijh} p_{jh} s_{ijh} + (1-\phi_{ijh}) q_{jh} s_{ijh}$. We report the mean, standard deviation, and 1st and 3rd quartiles of the distribution of this variable in the counterfactuals and in the observed scenario. Findings show that delivery spending per hospital remains virtually unchanged under full FFS despite reductions in average delivery prices. This is in line with the increase in the provision of c-sections, which are on average \$25 more expensive than

[11] See https://www.chcf.org/project/reducing-unnecessary-c-sections/

vaginal deliveries. Under full capitation we find instead that delivery spending per hospital decreases by 16 percent despite increases in average prices. While hospital revenues do not depend on consumer price sensitivity in this case, hospital demand does become more sensitive to price relative to the observed scenario as seen in panel A of appendix figure 2. Taken together, the effects of full FFS on delivery choice and spending are driven by hospital moral hazard, while the effects of full capitation are driven by women sorting in response to price effects.

8.2 Maternal Health Outcomes

To analyze whether our counterfactual regulations are welfare enhancing, we supplement our results on cost and price with results on maternal health outcomes post-delivery. Ideally, we would observe health outcomes for every woman at each hospital in her choice set. Because we do not, we predict these unobserved outcomes using a regression in the spirit of Abaluck, Caceres Bravo, Hull, and Starc (2021). We model the observed health outcome as

$$y_{it} = \sum_j \mu_j \Big(\sum_h \mu_h S_{ijht} \Big) D_{ijt} + x_{it}'\beta + \upsilon_{it} = \mu_{jht(i)} + x_{it}'\beta + \upsilon_{it} \tag{4}$$

where y_{it} is the health outcome of woman i in year t, S_{ijht} is an indicator variable for woman i choosing hospital h in the network of insurer j, D_{ijt} is an indicator variable for woman i choosing insurer j, and x_{it} are the woman's potentially time-varying observable characteristics.

OLS estimation of equation (4) would likely yield biased estimates of the insurer-hospital health outcome effect, μ_{jht}, due to selection: ν_{it} may be correlated with both S_{ijht} and D_{ijt}. In our main sample of women, we cannot account for this type of selection using individual fixed effects because these data have one observation per woman corresponding to the woman's first delivery. To estimate equation (4), we thus use the sample of women who have at least two childbirths between 2010 and 2011 at hospitals that provide at least

10 deliveries. In this sample we are able to control for selection by including the lagged health outcome as a regressor.[12] Appendix table 6 presents pooled summary statistics of this sample.

We further parameterize equation (4) as

$$y_{it} = \mu_{j(i)} + \mu_{h(i)} + \gamma y_{i,t-1} + \beta_1 \mathbf{1}\{\text{c-section}_{it}\} + \beta_2 p_{jht(i)} + \beta_3 q_{jht(i)} + x'_{it}\beta_4 + \upsilon_{it}$$

where the individual's choices of insurer and hospital are uncorrelated with ν_{it} conditional on $y_{i,t-1}$. y_{it} is an indicator variable that takes the value of one if any of the following occur in the month after childbirth: hospitalization, hemorrhage (ICD10 code R85), puerperal sepsis (ICD10 code O85), and infection of obstetric surgical wound (ICD10 code O86). Appendix table 7 presents regression estimates and appendix figure 3 presents the distribution of hospital fixed effects after applying the shrinkage procedure in Kane and Staiger (2008). We use these estimates to predict health outcomes in our main sample of women at every in-network hospital under observed and counterfactual prices and payment contracts as:

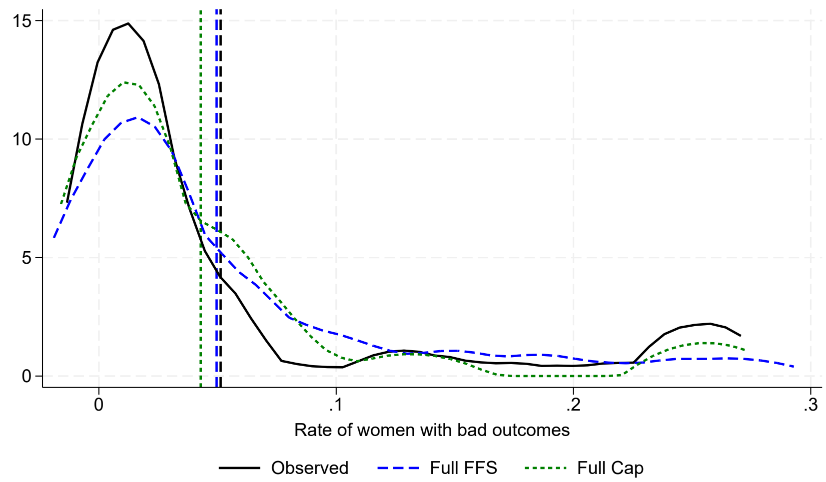
$$\hat{y}_{ijh} = \hat{\mu}_j + \hat{\mu}_h + \hat{\beta}_1 \phi_{ijh} + \hat{\beta}_2 p_{jh} + \hat{\beta}_3 q_{jh} + x'_i \hat{\beta}_4 \tag{5}$$

where p_{jh} and q_{jh} are c-section and vaginal delivery prices, respectively, and ϕ_{ijh} is the expected delivery procedure. Figure 3 shows the distribution of observed and counterfactual rates of women with a bad health outcome at every hospital, $\sum_{ij} \hat{y}_{ijh}\hat{s}_{ijh} / \sum_{ij} \hat{s}_{ijh}$. The dashed vertical lines correspond to the mean of the distribution.

We find that imposing a full FFS regime does not increase the rate of bad health outcomes at the average hospital. Two opposing forces may explain the near-zero effect of FFS contracts on women's health: on the one hand, a higher c-section likelihood increases the rate of bad health outcomes among women for whom it is medically unnecessary, as seen in the sign of $\hat{\beta}_1$ from equation (5). On the other hand, lower prices across hospitals may

[12] Inclusion of the lagged dependent variable to account for selection is motivated by the extensive literature on school value-added (Angrist, Hull, Pathak, and Walters, 2017).

FIGURE 3: Distribution of Bad Outcomes



Note: Figure shows the distribution of the rate of women with a bad health outcome in the month after childbirth per hospital in the observed scenario in black, the full FFS counterfactual in blue, and the full capitation counterfactual in green. The dashed vertical lines correspond to the median of the distribution.

increase the likelihood that women visit high-quality hospitals compared to the observed equilibrium, which may reduce the rate of bad outcomes. With full capitation, we find a 1.05 p.p. reduction in the rate of women with bad health outcomes at the average hospital, which corresponds to a 16 percent decrease from baseline. Since average prices rise in this counterfactual, reductions in the rate of c-sections among women for whom they are medically unnecessary is likely the primary mechanism by which full capitation improves maternal health outcomes.

In table 10 we explore heterogeneity in these results along the dimensions of pregnancy risk, income level, and costs up to delivery. Two things stand out: first, the decrease in the rate of bad outcomes under full capitation is particularly pronounced among the group of women with high-risk pregnancies. Second, not only is the rate of bad outcomes substantially higher among low-income women relative to high-income women, but a full capitation regime reduces this rate by a greater magnitude among the former than among the latter. Prospective payments therefore better align provider incentives with patient health and may improve health equity across the income distribution.

Table 10: Heterogeneity in Rate of Bad Outcomes

	Observed	Full FFS	Full Cap
Low-risk pregnancy	0.0514	0.0501	0.0436
High-risk pregnancy	0.0498	0.0453	0.0396
Low income	0.0599	0.0574	0.0508
High income	0.0380	0.0360	0.0302
Below median cost up to delivery	0.0514	0.0499	0.0429
Above median cost up to delivery	0.0513	0.0494	0.0430

Note: Tables shows the rate of bad health outcomes at the average hospital conditional on women with low-risk and high-risk pregnancies, women with low and high income, and women with above and below median costs up to delivery.

9 Conclusions

In this paper we consider the role of payment contracts in contributing to the rising cost of childbirth. We develop a structural model of price determination, hospital choice, and delivery procedure choice taking as given observed payment contracts. Estimation of our model shows that hospitals are more likely to offer c-sections if they are reimbursed under FFS. This finding is consistent with our pricing function estimates, which show that hospital markups on c-sections are higher than those on vaginal deliveries. Payment contracts also affect hospital demand, as patients are significantly less likely to visit a hospital reimbursed under FFS, all else equal. This negative impact on hospital demand is suggestive of insurers steering patients toward capitated hospitals.

Our counterfactuals assess the effect of alternative payment contract regimes on market and maternal health outcomes. We find that transitioning to a fully capitated regime results in higher delivery prices, lower c-section rates, and lower healthcare spending on deliveries. We also find that reductions in c-section use under the fully capitated regime are concentrated among low-risk women and that the transition to full capitation results in a 16 percent reduction in the rate of bad maternal health outcomes.

Our analysis is timely since the use of per-member capitation payments is increasingly popular among physician groups operating within insurer networks or Accountable Care

Organizations (Wisconsin State Journal, 2023; Healthcare Outcomes Performance, 2022). The findings of our paper speak to treatment decisions where overuse is a result of provider moral hazard, but they do not speak to misuse of medical treatments necessarily (Abaluck, Agha, Kabrhel, Raja, and Venkatesh, 2016). We show that the transition to capitated payments lessens overuse of expensive medical treatments and promotes substitution toward cheaper alternatives. Future research could examine the effects of other types of payment contracts such as performance-based payments.

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Appendix A Capitation Claims

Decree 441 of 2022 by the Ministry of Health explains how unit capitation prices are calculated and how they are reported in the claims data. First, insurers and hospitals determine the target population and the set of services that will be provided to this population under a capitation contract. Then, they estimate the frequency with which each target patient will claim each service. Finally, they estimate the price of each service - which we refer to as the unit price - in the capitated set taking into account wages, input costs, and other variable costs.

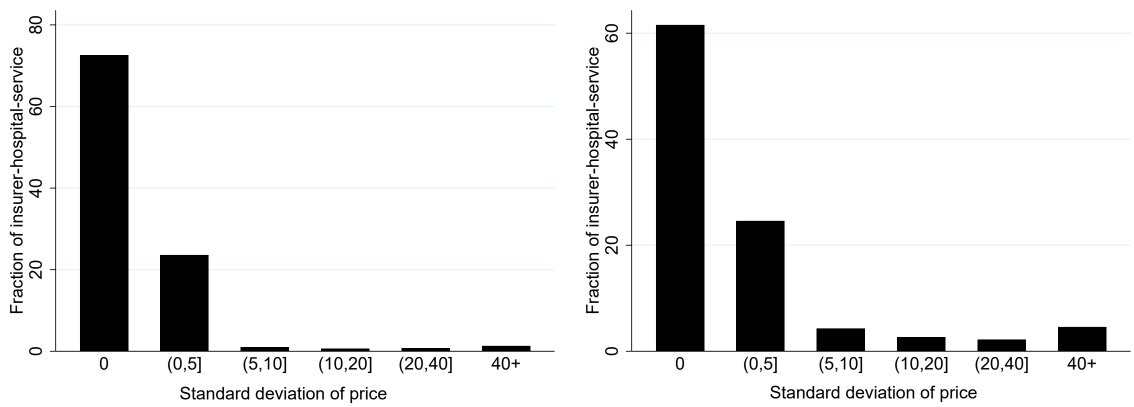
The final capitation payment from the insurer to the hospital equals the sum across all capitated services of the unit price, times the expected number of claims per person, times the number of enrollees covered under the contract. This payment is made prospectively at the beginning of each contracting period, typically a calendar year. Insurers and hospitals bargain over the target population, the set of services to be covered, and the unit price. The claims data reports this negotiated unit price, but we do not observe the target population. The sum of reported unit prices across all claims provided under a capitation contract must equal the total capitation payment made by the insurer to the hospital.

The procedure to estimate unit capitation prices as described in the Decree implies that these prices should not vary across claims for a given insurer-hospital-service triplet. This differs from FFS prices, which can vary across claims according to patient or care episode characteristics. We confirm this pattern in appendix figure 1 using the sample of claims provided nine months before childbirth. The figure shows the distribution of the standard deviation of prices across insurer-hospital-service triplets conditional on capitated claims in panel A and conditional on FFS claims in panel B. Over 75 percent of capitated claims and around 60 percent of FFS claims have a standard deviation equal to zero conditional on the insurer-hospital-service.

Appendix Figure 1: Claim Price Variation

(A) Capitation claims

(B) FFS claims



Note: Figure shows the distribution of the standard deviation of claim prices across insurer-hospital-service triplets conditional on capitated claims in panel A, and conditional on FFS claims in panel B. Figure uses the sample of claims provided during the nine months prior to childbirth.

Appendix B Obtaining Negotiated Prices from Claims

We estimate the following linear regression separately for every insurer j and delivery procedure s (vaginal or c-section), :

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

where $\tilde{p}_{ijhs}$ is the reported price, x_i are patient characteristics including age, an indicator for whether the woman has a chronic disease, and the woman's length-of-stay; f_{jhs} is an indicator for whether the delivery procedure s is covered under FFS between insurer j and hospital h; and γ_h is a hospital fixed effect.

Denote by $\hat{E}[\tilde{p}_{ijhs}|x_i, f_{jhs}, h]$ the predictions from these linear regressions. The negotiated price for each hospital-insurer-service under contract $k \in \{\text{FFS}, \text{Cap}\}$, p^k_{jhs}, is then:

$$p^k_{jhs} = \frac{1}{N_{j,h,s}} \sum_{j,h,s} \hat{E}[\tilde{p}_{ijhs}|x_i, f_{jhs} = k, h]$$

where $N_{j,h,s}$ is the number of women who had delivery claims of type s in insurer j and hospital h. We use this predicted price as the negotiated price throughout our analysis.

Appendix C Reduced-Form Pricing Model

Assume that insurers and hospitals bargain over the price of a service covered in a FFS contract and the unit price of a service under a capitation contract, holding hospital networks and enrollment decisions fixed. Insurer profits are given by:

$$\pi^j = \sum_i W_{ij}(p^1_{jh}, p^0_{jh}) - \sum_{h \in F_j} \sum_i (1 - c_i) p^1_{jh} s_{ijh}(p^1_{jh}, p^0_{jh}) - \sum_{h \in K_j} p^0_{jh} \sigma_j$$

where W_{ij} is consumer i's value for insurer j's network, $s_{jh} = \sum_i s_{ijh}$ denotes demand for hospital h from insurer j's enrollees with s_{ijh} representing consumer i's choice probability, σ_j is insurer demand, p^1_{jh} is the FFS price between insurer j and hospital h, F_j is insurer j's network of hospitals under FFS, p^0_{jh} is the unit price of the service under capitation, and K_j is insurer j's network of hospitals under a capitation contract. Conditional on the service, F_j and K_j are mutually exclusive: $F_j \cap K_j = \oslash$. In this profit function, insurers pay hospitals their FFS prices each time a person visits the hospital, but they pay capitation transfers for each enrollee regardless of whether they visit the hospital or not.

Hospital profits are given by:

$$\pi^h = \sum_{j \in F_h} (p^1_{jh} - m_{jh}) s_{jh}(p^1_{jh}, p^0_{jh}) + \sum_{j \in K_h} p^0_{jh} \sigma_j - \sum_{j \in K_h} m_{jh} s_{jh}(p^1_{jh}, p^0_{jh})$$

where m_{jh} is the marginal cost to hospital h of providing the service to insurer j's enrollees, F_h is the set of insurers that cover hospital h under a FFS contract, and K_h is the set of insurers that cover hospital h under a capitation contract. Here also, conditional on the service $F_h \cap K_h = \oslash$.

C.1 Equilibrium FFS Prices

Define the log of the Nash surplus for a FFS contract as:

$$\log(S^1_{jh}) = \beta \log\left(\pi^j_{F_j,K_j} - \pi^j_{F_j\backslash h, K_j\cup h}\right) + (1-\beta)\log\left(\pi^h_{F_h,K_h} - \pi^h_{F_h\backslash j, K_h\cup j}\right)$$

β represents the bargaining power of the insurer. The outside option for the insurer is not to drop the hospital altogether from its network as is typically done in the literature. Instead the outside option is to drop the hospital from the set that is covered under FFS, $F_j\backslash h$, and cover it under capitation, $K_j \cup h$. For the hospital, the outside option is analogous.

The first-order condition of the joint surplus maximization problem with respect to FFS prices is:

$$-\frac{\beta}{\left(\pi^j_{F_j,K_j} - \pi^j_{F_j\backslash h, K_j\cup h}\right)}\frac{\partial \pi^j_{F_j,K_j}}{\partial p^1_{jh}} = \frac{1-\beta}{\left(\pi^h_{F_h,K_h} - \pi^h_{F_h\backslash j, K_h\cup j}\right)}\frac{\partial \pi^h_{F_h,K_h}}{\partial p^1_{jh}}$$

Let $\mathbf{A}^1 = \frac{\partial \pi^j_{F_j,K_j}}{\partial p^1_{jh}}$, $\mathbf{B}^1 = \pi^j_{F_j,K_j} - \pi^j_{F_j\backslash h, K_j\cup h}$, $\Lambda^1 = \frac{\beta \mathbf{A}^1}{(1-\beta)\mathbf{B}^1}$, $\mathbf{d}^1 = \pi^h_{F_h\backslash j, K_h\cup j}$, and $\Omega^1 = \frac{\partial s_{jh}}{\partial p^1_{jh}}$. After writing the first-order condition in matrix form and re-arranging terms, we get the following expression for equilibrium prices in a FFS contract:

$$\mathbf{p}^1 = \mathbf{m} - (\Omega^1 + \Lambda^1\mathbf{s})^{-1}(\mathbf{s} + \Lambda^1\sigma\mathbf{p}^0 - \Lambda^1\mathbf{d}^1) \tag{6}$$

In this case, Λ^1 and Ω^1 are negative semidefinite. Therefore the expression shows that the higher the hospital's disagreement payoff the higher the FFS price. Unit capitation prices have ambiguous effects on FFS prices as the last two terms in equation (6) are functions of unit capitation prices.

C.2 Equilibrium Capitation Prices

Now define the log of the Nash surplus for a capitation contract as:

$$\log(S^0_{jh}) = \beta \log\left(\pi^j_{F_j,K_j} - \pi^j_{F_j\cup h,K_j\backslash h}\right) + (1-\beta)\log\left(\pi^h_{F_h,K_h} - \pi^h_{F_h\cup j,K_h\backslash j}\right)$$

The outside option for the insurer is to drop the hospital from the set that is covered under capitation, $K_j\backslash h$ and cover it under FFS, $F_j \cup h$. The disagreement payoff to the hospital is analogous. The first-order condition of the joint surplus maximization problem with respect to unit prices in a capitation contract is:

$$-\frac{\beta}{\left(\pi^j_{F_j,K_j} - \pi^j_{F_j\cup h,K_j\backslash h}\right)}\frac{\partial \pi^j_{F_j,K_j}}{\partial p^0_{jh}} = \frac{1-\beta}{\left(\pi^h_{F_h,K_h} - \pi^h_{F_h\cup j,K_h\backslash j}\right)}\frac{\partial \pi^h_{F_h,K_h}}{\partial p^0_{jh}}$$

Let $\mathbf{A}^0 = \frac{\partial \pi^j_{F_j,K_j}}{\partial p^0_{jh}}$, $\mathbf{B}^0 = \pi^j_{F_j,K_j} - \pi^j_{F_j\cup h,K_j\backslash h}$, $\Lambda^0 = \frac{\beta \mathbf{A}^0}{(1-\beta)\mathbf{B}^0}$, $\mathbf{d}^0 = \pi^h_{F_h\cup j,K_h\backslash j}$, and $\Omega^0 = \frac{\partial s^0_{jh}}{\partial p^0_{jh}}$. Re-writing the first-order condition in matrix form and re-arranging terms yields the following expression for the unit price in a capitation contract:

$$\mathbf{p}^0 = \sigma^{-1}\mathbf{m}\mathbf{s} + \sigma^{-1}(\mathbf{d} - (\mathbf{p}^1 - \mathbf{m})\mathbf{s} - (\Lambda^0)^{-1}(\sigma - \Omega^0\mathbf{m}))$$

In the expression above, Ω^0 and Λ^0 are negative semidefinite. Hence our model shows that the unit price under capitation is increasing in the hospital's disagreement payoff, but is ambiguous with respect to the FFS price.

C.3 Empirical Analogs

Let $TC_j = \sum_{h\in F_j}\sum_i (1-c_i)p^1_{jh}s_{ijh}(p^1_{jh}, p^0_{jh}) + \sum_{h\in K_j} p^0_{jh}\sigma_j$ be the insurer's total cost for deliveries. p^1_{jh} and p^0_{jh} map to our data as the reported prices for deliveries covered under FFS and the reported unit prices for capitated deliveries, respectively. Moreover, we proxy σ_j as $\hat{\sigma}_j = (|K_j|)^{-1}\sum_i\sum_{h\in F_j\cup K_j} s_{ijh}(p^1_{jh}, p^0_{jh})$. Let W_j be our approximation to insurer revenues as in Gowrisankaran et al. (2015), or the dollarized value of insurer j's network of hospitals. We derive a reduced-form expression for equilibrium FFS prices in market t from equation (6) as follows:

$$p^1_{jh} = \underbrace{\mu^1_j + \mu^1_{t(h)}}_{\mathbf{m}} - \underbrace{\left(\frac{\partial s_{jh}}{\partial p^1_{jh}} + \sum_{k \in F_j}\left(\frac{\partial W_j}{\partial p^1_{jh}} - \frac{\partial TC_j}{\partial p^1_{jh}}\right)s_{jk}\right)^{-1}\left(\omega^1 s_{jh} + \tau^1 \overline{p}^0_j\right)}_{(\Omega^1+\Lambda^1\mathbf{s})^{-1}(\mathbf{s}+\Lambda^1\sigma\mathbf{p}^0-\Lambda^1\mathbf{d}^1)} + \epsilon^1_{jh}$$

where τ^1, ω^1, μ^1_j, and $\mu^1_{t(h)}$ are parameters to be estimated, $\overline{p}^0_j$ is insurer j's average capitation transfer with hospitals in its network, and ϵ^1 is the FFS structural error. Inclusion of unit capitation prices in the FFS pricing function, $\overline{p}^0_j$, accounts for the hospital's disagreement payoff.

Our reduced-form expression for unit prices in a capitation contract is given by:

$$p^0_{jh} = \underbrace{\kappa^0 \frac{\overline{s}_{jh}}{\hat{\sigma}_j}}_{\sigma^{-1}\mathbf{ms}} \underbrace{-\delta^0 \sum_{j \in F_h} \frac{s_{jh} p^1_{jh}}{\hat{\sigma}_j} + \mu^0_{t(h)}}_{\sigma^{-1}(\mathbf{d}-(\mathbf{p}^1-\mathbf{m})\mathbf{s})} - \underbrace{\left(\hat{\sigma}_j \sum_{h \in K_j}\left(\frac{\partial W_j}{\partial p^0_{jh}} - \frac{\partial TC_j}{\partial p^0_{jh}}\right)\right)^{-1}\left(\tau^0 \hat{\sigma}_j - \omega^0 \sum_{h \in K_j} \frac{\partial s_{jh}}{\partial p^0_{jh}}\right) + \mu^0_j}_{(\sigma\Lambda^0)^{-1}(\sigma-\Omega^0\mathbf{m})} + \epsilon^0_{jh}$$

where $\overline{s}_{jh}$ is demand for insurer-hospital pair jh evaluated at average market prices, and $\kappa^0, \omega^0, \tau^0, \delta^0, \mu^0_j$, and $\mu^0_{t(h)}$ are parameters to be estimated.

Appendix D First-stage Estimates

D.1 Delivery Choice

This subsection presents first stage results of our delivery choice model. The endogenous variables are the price of c-sections and vaginal deliveries. We use the procedure price in other markets, lagged prices, and women's demographics as instruments.

Appendix Table 1: First-Stage Estimates for Delivery Choice

		C-section price		Vaginal price	
		coef	se	coef	se
C-section price other markets		373.92	(13.24)	254.84	(11.65)
Vaginal del. Other markets		-193.60	(7.78)	-147.24	(7.04)
Lagged c-section price		86.95	(0.37)	13.76	(0.20)
Lagged vaginal del. Price		-9.15	(0.38)	64.78	(0.28)
Demographics and health	Age 25-29	-0.25	(0.16)	-0.20	(0.16)
	Age 30-34	-0.24	(0.17)	-0.53	(0.17)
	Age 35 or more	-0.72	(0.21)	-1.13	(0.21)
	High risk pregnancy	-0.70	(0.22)	0.23	(0.24)
	Chronic disease	-0.09	(0.29)	-0.93	(0.33)
Day of week	Monday	0.25	(0.25)	0.35	(0.26)
	Tuesday	0.48	(0.25)	0.75	(0.26)
	Wednesday	0.79	(0.25)	0.61	(0.27)
	Thursday	0.41	(0.25)	0.80	(0.27)
	Friday	0.22	(0.25)	0.67	(0.27)
	Saturday	0.08	(0.26)	0.10	(0.28)
	Sunday	(ref)	(ref)	(ref)	(ref)
Missing lagged c-section price		333.92	(1.17)	30.78	(1.19)
Missing lagged vag. price		-87.45	(1.18)	173.90	(1.21)
R^2		0.95		0.93	
N		256,231		256,231	

Note: First-stage results of delivery choice model. Linear regressions of c-section price and vaginal delivery price on the average price in other markets and lagged prices. Specifications include insurer and municipality fixed effects. Robust standard errors in parenthesis. Coefficients and standard errors are multiplied by 100.

D.2 Hospital Demand

This subsection presents results for the first-stage regression for hospital demand. We estimate the following linear regression:

$$c_i\hat{p}_{jh} = \tau_1 p'_{jh} + \tau_2 q'_{jh} + \tau_3 \hat{f}_{ijh} + \tau_3 \hat{\phi}_{ijh} + x'_i\beta + \eta_h + \nu_{ijh}$$

where p'_{jh} and q'_{jh} are the average price for c-sections and vaginal deliveries in other markets, respectively; $\hat{f}_{ijh}$ is the expected payment contract; $\hat{\phi}_{ijh}$ is the c-section probability; and x_i is a vector of patient characteristics.

Appendix Table 2: First-Stage Estimates for Hospital Demand

	OOP Price	
	coef	se
Vaginal delivery price other markets	-0.23	(0.25)
C-section price other markets	8.62	(0.34)
Expected FFS contract	2.54	(0.25)
Expected c-section	-48.87	(0.13)
Previous visit	-1.49	(0.08)
Missing C-section FFS	1.97	(0.04)
Missing Vaginal delivery FFS	0.96	(0.04)
Chronic disease	1.59	(0.04)
High-risk pregnancy	3.80	(0.03)
Cost up to delivery	0.00	(0.02)
Age 30 or more	-4.09	(0.03)
Rural	-7.89	(0.11)
Low income	-22.53	(0.03)
Number of beds	-1.10	(0.06)
Bad outcomes	12.39	(0.36)
Maternal mortality	-2.22	(1.12)
Adjusted R^2	0.67	
N	763,213	

Note: First-stage OLS regression of out-of-pocket prices on the lagged out-of-pocket price and patient characteristics. Coefficients and standard errors are multiplied by 100 for exposition. Specification includes hospital fixed effects.

D.3 Pricing Functions

This subsection presents results for the first-stage regression of the pricing function for c-sections and vaginal deliveries. We use as instruments for demand and its derivatives, the lagged delivery prices. For c-sections, we also use the price and contract type of vaginal deliveries as instruments, and vice versa.

Appendix Table 3: First-Stage Estimates for FFS Pricing Functions

	C-section		Vaginal delivery	
	coef	se	coef	se
Markup 2	0.59	(0.09)	-0.05	(0.02)
Log vaginal delivery price	-6.39	(2.59)	—	—
Lag vaginal delivery price	—	—	1.43	(3.18)
C-section FFS	—	—	7.48	(10.0)
Lag vag price x C-section FFS			-5.80	(4.01)
F-stat	6.1		1.5	
N	565		576	

Note: First-stage regression of variables associated with ω^1/ω^0 for the FFS pricing functions. Specifications include insurer and municipality fixed effects. Robust standard errors in parenthesis.

Appendix E Robustness Checks on Demand

Table 4 in this appendix compares our main estimates of hospital demand against those without using a control function for the expected out-of-pocket price. Table 5 presents a robustness exercise to our sample selection criteria. Column (1) shows our main hospital demand specification estimated on the sample of women who do not switch their insurer and whose enrollment may not be continuous. Column (2) shows results on the sample of women who do not switch their insurer and have continuous enrollment spells. Column (3) shows results using the full sample of women without constraints on switching nor enrollment length.

Appendix F Additional Results

This appendix shows additional results for our counterfactual analysis as well as our main maternal health outcomes regressions. Appendix figure 2 presents linear predictions of demand for each of the counterfactuals and the observed scenario. For maternal health outcomes, appendix table 6 presents summary statistics of the sample of women who have at least two childbirths between 2010 and 2011. These statistics are pooled across years. Appendix table 7 presents estimates of the health outcomes function and appendix figure 3 shows the estimated hospital fixed effects.

Appendix Table 4: Hospital Demand Model Estimates Without Control Function

		(1) Main		(2) No control function	
		coef	se	coef	se
Expected OOP ($100)		-10.64	(0.74)	-0.67	(0.13)
Expected FFS contract		-1.15	(0.05)	-1.07	(0.05)
Expected c-section		-11.03	(0.64)	-6.00	(0.54)
Previous visit		1.44	(0.04)	1.62	(0.04)
Missing C-section FFS		-1.04	(0.02)	-1.16	(0.02)
Missing Vaginal delivery FFS		-1.16	(0.02)	-1.23	(0.02)
Interactions					
Expected OOP ($100)	Age 30 or more	1.44	(0.14)	1.07	(0.12)
	Chronic disease	1.24	(0.27)	1.09	(0.23)
	High-risk pregnancy	-0.75	(0.23)	-0.85	(0.19)
	Cost up to delivery	0.92	(0.14)	0.37	(0.10)
	Rural	-6.96	(0.95)	-1.49	(0.29)
	Low income	0.07	(0.14)	-0.08	(0.12)
Expected FFS contract	Age 30 or more	0.23	(0.05)	0.25	(0.05)
	Chronic disease	0.12	(0.10)	0.14	(0.10)
	High-risk pregnancy	0.53	(0.08)	0.53	(0.08)
	Cost up to delivery	0.47	(0.05)	0.45	(0.05)
	Large insurer	1.16	(0.06)	1.21	(0.06)
Expected c-section	Age 30 or more	0.62	(0.59)	-0.31	(0.58)
	Chronic disease	0.28	(1.07)	-0.21	(1.05)
	High-risk pregnancy	-0.22	(0.84)	-0.22	(0.83)
	Cost up to delivery	-1.78	(0.53)	-2.32	(0.51)
Previous visit	Age 30 or more	-0.06	(0.05)	-0.07	(0.05)
	Chronic disease	-0.24	(0.06)	-0.23	(0.06)
	High-risk pregnancy	-0.28	(0.05)	-0.29	(0.05)
	Cost up to delivery	0.03	(0.05)	0.01	(0.05)
Pseudo-R^2		0.38		0.38	
N		763,213		763,213	

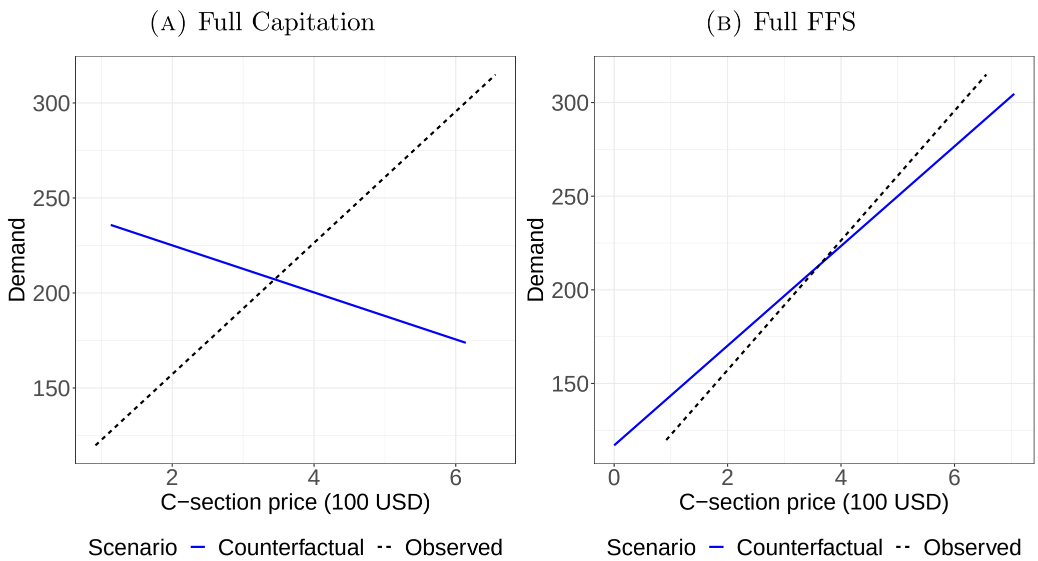
Note: Hospital demand in the main sample with control function in column (1) and without control function in column (2). Specifications include interactions between number of beds, an indicator for bad outcomes post-delivery, and maternal mortality rate for each hospital with patient characteristics including dummies for age group, having a chronic disease, having a high-risk pregnancy, and zone of residence. Specifications also include hospital fixed effects. Bootstrap standard errors in parenthesis based on 100 resamples.

Appendix Table 5: Hospital Demand Model Estimates in Alternative Samples

		(1) No switch Not contin.	(2) No switch Continuous	(3) Switch Not contin.
Expected OOP ($100)		-10.64	-11.40	-10.63
		(0.74)	(0.89)	(0.62)
Expected FFS contract		-1.15	-1.16	-1.13
		(0.05)	(0.06)	(0.05)
Expected c-section		-11.03	-11.06	-10.90
		(0.64)	(0.73)	(0.55)
Previous visit		1.44	1.44	1.42
		(0.04)	(0.05)	(0.04)
Missing C-section FFS		-1.04	-0.90	-0.88
		(0.02)	(0.03)	(0.02)
Missing Vaginal delivery FFS		-1.16	-1.13	-1.19
		(0.02)	(0.02)	(0.02)
Interactions				
Expected OOP ($100)	Age 30 or more	1.44	1.58	1.48
		(0.14)	(0.17)	(0.13)
	Chronic disease	1.24	1.39	1.22
		(0.27)	(0.28)	(0.28)
	High-risk pregnancy	-0.75	-0.84	-0.72
		(0.23)	(0.24)	(0.23)
	Cost up to delivery	0.92	0.68	0.75
		(0.14)	(0.15)	(0.12)
	Rural	-6.96	-6.41	-6.72
		(0.95)	(1.13)	(0.77)
	Low income	0.07	0.08	0.25
		(0.14)	(0.16)	(0.12)
Expected FFS contract	Age 30 or more	0.23	0.26	0.16
		(0.05)	(0.06)	(0.05)
	Chronic disease	0.12	0.17	0.15
		(0.10)	(0.10)	(0.10)
	High-risk pregnancy	0.53	0.55	0.56
		(0.08)	(0.08)	(0.08)
	Cost up to delivery	0.47	0.43	0.35
		(0.05)	(0.06)	(0.04)
	Large insurer	1.16	1.17	1.17
		(0.06)	(0.07)	(0.05)
Expected c-section	Age 30 or more	0.62	0.34	1.55
		(0.59)	(0.69)	(0.51)
	Chronic disease	0.28	0.13	0.25
		(1.07)	(1.09)	(1.06)
	High-risk pregnancy	-0.22	-0.12	-0.60
		(0.84)	(0.87)	(0.83)
	Costs up to delivery	-1.78	-1.88	-2.30
		(0.53)	(0.57)	(0.45)
Previous visit	Age 30 or more	-0.06	-0.05	-0.06
		(0.05)	(0.05)	(0.05)
	Chronic disease	-0.24	-0.25	-0.25
		(0.06)	(0.06)	(0.06)
	High-risk pregnancy	-0.28	-0.28	-0.27
		(0.05)	(0.05)	(0.05)
	Cost up to delivery	0.03	0.03	0.01
		(0.05)	(0.05)	(0.04)
N		763,213	555,560	1,039,448

Note: Hospital demand in the main sample with control function in column (1), in the sample of women who do not switch insurers and have continuous enrollment spells in column (3) and in the full sample of women in column (4). Specifications include interactions between number of beds, an indicator for bad outcomes post-delivery, and maternal mortality rate for each hospital with patient characteristics including dummies for age group, having a chronic disease, having a high-risk pregnancy, and zone of residence. Specifications also include hospital fixed effects. Bootstrap standard errors in parenthesis based on 100 resamples.

Appendix Figure 2: Elasticity of Demand for C-sections



Note: Figure shows a linear prediction of demand for c-sections under the observed scenario in black and the full capitation counterfactual in blue in panel A and the full FFS counterfactual in blue in panel B.

Appendix Table 6: Summary statistics for outcomes analysis

		All (1)	Vaginal (2)	C-section (3)
Contracts	C-section price	288.0 (128)	—	272.9 (116)
	Vaginal delivery price	234.6 (122)	254.4 (132)	—
	C-section FFS	0.67 (0.47)	—	0.71 (0.45)
	Vaginal delivery FFS	0.66 (0.47)	0.62 (0.48)	—
	C-section	0.48 (0.50)	—	—
Demographics	Age less than 29	0.32 (0.46)	0.35 (0.48)	0.28 (0.45)
	Low income	1.00 (0.03)	1.00 (0.00)	1.00 (0.04)
	Rural municipality	0.47 (0.50)	0.39 (0.49)	0.57 (0.50)
Health	High-risk pregnancy	0.19 (0.39)	0.17 (0.38)	0.21 (0.41)
	Chronic disease	0.28 (0.45)	0.23 (0.42)	0.33 (0.47)
	Bad health outcome	0.07 (0.26)	0.05 (0.23)	0.09 (0.29)
Providers		117	113	117
Insurers		12	12	12
Individuals x Years		5,301	2,743	2,558

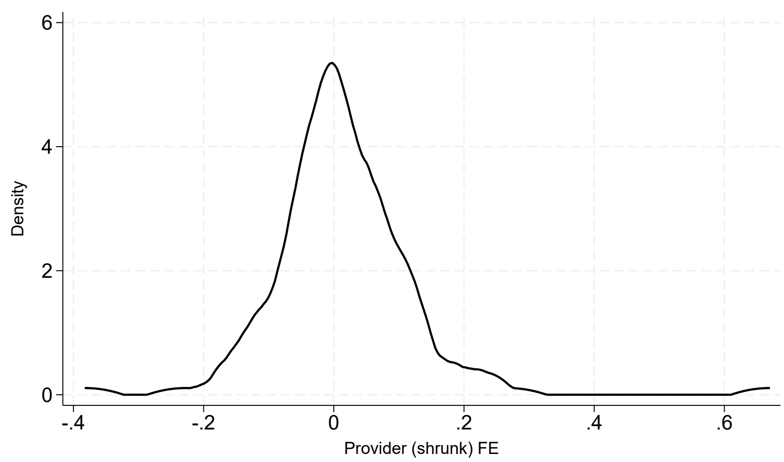
Note: Table shows pooled mean and standard deviation in parentheses of main variables in the sample of women who have at least two childbirths between 2010 and 2011 at hospitals that perform at least 10 deliveries. Column (1) uses the total number of deliveries, Column (2) conditions on vaginal deliveries, and Column (3) conditions on c-sections. Prices and costs are measured in dollars.

Appendix Table 7: Health Outcome Function Estimates

	coef	se
Lag bad outcome	0.225	(0.018)
C-section	0.024	(0.009)
C-section price	-0.018	(0.018)
Vaginal delivery price	-0.033	(0.020)
Age less than 30	-0.003	(0.010)
Chronic disease	0.024	(0.010)
High-risk pregnancy	0.009	(0.012)
Low income	0.062	(0.121)
Rural	-0.015	(0.026)
R^2	0.19	
N	3,250	

Note: Linear regression of an indicator for bad health outcomes in the month after delivery on payment contract characteristics and women characteristics. Includes hospital and insurer fixed effects. Estimation sample are women who have at least two childbirths between 2010 and 2011 at a hospital that performs at least 10 deliveries.

Appendix Figure 3: Distribution Hospital Fixed Effects in Health Outcomes Function



Note: Figure shows the distribution of hospital fixed effects from the health outcomes regression after applying a Bayes shrinkage procedure.