Healthcare Provider Referral and Treatment Decisions Under Mixed Contracts

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Abstract

In this paper, we quantify the extent to which physicians' referral and treatment decisions respond to financial incentives when contract types and prices are determined between hospitals and insurers at the service level. We do so using the universe of claims for pregnant patients enrolled in Colombia's national health insurance plan in 2011. We develop a two stage model of the primary care physician's referral of their pregnant patient to a hospital for delivery and the delivering hospital's choice between performing a vaginal delivery and cesarean section. We show that physician moral hazard in both stages is substantial even under mixed contracts. Uncertainty over contract types makes delivering physicians more likely to choose cesarean section and referring physicians more likely to retain the patient. We find that the capitation rate that minimizes the effect of physician moral hazard in treatment choice equals 50%.

Keywords: Physician moral hazard; Capitation; Fee-for-service; Health insurance.

JEL codes: I12, I13, I18, D80.

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1 Introduction

In markets where public health insurance is supplied by private insurers, payments from insurers to providers are typically made under either capitation or fee-for-service (FFS) contacts. These forms of reimbursement are antithetical with respect to the incentives they present to providers. Capitation payments are ex-ante lump sum transfers that cover all of a patient's health care claims. Because providers bear the full cost of treatment beyond the capitation payment, reimbursement by capitation may incentivize providers to under-provide services, substitute toward cheaper care, or provide care more efficiently (Frakt and Mayes, 2002; Frank et al., 1995; Hillman et al., 1989; Stearns et al., 1992; Brot-Goldberg and De Vaas, 2018). Papers studying provider behavior under capitation have found evidence that they respond to these incentives without affecting quality of care or patient outcomes (Ho and Pakes, 2014a). Under a FFS reimbursement scheme, the insurer and hospital negotiate a price for each service that is paid to the provider each time the service is rendered. Because provider profits are proportional to the number of services rendered under FFS, this reimbursement scheme generates incentives to over-provide or substitute to more expensive treatments (Shafrin, 2010). Research has found that use of FFS contracts explains much of the rising healthcare costs in countries like the United States (RAND Corporation, 2019), Norway (Grytten and Skau, 2008), and China (Eggleston et al., 2004). The papers that examine provider responses to these polar contracts have focused on settings where one contract type is present between any insurer-provider pair. We contribute to this literature by studying provider incentives and behavior in a setting where contract type is determined at the service level between each insurer-hospital pair. This paper provides an understanding of provider behavior in a context where incentives vary across both insurers and services, and studies the effect of this variation on referral and treatment decisions.

Our setting is the Colombian healthcare market, which is characterized by near universal coverage under a basic national health insurance plan. Individuals choose a private insurer through which to access the national plan. Those above a monthly income threshold pay a monthly contribution to the government for access to the national plan, while those below that threshold have their health care subsidized. Enrollees do not pay premiums and coinsurance rates, copays, and maximum out-of-pocket expenditures are set by the government. Insurers form networks of healthcare providers and negotiate reimbursements for healthcare services. These negotiations entail determining both a contract type and price for each service. Almost 40% of all claims filed during

2010 were reimbursed under a capitation contract, while another 40% were reimbursed under a FFS contract. The government mandates that certain low complexity services with relatively high demand and low markups must be covered under capitation. While the government recommends that high complexity services be covered under FFS, the contract type is ultimately determined through negotiations between insurers and providers and for many services there is variation across insurer-provider pairs in the type of contract that the service is reimbursed under. Additionally, the services required to treat a single patient might be reimbursed under different types of contracts. This raises the question of whether providers are still responsive to financial incentives in their referral and treatment decisions when there is variation across services in contract type for a single patient. Leveraging both the highly regulated nature of the setting we study as well as the detail of our claims data, which contains information on the contract type of each claim filed, we are able to quantify the profitability of any given claim and assess its relationship to providers' treatment decisions.

We quantify the extent to which to which providers respond to the financial incentives present under mixed contracts in both their referral and treatment decisions. We do this by focusing on a subset of the population with a specific acute condition - pregnancy - for which there are two primary treatments - vaginal delivery and cesarean delivery (c-section). We leverage the fact that referrals in the Colombian health system, including those to an OB/GYN, must be made by a primary care physician (PCP) and examine the PCP's decision to refer the patient to a specialist within their own hospital or to a specialist at another hospital given the contract types and prices of each delivery type negotiated with the patient's insurer. We also examine the delivering provider's decision to perform either a vaginal delivery or c-section given negotiated contract types and prices of each procedure. These prices and contracts will be different from those considered by the PCP if the referral was to a specialist outside their own hospital.

There is a large literature showing that c-section rates vary substantially across hospitals, even among women with similar health risks. Non-medical geographic factors including provider density and malpractice pressure have been shown to explain part of the variation in cesarean rates (Kozhimannil et al., 2013; Baiker et al., 2006). However, to our knowledge, there has been no examination of the role of provider moral hazard in explaining the decision to perform a c-section. Whether mixed contracts alleviate provider moral hazard is an important question generally, but is especially important in the specific case of delivery procedure choice. Procedure choice at the time of delivery has been shown to impact the rate of delivery injuries as well as rates of asthma, immune deficiencies, and breastfeeding among infants (Card et al., 2020). The determinants and consequences of delivery choice are also of keen interest to the many medical and international organizations that have called for regulation aimed at reducing the recent and uneven rise in global c-section rates (Teleki, 2020; World Health Organization, 2018; USA Today, 2020).

We develop and estimate a two-stage model of referral and delivery procedure choice for a pregnant patient under two assumptions: full information and imperfect information over contract types. In the first stage, the PCP decides whether to refer the patient to a specialist inside or outside their own hospital. This decision is a function of the reimbursement that the PCP's hospital would receive if the patient were referred inside. The second stage takes the referral decision as given, and models the delivering provider's treatment decision between c-section and vaginal delivery as a function of the reimbursements that the delivering provider's hospital would receive. In the model with imperfect information, we additionally include a term that captures physicians' disutility from high contract variance. In this model, we find that both referring and delivering providers are responsive to financial incentives: a \$100 thousand pesos increase in expected reimbursement under FFS generates a 31.6 percentage point increase in the likelihood of a referral inside, while the same increase in price of c-section relative to vaginal delivery generates a 7.4 percentage point increase in the likelihood of delivery by c-section. In both stages, we control for the patient's suitability for each procedure, which we estimate parametrically using a logit model.

Our findings show that uncertainty over contract type has important effects on referral and treatment decisions. The higher the variance in the probability that a service is covered under capitation, the more likely is the delivering physician to choose c-section over vaginal delivery, even after controlling for the woman's suitability for c-section. In fact, the c-section rate is concave in the capitation rate and maximized when capitation rates equal 50%. Similarly, we find that inside referral rates are decreasing and concave in the capitation probability, with the maximal rate achieved at 30% of capitation. This pattern of inside referrals is consistent with the intuition that physicians bear higher financial risk under capitation than under FFS. So, the more uncertainty there is over contract type, the less likely is the physician to treat the patient in their hospital. Defining the optimal capitation rate as the one that minimizes the distance between the predictions of a model where procedure choice is made solely based on health status and those made in the presence of moral hazard, we find that the optimal rate equals 50%.

Our findings are consistent with other papers that study insurer and provider responses to financial incentives (McClellan, 2011; Hillman et al., 1989). Variation in FFS prices has been linked to the number and duration of PCP visits (Brekke et al., 2017), the likelihood of providing specialty care (Grant, 2009), and the likelihood of being prescribed a generic drug (Liu et al., 2009). The literature has also found evidence not only of under-provision of services under capitation (Stearns et al., 1992), but also of insurer responses to referral choices. In particular, Ho and Pakes (2014a) and Ho and Pakes (2014b) find that insurers with a higher share of capitated physicians are more price sensitive and more likely to refer their patients to cheaper, farther away hospitals. Other papers have studied provider behavior when multiple contract types are present across patients and have found providers to be responsive (Hennig-Schmidt et al., 2011). We contribute by showing that this responsiveness remains even when variation in contract types exists at the service level, and that it plays an important role in the decision to perform c-sections.

2 The Colombian Healthcare System

The Colombian healthcare system is divided into two income-based regimes: the Contributory regime (CR) and the Subsidized regime (SR). The CR covers all individuals above a monthly income threshold, and these individuals pay a monthly contribution to the government for access to the national health insurance plan. Those below the monthly income threshold belong to the SR, and their healthcare is completely subsidized through tax revenue. Members of both regimes have access to the same national health insurance plan called POS by its Spanish acronym. The healthcare system has nearly universal coverage, approximately 51% of the population belonging to the CR, and the other 49% to the SR.

The design of the national health insurance plan is determined by the government. The plan covers a set of around 7 thousand procedures, services, and devices, as well as more than 700 prescription medications, all of which are chosen by the government. This plan is provided by private insurers, each of which forms its own network of providers with whom they engage in bilateral negotiations over contract terms and reimbursement rates. The government specifies the contract types that insurers and providers may use in determining reimbursements. These include capitation, FFS, fee-for-package, and fee-for diagnosis. Capitation and FFS are by far the most commonly used contract types, together accounting for over 80% of all claims filed in the CR in 2011. The government mandates that certain common, low-complexity services, like visits to the PCP, must be covered under capitation. For all other services, contract type is decided by the insurer and hospital. Access to any specialist or high-complexity service can only be obtained through a referral from a PCP. This referral may be to another physician within the PCP's own hospital or to a physician at a different hospital; we will refer to the former type of referral as an inside referral and the latter as an outside referral.

Those who enroll in the national health insurance plan do not pay premiums to their insurer. Instead, the government reimburses plans with risk-adjusted per-capita transfers. The risk adjustment formula controls only for sex, age category, and municipality of residence. The government also sets copays, coinsurance rates, and yearly maximum out-of-pocket expenditures. Theses prices vary across individuals based on their monthly income but do not vary across services, providers, or insurers. For enrollees who made less than 2 times the monthly minimum wage (MMW), the copay, coinsurance rate, and OOP limit in 2011 were 4,000 pesos, 11.5%, and 57.5%$\times$ MMW respectively. For those who made between 2 and 5 times the MMW, the copay, coinsurance rate, and OOP limit were 8,000 pesos, 17.3%, and 230%$\times$ MMW respectively. Finally, for those who made over 5 times the MMW, the copay, coinsurance rate, and OOP limit were 20,900 pesos, 23%, and 460% $\times$ MMW. These prices have remained unchanged for the past 20 years.[1]

3 Model

To quantify the effect of contract variance on physicians' responsiveness to financial incentives, we start by presenting a model of referral and delivery procedure choice by primary care providers and delivering hospitals, respectively. Suppose woman i whose health insurance is provided by carrier j becomes pregnant. She may have her baby delivered at hospital h by one of two procedures. Let

$$x_{ijh} = \begin{cases} 1 & \text{if} \quad \text{Caesection} \\ 0 & \text{if} \quad \text{Vaginal delivery} \end{cases}$$

and

$$l^x_{jh} = \begin{cases} 1 & \text{if} \quad x \text{ is covered under fee-for-service} \\ 0 & \text{if} \quad x \text{ is covered under capitation.} \end{cases}$$

Woman i's health condition makes her differentially suitable for each procedure. Let f^x_i denote woman i's suitability for procedure x. Woman i's out-of-pocket cost of having a delivery of type x is $OOP^x_{y(i)jh}$. The out-of-pocket payment varies across enrollees of different incomes y, because the coinsurance rates are income-specific, and across hospital-insurer pairs because it is at this level that prices are negotiated.

[1]The average exchange rate during 2011 was 1,847 COP/USD

Woman i's utility from receiving treatment x is

$$U^x_{ijh} = f^x_i + \omega^D[y_i - OOP^x_{y(i)jh}]$$

Here ω^D captures the extent of moral hazard on the patient's side. Moral hazard can be understood as the patient's incentive to over-consume healthcare services when cost-sharing is low or insurance coverage is high.

Sometime between woman i's becoming pregnant and her delivery, she visits a PCP at hospital h, who refers her to a specialist and a hospital at which to have her baby. The transfers made from woman i's insurance carrier to hospital h can be summarized by a lump sum payment per patient under a capitation contract, L_{jh}, and procedure-specific prices under a fee-for-service contract, p^x_{jh}. The payoff to the hospital where the PCP works from treating woman i with procedure x is a weighted average of the woman's utility from delivery by procedure x and the profit to hospital h from performing procedure x,

$$W^{xl}_{ih} = U^x_{ijh} + \omega^S[L_{jh} + p^x_{jh}(l^x_{jh} - \alpha(l^x_{jh} - \Pr(l^x_{jh} = 1))^2) - mc^x_h]$$

where mc^x_h is the marginal cost to hospital h of performing procedure x, $\Pr(l^x_{jh})$ is the probability that service x is covered under a fee-for-service contract between insurer j and hospital h, and ω^S is the weight on hospital financial payments that captures physician moral hazard. Moral hazard from the supply side arises from physicians incentives being aligned with hospital's profit maximizing incentives. If physicians are significantly more responsive to service prices than to patient health status, they will choose the treatment that maximizes hospital profits and not necessarily the one that maximizes patient utility. We assume physicians' responsiveness to financial incentives is decreasing in deviations from the average contract. The fact that physicians only observe deviations from the average contract but not contract types themselves implies that there is asymmetric information between the physician and the hospital, the degree of which is captured by α. Given that contract types are negotiated between the hospital's administration and the insurer, it is reasonable to assume that physicians have imperfect information about the result of this bargaining process. We model the cost of deviations from the average contract as a quadratic function $(l^x_{jh} - \Pr(l^x_{jh}))^2$. Despite physicians having imperfect information about contract types, we assume they fully observe service prices when making treatment decisions. Hospitals usually have electronic systems that notify physicians about service prices, but not about contracts. PCPs consider the payoff to their hospital when deciding whether to refer their patient to a specialist within or outside of their own hospital.

To summarize, the timing of the model is as follows:

Period 1: The woman becomes pregnant and visits the PCP. The PCP observes L_{jh}, p^x_{jh}, and mc^x_h, and refers the woman to hospital h', where $h' = h$ implies a referral inside.

Period 2: The woman's health status f^x_i is realized. Hospital h' observes f^x_i, $L_{jh'}$, $p^x_{jh'}$, and $mc^x_{h'}$, and decides whether to deliver the woman's baby via c-section or vaginal delivery.

3.1 Equilibrium under full information

We solve this two stage model by backward induction. To do so, we rely on the assumption that prices and contracts are determined at the hospital's administrative level and thus are exogenous to physicians when making referral and procedure decisions. We begin by solving the model where physicians have full information on prices and contracts, so $\alpha = 0$. Let $x_{ijh'}$ be the optimal delivery type for hospital h' treating woman i covered by insurer j in the second stage, and let $\tilde{x} = 1 - x$. When prices and contracts are fully observable, the choice by the specialist at hospital h' will satisfy the following inequality:

$$\begin{aligned} f^x_i + \omega^D[y_i - OOP^x_{y(i)jh'}] + \omega^S[L_{jh'} + p^x_{jh'} l^x_{jh'} - mc^x_{h'}] \geqslant \\ f^{\tilde{x}}_i + \omega^D[y_i - OOP^{\tilde{x}}_{y(i)jh'}] + \omega^S[L_{jh'} + p^{\tilde{x}}_{jh} l^{\tilde{x}}_{jh'} - mc^{\tilde{x}}_{h'}], \end{aligned}$$

or

$$[f^x_i - f^{\tilde{x}}_i] - \omega^D[OOP^x_{y(i)jh'} - OOP^{\tilde{x}}_{y(i)jh'}] + \omega^S[p^x_{jh'} l^x_{jh'} - p^{\tilde{x}}_{jh'} l^{\tilde{x}}_{jh'} - mc^x_{h'} + mc^{\tilde{x}}_{h'}] \geqslant 0 \qquad (1)$$

Equation (1) suggests that a procedure is more likely to be performed if it is covered under a FFS contract. This choice probability is increasing in the relative FFS price and decreasing in the relative marginal cost. The extent to which relative prices and marginal costs matter in the specialist's decision is captured by ω^S. Likewise, the likelihood of procedure x being performed is decreasing in its relative out-of-pocket cost to the patient. The importance of out-of-pocket payments in the specialist's decision is captured by ω^D. Finally, a procedure is more likely to be performed the relatively more suitable it is for the patient with respect to her health condition at the time of delivery. Importantly, we note that the capitation payments do not figure into the referral decision, as they are made to the provider regardless of which procedure is chosen.

In the first stage, the PCP at hospital h makes a referral decision by comparing the expected profit of referring the woman inside versus outside. Let

$$\begin{aligned}\Pr(x_{ijh}=x) = \Pr\Big(E\Big[(f_i^x - f_i^{\tilde{x}}) - \omega^D(OOP_{y(i)jh}^x - OOP_{y(i)jh}^{\tilde{x}}) \\ + \omega^S(p_{jh}^x l_{jh}^x - p_{jh}^{\tilde{x}} l_{jh}^{\tilde{x}} - mc_h^x + mc_h^{\tilde{x}})\Big] \geqslant 0\Big)\,, \quad \text{for} \quad x \neq \tilde{x}\end{aligned}$$

Then, under full information and exogeneity of contracts and prices, the PCP will refer woman i inside if:

$$E_x[W_{ih}^{xl}] \geqslant \omega^S L_{jh}. \tag{2}$$

Note that we can write equation (2) as:

$$\begin{aligned}&\Pr(x_{ijh}=x)[U_{ijh}^x + p_{jh}^x l_{jh}^x - mc_h^{\tilde{x}}] \\ &+ (1-\Pr(x_{ijh}=x))[U_{ijh}^{\tilde{x}} + p_{jh}^{\tilde{x}} l_{jh}^{\tilde{x}} - mc_h^{\tilde{x}}] + \omega^S L_{jh} \geqslant \omega^S L_{jh}.\end{aligned} \tag{3}$$

The capitation payments cancel out, and do not factor into the referral decision, as they are sunk profits.

3.2 Equilibrium under uncertainty

If we relax the assumption that physicians have full information on contracts, the specialist deciding on which procedure to perform in the second stage will choose x over $\tilde{x}$ whenever the following inequality is satisfied:

$$\begin{aligned}&[f_i^x - f_i^{\tilde{x}}] - \omega^D E[OOP_{y(i)jh'}^x - OOP_{y(i)jh'}^{\tilde{x}}] + \omega^S E[p_{jh'}^x] Pr(l_{jh'}^x) - \alpha\omega^S E[p_{jh'}^x]\Pr(l_{jh'}^x)(1-\Pr(l_{jh'}^x)) \\ &- \omega^S E[p_{jh'}^{\tilde{x}}]\Pr(l_{jh'}^{\tilde{x}}) + \alpha\omega^S E[p_{jh'}^{\tilde{x}}]\Pr(l_{jh'}^{\tilde{x}})(1-\Pr(l_{jh'}^{\tilde{x}})) - \omega^D[mc_{h'}^x - mc_{h'}^{\tilde{x}}] \geqslant 0\end{aligned}$$

Unlike equation (1), here we have taken expectations of prices and contract types across the set of services offered by the hospital. We assume that these contract characteristics are random variables that vary over services, and that the physician only observes their means. Moreover, we have used the fact that prices and contract types are determined simultaneously to write $E[p_{jh'}^x l_{jh'}^x] = E[p_{jh'}^x]\Pr(l_{jh'}^x)$. The specialist believes that procedure x is covered under FFS with probability $\Pr(l^x_{jh'})$ and the expected procedure price is given by $E[p^x_{jh'}]$. We also note that $E[(l^x_{jh'} - \Pr(l^x_{jh'}))^2] = Var(l^x_{jh'}) = \Pr(l^x_{jh'})(1 - \Pr(l^x_{jh'}))$.

Denoting by $\overline{\Pr}(x_{ijh} = x)$ the probability that x is chosen in the second stage, the PCP in the first stage of the model will refer the woman inside whenever the following equation holds:

$$\begin{aligned} &\overline{\Pr}(x_{ijh} = x)\Big(E[U^x_{ijh}] + \omega^S E[p^x_{jh}]\Pr(l^x_{jh}) + \alpha\omega^S E[p^x_{jh}]\Pr(l^x_{jh})(1 - \Pr(l^x_{jh})) - mc^{\bar{x}}_h\Big) \\ &+ (1 - \overline{\Pr}(x_{ijh} = x))\Big(E[U^{\tilde{x}}_{ijh}] + \omega^S E[p^{\tilde{x}}_{jh}]\Pr(l^{\tilde{x}}_{jh}) + \alpha\omega^S E[p^{\tilde{x}}_{jh}]\Pr(l^{\tilde{x}}_{jh})(1 - \Pr(l^{\tilde{x}}_{jh})) - mc^{\tilde{x}}_h\Big) \\ &+ \omega^S L_{jh} \geqslant \omega^S L_{jh}. \end{aligned} \tag{4}$$

In this case not only does the PCP have expectations over profits across procedures but also across contracts. The PCP believes procedure x is covered under FFS with probability $\Pr(l^x_{jh})$ and the expected price associated to this contract is given by $E[p^{xl}_{jh}]$.

4 Data

To estimate our model of physician's referral and treatment decisions, we data on all claims filed by pregnant women in the nine months preceding the first claim for childbirth. These women are enrolled to the contributory system during 2011. We observe the ICD-10 diagnosis code for each claim, and obtain comorbidities by grouping ICD-10 codes into the following conditions according to Alfonso et al. (2013): genetic anomalies, arthritis, arthrosis, asthma, autoimmune disease, cancer, cardiovascular disease, diabetes, long-term pulmonary disease, renal disease, HIV-AIDS, transplant, tuberculosis, and epilepsy. We observe the hospital at which each service was provided and can distinguish visits with specialists from visits with PCPs. We assume that the PCP that makes each woman's referral decision is the last one she sees before her delivery. We can determine that a PCP referred a woman to an OB/GYN inside if the PCP's hospital is the same as that of the rendering provider for her delivery. If the PCP operates at a different hospital than that at which the childbirth took place, then we conclude that the PCP referred the woman's childbirth to an OB/GYN outside. We observe the contract type under which each claim was reimbursed and the price of each claim reimbursed under a FFS contract, but not the lump sum payments made from the insurer to the provider for capitated services. In addition to her comorbidites, we also observe each enrollee's age and municipality of residence.

Our raw data consists of 114,167 childbirths. We drop deliveries that take place at hospitals that either perform fewer than 40 deliveries during the sample period, or that contract with fewer than two insurers. The former restriction ensures that the hospitals in our sample are those that regularly perform childbirths. The latter restriction implies dropping from our sample providers who face no potential variation with respect to contract type, reimbursement rates, or coinsurance payments across patients undergoing the same procedure. These restrictions amount to dropping the smallest providers in our sample: applying them results in dropping 83% of providers, but only 20% of deliveries, so that our final analysis sample consists of 89,884 childbirths performed by 229 unique hospitals and covered by 11 unique insurers.

We use Gowrisankaran et al. (2015)'s methodology to recover the procedure-specific negotiated prices from our claims data. Prices observed in the claims data may differ from prices negotiated at the insurer-hospital level due to complications during childbirth that are exogenous or unobserved by the insurer and the hospital at the time of bargaining. Using observed claims prices under FFS associated to each delivery type, we recover the negotiated prices as the average prediction of a linear regression of claims prices on patient characteristics and hospital fixed effects. Formally, we estimate the following regression via OLS, separately for each insurer j and procedure x:

$$p^x_{cjh} = \alpha_0 X_i + \lambda_h + \epsilon_{cjh}$$

Here c indexes a claim, X_i are patient i's demographic characteristics and diagnoses, and λ_h are hospital fixed effects. We compute negotiated prices as the average prediction: $p^x_{jh} = (1/C^x_{jh}) \sum_c \hat{p}^x_{cjh}$, where C^x_{jh} is the number of claims for procedure x between hospital h and insurer j. The (unweighted) average R-squared across these regressions for c-section is 0.48 and for vaginal delivery is 0.42.

Because in the procedure choice stage we only need to observe whether the woman received a c-section or a vaginal delivery, we can use the information on all deliveries to identify the model's coefficients. Table 1 presents some summary statistics of the main variables in our analysis sample for the procedure choice stage, separately by type of procedure and type of referral. The unit of observation is a delivery. 48% of all childbirths are vaginal deliveries, while the remaining 52% are c-sections. 7% of all childbirths are referred inside, while the remaining 93% are referred outside. The average FFS price perceived by the delivering hospital for a c-section referred outside is \$456 thousand pesos, and that for a vaginal delivery is \$337 thousand pesos. We see that the average price for vaginal deliveries that are referred inside is lower than those performed outside, similarly

Table 1: Characteristics of deliveries by referral and procedure type

	All	Referred inside		Referred outside	
		Vaginal	C-section	Vaginal	C-section
Financial characteristics					
Capitation (%)	13.60	54.37	38.33	12.08	10.39
Price (delivery hospital)	3.98 (2.09)	3.17 (1.24)	4.41 (1.58)	3.37 (1.81)	4.54 (2.20)
Price (PCP's hospital)	3.92 (1.75)	3.17 (1.24)	4.41 (1.58)	3.30 (2.11)	4.60 (3.17)
Demographics					
Age, mean (sd)	27.90 (5.66)	26.81 (5.31)	28.67 (5.79)	27.29 (5.49)	28.28 (5.75)
Diagnoses (%)					
Arthritis	0.51	0.20	0.53	0.42	0.62
Asthma	1.23	1.45	1.64	1.06	1.35
Autoimmune disease	0.28	0.27	0.19	0.24	0.32
Cancer	10.90	7.33	12.82	9.54	12.25
Cardiovascular disease	6.18	4.10	6.95	4.54	7.76
Diabetes	0.62	0.30	0.93	0.38	0.83
Epilepsy	0.40	0.13	0.53	0.34	0.45
Genetic anomalies	1.26	0.84	1.18	1.14	1.40
HIV-AIDS	0.20	0.24	0.12	0.11	0.29
Long term pulmonary disease	0.48	0.47	0.25	0.37	0.59
Renal disease	0.53	0.50	0.43	0.45	0.61
Transplant	0.01	0.00	0.03	0.01	0.01
Tuberculosis	0.10	0.20	0.06	0.10	0.09
Type of municipality (%)					
Metropolitan	45.28	50.57	43.85	50.64	40.11
Normal	53.43	45.36	54.90	48.01	58.82
Special	1.30	4.07	1.24	1.35	1.07
N	89,585	2,974	3,222	39,842	43,547

Note: This table shows summary statistics of the final sample separately by type of procedure and type of referral. The unit of observation is a delivery. † measured in 100,000 Colombian pesos.

for c-sections. One might initially take this as evidence against the hypothesis that PCPs are responding to financial incentives in their referring decisions. However, we note that the relevant price for a PCP considering whether to refer outside is the price established between the PCP's hospital and the patient's insurer. This price is not the price of delivery for the woman observed in the data if the woman is referred outside. These counterfactual prices can be obtained from the price data of other women enrolled with the same insurer who have their baby delivered at the same hospital as the PCP of the woman who was referred outside. The average c-section price that the PCP's hospital would have perceived if an outside referral were to be made inside equals $459 thousand pesos, almost the same as the price perceived by the delivering hospital. In the case of vaginal deliveries, the average price that the PCP's hospital would have perceived for an outside referral made inside equals $329 thousand pesos, which is lower than the price perceived by the delivering hospital.

Turning to enrollee characteristics, we see that a little over 20% of deliveries are associated to women with at least one comorbidity. The most common comorbidity is cancer, which affects 11% of women in our sample, followed by cardiovascular diseases in 6% of women. The rate of nearly every comorbidity is higher among the set of women who receive c-sections than those who have vaginal deliveries. Women who receive c-sections are also 2 years older on average than those who have vaginal deliveries. This is consistent with the use of c-section to prevent complications that arise in labor for high-risk births. It also highlights the importance of controlling for a woman's suitability for c-section with respect to her health status when evaluating the determinants of providers' procedure choice. We detail our measure of procedure suitability in section 5. Finally, 53% of women in our sample reside in normal municipalities defined as those that are adjacent to metropolitan areas, followed by 45% in metropolitan areas, and 1% in special or peripheral municipalities.

Table 2: Characteristics of deliveries by referral and procedure type for subsample of primary care providers

	All	Referred inside		Referred outside	
		Vaginal	C-section	Vaginal	C-section
Financial characteristics					
Capitation (%)	35.83	60.93	39.45	22.32	22.12
Price (PCP's hospital)	3.73 (1.68)	2.90 (1.17)	4.18 (1.53)	3.22 (2.03)	4.24 (2.47)
Demographics					
Age, mean (sd)	28.19 (1.68)	26.70 (5.22)	28.77 (5.77)	27.73 (5.72)	29.42 (5.97)
Diagnoses (%)					
Arthritis	0.39	0.05	0.50	0.33	0.66
Asthma	1.46	1.52	1.91	0.95	1.42
Autoimmune disease	0.49	0.20	0.23	0.38	1.13
Cancer	8.06	6.81	14.17	5.53	5.39
Cardiovascular disease	6.20	3.71	7.33	4.77	8.74
Diabetes	0.62	0.30	0.82	0.52	0.80
Epilepsy	0.51	0.20	0.59	0.72	0.52
Genetic anomalies	1.46	0.66	1.37	1.62	2.13
HIV-AIDS	0.39	0.20	0.18	0.00	1.18
Long term pulmonary disease	0.43	0.51	0.23	0.38	0.61
Renal disease	0.61	0.46	0.55	0.67	0.76
Transplant	0.02	0.00	0.05	0.00	0.05
Tuberculosis	0.04	0.10	0.05	0.00	0.00
Type of municipality (%)					
Metropolitan	66.97	60.37	49.34	80.35	78.12
Normal	32.47	37.96	50.21	19.55	21.79
Special	0.56	1.68	0.46	0.10	0.09
N	8,376	1,968	2,195	2,097	2,116

Note: This table shows summary statistics of the subsample of observations associated to hospitals at which both PCPs are affiliated and deliveries take place. The unit of observation is a delivery. † measured in 100,000 Colombian pesos. For continuous variables, the mean and standard deviation in parenthesis are presented.

For the referral choice stage, we need to constrain our sample to the subset of childbirths for women whose PCP is affiliated with an institution at which childbirths take place. Women whose PCPs are affiliated with institutions at which childbirths do not take place will always be referred outside. There are over a thousand unique institutions at which the women in our sample receive primary care. 150 of these are hospitals at which childbirths take place. These 150 hospitals account for 6,422 of the childbirths in our sample. Table 2 provides summary statistics for this sample. Restricting the sample to providers who perform primary care visits increases the rate of inside referrals to over 70%. Rates of capitation are much higher among these providers (56%) than among the sample as a whole presented in table 1 (13%), but patient characteristics exhibit similar patterns. For example, women who receive a c-section at the PCP's hospital are on average older and have higher rates of every comorbidity compared to women who have a vaginal delivery. This sample is more urban that the full sample, with 56% of women living in municipalities in metropolitan areas. Vaginal deliveries at the PCP's hospitals are significantly cheaper than c-sections. For inside referrals c-sections are almost $200 thousand pesos more expensive than vaginal deliveries, and for outside referral this difference is close to $100 thousand pesos.

5 Empirical specification

In this section, we describe the empirical analogues of the key elements of the model presented in the section 3. We begin by describing our measure of each patient's suitability for c-section. Then we present the equations for the treatment and referral decisions of providers.

5.1 Patient's suitability for c-section

We take a parametric approach to the measurement of each patient's appropriateness of c-section. Similar to Currie and MacLeod (2017), we assume this variable follows a logistic distribution given by

$$f_i^x = \Lambda(X_i, D_i, M_i, t; \theta) \tag{5}$$

where X_i is a vector of demographic characteristics including sex, age, and department of residence; D_i is a vector of dummies for each 2-digit ICD-10 diagnosis code as well as for the ICD-10 disease groups listed in Alfonso et al. (2013) that the woman is diagnosed with before delivery; M_i is a vector of dummies for each 2-digit ATC code associated to the woman's prescribed medications before delivery; t is an indicator for the calendar month when delivery occurs; and θ are the parameters of the model. We do not include reimbursement measures or non-medical patient characteristics, as our goal is to measure the medical risk of requiring a c-section free of financial incentives. We train our logit model for appropriateness of c-section on a random sample of 70% of observations.

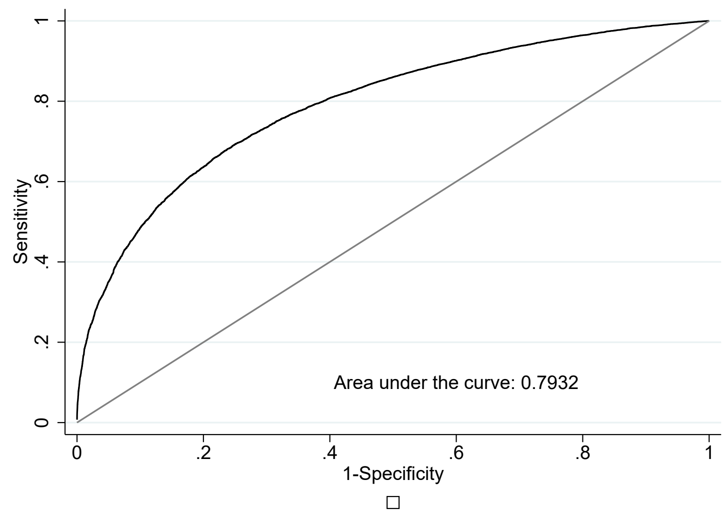

Figure 1: ROC curve for logistic classifier

Figure 1 shows the ROC curve and area under the curve achieved by our model out-of-sample in the remaining 30% of the data. A perfect fit would suggest that women are always rendered the procedure that they are most suitable for. The fact that the area under the ROC curve is below 100 is consistent with physicians deviating from the most suitable treatment even after observing patient characteristics.

In using (a random sample of) the entirety of our analysis sample when estimating and predicting appropriateness of c-section, we are implicitly assuming that actual practice is reflective of a woman's true medical risk for c-section. We test the validity of this assumption by re-estimating the logit model restricting the sample to a subset of providers that have relatively low rates of negative outcomes related to childbirth. We consider hospitalizations, hemorrhages, puerperal sepsis, and infections of obstetric surgical wounds within one to three months after delivery as negative outcomes. Comparing our classifier with the one obtained using this subset of providers in appendix A, we find no significant differences in their predictive power.

5.2 Fee-for-service probability and expected prices

In our model with physician uncertainty over reimbursement structure, the assumption of prices and contracts being bargained simultaneously implies:

$$E[p^x_{jh'} l^x_{jh'}] = E[p^x_{jh'}]\Pr(l^x_{jh'})$$

Since $l^x_{jh'}$ is a binary variable, we recover $\Pr(l^x_{jh'})$ non-parametrically as the proportion of services in the national insurance plan that are covered under FFS for each insurer-hospital pair. We also assume physicians always have full information on prices, so $E[p^x_{jh'}] = p^x_{jh'}$. This is a reasonable assumption given that hospital electronic systems usually notify physicians of prices and available services. If physicians had imperfect information on service prices and observed only the average price of a delivery, we would not be able to identify the effect of physician moral hazard on referral and treatment decisions. Physician moral hazard in our model is identified mainly from the variation in prices across delivery services. By assuming physicians observe average prices instead, we eliminate that source of price variation.

5.3 Procedure choice

Our empirical specification for the second stage of the model in which the specialist at hospital h chooses the type of delivery is:

$$\begin{aligned} x_{ijh'} &= \beta_0(f^x_i - f^{\tilde{x}}_i) + \beta_1(OOP^x_{y(i)jh'} - OOP^{\tilde{x}}_{y(i)jh'}) + \beta_2(p^x_{jh'} l^x_{jh'} - p^{\tilde{x}}_{jh'} l^{\tilde{x}}_{jh'}) \\ &+ \beta_3(p^x_{jh'} l^x_{jh'} - p^{\tilde{x}}_{jh'} l^{\tilde{x}}_{jh'})^2 + \beta_4(p^x_{jh'} l^x_{jh'} - p^{\tilde{x}}_{jh'} l^{\tilde{x}}_{jh'}) Pr(l_{jh'})(1 - Pr(l_{jh'})) \\ &+ \beta_5 Pr(l_{jh'})(1 - Pr(l_{jh'})) + \eta_{h'} + \varepsilon_{ijh'} \\ &= \delta(OOP_{y(i)jh'}, p_{jh'}, \eta_{h'}; \beta) + \varepsilon_{ijh'}. \end{aligned} \tag{6}$$

$x_{ijh'}$ is an indicator for woman i receiving a c-section at hospital h', the outside option being vaginal delivery. β_1 measures the degree of provider altruism, as it is associated to the portion of the physicians' payoff that is explained by patient utility. We model the effect of provider moral hazard as a non-linear function of the relative price of c-sections. β_2 is the linear component of provider moral hazard or the average sensitivity of treatment choice to the relative price, while β_3 is the quadratic component. We expect physicians to be relatively less responsive to service prices the higher is the price level. $\eta_{h'}$ is a delivering hospital fixed effect that captures the hospital's average marginal cost across procedures. Both f^x_i and $f^{\tilde{x}}_i$ are computed using the logit model described in section 5.1.

In the model with full information, we assume $\beta_4 = 0$ as this is the empirical analog of α capturing the degree of information asymmetry between the hospital and the specialist in our theoretical model. Under full information, prices for c-section $p^{xl}_{jh'}$ and vaginal delivery $p^{\tilde{x}l}_{jh'}$ correspond to negotiated prices between the delivering hospital h' and the woman's insurance carrier j. These prices are computed as detailed in the previous section. With asymmetric information or uncertainty over contracts, $\beta_4 > 0$ and we replace contract types by the probability that a service is covered under FFS for every insurer-hospital pair. In each model, we assume ε_{ijh} is normally distributed and estimate equation (6) via OLS.

5.4 Referral choice

As in equation (3), PCP's referral decisions are a function of the expected profits from an inside referral. Expected profits are given by the sum of profits to the PCP's hospital from c-section and vaginal delivery, weighted by the probability of each procedure being rendered in the second stage conditional on an inside referral. We therefore proceed by backward induction, estimating the second stage procedure choice using the prices, contract types, and coinsurance rates of the referring hospital. Let $\hat{x}_{ijh}$ be the predicted probability of hospital h delivering woman i's child by c-section conditional on an inside referral, and let z_{ijh} be a binary indicator that takes the value of one for an inside referral and zero for an outside referral. Our empirical model for the first stage is:

$$\begin{aligned} z_{ijh} = {} & \gamma_0(\hat{x}_{ijh} f_i^x + (1-\hat{x}_{ijh}) f_i^{\tilde{x}}) + \gamma_1(\hat{x}_{ijh} OOP^x_{y(i)jh} + (1-\hat{x}_{ijh}) OOP^{\tilde{x}}_{y(i)jh}) \\ & + \gamma_2(\hat{x}_{ijh} p^x_{jh} l^x_{jh} + (1-\hat{x}_{ijh}) p^{\tilde{x}}_{jh} l^{\tilde{x}}_{jh}) + \gamma_3(\hat{x}_{ijh} p^x_{jh} l^x_{jh} + (1-\hat{x}_{ijh}) p^{\tilde{x}}_{jh} l^{\tilde{x}}_{jh}) Pr(l_{jh})(1-Pr(l_{jh})) \\ & + \gamma_4 Pr(l_{jh})(1-Pr(l_{jh})) + \gamma_5(\hat{x}_{ijh} p^x_{jh} l^x_{jh} + (1-\hat{x}_{ijh}) p^{\tilde{x}}_{jh} l^{\tilde{x}}_{jh})^2 + \eta_h + \mu_{ijh} \end{aligned} \tag{7}$$

where η_h are PCP's hospital fixed effects representing the hospital's average marginal cost across procedures. γ_1 is the marginal effect of an increase in the patient's expected out-of-pocket payments during the delivery stage on the PCP's referral decision. To the extent that the PCP's payoff declines with the woman's expected out-of-pocket payments, this parameter captures the degree of PCP altruism. γ_2 represents PCP moral hazard, and measures the sensitivity of the referral probability to expected prices. We allow this price-sensitivity to be non-linear with γ_5 representing the quadratic component. In the model with full information, we constrain γ_3 and γ_4 to be equal to zero, prices are given by negotiated prices calculated with the methodology of section 4, and contracts are as observed in the data. In the model with uncertainty, we allow γ_3 and γ_4 to be different from zero and the expectation of contract type is given by the probability that a service is covered under FFS between insurer j and hospital h. In that case, γ_3 represents the disutility to the PCP from volatility in expected prices due to uncertainty in contract type; and γ_4 is the mean effect of contract type uncertainty on the PCP's referral decision. We assume μ_{ijh} is a mean zero normal error and estimate equation 7 by OLS, bootstrapping standard errors.

6 Identification

To identify the coefficients on vaginal delivery and c-section prices in our empirical model, we rely on the assumption that prices and contracts are exogenous to the physicians. This rules out traditional simultaneity problems and selection of physicians into high-priced hospitals based on unobserved physician characteristics. Because our specification for the procedure choice and referral choice stages both include hospital fixed effects, we require two types of within-hospital variation to identify β_2-β_5 and γ_2-γ_4. First, we require variation in the relative price of c-sections, relative to vaginal deliveries, which comes from variation in negotiated procedure prices across the insurers that each hospital contracts with. We summarize the availability of such variation in figure 2. The left-side panel of the figure presents the distribution of prices for c-section and vaginal delivery across deliveries. We note that there is significant price variation within procedure and that vaginal deliveries are significantly cheaper than c-sections. The right-side panel of the figure presents the residuals from a linear regression of negotiated procedure prices on hospital fixed effects. While there is an important mass at zero, we see relevant variation in the c-section price residuals, which range from -20 to 20 million pesos. Similarly, vaginal delivery price residuals range from -10 to 10 million pesos.

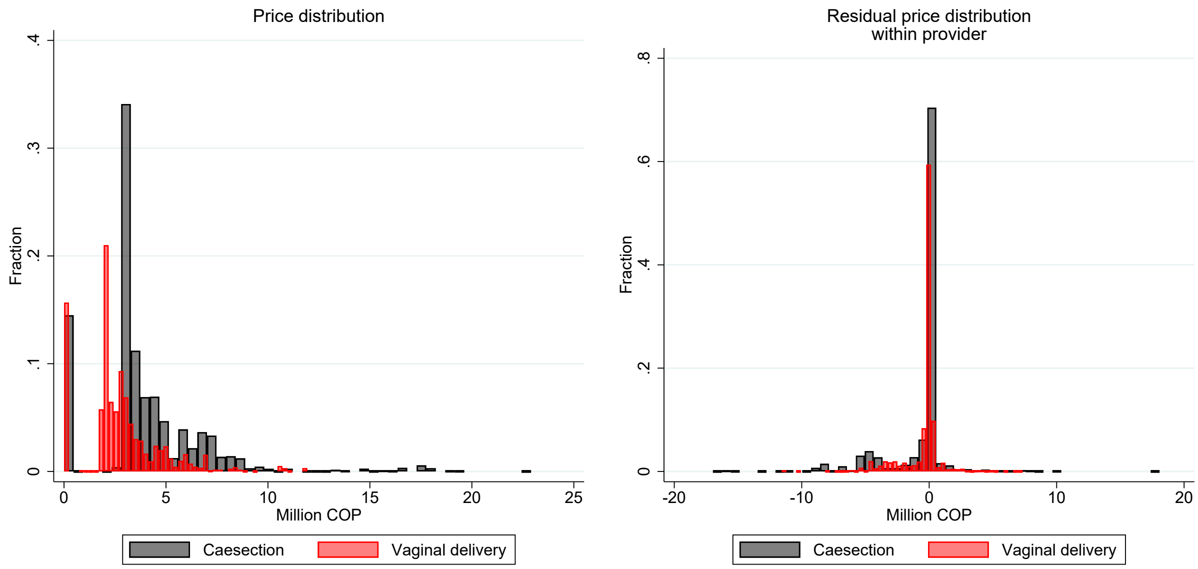

Figure 2: Price distribution within hospitals

Second, we require variation in contract type within hospitals to identify the effect of contract type uncertainty on procedure and referral choices. This variation comes from contract type heterogeneity across the services that a hospital can provide for the same insurer and across insurers. For every insurer-hospital pair, we need to observe at least one service covered under FFS and at least one service covered under capitation to identify β_5 and γ_4 in our empirical model. In figure 3 we present the distribution of the average proportion of capitated services per hospital across insurers. The figure shows that for around 25% of hospitals in our sample, the proportion of capitated services is greater than zero, which means that for these hospitals contract type varies across the insurers it has a contract with.

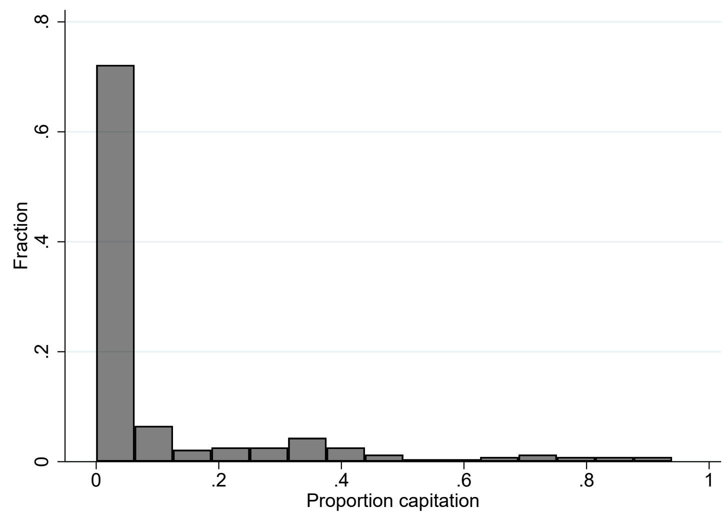

Figure 3: Distribution of proportion capitated services

The remaining parameters in our model associated to out-of-pocket payments, β_1 and γ_1, can be identified from the within-hospital price variation described above, as well as from two additional sources of variation. The first is variation in income across patients within a hospital. Even though we do not observe income at the patient level, we have information on the parameters of the income distribution per municipality. We observe the average and standard deviation of income in every market, which allows us to simulate income values for every woman in our data assuming that this variable follows a log-normal distribution. In the left-side panel of figure 4 we report the distribution of coinsurance payments across deliveries, and in the right-side panel we present the residuals from a regression of coinsurance payments on hospital fixed effects. These figures show that there is significant variation in coinsurance payments within hospital that enable identification of β_1 and γ_1. The second source of identification stems from the fact that while variable reimbursements for capitated services are zero, coinsurance payments are not. The procedure choices of hospitals for which both c-section and vaginal delivery are capitated therefore help us identify the coinsurance payment variables.

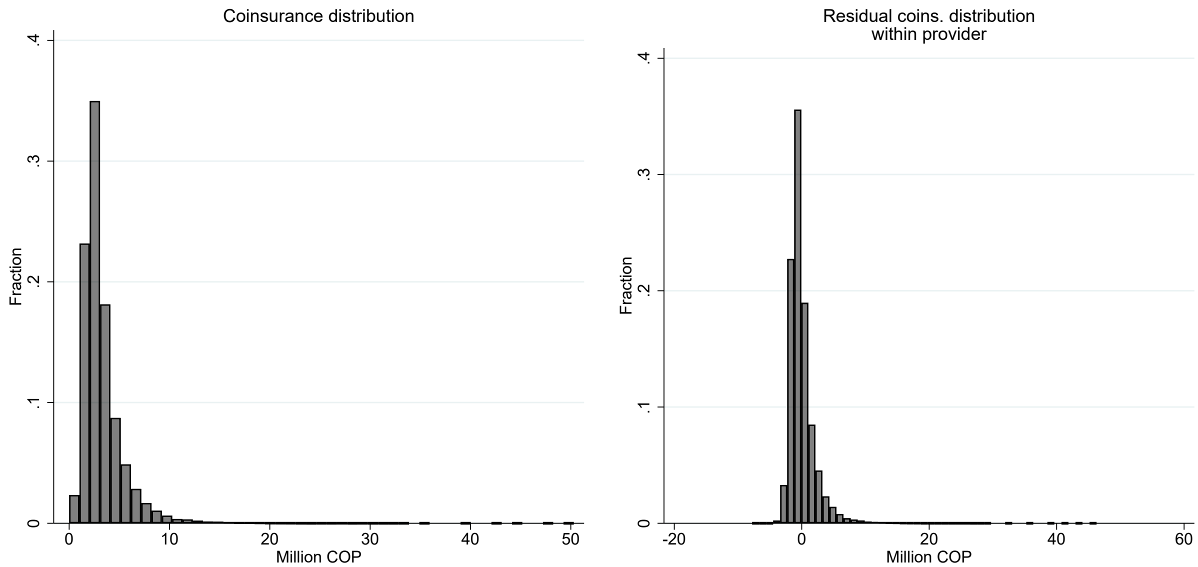

Figure 4: Coinsurance payment distribution

7 Results

In this section, we present the linear regression estimates for equations (6) and (7). Estimates for equation (6) are presented in table 3. Column 1 reports the coefficients from the model with full information and column 2 reports the model with uncertainty. Results are qualitatively similar across both specifications, but greater in magnitude when we assume that physicians have imperfect information on contract type. With full information, our results show that the likelihood of delivery by c-section is increasing in the relative price of c-section, relative to vaginal delivery, suggestive of substantial provider moral hazard in the choice of procedure. These estimates imply that an increase of \$100 thousand pesos in the relative price of c-section increases the likelihood of delivery by c-section by 6.2 percentage points. When we relax the assumption of full information in column 2, our estimate for the sensitivity of c-section to its relative price equals 7.4 percentage points. Physicians' responsiveness to service prices is concave in the price level. The likelihood that delivering specialists choose c-section increases at a decreasing rate with the relative procedure price.

In column 2, we find that the likelihood of c-section does not change with the patient's coinsurance payments, which suggests that specialists in delivering hospitals do not take into account their patient's healthcare expenses when recommending certain treatment. While it is desirable that physician decisions are not affected by moral hazard from the demand side, physician's responsiveness to their hospital's profits raises the possibility that their treatment recommendations are not necessarily the ones that improve patient health status or welfare. By including a measure of the woman's relative suitability for c-section, we are able to capture whether hospital incentives and patient health status are aligned. In column 2, we find that that delivering specialists are more likely to choose c-section the more suitable is this procedure for the woman. A one standard deviation increase in the relative suitability, increases the likelihood of c-section by 25 percentage points. Prices also have a sizable effect on physicians' decisions, as a one standard deviation increase in the relative price of c-section, raises the likelihood of c-section by 11 percentage points. This effect is almost half of the one explained by the woman's suitability for c-section.

Findings from the model with uncertainty indicate that when contract types are not perfectly observable, physicians will default to choosing c-section, regardless of prices and patient characteristics. Even though the effect of contract variance on the likelihood of choosing c-section is decreasing in the relative price of c-section, we find that a one standard deviation increase in contract variance alone raises the probability of c-section by over 95 percentage points.

Table 3: Estimates for second stage regression model of procedure choice

	(1) Full information	(2) Uncertainty
Price diff.	0.062***	0.074***
	(0.002)	(0.003)
Price diff.^{2}	-0.003***	-0.003***
	(0.0003)	(0.0003)
Price diff. $\times$ Contract var.	—	-0.242***
		(0.023)
Contract variance	—	1621.82***
		(338.83)
Coinsurance diff.	-0.003	-0.006*
	(0.005)	(0.004)
Suitability diff.	0.479***	0.479***
	(0.003)	(0.003)
N	83,683	83,683
R^2	0.31	0.31

Note: This table presents results from a OLS regressions of procedure choice. Column 1 presents results from the model with physician full information where $\alpha = 0$, and column 2 presents results from the model with uncertainty over contract type. Both models include hospital and department fixed effects. Bootstrap standard errors based on 100 resamples at the patient level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Using the estimates for the procedure stage in the model with uncertainty, we predict the average elasticity of c-section with respect to relative c-section prices for each provider as:

$$\hat{\beta}_2 + 2\hat{\beta}_3(p^x_{jh'}l^x_{jh'} - p^{\tilde{x}}_{jh'}l^{x'}_{jh'}) + \hat{\beta}_4 Pr(l_{jh'})(1 - Pr(l_{jh'})) \times \frac{(p^x_{jh'}l^x_{jh'} - p^{\tilde{x}}_{jh'}l^{x'}_{jh'})}{\overline{\hat{x}}_{ijh'}}$$

where $\overline{\hat{x}}_{ijh'}$ is the average predicted probability that patient i enrolled to insurer j who visits hospital h' is rendered a c-section. This elasticity is our measure of delivering provider moral hazard depicted in figure 5. There is significant heterogeneity in moral hazard across the providers that make procedure choices, but this elasticity is less than 1. The elasticity variation is undesirable from the patient's point of view, since it implies that matching with a provider who is more likely to choose the most suitable procedure, when this procedure is vaginal delivery, is more difficult. The fact that the choice of c-section is virtually inelastic with respect to the relative price of the procedure, suggests that no matter how cheap vaginal deliveries are, delivering physicians are always more likely to render c-sections.

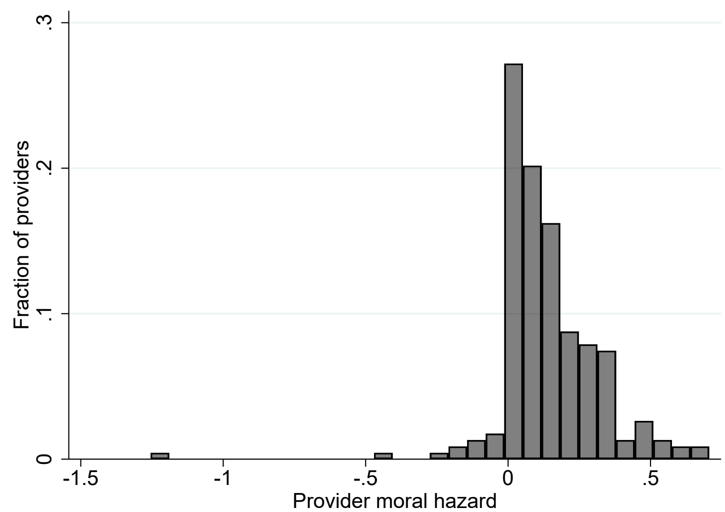

Figure 5: Distribution of delivery provider elasticity

Estimates for equation (7) are presented in table 4. Column 1 reports the coefficients and standard errors from the model with full information, and column 2 reports results from the model with contract type uncertainty. As before, our estimates from both models are qualitatively similar. In both models we include a variable denoting the number of previous visits with the PCP, to control for provider loyalty or inertia. We also include the distance from the PCP's hospital to the delivering specialist's hospital. Our intuition here being that for pregnant women the disutility of having to travel long distances to get treatment is greater than for patients without immediate health conditions.

Focusing on column 2, we see that PCPs are responsive to the expected profit of retaining a pregnant patient: a $100 thousand pesos increase in the expected profit results in a 31.6 percentage point increase in the likelihood of a referral inside. The effect of expected profits on the probability of an inside referral is concave in the profit level. Our findings also show that a one standard deviation increase in the woman's expected suitability for c-section in the second stage of the model, reduces the likelihood of an inside referral by 2.3 percentage points. These results together imply that provider moral hazard is one of the main determinants of referral choice even after controlling for a patient's expected suitability of c-section under mixed contracts.

We find that referring providers do not respond to the patient's expected out-of-pocket payments in the second stage, so demand-side moral hazard is less important than provider moral hazard for referral decisions. As expected, we estimate a negative coefficient on the distance from the PCP's hospital to the delivering provider's hospital, which means that PCPs are more likely to refer to specialists that are located nearby. But, we find no significant effect of PCP inertia on referral choice. On the contrary, contract type uncertainty is one of the main predictors of referral choice. The higher the degree of PCP imperfect information regarding procedure contract type, the more likely it is that she chooses to retain the patient. A one standard deviation increase in contract variance in the second stage, raises the probability of an inside referral by 11 percentage points.

We predict the average elasticity of an inside referral with respect to expected profits using the estimates of column 2, separately for each PCP. The elasticity is calculated as:

$$\hat{\gamma}_2 + 2\hat{\gamma}_5(\hat{x}_{ijh}p^{x}_{jh}l^{x}_{jh} + (1-\hat{x}_{ijh})p^{\tilde{x}}_{jh}l^{\tilde{x}}_{jh}) + \hat{\gamma}_3 Pr(l_{jh})(1-Pr(l_{jh})) \times \frac{(\hat{x}_{ijh}p^{x}_{jh}l^{x}_{jh} + (1-\hat{x}_{ijh})p^{\tilde{x}}_{jh}l^{\tilde{x}}_{jh})}{\bar{\hat{z}}_{ijh}}$$

where $\bar{\hat{z}}_{ijh}$ is the average predicted probability of an inside referral. This elasticity is our measure of PCP moral hazard, since it captures the sensitivity of referral choice to service prices. Figure 6 presents the distribution of this variable. PCP moral hazard is the biggest source of medical decision distortions compared to delivering physician moral hazard. The price-elasticity of an inside referral ranges from 0 to 2. If expected profits increase as a little as $160 pesos, which corresponds to 1% of the average expected profit, the probability of an inside referral increases by 2% from a baseline mean of 0.07.

Table 4: Estimates for first stage regression model of referral choice

	(1) Full information	(2) Uncertainty
Expected profit	0.311***	0.316***
	(0.012)	(0.014)
Expected profit^2	-0.024***	-0.024***
	(0.002)	(0.003)
Expected profit × Contract var.	—	-0.046
		(0.075)
Contract variance	—	1.151***
		(0.229)
Expected coinsurance	0.004	0.004
	(0.003)	(0.003)
Expected suitability for c-section	-0.089***	-0.088***
	(0.031)	(0.031)
Previous visits	-0.002	-0.002
	(0.003)	(0.003)
Distance/100	-0.002***	-0.001***
	(0.0004)	(0.0004)
N	8,376	8,376
R^2	0.62	0.62

Note: This table presents results from a OLS regressions of inside referral choice. Column 1 presents results from the model with physician full information where $\alpha = 0$, and column 2 presents results from the model with uncertainty over contract type. Both models include hospital and department fixed effects. Bootstrap standard errors based on 100 resamples at the patient level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

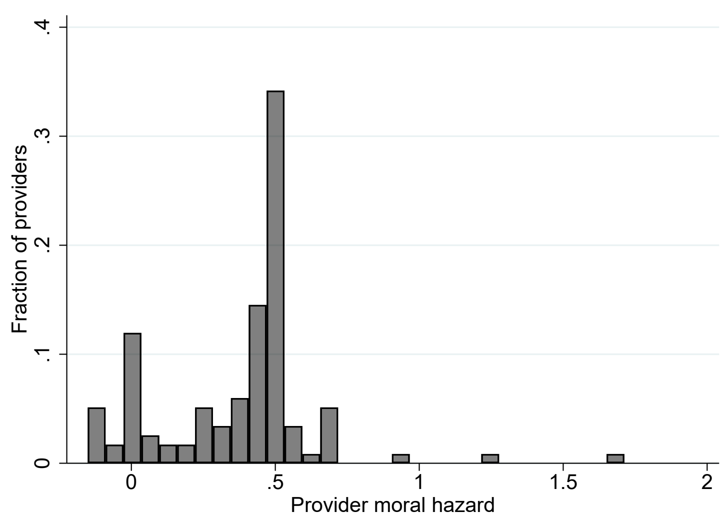

Figure 6: Distribution of referring provider elasticity

8 The effect of capitation

8.1 Full capitation

In this section we use our model estimate to examine the effect of full capitation on the rates of inside referrals and c-sections. To compute our counterfactual estimates, we assume that FFS prices do not depend on the capitated lump-sum transfers. Put differently, our assumption is that insurers and hospitals simultaneously bargain over coverage and reimbursement levels of capitation and FFS, so that they have no knowledge of capitation rates before negotiating service prices. This guarantees that regardless of the percentage of capitation, FFS prices in counterfactual are equal to observed prices. We conduct three counterfactual analyses: first, we impose full capitation only on c-sections, then only on vaginal deliveries, and finally on both types of delivery. By imposing full capitation on a given procedure, we are eliminating future expected profits for that procedure, so the price that a hospital receives from performing it equals zero.

Table 5: Counterfactual decisions under full capitation

		Full capitation		
	Observed	(1) C-section	(2) Vaginal	(3) Both
C-section probability	0.552 (0.289)	0.326 (0.308)***	0.666 (0.269)***	0.490 (0.294)***
Inside referral probability	0.571 (0.401)	0.501 (0.372)***	0.542 (0.396)***	0.387 (0.395)***

Note: This table presents the mean and standard deviation in parenthesis of the c-section probability and the probability of an inside referral for the observed scenario and three counterfactuals where we impose full capitation on: c-sections in column (1), vaginal delivery in column (2), and both procedures in column (3). These results correspond to the model with contract uncertainty. We also report the significance level of a difference-in-means t-test of each counterfactual relative to the observed scenario. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5 presents the mean and standard deviation (in parenthesis) of the probability of c-section and inside referral in the observed scenario and our three counterfactuals. The significance level of a t-test for the difference in means relative to the observed scenario is also reported. Consistent with the intuition that capitation generates a reduction in the number of services provided, we find a significant decrease in c-section rates when c-sections are subject to capitation across all insurer-hospital pairs. The rate decreases from 55.2% in the observed case to 32.6% in counterfactual. When imposing full capitation on vaginal deliveries, making them less profitable to the delivering hospital relative to c-sections, our findings show a significant increase of nearly 11 percentage points in the probability of performing a c-section. If we impose full capitation on both types of delivery, the relative profitability of c-sections versus vaginal deliveries is very similar to that of the observed scenario, so we predict that c-section rates under counterfactual are only slightly smaller in magnitude than the observed rates, although the difference is significant.

Table 5 also shows that a scenario where all insurer-hospital pairs have both types of delivery under full capitation, reduces the probability of an inside referral by nearly 18 percentage points relative to the observed scenario. We also see a reduction of 7 percentage points in the probability of an inside referral when only c-sections are subject to full capitation. But when full capitation is imposed on vaginal deliveries, the less profitable procedure, we find no meaningful difference in the resulting probability of an inside referral relative to the observed scenario. These results are consistent with providers bearing most of the financial risk in a capitation contract relative to insurers: under full capitation, providers respond to this increase in risk by increasing the rate at which they refer patients outside.

8.2 Alternative capitation rates

In this subsection, we use our model estimates to predict the rate of c-sections and inside referrals under counterfactual levels of capitation, to understand how contracts that vary across services affect physician decisions. In the left-side panel of figure 7, we present the predicted probability of c-section after imposing capitation rates, $Pr(l_{jh})$, between 0 and 1. The x-axis reports the counterfactual capitation rate, the y-axis is the c-section probability, and the different curves correspond to different levels of the relative price of c-sections. We explore in particular the effect on c-section rates when vaginal deliveries are as expensive as c-sections (price difference $\leqslant 0$), and when c-sections are between \$1 million to \$4 million pesos more expensive than vaginal deliveries (price difference $\geqslant 1$).

We find that c-section rates are maximized when there is an equal split of FFS and capitation. The fact that c-section rates differ significantly from the rate of vaginal deliveries even conditional on the patient's suitability for c-section, is entirely explained by moral hazard from the supply side and by physician's imperfect information over contract types. In the right-side panel of the figure, we find that when capitation rates equal 0.5, contract variance is maximized, which further increases the c-section rate. As expected, c-section rate levels are higher the greater is the price difference between c-sections and vaginal deliveries, while the capitation rate controls the shape of and movements along the c-section curve.

In figure 8 we explore how the rate of inside referrals vary with the capitation rate in the left-side panel and with contract variance in the right-side panel. In both panels the y-axis is the average

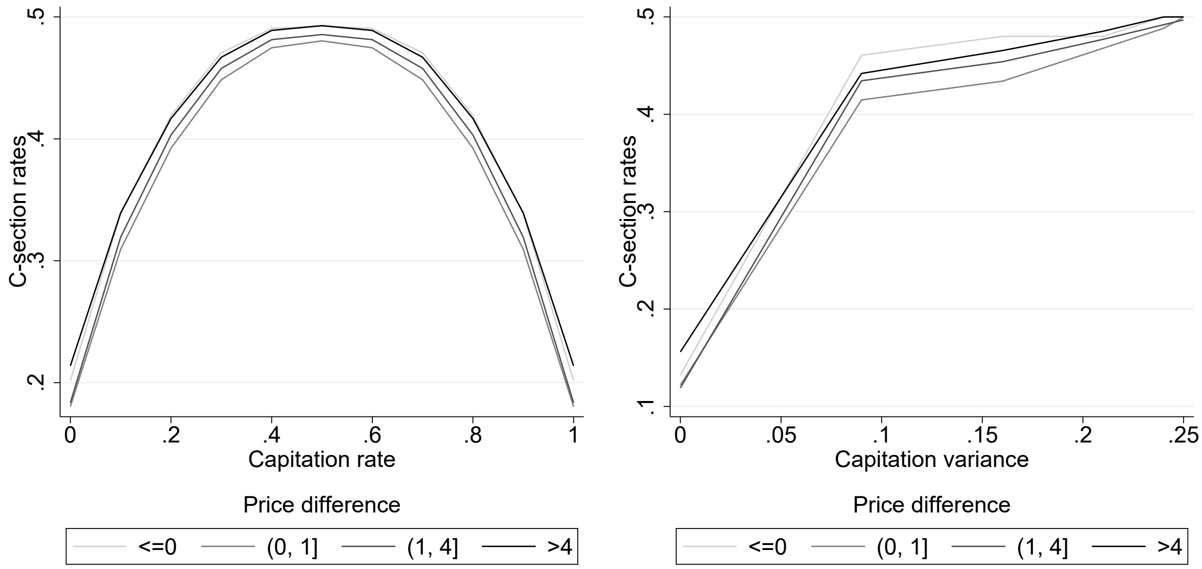

Figure 7: C-section rates under counterfactual capitation rates

referral rate and each line corresponds to a different level of the relative price of c-sections, relative to vaginal deliveries. Our results show that the probability of an inside referral is humped-shaped in the capitation rate. This is consistent with the idea that providers face higher financial risk in capitation contracts and, thus, are less likely to retain the patient if subsequent treatment is more likely to be covered under capitation. The probability of retaining the patient is maximized when the capitation rate equals 0.3 at all possible values of the relative price. If patients derived high utility from provider loyalty or inertia, imposing that at most 30% of services be covered under capitation between an insurer and a hospital, would be welfare enhancing. Our model, however, does not allow us to measure patient preferences for provider inertia.

We find that as the price of c-sections increases relative to vaginal deliveries, referring physician's are increasingly more likely to retain the patient. The fact that inside referral rates vary significantly with the capitation rate even after controlling for the woman's suitability for c-section in the second stage of the model, is indicative of the role of referring physician moral hazard in medical decisions. In the right-side panel of figure we see that the rate of inside referrals increases almost linearly with contract variance. Inside referrals are maximized when contract variance is maximized at a capitation rate of 0.5. This result is also suggestive of imperfect information over contract types having important welfare consequences.

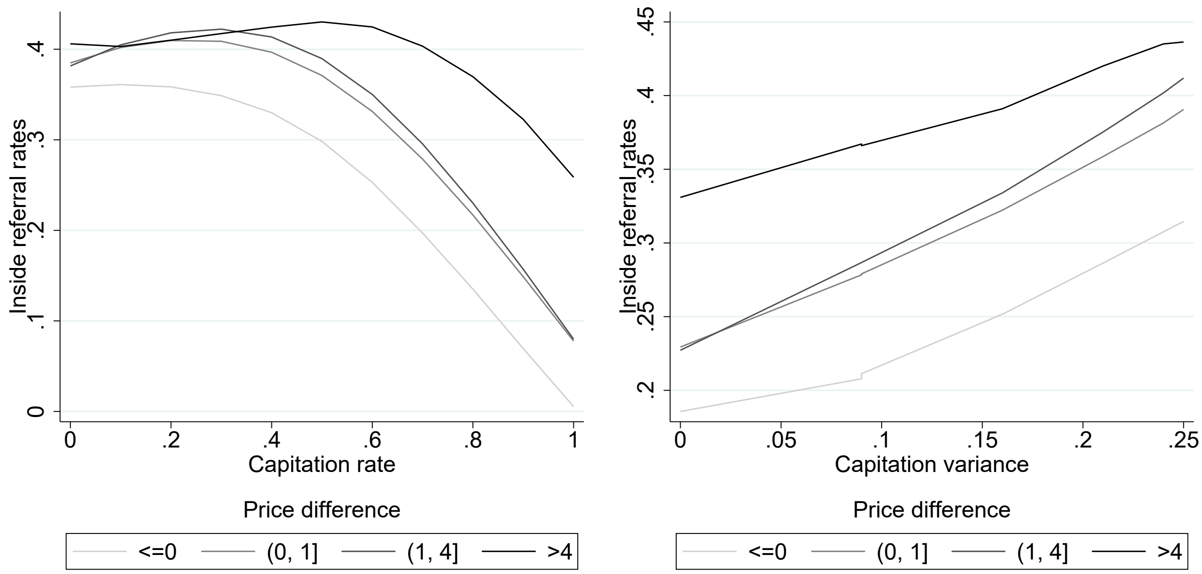

Figure 8: Inside referral rates under counterfactual capitation rates

8.3 Optimal capitation rate

Using our insights from the exercise of the previous subsection, here we get at the question of what is the optimal capitation rate. We define the optimal capitation rate as the one that minimizes the distance between the procedure choice predicted from the logit model for suitability of c-section and the procedure choice predicted from our model with physician moral hazard and imperfect information in the treatment stage. We use the root mean squared error as our loss function.

Figure 9 presents the relation of the RMSE between the two models in the y-axis and the capitation rate in the x-axis. Our findings show that physicians are more likely to choose the more suitable procedure for their patient, when capitation rates equal 50%. Given our definition of optimality, this implies that a policy that requires at least 50% of services between an insurer and a hospital to be covered under capitation, is potentially welfare enhancing. This result is conditional on physicians having imperfect information over contract types. So, another natural intervention would be to nudge physicians with regard to the contract types under which each procedure is covered. Our results indicate that the magnitude of physician moral hazard is smaller under full information than under uncertainty, contract variance also equals zero in the full information case. Thus, an informational policy of that kind could also potentially improve welfare.

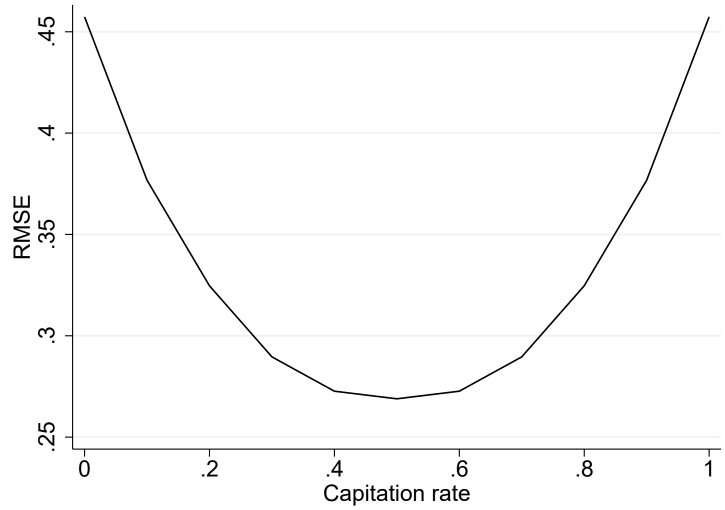

Figure 9: Optimal capitation rate

9 Conclusions

This paper measures physician moral hazard under capitation and fee-for-service contracts when the type of contract varies across services within a patient. Our context is the Colombian healthcare system, where private insurers provide coverage of the national health insurance plan by engaging in bilateral negotiations over contract types and prices with hospitals. Unlike healthcare systems like the United States, where agreement over a capitation contract involves having all services subject to capitation, in Colombia insurers and hospitals have discretion over which services to reimburse under capitation and which services under fee-for-service. We exploit this variation in contracts across services in the case of pregnant women for whom referral and treatment decisions are relatively standard: the primary care physician who first sees the woman decides whether to refer her to an OB/GYN in the same hospital or at a different hospital, and the OB/GYN decides whether to perform a vaginal delivery or a c-section, after observing contracts, prices, and the woman's suitability for a c-section.

Our findings show strong evidence of physician moral hazard in treatment and referral decisions even in a context with mixed contracts. Under the assumption that physicians have imperfect information on contract types, we find that the rates of inside referrals are higher the greater is the expected profit across types of delivery. On the procedure choice stage, we find that c-section rates are increasing in the relative c-section price, relative to vaginal deliveries. We conduct several counterfactual analyses to understand the effect of contract types on physician decisions. We impose full capitation on each type of delivery and find that if c-sections are fully capitated, the probability of performing a c-section decreases 22.6 percentage points, and the probability of an inside referral decreases nearly 7 percentage points relative to the observed scenario. On the contrary, if vaginal deliveries are subject to full capitation, we find higher rates of c-sections and similar rates of inside referrals relative to the observed scenario. C-section rates are maximized at a capitation rate of 50%, while inside referral rates are maximized at a capitation rate of 30%. Using the predicted relation between the probability of a c-section and the capitation rate, we evaluate what the optimal capitation rate would be. To do so, we minimize the distance between the predctions of a model where procedure decisions are made based only on patient demographics and diagnoses, and a model that has physician moral hazard and imperfect information over contract types. We find that the optimal capitation rate equals 50%.

The results in this paper confirm previous findings in the literature that associate higher capitation rates to lower utilization. Our findings indicate that even with contract type variation at the service level, provider moral hazard is still significant. That moral hazard remains an important determinant of referral and treatment decisions despite the presence of mixed contracts and the significance of the delivery procedure choice, suggests that different reimbursement schemes are needed to improve provider incentives. A market regulator that wishes to improve quality and contain procedure costs might facilitate alternative contract structures between capitation and fee-for-service such as fee-for-diagnosis.

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Appendix A Alternative measures of appropriateness of c-section

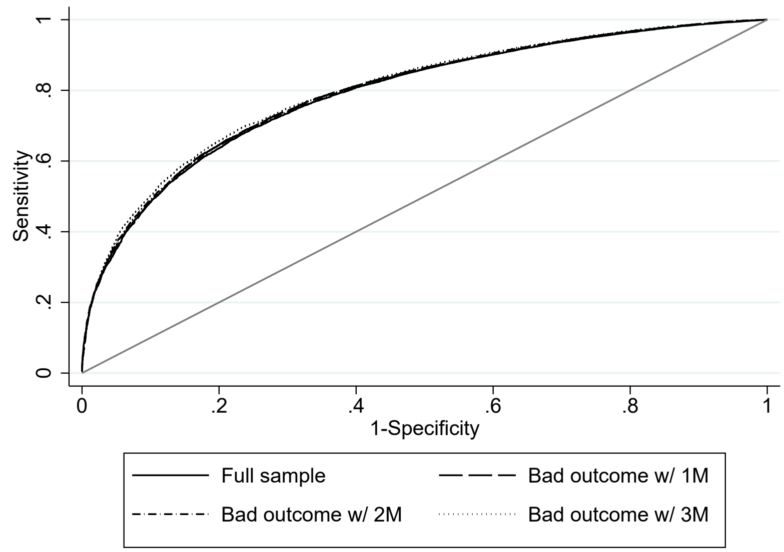

Figure 10: Comparison of samples for logit model of appropriateness of c-section