PHYSICIAN PRICES, HOSPITAL PRICES, AND TREATMENT CHOICE IN LABOR AND DELIVERY

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ABSTRACT

We study the effect of changing the price differential for cesarean versus vaginal deliveries paid by commercial insurers to hospitals and physicians on cesarean rates. Using eight years of claims data containing negotiated prices, we exploit within hospital–physician group–insurer price variation arising from contract renegotiations over time. We find that increasing the physician price differential by one standard deviation ($420) yields a 12 percent increase in the odds ratio for cesarean delivery. Increasing the hospital price differential by one standard deviation ($5,805) for births delivered by hospital-exclusive physician groups yields a 31 percent increase in the odds ratio. Our findings confirm and extend the prior literature on behavioral responses to physician and hospital prices in the context of private insurers, and point to further research questions to understand the hospital-physician principal-agent problem and the future of accountable care organizations.

KEYWORDS: health care, provider financial incentives, labor and delivery
JEL CLASSIFICATION: I11, I13, I18

I. Introduction

Hospital services and physician/clinical services are the two largest components of health-care spending in the United States. Combined, they totaled $1.4 trillion in 2011—more than half of all national health-care spending (Hartman et al. 2013)—and accounted for over 50 percent of the growth in US health-care spending between 2006 and 2010 (Schoenman 2012). In response to what is seen by many as an unsustainable growth rate in national health-care spending, many recent reforms alter prices paid to medical providers as a way to encourage more efficient and lower cost care.[1] Under these reforms, payers

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1 For example, some reforms implemented by the 2010 Patient Protection and Affordable Care Act (ACA) (including bundled payment initiatives, shared savings programs, and value-based purchasing) introduce payment structures that hold multiple providers responsible for the costs of a single episode of care or hold a single provider responsible for a broader package of costs. Part of the stated goal of these reforms is to improve the coordination of care across providers, for example, to mitigate duplicative or counterproductive procedures across hospitals and physicians. Additionally, the introduction of health insurance exchanges by

doi:10.1162/ajhe_a_00083
American Journal of Health Economics 3(3): 422–453

continue to use price structures in which clinically substitutable treatments yield different reimbursement rates (and potentially profit margins) for medical providers.[2] Insofar as reforms will shift, but not eliminate, the difference in prices (profit margins) across substitutable treatments, determining how medical providers change their treatment decisions in response to changes in these price differences sheds light on the possible effectiveness of such payment-based reforms.

Interest in the impact of provider payments on health-care utilization is not new.[3] Empirical studies of physician prices under Medicaid, Medicare, or private insurance have provided mixed evidence on whether physicians respond to increases in prices by increasing or decreasing their supply of services. Studies of hospital prices have found similarly conflicting results on whether the supply curve is upward or downward sloping.

In this paper, we study the effect of increasing the difference in negotiated prices paid to hospitals and physicians by commercial (private) insurers for substitutable treatments within the context of labor and delivery. The substitutable treatments we study are vaginal and cesarean delivery. This is a useful and important context for studying the effect of provider prices on treatment decisions for two reasons. First, there is a clinical gray area within labor and delivery where physicians may have leeway to choose treatment without raising scrutiny from insurers or hospitals. Second, cesarean deliveries are an important component of medical expenditures in the privately insured populations: cesarean delivery rates have increased 60 percent in the United States between 1996 and 2010 (Martin et al. 2012), and they are the most common operating room procedure in the United States (Podulka, Stranges, and Steiner 2011). Our analysis relies on detailed claims data covering approximately 8,000 deliveries by privately insured patients in California between 2004 and 2011. An important feature of the data is the inclusion of actual adjudicated and paid prices by private insurers ("allowed amounts") rather than charges.[4] This overcomes issues of nonclassical measurement error in price.

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the ACA may increase insurer competition, which may limit insurers' ability to offset increases in provider prices through higher premiums, thus potentially leading to lower negotiated hospital and physician prices (Ho and Lee 2017). Many private insurers and large employers have implemented, or are likely to implement, payment reforms akin to these public reforms.

2 For example, Medicare bases hospital payments on the major cause of the patient's hospitalization, known as a diagnosis-related group (DRG). Examples of separate DRG categories for substitute treatments include placement of drug-eluting versus non-drug-eluting coronary artery stents. The likelihood of uneven profit margins across substitute treatments is even greater among private payers, in which hospital bargaining power can lead to substantial markups (Ho 2009; Gowrisankaran, Nevo, and Town 2015).

3 See McGuire (2000) and Chandra, Cutler, and Song (2011) for an overview of this literature. We provide a review of papers in this literature most related to ours in Section II.

4 Though several prominent articles in the press have focused on variation in medical provider charges (e.g., Brill 2013; Rosenthal 2013), the prices affected by payment reforms are the transacted prices, which are either administratively set (in the case of Medicare and Medicaid) or bilaterally negotiated (in the case of private commercial insurers). For commercial insurers, previous research has used hospital charges multiplied by an average discount inferred from the hospital's aggregate annual financial data as an approximation to contracted prices, which are often private information. In reality, negotiated hospital prices are commonly specified as a combination of a percentage of charges, flat case rates, and fixed rates per day ("per diems"), sometimes with thresholds of cumulative charges above which a higher rate is paid ("stop-loss").

We model the choice of vaginal versus cesarean delivery as a function of the difference in expected physician prices for cesarean versus vaginal delivery (physician delivery price differential), the difference in expected hospital prices for cesarean versus vaginal delivery (hospital delivery price differential), patient characteristics, and a time-invariant preference parameter specific to each hospital, physician group, and insurer triad (hospital–physician group–insurer fixed effect) that captures idiosyncratic provider preferences for one treatment over the other. Crucially, by using these fixed effects, we are able to account for unobserved quality, marginal cost, or preference heterogeneity across different hospitals, physicians, and insurers for each treatment.

Our main findings are that there is a significant effect of changes in the physician delivery price differential on treatment choice: one standard deviation ($420) increase in the physician's payment for a cesarean delivery compared with her payment for a vaginal delivery yields a 12 percent increase in the odds ratio for cesarean delivery.

Although we find that hospital payments do not have a significant effect on treatment decisions when we study the full sample, we find a large and significant impact for births delivered by physician groups who deliver at only a single hospital: one standard deviation ($5,805) increase in the hospital's payment for a cesarean delivery compared with its payment for a vaginal delivery leads to a 31 percent increase in the odds of cesarean delivery. Since hospitals and physicians typically receive separate payments under both public and private insurance, our findings are consistent with the notion that hospitals transmit their incentives for choosing one treatment over the other to individuals present at a particular birth, including (but not limited to) the physician. Insofar as this suggests that hospitals are able to overcome the principal-agent problem that they face with physicians when those physicians practice *exclusively* at that hospital, it also implies that hospitals and physicians may be able to coordinate their actions within accountable care organizations (ACOs). We caution, however, that this explanation is only one possible interpretation of the results we have presented; we have no direct evidence of hospitals providing greater incentives for cesarean deliveries as their delivery price differential increases.

We make two main contributions to the existing literature. Our first contribution is that we use transacted prices and account for unobserved provider-level heterogeneity via hospital–physician group–insurer fixed effects. Prior studies of physician prices either use transacted prices or account for unobserved physician-level heterogeneity, but we know of no prior studies that do both or control for unobserved heterogeneity to the same degree.[5] In more stringently controlling for unobserved provider heterogeneity within insurer and hospital–physician group triads, we account for potential biases such as differences in physician treatment preferences across hospitals or differences in patient demand across hospital–physician group–insurer triads that are correlated with prices. The existing literature that uses transacted prices to study physician responses does not account for unobserved heterogeneity at the physician level, and may lead to biased estimates. Conversely, prior studies that account for observed and unobserved heterogeneity at the

5 A few studies, discussed in Section II, account for both effects in studying hospital prices but not for physician prices.

physician level use either charges or payer type rather than transacted price data. This is an important point given that transacted prices typically differ substantially from charges. Our results provide further support for the presence of behavioral responses to physician prices even when controlling for unobserved heterogeneity in physicians' treatment preferences. Second, we estimate the separate effects of hospital prices and physician prices within the same data set. To the best of our knowledge, this has not been studied in the prior literature because of the absence of data or identifying variation for one of the two prices.[6] By including both hospital and physician prices, we are able to estimate the price response for each provider type while controlling for the other. This approach allows us to make inferences about how payment reform for one provider type may affect behavior by the other. Furthermore, we estimate these price responses for two types of hospital-physician relationships—physicians who are exclusive to a single hospital and those who deliver at multiple hospitals—which provides insight into how hospital-physician relationships modulate the impact of payment reform on health-care utilization.[7] This is important for understanding the impact of accountable care organizations in the Affordable Care Act, which explicitly encourage close hospital-physician relationships.

Our primary identification strategy relies on *within* hospital, physician group, and insurer variation over time in the hospital and physician delivery price differentials, which results from the periodic renegotiation of contracted amounts between medical providers and private insurers. Based on discussions with hospital contracting executives and institutional sources, variation within a provider and private insurer pair often results from changes in bargaining circumstances (e.g., outside options) and in a provider's indirect (overhead and non-patient) costs, which are allocated across all services in revenue-producing departments. Since these changes are primarily driven by changes in services other than labor and delivery, we argue that these sources of variation are not problematic for our analysis.

Challenges to identification would occur if patient demand for cesareans (through unobservable health risks or preferences) or provider characteristics (such as expected

6 For example, many studies that utilize hospital discharge data do not have data on physician prices (e.g., Ho and Pakes 2014; Currie and MacLeod 2013). Studies utilizing variation in Medicare or Medicaid prices due to administrative policy changes observe identifying variation in only one of the two prices (see Section II). While this is not a hindrance to identification in these studies, it also does not provide insight into the correlation between hospital and physician prices under private payers, nor how physicians may respond differentially to changes in physician versus hospital prices.

7 He and Mellor (2012) study whether hospital responses to Medicare fee changes vary based on the presence of vertical integration with physicians. Like prior studies of hospital-physician integration (e.g., Ciliberto and Dranove 2006; Cuellar and Gertler 2006), they use data from the American Hospital Association (AHA) Annual Survey of Hospitals to define the degree of vertical integration. In our conversations with hospital consultants, integration can often vary across clinical departments within a hospital. Thus, for a particular clinical department (e.g., obstetrics), the degree of hospital-physician integration may be mismeasured by the AHA Annual Survey of Hospitals. We therefore use an empirical definition of integration based on whether we observe physicians delivering at more than one hospital in our data. Details of our methods and results can be found in the relevant sections of the paper.

marginal costs, skills, experiences, or composition of physicians) varied contemporaneously with or in anticipation of changes in provider price differentials. To minimize the extent to which unobservable health risks pose an identification problem, we exclude from our analysis patients with high-risk obstetrical diagnoses or any history of hypertension or diabetes, and we control for potential changes in patient severity or severity-related marginal costs with patients' ages and medical characteristics in our analysis. To address the concern that patients with unobservable preferences for cesarean delivery either select physician groups with high price differentials or are being steered to hospitals with higher delivery price differentials, we conduct robustness tests limiting our sample to births only within four months of a contracting break (noting that patients often select their physician earlier than four months from delivery and are likely unaware of *future* changes in price differentials), and repeat our analysis for physician groups who only deliver at a single hospital; we show that our findings are robust. Finally, to address the possibility that providers are negotiating higher prices in anticipation of changes in patient composition or changes in their own characteristics, we run robustness tests in which we restrict attention to providers that are present in all years of the data, or to sequential physician group–years that experience less than a 10 percent change in the number of obstetricians year-over-year; we also control for future price differentials. With regards to the last test, unless providers are timing their discrete re-contracting periods to coincide exactly with correctly anticipated future changes in (unobservable) patient or provider characteristics, future prices will be correlated with current cesarean rates through underlying changes in patient and provider characteristics. We find that our estimates are robust across all three tests, and we find that future prices are not correlated with current cesarean rates.[8]

We acknowledge several limitations of our analysis. First, we examine only labor and delivery among privately insured women in California, which may limit the generalizability of our findings to other states and to women insured under Medicaid. Second, we cannot state whether similar magnitudes of treatment responses would be found among other hospital or physician services. We draw some comparisons between our findings and related findings from other contexts in our discussion. Third, if physician groups make changes in response to higher delivery price differentials (e.g., by hiring physicians more likely to perform cesarean deliveries), and patients select physician groups based on these changes and on their own unobservable preferences, we may be overstating the provider response to financial incentives.

Our paper proceeds as follows. Section II provides a summary of the related literature on provider price response. Section III describes labor and delivery and how transacted prices are set between providers and private insurers. Section IV describes the data set and variable construction, including a description of the variation in both hospital and physician prices. We discuss our estimating equation and identification in Section V, and present results in Section VI. We discuss potential implications of our findings in Section VII before concluding in Section VIII.

8 Our results are also robust to the inclusion of current and future county-specific fertility rates, which were found to predict cesarean rates in Gruber and Owings (1996).

II. Previous Literature

A. PHYSICIAN AND HOSPITAL RESPONSES TO PRICE CHANGES

A large body of literature has looked at changes in treatment rates in response to changes in payments (or prices paid) to physicians or hospitals. Within this literature, several papers study changes in fee-for-service payments, the type of payments we observe in which payments are made on a per-service basis to physicians. Much of this work has centered on natural experiments arising from changes in Medicare policy. Rice (1983) and Christensen (1992) utilize the elimination of the Medicare urban-rural physician price difference in Colorado in 1977 as a source of area-specific exogenous price shocks and find evidence of a downward-sloping (potentially backward-bending) supply curve for physician services. In contrast, a more recent paper by Clemens and Gottlieb (2014) uses a similar identification strategy and finds evidence of an upward-sloping supply curve. They utilize price variation across county-years created by changes in Medicare's geographic adjustments for physician fees in 1997. Escarce (1993) and Yip (1998) study the effect of reducing Medicare prices for certain "overpriced" medical procedures in 1987 and find mixed results depending on which physician specialties and services are studied.

Within this literature on physician fee changes, two papers by Gruber, Kim, and Mayzlin (1999) and Keeler and Fok (1996) are most directly related to our current paper. Neither includes parameters for observed or unobserved physician heterogeneity. Gruber, Kim, and Mayzlin (1999) study changes in the Medicaid price differential for physicians between 1988 and 1992 in nine states. They find that a $100 increase in the physician fee differential for cesarean versus vaginal delivery is associated with a 0.7 percentage point increase in the cesarean rate. Their identification comes from within-state variation over time in Medicaid physician fees, under the assumption that such changes during this time period were exogenous to within-state trends in cesarean rates. Keeler and Fok (1996) study a 1993 policy change by California Blue Cross to equalize physician payments for vaginal and cesarean delivery. This policy resulted in a 3 percent increase in vaginal payments and an 18 percent decrease in cesarean payments. Comparing births in the 12 months before and after the policy change, they find no significant difference in the overall cesarean rate but a 1.2 percent decrease in the rate for non-breech deliveries. At the same time, they find a significant amount of physician mobility: only one-quarter of the physicians in their sample deliver births both before and after the policy change (although they deliver the majority of births); furthermore, the physicians who exited the sample had a cesarean rate that was 10 percentage points higher than their peers who remained in the sample, prior to the policy change.

Although not directly examining price changes, Gruber and Owings (1996) examine physician treatment decisions in response to income shocks: they find a strong negative correlation between within-state fertility and cesarean rates from 1970 to 1982, suggesting that physicians substituted towards higher reimbursed cesarean procedures when faced with negative income shocks brought on by declining fertility rates.

Similarly, a large body of papers has studied the hospital response to changes in prices paid, with most studying changes in hospital prices under Medicare or Medicaid (see, for example, Guterman and Dobson (1986); Hodgkin and McGuire (1994); Feder, Hadley, and Zuckerman (1987); and Newhouse and Byrne (1988)).

B. PHYSICIAN AND HOSPITAL UNOBSERVED HETEROGENEITY

We are aware of three papers that document the presence of physician heterogeneity in cesarean section rates (Currie and MacLeod 2013; Epstein and Nicholson 2009; Grant and McInnes 2004). They each focus on different explanations or characterizations of this heterogeneity while controlling for physician prices indirectly through proxy measures such as hospital charges or patient insurance type. The paper most related to ours is Currie and MacLeod (2013), in which they estimate a two-dimensional model of physician fixed preferences while controlling for physicians' financial incentives through the inclusion of hospital charges. They find that a one standard deviation ($2,600) increase in the difference in hospital charges for cesarean and vaginal deliveries is associated with an increase in cesarean deliveries of between 3.3 and 8.1 percent among low- or medium-risk women.

On the hospital side, a similar number of papers control for hospital-level unobserved heterogeneity when studying the impact of payment changes on broad measures of hospital utilization.[9] Norton et al. (2002), Dafny (2005), and He and Mellor (2012) use within-hospital price variation over time to estimate the response of hospitals to price changes under either Medicaid (Norton) or Medicare (Dafny, He).

III. Background on Labor and Delivery Services in Hospitals

A. CLINICAL SETTING AND UNCERTAINTY

The context for our study is hospital-based labor and delivery, or childbirth. Childbirth is the most common reason for a hospital admission in the United States (Weir et al. 2010). We focus our attention on women who have unscheduled deliveries, for whom there is a much greater potential for treatment choice after their arrival at the hospital.[10] For these women, a typical unscheduled delivery begins when the expectant mother arrives at the labor and delivery department because of frequent contractions or because she believes that her water has broken. If the medical evaluation shows that the patient is in active labor, she is admitted into a labor and delivery room.

During labor, there are many medical situations that may arise and lead to a cesarean delivery. Many of these fall into a clinical gray area. Among the most common clinical gray areas in labor and delivery are diagnoses of dystocias (abnormally slow labor) and fetal distress, with dystocia being the most common indication for first-time cesarean delivery (Cunningham et al. 2010). Both dystocia and fetal distress are subjective diagnoses with high rates of inter-physician discrepancy.[11] They both present clinical situations where

9 In addition, a few papers study nonhospital health-care facilities (e.g., skilled nursing facilities) and control for facility-level fixed effects. As an example, see Grabowski, Afendulis, and McGuire (2011).

10 In California, 29 percent of in-hospital deliveries between 2008 and 2010 were scheduled in advance. This figure is based on the authors' calculations from public discharge data.

11 Many experts believe that dystocia is often diagnosed before a sufficient trial of labor has been attempted. Physician convenience has been proposed as a potential explanation, although several other explanations

physicians may choose to perform a cesarean, choose to perform a vaginal delivery with instrumentation (e.g., forceps or vacuum), or wait to see whether labor improves and produces a spontaneous vaginal delivery. For a given birth that falls in this clinical gray area, it is difficult for insurers to determine whether a cesarean was medically necessary, and there may be lower professional or ethical costs to the physician from performing a cesarean compared with births in which labor evolves rapidly and smoothly into a spontaneous vaginal delivery.

Important for the validity of how we construct expected prices, births that fall in these gray areas are likely to have similar expected delivery price differentials to births that do not, conditional on the observed characteristics of the woman, which include our sample restriction to unscheduled births. This similarity is due to the uncertainty in making the diagnosis (thus, women who are not officially diagnosed with one of these conditions are likely to be very similar to women who are officially diagnosed) and the likelihood that the diagnosis may resolve spontaneously without a more intensive vaginal or cesarean delivery. This clinical feature will allow us to construct the expected delivery price differential by using observed, realized prices for all women presenting for unscheduled delivery.

B. STRUCTURE OF PRICES UNDER MANAGED CARE CONTRACTS

Prices for in-hospital services paid by commercial (private) insurers under managed care contracts are composed of "facility" and "professional" prices. For a particular hospital service (e.g., a birth), the facility price is the price paid to the hospital where the service occurs, while the professional price is the price paid to the physician or physician group who performs that service. For services rendered to patients covered under a commercial insurer, these prices are usually negotiated separately. Hospitals negotiate with insurers to set the facility prices, and physicians negotiate with insurers to set the professional prices.[12]

A hospital and an insurer typically contract over all hospital services, which may be paid through a variety of mechanisms (Kongstvedt 2001).[13] At many hospitals, the majority of hospital services are paid through per diem rates, where per diem rates may vary by

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are also possible, including fear of litigation, use of epidurals, and misunderstanding of how to diagnose dystocia (Cunningham et al. 2010).

Fetal distress is typically diagnosed on the basis of readings from electronic fetal monitoring (EFM). EFM measures fetal heart rate, which provides the physician with the best available information on the fetus's oxygenation state during labor. Low oxygenation can lead to adverse neonatal outcomes (American College of Obstetricians and Gynecologists 2010); the only "treatment" for low fetal oxygenation is delivery. In 2004, 86 percent of deliveries included EFM (Ananth et al. 2013). However, interpretation of EFM is imprecise. In one study, experts at reading fetal heart rate patterns agreed only 25 percent of the time on which patterns were pathological (Cunningham et al. 2010).

12 Exceptions include hospital employment of physicians (i.e., "clinical integration"), in which case prices can be negotiated jointly. However, hospitals in California are not allowed to directly employ physicians under the Corporate Practice of Medicine Doctrine.

13 Some of the comments in this section are based on conversations with contracting executives at several hospitals.

the type of service (e.g., intensive care unit versus regular medical/surgical unit).[14] Generally, obstetric services, however, are paid as case rate payments.[15] Case rate payments are flat per-service rates negotiated for specific services. Some hospitals are paid under “blended case rates” for labor and delivery services, in which both cesarean and vaginal deliveries are paid the same rate, which is the quantity-weighted average of the case rates for each service (Kongstvedt 2001). A given hospital may receive different forms of payment (e.g., case rates versus per diem) from different insurers for its obstetric services.

Physicians’ professional fees are typically negotiated over a fee schedule, in which professional services are enumerated by Current Procedural Terminology (CPT) codes. These fee schedules may vary by insurer. Some insurers negotiate fees as a percentage of Medicare fees, typically over 100 percent of Medicare fees. Other insurers use their own proprietary fee schedules in which the relative prices of services differ from relative prices on the Medicare fee schedule.

IV. Empirical Setting and Data Description

A. DATA SOURCES

Our primary data source is an eight-year sample (2004–11) of administrative health insurance claims data from CalPERS, a large California benefits manager that provides “retirement, health and related financial programs and benefits to more than 1.6 million public employees, retirees and their families and more than 3,000 public employers” (CalPERS 2013). These claims include facility and professional claims.[16]

We construct our sample using admissions data, which are facility and professional claims aggregated by the claims administrator into a single hospital admission and assigned a diagnosis-related group (DRG) code. Each admission record includes a unique patient identifier, admission and discharge dates, the tax ID and name of the admitting facility, an ID and name for the primary admitting physician or physician group, and the hospital and physician payments. The payments are actual adjudicated and paid amounts. Linked to these insurance claims data at the individual level are data on individual demographics and insurance plan choice.

We also use public hospital discharge data from the California Office of Statewide Health Planning and Development (OSHPD) between 2008 and 2010 for the purpose of comparing our sample against the population of privately insured births in California.

14 Hospitals also typically have stop-loss clauses to cover the costs of high-acuity patients, which set a threshold of cumulative charges for all provided services above which the reimbursed per diem rate is higher than the normal per diem rate. Some hospitals have also switched to payments based on diagnosis-related group (DRG) codes. The exact mix of reimbursement models is unique to a given hospital-insurer pair because of differences in hospital cost structures, insured populations, and negotiating power.

15 The details of hospital-insurer contracts are private information; therefore, we cannot know the exact frequency of case rate versus per diem payments at hospitals in our sample. Our comments about “common" payment structures in labor and delivery are based on conversations with hospital contracting executives and consulting executives.

16 Our data do not include claims data from Kaiser Permanente, an integrated managed care organization that insures approximately one-third of enrollees.

B. SAMPLE DESCRIPTION

We identify admissions for labor and delivery using assigned DRG codes. We drop a small number of observations because of missing insurance plan data, zero or negative payments, unidentifiable facilities, or the presence of two delivery admissions less than seven months apart. We trim outliers by dropping observations with lengths of stay above the 99th percentile. We also omit deliveries occurring at hospitals for which we observe fewer than 10 births for each treatment type during our sample.

Following our discussion of the clinical gray area in Section III, we focus on births, which are likely to have been unscheduled deliveries to women at low risk of complications. We designate as "likely scheduled" births those with diagnoses established in the previous literature as being strongly predictive of elective cesareans (Gregory et al. 2002).[17] We make this first restriction in order to focus on births for which the treatment decision may plausibly be thought to occur during labor because of unexpected clinical developments. We further restrict our sample to women without any history of hypertension or diabetes in order to exclude women who may be at higher risk for complications during or after delivery, which could be correlated with both our constructed price measures and the probability of cesarean delivery.[18] Our resulting sample contains approximately 8,000 births occurring in 93 hospitals and delivered by 231 unique physician groups, which form 315 unique hospital–physician group dyads and 375 unique hospital–physician group–insurer triads. The distribution of births across hospital–physician group–insurer triads is highly skewed with a median of 8 births, a mean of 21.6 births with a standard deviation of 43 births, and a maximum of 537 births during the duration of the sample.[19]

Table 1 shows summary statistics for the births in our sample ("unscheduled") compared with births that we exclude as likely scheduled. We also present statistics for all privately insured births in California between 2008 and 2010 from OSHPD public discharge data. The cesarean rate among births that we identify as "unscheduled" is 29 percent; this is similar to the statewide rate. The majority of women in our sample are enrolled in a health maintenance organization (HMO) plan rather than a preferred provider organization (PPO) plan.[20] Since each plan is run by a different insurer, we use the terms "insurer" and "insurance plan" interchangeably. The women in our sample have a similar age distribution to the privately insured births in our OSHPD data. Consistent with what is known about hospital charges, the mean hospital charges for vaginal and cesarean deliveries are much higher than the contracted prices observed in our claims data.

17 These diagnoses include malpresentation, antepartum bleeding, herpes, severe hypertension, uterine scar, multiple gestation, unengaged fetal head, maternal soft tissue disorder, preterm gestation, and fetal congenital anomaly. Prior studies of the choice between cesarean and vaginal delivery typically do not exclude observations with these diagnoses. We believe that this empirical choice is in line with our identification assumptions as described in Section V.

18 We also perform a robustness test in which these patients are included, and find broadly similar results.

19 The distribution across hospital–physician group dyads is also skewed with a median of 11 births and a maximum of 537 births during the duration of the sample.

20 We only consider women enrolled in these two most popular plans, which captures the vast majority of enrollees in our sample.

TABLE 1. Summary statistics

Variable	CalPERS sample data: Unscheduled mean	CalPERS sample data: Scheduled mean	OSHPD discharge data: Mean
Cesarean rate	0.29	0.71	0.31
HMO	0.78	0.73	–
Cord prolapse	0.002	0.001	0.002
Prior cesarean	0.12	0.33	0.15
Maternal age			
<20	0.05	0.03	0.04
20–24	0.08	0.09	0.12
25–29	0.30	0.26	0.29
30–34	0.36	0.38	0.34
35–39	0.18	0.20	0.18
≥40	0.03	0.04	0.03
Mean hospital payment/charge, cesarean	$13,330 [$11,544]	$12,324 [$9,669]	$28,101 [$23,096]
Mean hospital payment/charge, vaginal	$8,068 [$6,483]	$9,221 [$8,298]	$15,780 [$11,464]
Mean physician group payment, cesarean	$2,599 [$1,240]	$2,531 [$1,025]	–
Mean physician group payment, vaginal	$2,472 [$995]	$2,420 [$1,043]	–
Hospital delivery price differential ($\Delta p^h_{s(i)kc(t)}$)	$5,449 [$5,805]	$5,022 [$4,881]	–
Physician delivery price differential ($\Delta p^j_{s(i)kc(t)}$)	$131 [$420]	$121 [$347]	–
Number of births	8,086	1,579	645,069
Number of hospitals	93		
Number of physician groups	231		
Number of hospital/physician group/insurer triads	375		

Notes: An observation is a single birth. Sample data represent births among women enrolled in either the CalPERS HMO or PPO plan from 2004 to 2011. OSHPD discharge data are all hospital discharges for vaginal or cesarean delivery in California among privately insured women, extracted from public discharge data from 2008 to 2010. Mean hospital payments represent actual contractual payments from the insurer to the hospital (sample data) or the "charge amount" (not transacted price) in the OSHPD discharge data. Physician group payments are not available in the OSHPD data. $\Delta p^h_{s(i)kc(t)}$ is the difference in the mean payment to hospital h for cesarean and vaginal deliveries among patients of severity level $s(i)$, under a contract with insurer k during contract period $c(t)$. $\Delta p^j_{s(i)kc(t)}$ is the analogous price for physician groups. Determination of births as "scheduled" versus "unscheduled" is based on ICD-9 diagnosis codes and methodology described by Gregory et al. (2002). All dollar amounts are shown in 2004 dollars using the consumer price index for medical care services for West urban consumers from the Bureau of Labor Statistics. Contract period and price construction is detailed in Section IV.D and in the Online Appendix. Standard deviations are in brackets.

In Section IV.D, we discuss the construction of the hospital and physician delivery price differentials shown in Table 1; they represent the computed difference in average treatment prices for a particular insurer, physician group, hospital, and time period. Before discussing these terms further, we describe the variation in hospital and physician prices used to construct these variables.

C. DESCRIPTIVE STATISTICS OF HOSPITAL AND PHYSICIAN PRICES

Table 2 shows time series trends in the average and median prices paid to hospitals and physician groups in our sample. The top two panels of Table 2 report average and median hospital prices and quantities of vaginal and cesarean births over our eight-year sample, broken down by insurer type (PPO or HMO). The second two panels of Table 2 show the same statistics for physicians. The average real hospital price of both vaginal and cesarean births roughly tripled over the eight-year period; median prices exhibit a similar pattern. Average prices paid to physicians experienced a smaller increase of approximately 60 percent for both delivery types over the eight-year period. Median prices were consistently higher for cesarean births for hospitals and physicians. Finally, shown at the bottom of the table, the overall share of cesarean births varied between 27 and 31 percent during the sample period with no monotonic trend.

Table 2 shows significant price variation in negotiated rates for both physicians and hospitals in a single year. This variation stems from two sources: (1) across-provider variation and (2) within-provider variation. Across-provider variation arises from differences in the negotiated rates that each provider may obtain, conditional on the resources used per birth. It may also arise from differences across providers in the volume of resources used for each birth, based on either patient or physician preferences and conditional on the negotiated rates.[21] For example, two hospitals that negotiate the same per diem rate may differ in the typical length of stay for a vaginal delivery. As another example, two physician groups that receive the same rate for the bundle of services associated with a vaginal delivery may differ in the frequency with which they perform fetal nonstress tests, which are often reimbursed apart from the bundled rate.[22] Within-provider variation in prices for a given year could arise from midyear contract renegotiation, variation in the resource intensity of births during the year, or differences in negotiated rates across the two insurers.

To better visualize these two sources of price variation, Figure 1 displays across- and within-provider variation in the average price paid to medical providers for vaginal or cesarean births in 2009 (similar variation is seen in other sample years). Variation across the bars in Figure 1 reflects across-provider variation; standard deviations on each bar reflect within-provider variation for the specific provider-year shown. Within a single year, hospitals exhibit significant across- and within-provider variation for both delivery types;

21 We do not observe specific line items for each delivery in our sample, which would allow us to evaluate the specific set of resources used at each birth.

22 This example is based on web searches of insurer policies outlining which obstetric services are and are not covered under the bundled payments, which are payments that cover basic antepartum care, the delivery, and basic postpartum care. These bundled payments are also known as "global" rates.

TABLE 2. Hospital and physician prices for labor and delivery, 2004–11

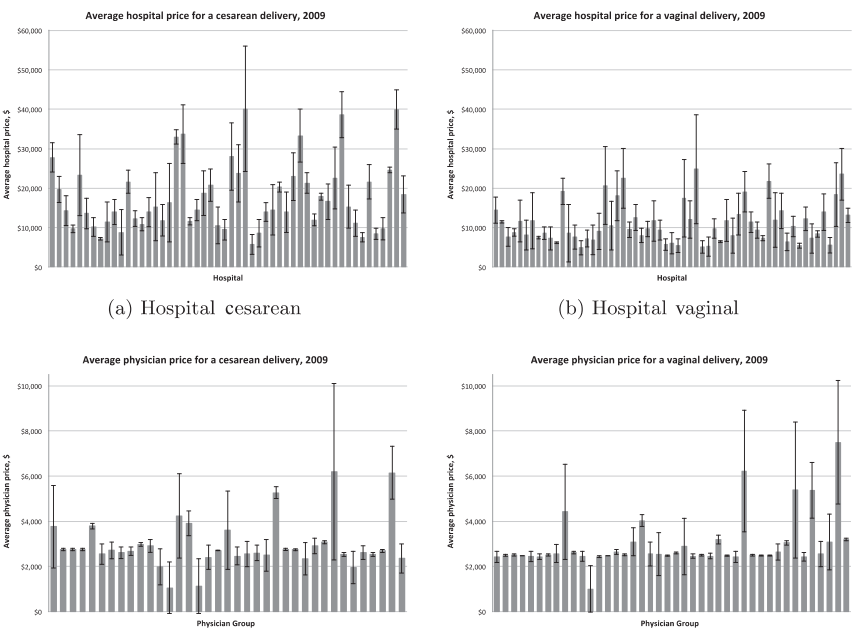
		2004	2005	2006	2007	2008	2009	2010	2011
Hospital price for vaginal births, ($)									
All	Mean	4,234 [2,238]	4,834 [2,706]	5,904 [3,239]	7,256 [4,581]	10,371 [6,223]	12,446 [7,644]	13,505 [9,097]	15,012 [9,796]
	Median	3,741	4,214	5,192	6,005	8,711	10,124	10,752	12,056
	N	717	1,101	973	775	805	643	413	307
HMO	Median	3,657	4,015	4,903	5,810	8,325	9,649	9,582	10,287
	N	571	913	761	609	603	466	301	235
PPO	Median	4,522	6,426	5,918	8,432	10,395	13,587	12,376	14,715
	N	145	185	208	161	202	176	110	72
Hospital price for cesarean births, ($)									
All	Mean	6,911 [4,492]	8,223 [4,771]	10,378 [6,689]	11,861 [7,790]	17,816 [16,631]	18,794 [10,871]	21,165 [15,229]	23,253 [14,527]
	Median	5,595	6,868	8,632	9,344	13,911	16,358	15,705	18,739
	N	295	413	425	301	339	262	191	126
HMO	Median	5,702	6,926	8,713	9,241	13,728	16,737	14,663	16,656
	N	235	357	331	240	261	203	133	91
PPO	Median	5,152	6,604	8,575	9,816	15,508	15,190	19,093	21,014
	N	60	56	94	61	78	59	58	35
Physician price for vaginal births, $									
All	Mean	2,040 [668]	2,146 [608]	2,285 [622]	2,442 [909]	2,654 [942]	2,871 [1,346]	3,031 [1,275]	3,250 [1,466]
	Median	1,950	2,038	2,138	2,266	2,368	2,472	2,630	2,840
	N	710	1101	973	775	805	643	413	307
HMO	Median	1,950	2,038	2,138	2,266	2,368	2,472	2,630	2,840
	N	572	916	765	614	603	467	303	235
PPO	Median	2,001	2,299	2,413	2,583	2,699	2,868	3,143	3,355
	N	145	185	208	161	202	176	110	72
Physician price for cesarean births, $									
All	Mean	2,028 [1,007]	2,281 [673]	2,409 [828]	2,601 [1,177]	2,815 [1,273]	3,002 [1,601]	3,240 [1,629]	3,231 [1,699]
	Median	2,135	2,231	2,341	2,481	2,593	2,707	2,879	2,962
	N	295	413	425	301	339	262	191	126
HMO	Median	2,135	2,231	2,341	2,481	2,593	2,707	2,879	2,962
	N	235	357	331	240	261	203	133	91
PPO	Median	2,001	2,090	2,413	2,557	2,699	2,807	3,091	3,051
	N	60	56	94	61	78	59	58	35

TABLE 2. *Continued*

	2004	2005	2006	2007	2008	2009	2010	2011
Cesarean rate								
All	0.29	0.27	0.30	0.28	0.30	0.29	0.31	0.29

Notes: Sample: “unscheduled” births among women enrolled in either an HMO or a PPO plan offered by a large California benefits manager, 2004–11. Hospital and physician prices represent actual contractual payments from the insurer to the hospital. Determination of births as “scheduled” versus “unscheduled” is based on ICD-9 diagnosis codes and methodology described by Gregory et al. (2002). All dollar amounts are shown in 2004 dollars using the consumer price index for medical care services for West urban consumers from the Bureau of Labor Statistics. Standard deviations are in brackets.

FIGURE 1. Price variation across and within providers by delivery type, 2009

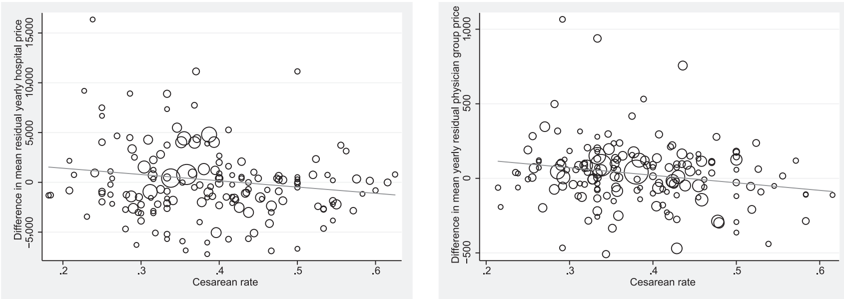


(a) Hospital cesarean (b) Hospital vaginal

(c) Physician cesarean (d) Physician vaginal

Notes: Each graph shows the average price paid to different medical providers in the sample for a cesarean ((a) and (c)) or vaginal ((b) and (d)) delivery in 2009. Each bar represents the average price for a single provider, with error bars indicating the standard deviation. Hospitals or physician groups with only one delivery of a particular type in 2009 are omitted from the associated graph. The sample is labor and delivery admissions for unscheduled deliveries in our sample. All prices are in 2004 dollars.

FIGURE 2. Correlation between difference in average residual provider prices for cesarean versus vaginal delivery and cesarean rate, 2004–11



(a) Hospitals (b) Physicians

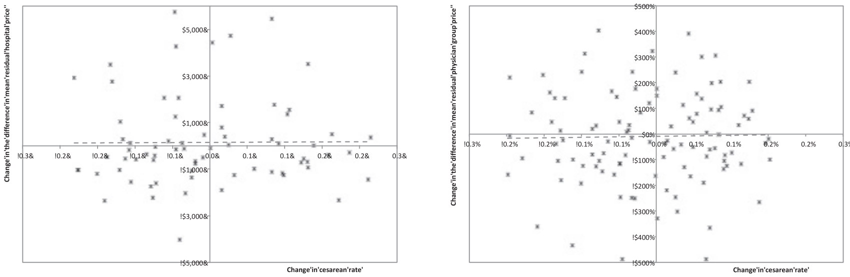
Notes: Each graph plots the difference in residual mean cesarean and vaginal prices (y-axis) for a given hospital (panel a) or physician group (panel b) and year against the cesarean delivery rate in that hospital and year as observed in the sample. An observation is a single hospital-year. Residuals are computed after regressing prices on year fixed effects, age (binned), prior cesarean, and cord prolapse for each delivery type, and separately for physicians and hospitals. See the text for additional details. The relative sizes of the circles are indicative of the relative number of births performed in that hospital and year, where the number used is the minimum of the number of cesarean births and the number of vaginal births in that hospital and year. A linear trend line is plotted to show the correlation between the two variables. The sample is labor and delivery admissions for unscheduled deliveries between 2004 and 2011. All prices are in 2004 dollars.

physician groups receive similar prices across providers with little within-provider variation except for some notable outliers.

In the Online Appendix (see http://www.mitpressjournals.org/doi/suppl/10.1162/ajhe_a_00083), we provide a figure showing the relationship between the mean hospital and physician prices for all births in the sample. We find a positive correlation, which may not be surprising given that both hospital and physician prices increased in real terms over the sample period.

We next examine correlations between prices and cesarean rates. To adjust for time trends and potential differences in patient characteristics across hospitals, we regress the price on observable patient characteristics, specifically age, prior cesarean delivery, cord prolapse, and year, for each delivery type. We then plot the difference in the mean price residuals between a cesarean birth and a vaginal birth for a given provider (hospital or physician group) and year against the provider's cesarean rate (Figure 2). Both plots demonstrate a negative correlation between the residual price difference and the cesarean rate across providers as indicated by the plotted trend line. This seems surprising, given previous findings that the supply of cesarean deliveries is upward sloping (e.g., Gruber, Kim, and Mayzlin 1999). We have controlled for several salient observable differences across hospitals that might lead to a spurious negative correlation as well as yearly time trends. The remaining negative correlation in the price residuals could reflect other

FIGURE 3. Correlation between one-year within-provider change in delivery price differential and change in cesarean rate, 2004–11



(a) Hospitals (b) Physicians

Notes: Each graph plots the year-over-year change in delivery price differential (y-axis) against the change in the cesarean delivery rate for a given hospital (panel a) or physician group (panel b) in the sample. An observation is a single provider and pair of contiguous years. Data from all years are plotted. The delivery price differential is the difference between the mean residual price paid to a provider for a cesarean birth compared with a vaginal birth in a particular year. Further details on how residual prices are obtained can be found in the text. A linear trend line is plotted to illustrate the correlation between the two variables. Observations in the upper or lower 5 percent of the distribution are not plotted. The sample is labor and delivery admissions for unscheduled deliveries between 2004 and 2011. All prices are in 2004 dollars.

unobservable differences between providers. This highlights the need to control for unobserved heterogeneity across hospitals and physician groups.

Figure 3 exemplifies the within-provider-insurer price variation that we exploit in our empirical analysis. Specifically, it plots the year-over-year change in the delivery price differential against the year-over-year change in the cesarean delivery rate for each hospital-year. Unlike the negative correlation in the cross-sectional plot, there is a slight, positive correlation between year-over-year changes in prices and rates, although the trend is small. We note that this is not an exact graphical representation of our identification strategy, which, among other differences, uses changes across contract-specific time periods rather than years.

D. CONSTRUCTION OF PRICES

Ideally, we would observe and use the true expected conditional delivery price differential in our estimation. In actuality, we observe realized prices. Realized prices differ from the provider's expected conditional price prior to treatment choice because of shocks realized during or immediately following the delivery process, such as maternal hemorrhage, the degree of vaginal lacerations during vaginal delivery, or postdelivery infection.

Given the presence of these shocks, we construct providers' expected prices under two assumptions. First, we assume that these shocks are mean zero for both treatment choices. Thus, these shocks affect our observed prices but do not enter into the provider's choice decision. Second, we assume that providers' expectations are correct on average. Under these assumptions, we can construct expected delivery price differentials in two steps.

In the first step, we determine the appropriate window over which we can compute a measure of the expected conditional price. Since the identifying variation we want to capture is from contract renegotiation, the appropriate time window is a single "contract period," $c(t)$, for a given medical provider–insurer pair. During a contract period, the contracted price remains constant. We use a recursive regression analysis of our time series of payment data to identify dates of contract renegotiation (further details are provided in the Online Appendix). We perform this analysis separately for each hospital-insurer or physician group–insurer pair, since each provider-insurer pair may negotiate its contract at a different date from every other provider-insurer pair.

In the second step, we compute the mean payment for a vaginal or cesarean delivery separately for each contract period $c(t)$, provider (hospital h or physician group j), insurer k, and pregnancy severity bin $s(i)$. We proxy for severity using age bins (<25, 25 to 34, ≥ 35). With these constructed prices, we find that for a given contract period, insurer, and severity category, the average hospital payment for a cesarean delivery is $5,493 more than the average payment for a vaginal delivery among unscheduled deliveries (see Table 1). The average physician payment for cesarean delivery is $151 more than the average physician payment for a vaginal delivery.

To provide some context for assessing the validity of our price measure, we report the degree to which our constructed prices explain variation in the observed, realized prices. If all providers were paid at a fixed rate within the cells we used to construct expected prices, we would expect our constructed prices to explain 100 percent of the observed price variation. This would be the case, for example, if all hospitals were paid case rates with no stop-loss and if all physicians were paid bundled payments with no ability to bill for any additional services.

Examination of the raw data suggests that both of these payment scenarios occur for some providers at some point in the sample, but that neither is the predominant payment scheme in place for all providers for the entire duration of the sample. As such, we do not expect our constructed prices to perfectly explain variation in the observed, realized prices; nonetheless, they give the reader an idea of how much realized prices deviate from our constructed, expected prices.

We assess the degree of explained price variation by regressing observed prices on fixed effects for each price bin that we construct above. For example, realized hospital prices are regressed on a set of fixed effects, in which there is a fixed effect for every observed combination of hospital, insurer, age group, and contract period. We perform this regression separately for cesarean and vaginal deliveries and separately for hospitals and physician groups, and we obtain an adjusted R^2 for each regression. The adjusted R^2 for hospital prices are 0.62 and 0.70 for cesarean and vaginal deliveries, respectively. The analogous adjusted R^2 for physician prices are 0.48 and 0.69. We will assume that the remaining variation results from random shocks that do not affect the treatment decision but do affect realized payments since payments are not exclusively case rates for hospitals and bundled payments for physicians. We acknowledge that we cannot rule out the possibility that payments vary across other unobserved patient characteristics that also affect the treatment decision; we attempt to minimize this concern by restricting our sample to a healthy patient population.

V. Estimation

Our main regression specification is based on a latent variable model of the probability that a patient is delivered by cesarean:

$$ces^*_{ijkht} = \alpha_1 \Delta p^j_{s(i)kc(t)} + \alpha_2 \Delta p^h_{s(i)kc(t)} + X_{it}'\beta + \delta_t + \zeta_{hjk} + \varepsilon_{ijkht} \quad (1)$$

$$ces_{ijkht} = \begin{cases} 1 & \text{if } ces^*_{ijkht} \geq 0 \\ 0 & \text{if } ces^*_{ijkht} < 0 \end{cases} \quad (2)$$

where ces^*_{ijkht} is the underlying latent probability of a cesarean delivery for patient i insured under plan k who is delivered by physician group j at hospital h during contract period $c(t)$, and $\Delta p^j_{s(i)kc(t)}$ and $\Delta p^h_{s(i)kc(t)}$ represent the physician and hospital delivery price differentials between cesarean and vaginal delivery.

Our model of treatment choice also includes patient characteristics (X_{it}), comprising age, whether the delivery involved cord prolapse, and whether the patient had a prior cesarean; year fixed effects (δ_t); and time-invariant differences in the propensity to perform cesareans captured by hospital–physician group–insurer fixed effects (ζ_{hjk}) in our preferred specification. We use physician group–hospital–insurer fixed effects rather than physician-insurer fixed effects to account for not only idiosyncratic physician preferences but also differences in the propensity of a given physician group to perform cesareans across hospitals because of differences in hospitals' marginal costs, relative quality, or nursing staff.[23] In some specifications, we include hospital and physician group fixed effects; or hospital, physician group, insurer, and age group fixed effects.

We estimate a fixed-effects logistic regression under the assumption that the error term, ε_{ijkht}, is independent across observations and has a type I extreme value distribution:

$$Pr[ces_{ijkht} = 1|X_{it}] = \Lambda(\alpha_1 \Delta p^j_{s(i)kc(t)} + \alpha_2 \Delta p^h_{s(i)kc(t)} + X_{it}'\beta + \delta_t + \zeta_{hj}) \quad (3),$$

where Λ is the logistic function.[24]

A. IDENTIFICATION

Our primary coefficients of interest are α_1 and α_2, which represent the impact of changing the physician and hospital delivery price differentials on the probability of cesarean

23 For example, suppose hospital A has a higher quality of cesarean operating facilities than other hospitals. If this quality difference is reflected in both a higher delivery price differential and a lower threshold for physicians to perform cesareans at hospital A, an estimate of the price coefficient without our combined hospital–physician group–insurer fixed effects would suffer from upward bias.

24 A linear probability model generates similar results.

delivery. In our preferred specification, they are identified using *within* hospital, physician group, and insurer variation over time in the hospital and physician delivery price differentials, which in turn results from the periodic renegotiation of contracted amounts between medical providers and private insurers. Our estimates will be unbiased if the error term in our estimating equation—and any problematic omitted variables—are uncorrelated with the included regressors. In the introduction, we discussed how price variation for a particular service, such as a cesarean delivery, is often driven by changes in a provider's bargaining leverage or outside options when negotiating with an insurer, as well as a provider's indirect (overhead and non-patient) costs. We argued that these two sources of price variation are plausibly uncorrelated with our outcome variable.

In this subsection we explore other potential sources of price variation that may be correlated with the choice of delivery method at the margin, and we assess whether they may pose a threat to our identification strategy. These include changes over time *within a particular hospital–physician group–insurer* in (1) patient demand for cesarean versus vaginal deliveries; and (2) providers' expected marginal costs, skills or experience, and composition.[25]

A.1. PATIENT DEMAND. Conditional on observables, patients may have unobserved heterogeneity in their demand for cesarean delivery, either based on unobservable health risks that make them more or less suited for cesarean delivery, or based on underlying preferences for cesarean delivery.

Any unobserved heterogeneity in the expected health risks of the mother and child are a concern if such health risks affect treatment choice and are correlated with the included regressors, conditional on the included patient observables (i.e., age, prior cesarean, cord prolapse, and insurance plan enrollment) and on our sample restriction, in which we have excluded patients with high-risk obstetrical diagnoses or any history of hypertension or diabetes.[26] Of note, we also compute expected prices conditional on this sample restriction and on patient age. Given these conditions, we believe that we have mitigated this concern. We therefore focus on patient preferences in the remainder of our discussion on patient demand heterogeneity. Nonetheless, many of the same arguments we make below would apply to any residual unobserved differences in health risks.

Unobserved heterogeneity in patient preferences for cesarean versus vaginal delivery may challenge our identification if two conditions are met: (1) patient preference for cesarean delivery is correlated with the delivery choice, and (2) patient preference is correlated with prices over time within a particular hospital–insurer–physician group.

25 Note that we specify *expected* marginal costs since only the expected quantities will affect treatment choice. Any differences between expected and realized marginal costs will not impact ex ante treatment choices.

26 Examples of differences that could affect health outcomes include chorioamnionitis (bacterial infection of the fetal membranes), time elapsed since rupture of the amniotic sac (predictive of chorioamnionitis), and maternal or fetal vital signs (e.g., heart rate, maternal blood pressure) during labor. In a robustness test, we have also excluded patients who have had a prior cesarean delivery and obtained nearly identical results.

The first of these conditions could be satisfied in one of two ways: (1) patient preferences could directly enter the delivery choice of a particular provider, or (2) patients with certain preferences select or are selected by certain physician groups or hospitals (Lazarus 1994). With regards to (1), even if patient preferences enter the choice of delivery (e.g., as an additional parameter in equation 3), they are unlikely to be correlated with the physician or hospital delivery price differential through any direct mechanism; for example, it would be unlikely for a physician to receive a higher price differential for patient A than for patient B simply because patient A had a stronger preference for cesarean.

We thus address explanation (2), that patients select or are selected by providers based on preferences. For example, it may be plausible that patients with unobservably higher demand for cesarean delivery could *contemporaneously* select providers with higher cesarean price differentials; furthermore, although patients generally do not observe negotiated prices, they may select their providers based on some characteristic (e.g., perceived quality) that is correlated with price and observable to the patient but not to the econometrician.[27] To address this concern, we conduct a robustness test where we restrict attention to births within four months of a physician group–insurer contract break. To the extent that patients select their obstetrician more than four months in advance of their delivery, it is unlikely that the distribution of unobservable preferences for cesareans within a hospital-physician-insurer-age category group would change discontinuously around a future contracting break. For example, consider two patients that choose the same physician in January and February; assume both deliver nine months after their choice. If a contract break for that physician occurs on October 1, we are comparing the first patient's delivery decision in September with the second patient's delivery decision in October. As long as the physician's observables that patients condition on when making their decisions in January and February are similar, our test helps mitigate the possibility that patients are choosing physicians differentially over time based on the price differentials that they will face *in some future contracting period* when giving birth.

Another source of correlation between patient preferences and prices may result from provider behavior. This could include physicians selecting patients on the basis of the physician's delivery price differential, or through physicians steering patients with stronger unobserved cesarean preferences to hospitals that have higher delivery price differentials. In either case, the physician behavior would still be consistent with physicians responding to financial incentives, although through a different mechanism with different policy implications. We explicitly test the latter possibility, whether physicians may be steering their patients to hospitals with higher delivery price differentials, by estimating our baseline specification on the subset of physician groups that admit to a single hospital. If physician groups were indeed steering their patients, we would expect to see a smaller estimated coefficient on the hospital delivery price differential among physicians who deliver at a single hospital compared with physicians that deliver across multiple hospitals, as the former cannot steer patients.

27 Note also that this scenario would pose a threat to our identification strategy only if such provider characteristics correlated over time with price for a given provider. We discuss this issue in the following section on provider changes and refer the reader accordingly.

Finally, one remaining concern is that providers negotiate for higher cesarean prices *in anticipation* of increasing patient demand for cesarean deliveries; in other words, one might be concerned about reverse causality. Under this scenario, patient preferences for cesarean delivery affect delivery choice; providers are aware of this effect, and therefore preferentially negotiate for higher cesarean prices leading to a higher delivery price differential. A slight modification to this story may include providers anticipating changes in the *overall* demand for childbirth, which could lead to changes in physician behavior under the "target income" model demonstrated by Gruber and Owings (1996). We address both these concerns by conducting another robustness test that controls for future price differentials as well as current and future county-specific fertility rates. We assume that changes in patient demand are less discrete or abrupt than changes in negotiated prices. Under this assumption, demand for cesarean deliveries in the next contract period will be reflected in demand and thus cesarean rates in the current contract period. Similarly, controlling for fertility rates addresses the concern that physicians may anticipate and respond to current and overall demand for childbirth when negotiating prices.

We note that this robustness test relies on the assumption that changes in patient demand are less abrupt than changes in negotiated prices. We argue that this is a reasonable assumption, since it is violated only if providers correctly forecast future changes in (unobservable) patient preferences or characteristics making them predisposed to cesarean deliveries and incorporate these future changes into negotiated prices, and if these changes are timed exactly to occur at discrete re-contracting periods. Furthermore, our conversations with hospital executives indicate that hospitals typically use models of static demand in computing the expected impact of different price schedules on profits during the negotiation process; this suggests that providers do not anticipate changes in future patient preferences for cesarean deliveries when negotiating the terms of a new contract.[28]

A.2. PROVIDER CHANGES. We now turn to identification concerns arising from changes over time within a particular hospital–physician group–insurer in providers' expected marginal costs, skills or experience, and composition.

Expected marginal cost differences across the two treatments can be either hospital costs (e.g., surgical technician wages for cesarean delivery or forceps for assisted vaginal delivery) or physician costs (e.g., physicians may require additional time or physical effort for surgical procedures or for monitoring the progress of a vaginal delivery). Since our panel identification relies on variation in the delivery price differential across contract periods, changes in either a hospital's or a physician group's expected marginal cost differential between treatments will pose a threat to identification only if the medical provider correctly forecasts future changes and incorporates those changes into their renegotiated prices, and if these changes occur at the time of contract renegotiation. We believe that error in these forecasts, idiosyncratic noise accrued in the renegotiation process (e.g., the timing of contract renewal, which affects all services provided by a hospital or physician group), and variation in contracting periods across insurers for a given medical provider greatly limits the scope for potential bias. We also argue that changes in a physician group's

28 For example, it is not uncommon for hospitals to use previous year patient case mixes when evaluating the financial implications of proposed contracts.

marginal costs are unlikely to be correlated with a hospital delivery price differential, and vice versa. Furthermore, our robustness test that restricts attention to births within a small time window around a contract break limits the scope for contemporaneous changes that must be systematically occurring at discrete contract breaks (which, again, differ within physician group across insurers).

We may also be worried that physician groups may be negotiating higher prices in anticipation of adjusting their hiring practices, skills, or experience for cesareans. Our robustness test that includes future price differentials also addresses this concern: unless providers were able to precisely time such changes with contracting periods, future price differentials should be correlated with current provider cesarean rates if this particular issue was of concern. We also conduct robustness tests where we restrict our sample to providers present in all years of our sample, or only to sequential physician group–years that experience less than 10 percent change in the number of obstetricians year-over-year to address concerns regarding changing physician composition.

Finally, we note that physician groups may still be able to select patients with stronger preferences for cesarean delivery, or adjust their composition (e.g., hiring decisions) or cesarean skill and experience, *in response to price changes*. If patients choose their providers on the basis of these changes, our estimates would capture both the initial provider response for a given set of patients and subsequent changes in patient and provider composition; thus, our results may represent an overestimate of the magnitude of the provider response alone for a given patient. Though we note that these behaviors are still consistent with physician groups responding to financial incentives, we are not able to test for this aspect of physician behavior directly. We acknowledge this caveat to the conclusions we can draw from our results.

VI. Results

A. MAIN RESULTS

Table 3 reports estimates from the model of treatment choice shown in equation 3. Our preferred specification, shown in column 2, includes fixed effects at the level of unique hospital–physician group–insurer triads. Column 2 is our preferred specification because it controls for potential endogeneity concerns arising from patient sorting across insurers within a hospital and physician group pair (Hellinger 1995). In column 1, we find that we obtain nearly identical results from an estimation that uses only hospital–physician group fixed effects, which indicates that these endogeneity concerns are not significant in our sample. In all specifications shown, standard errors are clustered at the hospital–physician group level.[29] Our preferred specification (column 2) shows that a $100 increase in a

29 We note that the ideal clustering of standard errors would allow for arbitrary correlation not only within a hospital and physician group pair but also across hospitals within a physician group and across physician groups within a hospital. We test the robustness of our choice of standard errors by running our estimation under two alternative assumptions: clustering at the hospital level and clustering at the physician group level. We recover nearly identical results in both scenarios.

TABLE 3. Fixed-effects logistic regression of the probability of cesarean delivery

Dependent variable: Probability of receiving a cesarean delivery			
	(1)	(2)	(3)
$\Delta p^{j}_{s(i)kc(t)}$	0.026[a]	0.027[a]	0.021[c]
	(0.009)	(0.009)	(0.012)
$\Delta p^{h}_{s(i)kc(t)}$	0.003	0.002	−0.011
	(0.010)	(0.010)	(0.009)
Cord prolapse	1.675[a]	1.696[a]	1.683[b]
	(0.596)	(0.595)	(0.658)
Prior cesarean	5.318[a]	5.320[a]	5.232[a]
	(0.280)	(0.281)	(0.303)
Maternal age			
20–24	0.039	0.033	
	(0.157)	(0.158)	
25–29	−0.375[a]	−0.392[a]	
	(0.137)	(0.138)	
30–34	−0.388[a]	−0.408[a]	
	(0.139)	(0.141)	
35–39	−0.203	−0.220	
	(0.135)	(0.136)	
≥40	−0.043	−0.032	
	(0.195)	(0.194)	
HMO	−0.143		
	(0.228)		
Fixed effect	Hospital-physician	Hospital-physician-insurer	Hospital-physician-insurer-age
Observations	7,942	7,936	7,276

Notes: An observation is a single birth. The sample is women enrolled in an HMO or a PPO plan (2004–11), excluding deliveries that are likely to have been scheduled in advance (based on a classification scheme used in Gregory et al. (2002)) and deliveries to mothers with any prior diagnosis of diabetes or hypertension. Estimates are from a fixed-effects conditional logistic regression. $\Delta p^{j}_{s(i)kc(t)}$ represents the difference in the mean payment to physician group j for cesarean versus vaginal deliveries among patients of severity level $s(i)$ under a negotiated contract with insurer k during contract period $c(t)$. $\Delta p^{h}_{s(i)kc(t)}$ represents the analogous difference for hospital h. All specifications include year fixed effects. Standard errors clustered at the hospital–physician group level are shown in parentheses. $^{a}p < 0.01$, $^{b}p < 0.05$, $^{c}p < 0.10$.

physician's delivery price differential ($\Delta p^{j}_{s(i)kc(t)}$) leads to a 0.027 increase in the log-odds (or a 2.7 percent increase in the odds ratio) that a cesarean delivery will be performed. Alternatively, increasing the physician price differential by one standard deviation ($420) yields a 12 percent increase in the odds ratio for cesarean delivery. Our estimation strategy, which avoids the incidental parameter problem, does not estimate fixed effects. As a result, we can estimate an average price elasticity only under strong assumptions. With this caveat, we estimate an average price elasticity of 0.02 under the assumption that a particular hospital–physician group–insurer triad is predicted to perform cesareans at the average rate and for the average price observed in the sample. Coefficients on our other covariates are in the expected direction. Cord prolapse is an emergency situation that typically leads to cesarean section. Women with prior cesareans who attempt vaginal births are also more likely to deliver via cesarean section, because they are likely to have the same issue that they had in their first birth (e.g., failure to progress in labor), and because most physicians have a lower threshold for performing a cesarean section in these women because of the small but catastrophic risk of uterine rupture.

We find that our results are robust to inclusion of hospital–physician group–insurer–age group fixed effects, shown in column 3. Column 3 tests whether our results are, for example, due to some physician groups serving progressively older patient populations over time that have higher cesarean rates because of unobserved delivery complexity and higher physician delivery price differentials due to this unobserved difference in delivery complexity. We find that our baseline estimate is robust to this alternative specification although the coefficient on the physician delivery price differential, $\Delta p^{j}_{s(i)kc(t)}$, is smaller and less precisely estimated.

Taken together, we find that physician groups respond to an increase in the price differential by performing more cesareans, and that this response is not due to unobserved differences in patient age or insurer mix across hospital–physician groups that are correlated with prices.

A.1. HOSPITAL DELIVERY PRICE DIFFERENTIAL. We find the coefficient on the hospital delivery price differential ($\Delta p^{h}_{s(i)kc(t)}$) to be insignificant in our baseline specification. However, we find a a positive and statistically significant coefficient for $\Delta p^{h}_{s(i)kc(t)}$ when we restrict our sample to physician groups who only deliver at a single hospital during our entire sample period (Table 4, column 1). Our coefficient in the latter specification indicates that a $1,000 increase in the hospital's delivery price differential leads to a 0.048 increase in the log-odds that a cesarean delivery will be performed or a 4.9 percent increase in the odds of cesarean delivery. Stated another way, increasing the hospital's delivery price differential by one standard deviation ($5,805) for births delivered by hospital-exclusive physician groups yields a 31 percent increase in the odds ratio.

B. ROBUSTNESS TESTS

In Section V.A, we discussed changes over time within a particular hospital–physician group–insurer triad in patient demand or provider characteristics that could challenge our identification strategy. In this section, we perform several additional robustness tests to address those concerns. We use hospital–physician group–insurer fixed effects in all our robustness tests to match our preferred baseline specification. We briefly review the identification concerns relevant to each test; however, we refer the reader to Section V.A for a more complete discussion of these concerns.

We first address the concern that physicians may be steering patients on the basis of unobserved demand heterogeneity to hospitals that have higher delivery price

TABLE 4. Robustness tests

Dependent variable: Probability of receiving a cesarean delivery				
	(1)	(2)	(3)	(4)
$\Delta p^{j}_{s(i)kc(t)}$	0.052[c]	0.028[b]	0.027[c]	0.026[b]
	(0.028)	(0.013)	(0.014)	(0.011)
$\Delta p^{h}_{s(i)kc(t)}$	0.048[b]	−0.005	−0.006	0.003
	(0.022)	(0.007)	(0.007)	(0.017)
Cord prolapse		2.235[a]	2.246[a]	2.566[a]
		(0.670)	(0.670)	(0.730)
Prior cesarean	5.574[a]	5.470[a]	5.473[a]	5.133[a]
	(0.799)	(0.319)	(0.321)	(0.418)
$\Delta p^{j}_{s(i)kc(t+1)}$			−0.014	
			(0.013)	
$\Delta p^{h}_{s(i)kc(t+1)}$			−0.002	
			(0.007)	
Maternal age				
20–24	−0.632	0.170	0.168	0.058
	(0.432)	(0.235)	(0.234)	(0.262)
25–29	−0.876[b]	−0.184	−0.188	−0.376
	(0.393)	(0.173)	(0.174)	(0.267)
30–34	−0.929[b]	−0.297[c]	−0.301[c]	−0.476[c]
	(0.416)	(0.179)	(0.180)	(0.277)
35–39	−0.909[b]	−0.022	−0.028	−0.208
	(0.392)	(0.194)	(0.197)	(0.261)
≥40	−0.523	0.090	0.086	−0.153
	(0.540)	(0.243)	(0.244)	(0.361)
Sample	Single hospital	Has future prices	Has future prices	Physician prices within 4 months
Observations	1,894	5,447	5,447	2,418

Notes: An observation is a single birth. The underlying sample is women enrolled in an HMO or a PPO plan (2004–11), excluding deliveries that are likely to have been scheduled in advance (based on a classification scheme used in Gregory et al. (2002)) and deliveries to mothers with any prior diagnosis of diabetes or hypertension. Column 1 further restricts the sample to deliveries in which the delivering physician group is observed to deliver only at a single hospital for the entire duration of the sample. Columns 2 and 3 restrict the sample to deliveries for which a future price for both physicians and hospitals can be observed. Estimates are from a fixed-effects conditional logistic regression. Fixed effects are at the hospital–physician group–insurer level in all specifications. $\Delta p^{j}_{s(i)kc(t)}$ represents the difference in the mean payment to physician group j for cesarean versus vaginal deliveries among patients of severity level $s(i)$ under a negotiated contract with insurer k during contract period $c(t)$. $\Delta p^{h}_{s(i)kc(t)}$ represents the analogous difference for hospital h. All specifications include year fixed effects. Standard errors are shown in parentheses; they are clustered at the hospital–physician group level. $^{a}p < 0.01$, $^{b}p < 0.05$, $^{c}p < 0.10$.

differentials. This concern is eliminated if physicians only deliver at one hospital. Column 1 in Table 4 therefore runs our main estimation specification on the sample of births delivered by physician groups who only deliver at a single hospital during our entire sample period. Of the 231 unique physician groups in our data, 129 are identified as single-hospital physician groups; they represent approximately a quarter of the births in our sample.[30] We recover a larger point estimate on the physician delivery price differential among the sample of single-hospital physicians compared with our baseline estimate. Our next robustness test addresses the concern for reverse causality. This concern states that providers negotiate for higher cesarean prices *in anticipation* of future increased patient demand for cesarean deliveries, future changes in their hiring practices, skills, or experience for cesareans, or future increases in the marginal cost differential between cesarean and vaginal deliveries. To address this concern, we conduct two robustness tests. In the first, we add future hospital and physician delivery price differentials to our baseline specification;[31] in the second, we restrict our analysis to births occurring within four months of a new contract date for physician groups.[32] Future price differentials would be correlated with current provider cesarean rates if providers were negotiating their prices in anticipation of future provider or patient changes and such anticipated changes did not perfectly align with contracting periods. Therefore, finding a significant positive effect of future price differentials on current provider cesarean rates would provide support to this alternative hypothesis.

In our second test, we test whether the likelihood of a cesarean delivery is greater in the four months after an increase in the delivery price differential compared with the four months preceding the price change. If our baseline findings were being driven by changes in cesarean rates occurring far from the change in contracts, the point estimate on the physician delivery price differential would fall to zero. This would be inconsistent with physician groups responding on the margin to exogenous changes in the delivery price differential. Instead, it would be more consistent with the alternative hypothesis that incremental changes in patient demand or provider composition were driving gradual trends in the cesarean rate. In contrast, estimating a coefficient on the physician delivery price

30 The set of single-hospital physician groups have approximately the same cesarean rate as the multi-hospital physician groups (32 percent versus 33 percent), receive on average similar physician reimbursement rates for both types of delivery, but deliver fewer births per year on average in our sample (4.5 versus 14.6 births). Los Angeles county contains the most multi- and single-physician groups in our sample (24 and 22). Over half of single-hospital physician group births (51 percent) occur in Butte, Monterey, and Los Angeles, while 35 percent of multi-hospital physician group deliveries occur in Los Angeles and Sacramento counties (with no other county comprising more than 7 percent of multi-hospital physician group deliveries).

31 Since we compute prices within a group defined by a unique combination of contract period, provider (hospital or physician group), insurer, and pregnancy severity bin, we use the price in the next contract period as the future price for each of these groups.

32 We also perform a similar analysis for births occurring within five or six months of a new contract date for hospitals and find no significant change in the estimated coefficients for either hospitals or physician groups.

differential similar to our baseline result would further support our interpretation of our results.

The results for both of these robustness tests are displayed in Table 4. Since including future prices drops observations in the last contracting period for each provider-insurer pair in our sample, we also rerun our main specification in column 2 on this smaller sample to ensure the stability of our baseline results prior to running our first robustness test. We find that our baseline results are reassuringly unchanged with the sample restriction. In column 3 we run our robustness test with future prices and find that the coefficients on *current* physician and hospital delivery price differentials are stable to the inclusion of future price differentials. Furthermore, the point estimate on the future physician delivery price differential is small and nonsignificant.[33] In column 4, we run our second robustness test, using only births occurring four months before or after around a physician-insurer contract renegotiation. We find point estimates on the physician delivery price differential that are not significantly different from our baseline estimates.

In addition to our main robustness tests presented here, we run several additional specification checks where we examine whether the following factors could be affecting our results: the entry and exit of physician groups and/or hospitals, changes in the number of obstetricians within a physician group, and the presence of patient exposure to physician prices through coinsurance. We recover similar estimates in all of these specification checks. These results can be found in the Online Appendix.

VII. Discussion

Our findings indicate that changes in the relative prices received by medical providers for substitutable treatments significantly affect the choice of either cesarean or vaginal delivery for women in labor. Our results contribute three new insights to the understanding of the effect of provider prices on treatment choice.

First, we document behavioral responses to transacted prices at the level of a single provider, controlling for unobserved heterogeneity at the hospital–physician group–insurer level. To the best of our knowledge, no previous studies have documented behavioral responses to provider prices at this level of specificity, which points to actual changes in individual physician group behavior rather that shifts in the supply of physician groups or hospitals for a given insurer. In addition, we account for the existence of idiosyncratic provider preferences across treatments, and we allow these preferences to vary by practice setting (i.e., hospital) and insurer. If not accounted for, this unobserved heterogeneity could bias estimates of the price coefficients. Among physicians, we find behavioral responses that are of the same order of magnitude as those found in previous studies of our clinical context that do not account for unobserved physician or hospital heterogeneity (Gruber, Kim, and Mayzlin 1999; Keeler and Fok 1996). Studies of physician price elasticities in other contexts have sometimes found larger estimates: for example, Clemens and

33 In unreported results, we also include current and future county-specific fertility rates to address the concern regarding provider responses to current or future overall demand for childbirth; we find no significant change in our main point estimates.

Gottlieb (2014) recently estimated a long-run price elasticity of 1.5 in response to changes in Medicare's physician payments. Again, though these estimates are not directly comparable, they perhaps suggest that the impact of relative prices on treatment choice in other contexts may be even larger than what we estimate here.

Second, our inclusion of both hospital and physician prices shows that our findings on physician behavioral responses are robust to controlling for hospital prices. Omitting hospital prices could bias the physician price coefficient through two possible channels: (1) there is a positive correlation between hospital and physician prices but the true effect arises from hospitals responding to their own price incentives, and/or (2) hospitals transmit their price incentives to physicians practicing at their facilities. Indeed, our data show a positive correlation between hospital and physician prices (see the Online Appendix). Similarly, omitting physician prices could bias the hospital price coefficient. Previous studies of supply-side provider responses to price changes have included only one price or the other. Our findings may therefore serve as added robustness checks for previous results. Third, with the richness of our price data, we are able to present a new finding that treatment choice responds strongly to changes in the *hospital* delivery price differential only when the delivering physicians do not deliver at any other hospital in the sample. Insofar as the hospital is not deciding on each individual patient's treatment choice, our findings may be consistent with hospitals transmitting their financial incentives for choosing one treatment over the other to one or more of the parties involved in choosing the treatment. From the list of involved persons (e.g., nurses, patients' family members), we find it most plausible to imagine that hospitals are providing incentives to physicians. This interpretation suggests that hospitals are able to overcome the principal-agent problem that they face with physicians, in which physicians make many of the treatment decisions that affect hospital profits. This is consistent with evidence that hospitals actively work to get physicians to adopt practices that increase hospital profit or further the hospital's mission.[34] If this interpretation proves to be true, it implies that hospitals and physicians may be able to coordinate their actions within accountable care organizations (ACOs). ACOs receive a share of the aggregate reduction in Medicare spending for their beneficiaries, but the program leaves the exact division of these additional monies up to the hospitals, physicians, and other providers in the ACO. A key component of the success of ACOs depends on the ability of hospitals and physicians to structure the additional savings into effective incentives to achieve sustained spending reductions. Our findings suggest that hospitals and physicians may already be successfully aligning their incentives, which suggests a positive

34 Surveys of hospitals have uncovered several ways in which hospitals may use financial and nonfinancial incentives to try to steer physician behavior toward higher hospital margins (Mark et al. 1998; Casalino et al. 2008; Ketcham and Furukawa 2008). These include (1) financial incentives, (2) participation in hospital decision-making and management, (3) education and feedback, and (4) joint ventures. In addition, hospital trade publications and consulting firms frequently discuss strategies for "physician alignment," or getting physician actions in line with a hospital's goals. See, for example, the following company websites (accessed May 26, 2013): http://www.deloitte.com/view/en_US/us/Industries/health-care-providers/health-reform/accountable-care-solutions/index.htm; http://www.thecamdengroup.com/our-services/strategic-business-planning/physician-hospital-alignment/; http://www.advisory.com/Consulting.

outlook for the success of ACOs. On the other hand, they also underscore the importance of selecting quality metrics that prevent hospitals and physicians from aligning incentives to cut costs at the expense of quality. However, we caution that our interpretation is simply one of several possible interpretations of the results we have presented; we have no direct evidence of hospitals providing greater incentives for cesarean deliveries as their delivery price differential increases.

Even if our results imply nothing about the principal-agent problem between hospitals and physicians, they still point out the importance of considering *relative* payments across substitutable treatments to *both* hospitals and physicians in crafting effective provider payment reform. The Medicare payment reforms on the table today focus on reducing costs through broader bundling of payments across an individual patient episode or across providers and through rewarding a set of specific value metrics. All of them use the prospective payment system for paying hospitals, under which different treatments often have different prices, and they all directly or indirectly use fee-for-service payments for physicians.[35] Our results indicate that continued efforts to restructure both physician and hospital payments with careful attention to relative payments for substitutable treatments may also play an important role in improving the efficiency of health care under any of the above reforms.

VIII. Conclusion

In this paper, we study the effect of relative differences in prices paid by an insurer to a hospital for substitutable medical treatments on the treatment received by patients. Our context is the choice of cesarean or vaginal delivery for privately insured women in California from 2004 to 2011.

We find that increasing the physician price differential by one standard deviation ($420) yields a 12 percent increase in the odds ratio for cesarean delivery. Under certain assumptions, this implies a physician price elasticity of 0.02. Changes in the price differential for hospitals affect the cesarean rate only for births delivered by physicians that practice at a single hospital. Among this subset of births, increasing the hospital price differential by one standard deviation ($5,805) for births delivered by hospital-exclusive physician groups yields a 31 percent increase in the odds ratio.

Our findings suggest several areas for future research. First, broader study of the impact of changing relative physician *and* hospital payments across different clinical and geographical contexts may provide additional external validity and insight into heterogeneity in this response. Second, additional research examining the mechanism by which hospital prices affect treatment choices (e.g., through incentives paid to physicians) would elucidate potential avenues for policy to affect treatment choice and, ultimately, healthcare costs.

35 Medicare's Pioneer ACO payment structure does use population-based payments for physicians, but these payments are based in part on an underlying fee-for-service payment structure. See http://innovation.cms.gov/Files/x/PioneerACOBmarkMethodology.pdf for additional details on how these payments are computed.

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