Online Appendix for

Disentangling Sources of Variation in C-Section Rates

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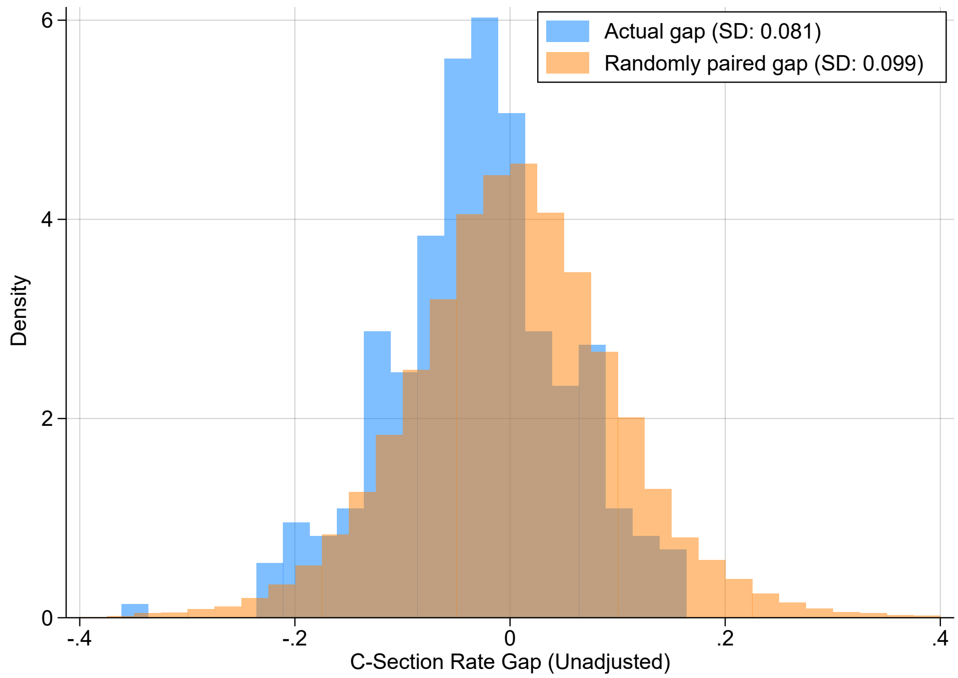
Appendix contents. This supplementary appendix contains additional figures, tables, robustness analyses, supporting methodological details, and the expert-survey instruments referenced in the main manuscript.

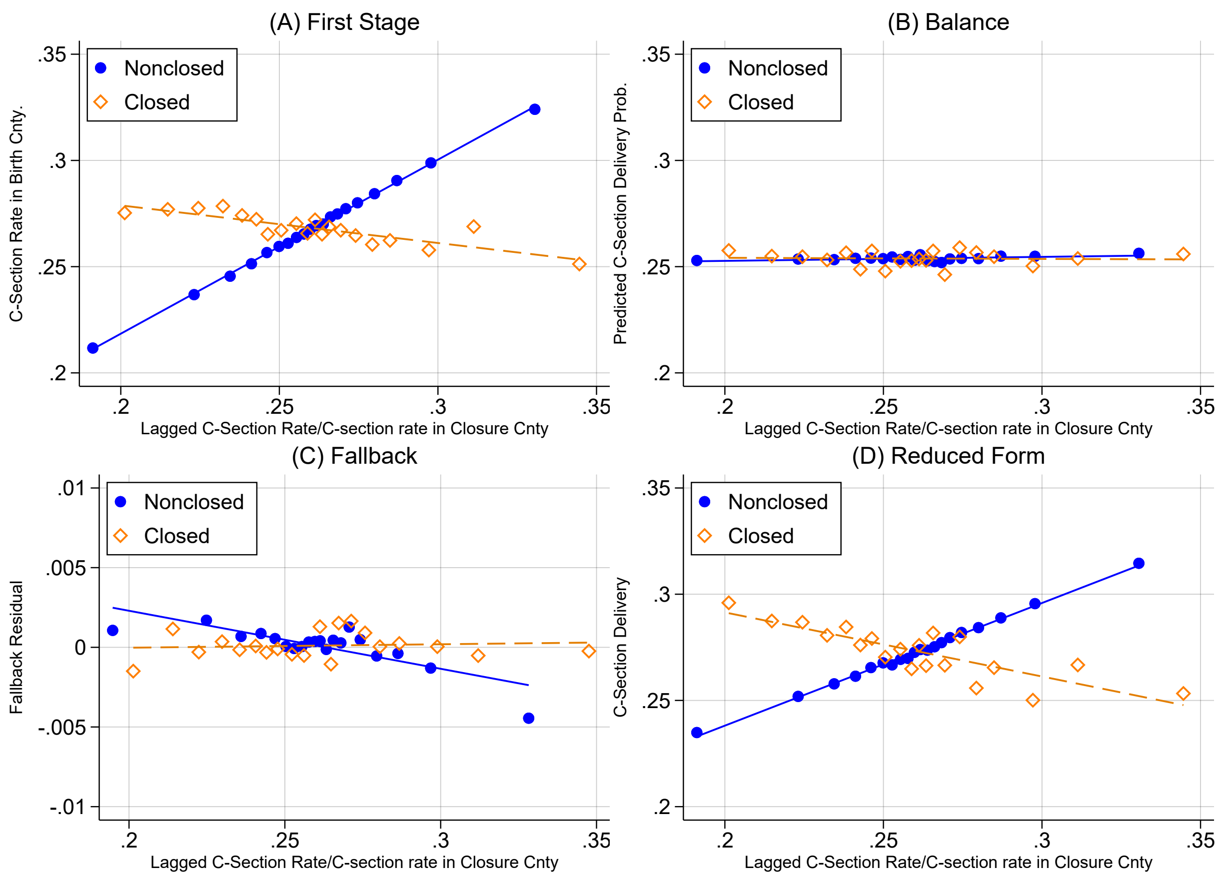
A Supplemental Figures and Tables

Figure A1: Distributions of Actual and Randomly Paired C-Section Gaps



Notes: The blue-colored plot shows the actual distribution of C-section rate gaps between closure and receiving counties (as in Figure 3A). The orange-colored plot shows the distribution of C-section rate gaps from randomly-paired counties. To construct this counterfactual, we calculate the average C-section rate for each county-year over the three years prior, and then randomly pair counties within each year (without replacement) to compute the gap between each pair.

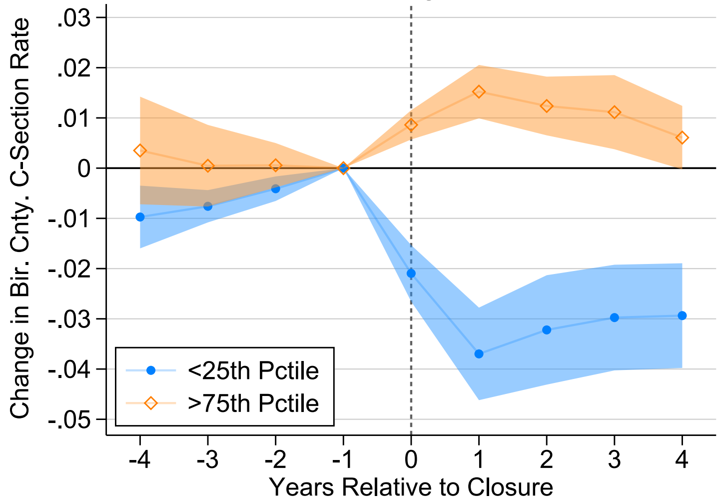
Figure A2: Binned Scatter Plots for Graphical Representation of First Stage, Balance Test, Fallback Condition, and Reduced Form



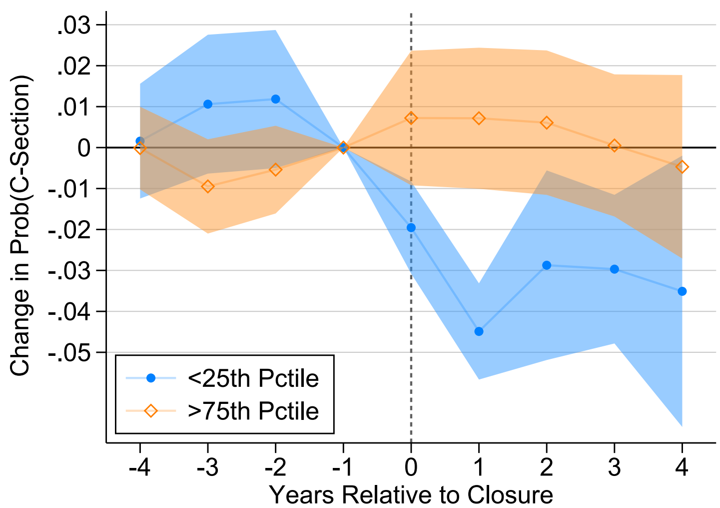
Notes: This figure illustrates the three assumptions underlying the complementary IV approach using $Z = \text{Closed}_{rt} * \text{Pre-Closure C-section Rate}_r$ (i.e., strong first stage, exclusion restriction, and the fallback condition) and the reduced form using binned scatter plots. In all figures, the X-axis represents the lagged C-section rate: for non-closure counties, this is the rate in the previous year; for closure counties, it is the rate measured in the three years prior to the closure. We control for county-level time varying covariates (female population shares for 5-year age bands, per-capita personal income, per-capita governmental transfers, and the employment-population ratio), county of residence fixed effects, and urban group-by-year fixed effects in all plots. [Panel A] The Y-axis represents county-level C-section rate. [Panel B] The Y-axis represents C-section rate predicted by demographic variables and risk factors (See Section 5 "Exogeneity," for the choice of variables). [Panel C] The Y-axis represents the fallback residual (See Section 5 "Fallback Condition" for the construction of this measure). [Panel D] The Y-axis is the indicator of whether a mother actually receives a C-section.

Figure A3: Effects of Closures by Gap: de Chaisemartin and D'Haultfoeuille (2020) Estimator

(A) First Stage

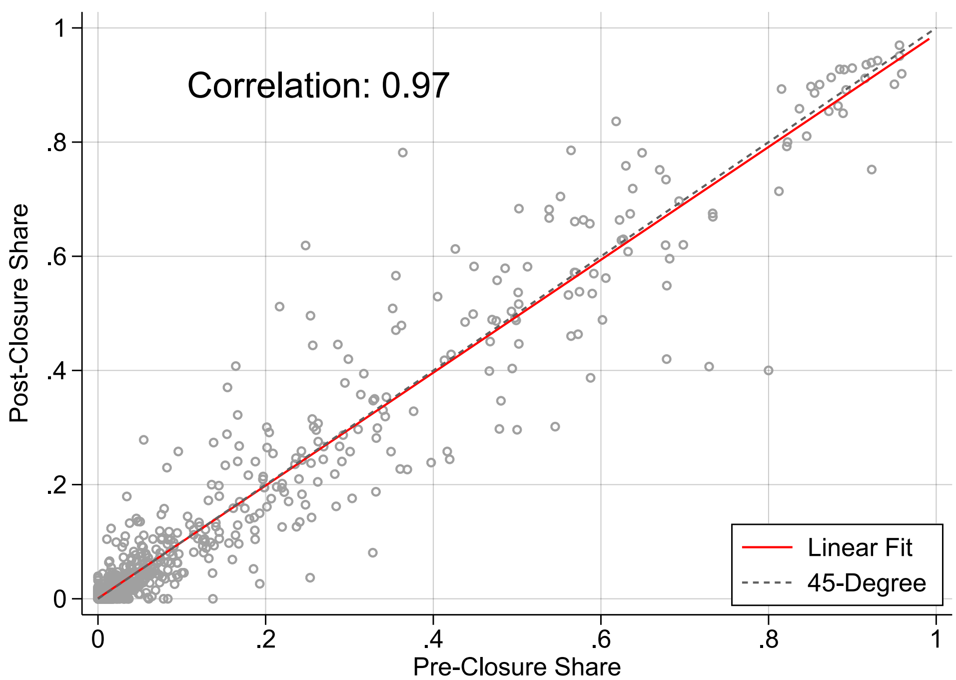


(B) Reduced Form



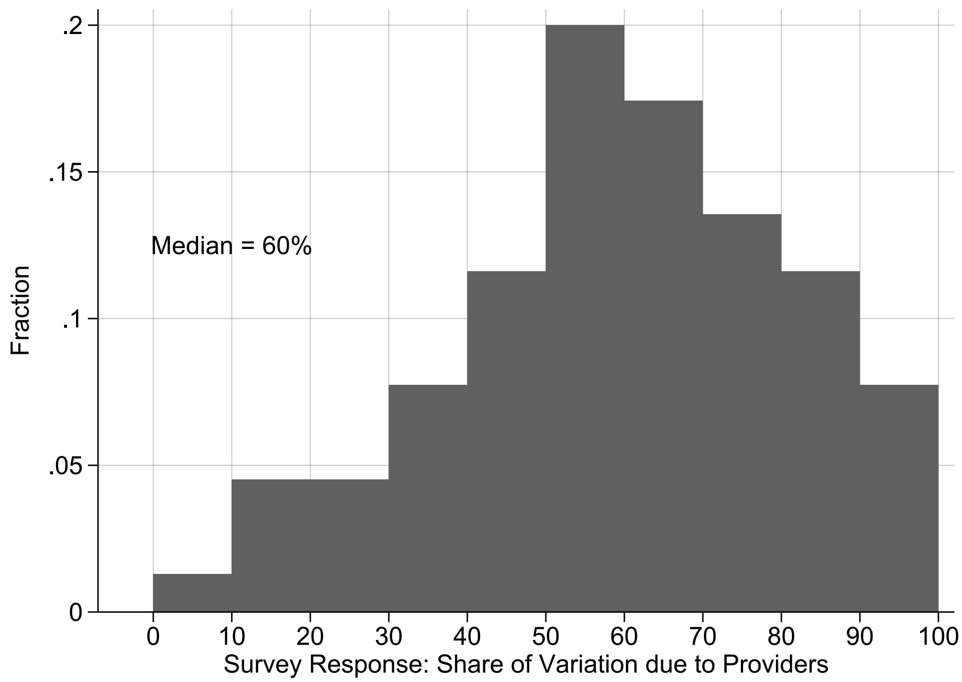
Notes: These figures plot estimated ψ_j from Equation (9) using the de Chaisemartin and D'Haultfoeuille (2020) estimator. The outcome is C-section rate in county of delivery in Panel (A), whereas the outcome is probability of C-section in Panel (B). In each subfigure, treated counties in the first (blue) and fourth (orange) quartile of the Gap_r are used. Circles represent the point estimates of dynamic treatment effects and the shaded areas represent the 95% confidence intervals. All the regressions include controls for county of residence fixed effects, urban group-by-year fixed effects, county-level time varying covariates (female population shares for 5-year age bands, per-capita personal income, per-capita governmental transfers, and the employment-population ratio).

Figure A4: Correlation between Pre- and Post-Closure Receiving County Shares (Indirect Test of Fallback Condition)



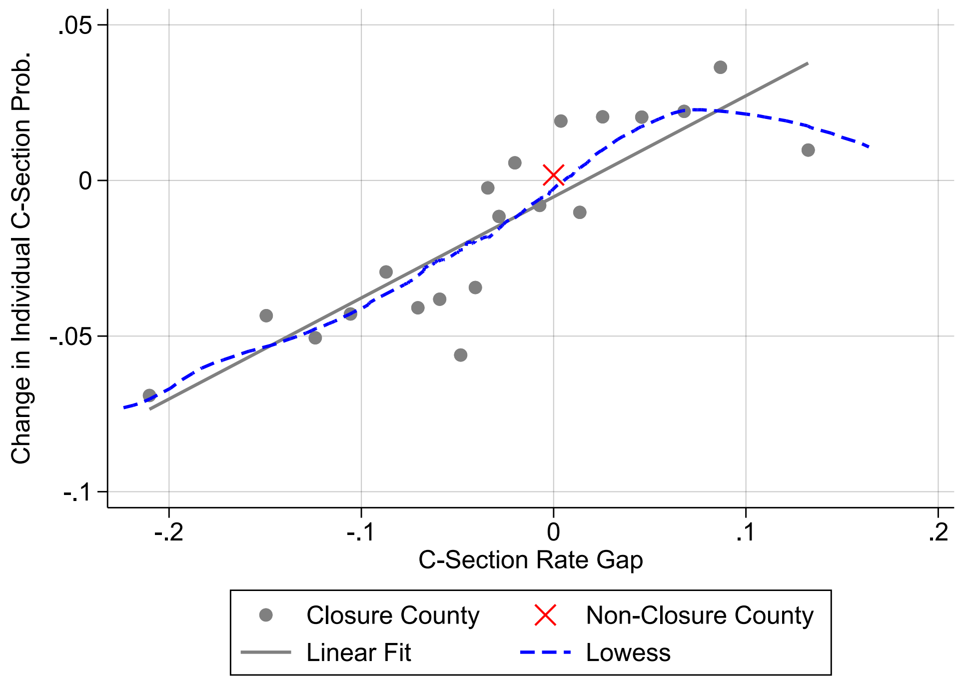
Notes: The figure plots the share of births occurring in each receiving county for a given closure county, measured three years before (pre-closure share on the x-axis) and three years after (post-closure share on the y-axis) the closure event. Pre-closure shares are calculated conditional on mothers giving birth outside the closure county. The red line shows the linear fit between pre- and post-closure shares, while the dotted 45-degree line connects (0,0) and (1,1) for reference. For visual clarity, we display a 20% random sample of all closure–receiving county pairs.

Figure A5: Experts' Prediction of the Fraction of Variation Due to Providers



Notes: This histogram shows the distribution of responses to survey questions eliciting experts' beliefs about the provider contribution to geographic variation in C-section rates. In some versions, respondents reported the predicted percentage-point difference in C-section probability between otherwise identical mothers randomly assigned to counties with different C-section rates: one county with a 25% C-section rate and another with a 35% C-section rate. In another version, respondents directly reported the percentage of county-level differences they believed was causally due to healthcare providers (such as hospital or healthcare personnel). Responses are based on predictions from 225 experts, including practicing obstetricians, obstetrics researchers, and health economists. The survey instruments are provided in Appendix B.

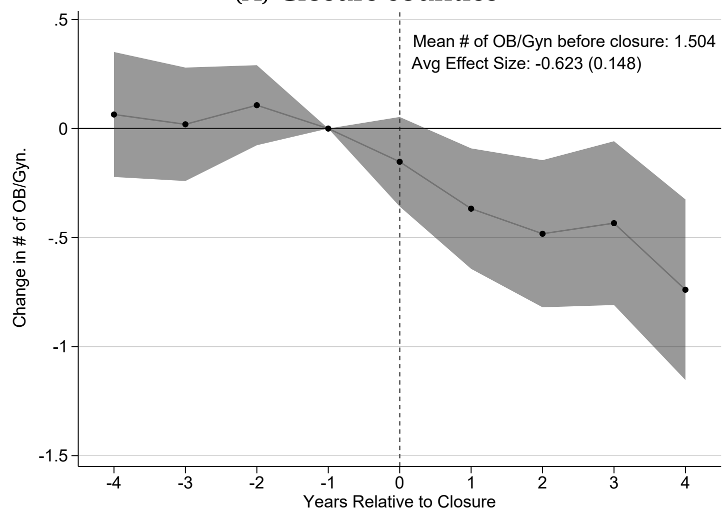
Figure A6: Linearity between the Individual C-section Rate and the C-section Rate Gap



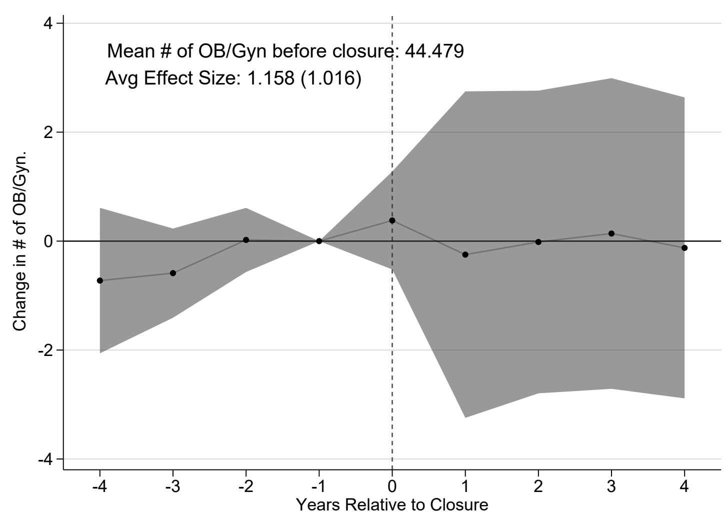
Notes: This figure plots the relationship between the C-section rate gap and changes in individual C-section probability. For closure counties, the outcome on the Y-axis is defined as the change in individual C-section probability from the two years before closure to the two years after closure, excluding the year of closure, as in our preferred 4-Year specification (Section 6.1; see Column (1) of Table 3). For non-closure counties, the outcome on the Y-axis is defined as the change in individual C-section probability relative to the previous year. Gray circles denote closure counties, and the red "X" denotes non-closure counties. The solid gray line shows the linear fit, while the dashed blue line shows a locally weighted regression fit. As a point of reference, the vertical line at 0.1 marks approximately the 95th percentile of the C-section rate gap. The corresponding gap distribution is shown in Figure 3A.

Figure A7: Changes in Numbers of OB/GYN Physicians in Closure and Receiving Counties

(A) Closure counties

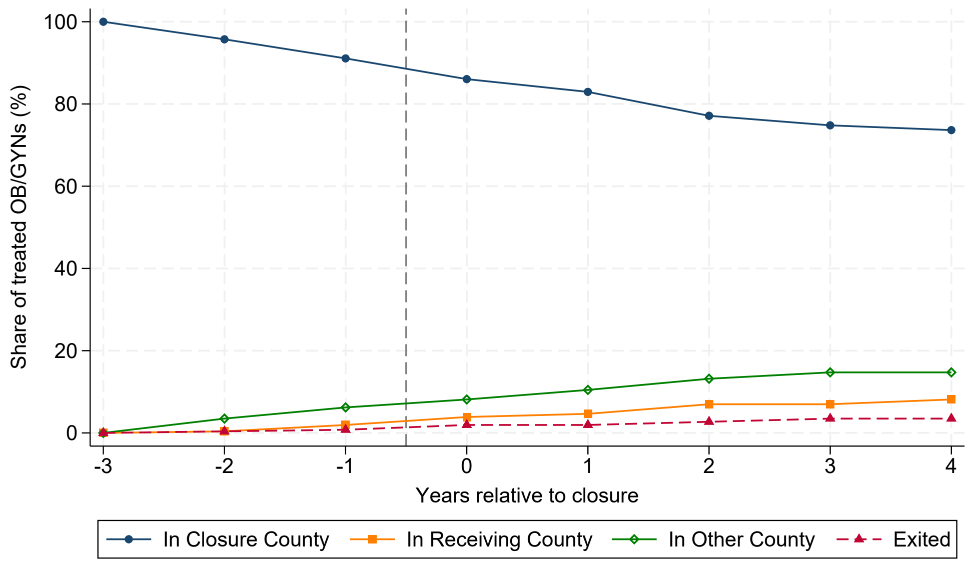


(B) Receiving counties



Notes: These figures plot estimated ψ_j from Equation (9) for the number of OB/GYN in county, sourced from Area Health Resources Files (AHRF). Panel A (Panel B) shows the results from an event-study specification using closure counties (receiving counties) and control counties. Circles represent the point estimates of dynamic treatment effects and the shaded areas represent the 95% confidence intervals. All the regressions include controls for county fixed effects, urban group-by-year fixed effects, county-level time varying covariates (female population shares for 5-year age bands, per-capita personal income, per-capita governmental transfers, and the employment-population ratio). Standard errors are clustered at county level. Because AHRF data are available since 1995, closure counties in which the closure event happened prior to 1995 and their receiving counties are not included in this analysis.

Figure A8: NPPES-Registered Practice Location of Closure-Affected OB/GYNs



Notes: The figure plots the share of treated OB/GYNs in four mutually exclusive location categories at each event time relative to obstetric unit closure. Treated OB/GYNs are defined as physicians with primary NPPES taxonomy code 207V00000X (Obstetrics & Gynecology) whose primary practice address registered in NPPES was in the closure county three years before the closure ($t = -3$). The sample includes closure events occurring between 2011 and 2017. "In closure county" indicates that the physician's NPPES primary practice address remains in the closure county. "In receiving county" indicates that the primary or secondary practice address (the latter available from 2018) is in a receiving county, defined as in Section 7.1. "In other county" indicates that the primary practice address is in a county that is neither the closure county nor a receiving county. "Exited" indicates that the physician's NPI no longer appears in NPPES. Source: NPPES monthly snapshots from the NBER NPPES data archive (National Bureau of Economic Research, 2008–2021).

Table A1: C-Section Gap and Travel Distance

	(1)
Dependent variable	Actual Travel Distance (miles)
$\text{Closed}_{rt} \times \text{Gap}_r$	4.290
	(4.282)
Closed_{rt}	7.611***
	(0.391)
Observations	29,025,019

Notes: This table reports the coefficient and standard error from a regression of the actual travel distance (in miles) from the mother's county of residence to the delivery hospital on the instrument and the closure indicator. Estimates use singleton first births as the sample. Standard errors clustered at the county of residence level. The regression controls for county of residence fixed effects, urban group-by-year fixed effects, and county-level time-varying covariates (female population shares for 5-year age bands, per-capita personal income, per-capita governmental transfers, and the employment-population ratio). ***, **, *, + indicate significance at the 0.1%, 1%, 5%, and 10% levels.

Table A2: Assumptions and IV Estimates (Risk-Adjusted)

Panel A: Assumptions	(1) C-section Rate in Delivery Cnty. (First Stage)	(2) Individual C-section (Reduced Form)	(3) Predicted C-Section (Balance Test)	(4) Fallback Residual (Fallback Test)	
Closed × Gap	0.288***	0.228***	-0.093	-0.00852	
	(0.054)	(0.043)	(0.071)	(0.00992)	
First-Stage F	28.6				
N	29,028,188	29,028,359	29,028,359	23,542,885	
Panel B: IV Estimate with Varying Time-Window	(1) 4-Year	(2) 6-Year	(3) 8-Year	(4) 10-Year	(5) Unrestricted
County C-Section Rate	0.793***	0.827***	0.770***	0.763**	0.971*
	(0.180)	(0.191)	(0.202)	(0.232)	(0.478)
N	29,028,188	29,095,583	29,159,791	29,222,280	29,969,594
Panel C: Robustness	Interaction IV	P-Weighted	Median Instrument	$R_{Closure}$ Instrument	Distance Controls
County C-Section Rate	0.919***	0.788***	0.812***	0.736***	0.791***
	(0.174)	(0.176)	(0.197)	(0.221)	(0.178)
N	29,028,188	23,652,116	29,028,188	29,028,188	29,028,188
Panel D: Heterogeneity	Low Need	High Need	2nd+ Birth	HHI $< 10,000$	HHI $= 10,000$ (Monopolized)
County C-Section Rate	0.966***	0.794	0.430*	0.665***	0.913**
	(0.232)	(0.568)	(0.201)	(0.165)	(0.337)
N	21,811,690	7,216,498	41,555,814	23,028,876	3,783,302

Notes: This table presents regression estimates and standard errors from several analyses. Panel A reports tests of identifying assumptions. Column (1) presents the first stage, where the outcome is the county-level C-section rate. Column (2) shows the reduced form, where the outcome is an indicator for whether an individual had a C-section. Column (3) provides an indirect test of the exclusion restriction, using as the outcome a predicted C-section indicator based on a regression of balance variables (marital status, race indicators, birth order, age bands, and risk factors). Column (4) tests the "fallback condition" as described in Abaluck et al. (2021). Panel B reports IV estimates using different time windows, with the individual likelihood of C-section as the dependent variable and the county-level C-section rate as the main independent variable. Panel C presents robustness checks of the IV estimates. Column (1) uses $Z_{rt} \times s_r$ (where s_r is the share of mothers giving birth in their county of residence in the three years prior to the closure) as the instrument. Column (2) weights observations by the propensity to experience a closure. Column (3) replaces Gap_r in Equation (6) with an indicator for whether the gap exceeds the median. Column (4) uses the pre-closure C-section rate in closure counties as the instrument, rather than the gap. Column (5) adds controls for distance to the nearest hospital-based obstetrics unit and its square. Panel D presents heterogeneity analyses for the IV estimates. In Columns (1) and (2), the sample is classified as Low-Need if a mother's predicted probability of receiving a C-section falls below the 75th percentile; otherwise, the mother is classified as High-Need. Column (3) restricts the sample to second or higher-order singleton births. Columns (4) and (5) explore heterogeneity by hospital market competitiveness in the receiving county: Column (4) includes mothers with at least two hospital options; Column (5) includes those with effectively only one. All regressions control for county-of-residence fixed effects, urban group-by-year fixed effects, and county-level time-varying covariates: female population shares in 5-year age bands, per-capita personal income, per-capita government transfers, and the employment-population ratio. County-level C-section rates are risk-adjusted using inverse probability weighting. The probability of a C-section is predicted using maternal age, breech presentation, eclampsia, chronic hypertension, pregnancy-related hypertension, pregnancy-related diabetes, and gestational age. Weighted rates are then standardized by multiplying by the average C-section rate in the full sample. Standard errors are clustered at the county of residence level. ***, **, *, + indicate significance at the 0.1%, 1%, 5%, and 10% levels, respectively.

Table A3: Reduced-Form and IV Estimates by Sign of the C-Section Gap and Distance to Hospital-Based Obstetric Care

Panel A: By Sign of Gap (Reduced Form)	(1) Positive Gap	(2) Negative Gap
$\text{Closed}_{rt} \times \text{Gap}_r$	0.170	0.249***
	(0.112)	(0.054)
N	28,936,225	28,972,523

Panel B: By Sign of Gap (IV Estimates)	(1) Positive Gap	(2) Negative Gap
County C-Section Rate	0.616	1.083***
	(0.390)	(0.255)
First-Stage F	13.78	35.79
N	28,936,059	28,972,352

Panel C: By Sign of Gap and Distance (IV Estimates)	(1) Positive Short (< Median)	(2) Positive Long (≥ Median)	(3) Negative Short (< Median)	(4) Negative Long (≥ Median)
County C-Section Rate	0.585	0.604	1.089***	1.058*
	(0.535)	(0.562)	(0.306)	(0.424)
First-Stage F	6.44	21.13	33.08	5.66
N	28,920,164	28,899,455	28,940,083	28,915,829

Notes: Panel A reports the reduced-form estimates (Eq. (8)) from our instrumental variable design, stratified by the sign of the C-section gap experienced by the closure county. Panel B shows IV regression coefficients and standard errors stratified by the sign of the C-section gap. Panel C stratifies by both the sign of the gap and the distance to the nearest county with a maternity ward after closure. In Panel C, "short" and "long" denote a distance to the nearest county with a hospital-based obstetric unit (after the closure) that is below or above the median (22.9 miles) across closure counties, respectively. All estimates use singleton first births. County-level C-section rate is risk-unadjusted (i.e., crude C-section rate). Standard errors are clustered at the county of residence level. The estimate includes four years of data (2 years prior to the closure and 2 years after the closure, excluding the year when the closure happened) for treated counties. All the regressions include controls for county of residence fixed effects, urban group-by-year fixed effects, county-level time varying covariates (female population shares for 5-year age bands, per-capita personal income, per-capita governmental transfers, and the employment-population ratio). ***, **, *, + indicate significance at the 0.1%, 1%, 5%, and 10%.

Table A4: Results Including Closure Counties with Zero C-section Rates without Empirical Bayesian Shrinkage

Dep. Var.	Individual C-Section				
	(1) 4-Year	(2) 6-Year	(3) 8-Year	(4) 10-Year	(5) Unrestricted
County C-Section Rate	1.174***	1.206***	1.166***	1.126***	1.007***
	(0.133)	(0.122)	(0.116)	(0.110)	(0.113)
First-Stage F	146.9	118.0	102.4	77.28	59.85
N	29,045,770	29,121,384	29,193,663	29,263,654	30,113,025

Notes: This table presents IV estimates and standard errors using a sample that includes all closures, not just those with non-zero C-section rates. The dependent variable is a binary indicator for whether an individual had a C-section, and the main independent variable is the county-level C-section rate. Each column corresponds to a different time window around the closure event. The preferred specification, labeled "4-Year," uses data from two years before and two years after the closure (excluding the year of the closure) for treated counties. The remaining columns report estimates from models using longer time windows. All estimates use singleton first births. County-level C-section rates are unadjusted (i.e., crude rates without risk adjustment). We do not apply an empirical Bayes shrinkage adjustment to these estimates. Standard errors are clustered at the county of residence level. All regressions include county-of-residence fixed effects, urban group-by-year fixed effects, and county-level time-varying covariates: female population shares by 5-year age bands, per-capita personal income, per-capita government transfers, and the employment-population ratio. ***, **, *, + indicate significance at the 0.1%, 1%, 5%, and 10% levels, respectively.

Table A5: Hospital Characteristics Regression (Gap Instrument)

Dep. Var.	Individual C-section					
	Profit Motive		Quality & Resources		Labor & Capacity	
For Profit	0.0234					
	(0.0260)					
Full Integration		-0.0158				
		(0.0322)				
Med-School Affiliation			-0.0902*			
			(0.0408)			
NICU Hospital				-0.0457		
				(0.0460)		
Share of Births Attended by Midwives					-0.0606	
					(0.124)	
(Birth/Bassinets)*100						-0.00612
						(0.0615)
First-Stage F	86.6	44.8	59.2	69.9	39.9	12.0
N	23,685,260	23,685,260	23,685,260	23,572,655	29,028,423	23,679,092

Notes: This table presents IV estimates from regressions where the dependent variable is a binary indicator for whether an individual had a C-section, and the main independent variable is the hospital characteristic listed in the corresponding row. Unlike Table 6, the instrument is Z_{rt} rather than $Z_{rt} \times s_r$. All hospital characteristics, except for the share of births attended by midwives, are sourced from the AHA Annual Survey. The midwife share is constructed using the NVSS Natality files, following the same three-year averaging approach used for the C-section rate. We do not apply empirical Bayes shrinkage because many closure counties have only one hospital, making shrinkage-based standard errors infeasible. Hospital characteristics are averaged over the three years preceding the birth. All regressions include county-of-residence fixed effects, urban group-by-year fixed effects, and county-level time-varying covariates (female population shares in 5-year age bands, per-capita personal income, per-capita government transfers, and the employment-population ratio). Standard errors are clustered at the county of residence level. ***, **, *, $^{+}$ indicate significance at the 0.1%, 1%, 5%, and 10% levels.

Table A6: IV Estimates: Maternal and Infant Health Outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dep. Var.	Mat. Morbidity Revised	Mat. Morbidity Unrevised	Inf. Morbidity Unrevised	Low Birthwt. (< 2,500g)	Preterm (< 37 weeks)	Low APGAR (< 7)	Infant Death
County C-Section Rate	-0.239	0.629	0.0206	0.0604	-0.0740	-0.103	-0.00938
	(0.286)	(0.499)	(0.349)	(0.0710)	(0.101)	(0.070)	(0.0240)
Mean Dep. Var.	0.0114	0.0398	0.0139	0.0714	0.0994	0.0189	0.00559
First-Stage F	63.86	27.64	66.70	124.3	124.5	118.9	97.46
N	9,971,315	14,429,509	18,743,541	29,001,878	28,860,332	24,804,414	22,991,363

Notes: This table reports IV coefficients and standard errors from seven separate regressions of maternal and infant health outcomes on county-level C-section rates. All estimates use singleton first births as the sample. County-level C-section rates are unadjusted (i.e., crude rates). Standard errors are clustered at the county of residence level. All regressions use a 4-year window around the closure (two years before and after, excluding the year of closure), consistent with the main specification reported in Column 1 of Table 3. Columns (1) and (2) report estimates for composite measures of maternal morbidity. Higher values indicate worse maternal health. Because the components of these composite measures differ based on whether a state has adopted the 2003 revision of the birth certificate, we construct two separate versions: "Maternal Morbidity (Unrevised)" (available 1989–2006) includes maternal fever, excessive bleeding, and maternal seizures and is estimated only for state-years using the unrevised birth certificate; "Maternal Morbidity (Revised)" (available 2009–2019) includes maternal transfusion, 3rd–4th degree perineal laceration, ruptured uterus, unplanned hysterectomy, and ICU admission and is estimated only for state-years using the revised birth certificate. "Infant Morbidity (Unrevised)" is a composite outcome that includes meconium staining, birth injury, infant seizures, and ventilator use. As several components were phased out with the 2003 revision, this measure is constructed using only state-years with unrevised birth certificates (last available in 2006 for some states). Higher values indicate worse infant health. The APGAR score measures the infant's condition five minutes after birth and ranges from 0 to 10, with higher scores indicating better health. It is based on skin color, heart rate, reflexes, muscle tone, and breathing effort. All regressions include county-of-residence fixed effects, urban group-by-year fixed effects, and county-level time-varying covariates: female population shares in 5-year age bands, per-capita personal income, per-capita government transfers, and the employment-population ratio. ***, **, *, $^{+}$ indicate significance at the 0.1%, 1%, 5%, and 10% levels, respectively.

B Online Survey

UC **SANTA BARBARA**

Version 1

By checking the "Yes" box below, I understand that my participation in this survey is voluntary and that I am free to withdraw at any time, without giving a reason and without penalty.

☐ Yes

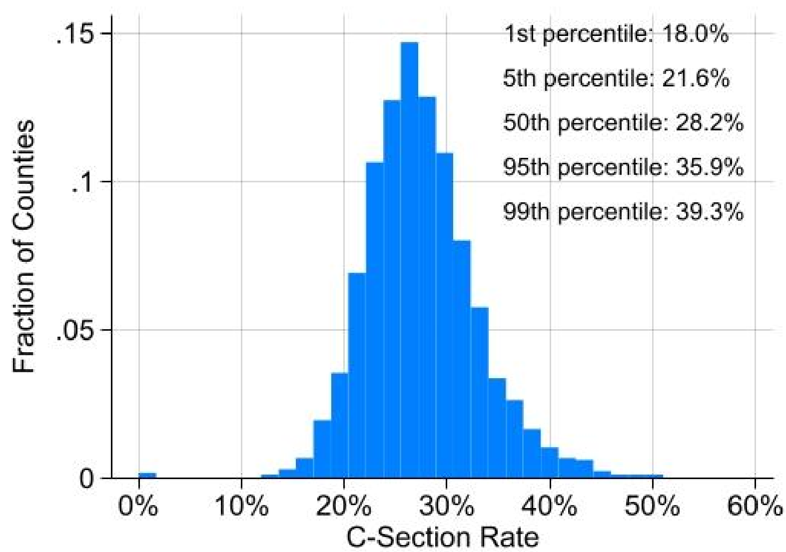
First and Last Name

Email Address

Primary Affiliation

Background: There is substantial variation in C-section rates across counties. The causes of these differences are unclear.

First Birth C-Section Rates Across US Counties - 2019 (Counties with More 100 Births)

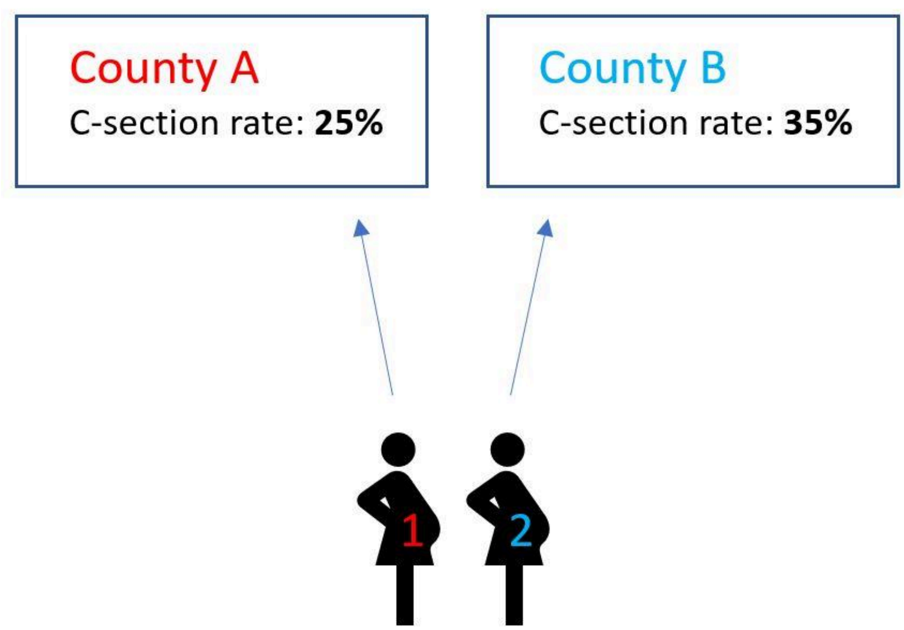


Consider the following scenario with 2 identical mothers who live in the same place. Mother 1 is randomly assigned to give birth in County A and Mother 2 is randomly assigned to County B.

The C-section rates between County A and B may differ due to many factors, including

(a) **healthcare providers (hospitals, healthcare personnel)**, including hospital ownership structure, physician training, reimbursement rates, etc.

(b) **patient characteristics**, including preferences and risk factors



On average, how much more likely do you believe Mother 2 is to have a C-section compared to Mother 1? Please give a response ranging from 0 to 10 percentage points.

Choosing the **"0 percentage points"** option implies that the 2 women are equally likely to have a C-section, and thus **none of the C-section rate variation** across counties is attributable to healthcare providers.

Choosing the **"5 percentage points"** option implies that the probability that Woman 2 has a C-section is 5 percentage points higher than Woman 1, and thus **half of the C-section rate variation** across counties is attributable to healthcare providers.

Choosing the **"10 percentage points"** option implies that the probability that Woman 2 has a C-section is 10 percentage points higher than Woman 1, and thus **all of the C-section rate variation** across counties is attributable to healthcare providers.

	0	1	2	3	4	5	6	7	8	9	10	
Percentage point difference:												0.5

Why did you give this answer? Briefly explain.

Version 2

By checking the "Yes" box below, I understand that my participation in this survey is voluntary and that I am free to withdraw at any time, without giving a reason and without penalty.

☐ Yes

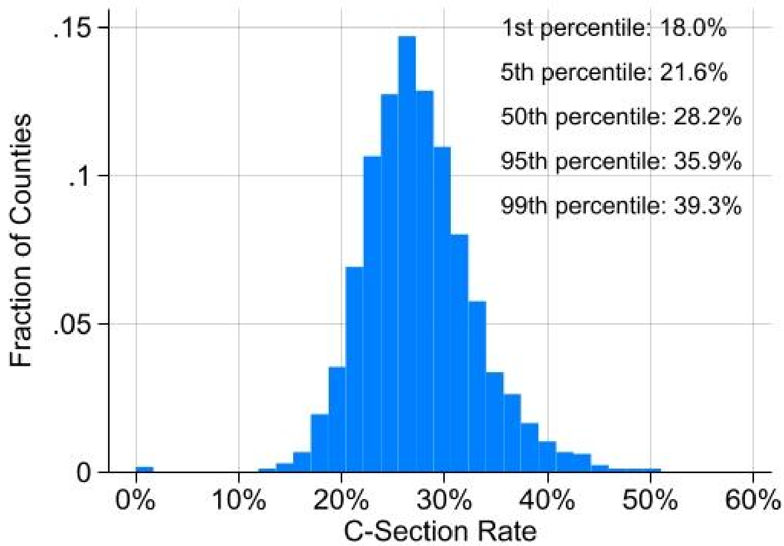
First and Last Name

Email Address

Primary Affiliation

Background: There is substantial variation in C-section rates across counties. The causes of these differences are unclear.

First Birth C-Section Rates Across US Counties - 2019 (Counties with More 100 Births)



Consider the following scenario with 2 identical mothers who live in the same place. Mother 1 is <u>randomly assigned</u> to give birth in County A and Mother 2 is <u>randomly assigned</u> to County B.

The C-section rates between County A and B may differ due to many factors, including

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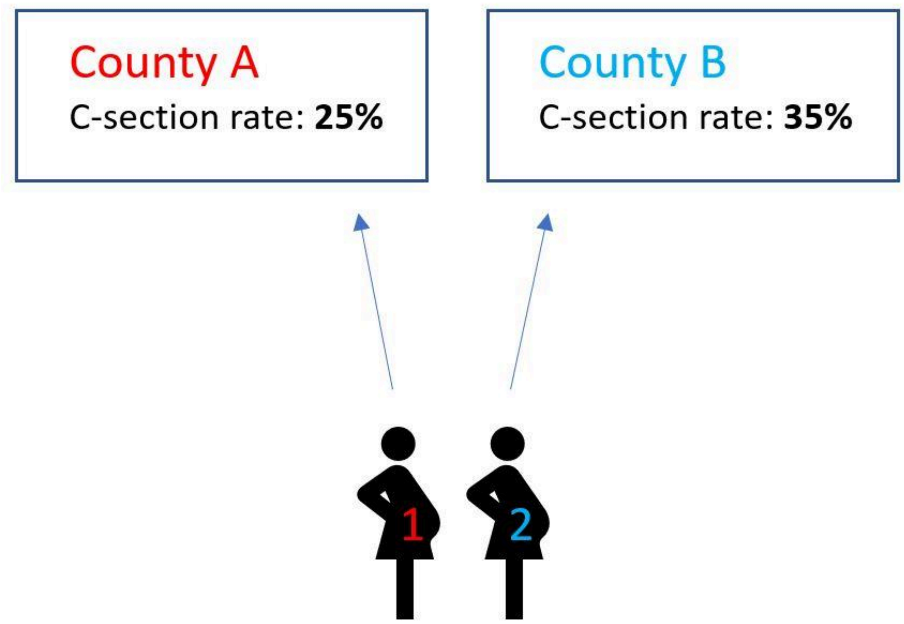
(b) **patient characteristics**, including preferences and risk factors



On average, how much more likely do you believe Mother 2 is to have a C-section compared to Mother 1? Please give a response ranging from 0 to 10 percentage points.

Choosing the **"0 percentage points"** option implies that the 2 women are equally likely to have a C-section, and thus **none of the C-section rate variation** across counties is attributable to healthcare providers.

Choosing the **"10 percentage points"** option implies that the probability that Woman 2 has a C-section is 10 percentage points higher than Woman 1, and thus **all of**

the C-section rate variation across counties is attributable to healthcare providers.

	0	1	2	3	4	5	6	7	8	9	10	
Percentage point difference:												0.5

Why did you give this answer? Briefly explain.

Version 3

By checking the "Yes" box below, I understand that my participation in this survey is voluntary and that I am free to withdraw at any time, without giving a reason and without penalty.

☐ Yes

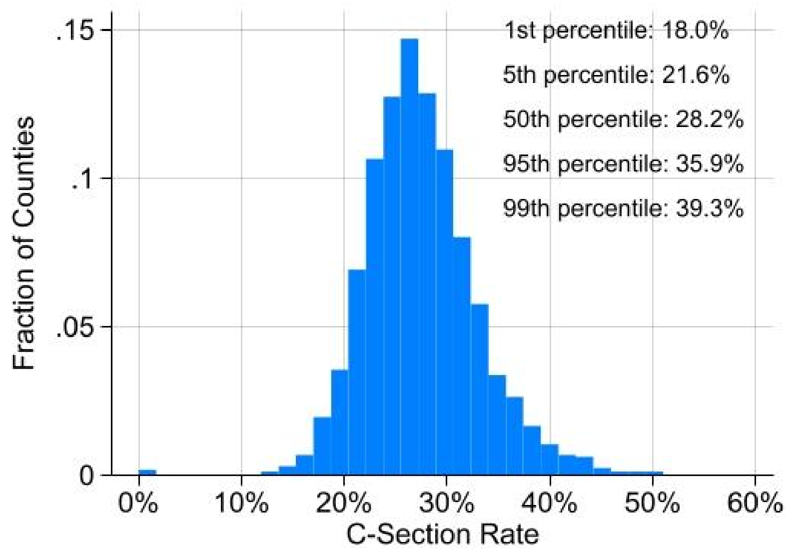
First and Last Name

Email Address

Primary Affiliation

Background: There is substantial variation in C-section rates across counties. The causes of these differences are unclear.

First Birth C-Section Rates Across US Counties - 2019 (Counties with More 100 Births)



What percentage of the differences in county C-section rates do you believe is **causally** due to **healthcare providers** (hospitals, healthcare personnel)?

	0	10	20	30	40	50	60	70	80	90	100	
Percentage due to providers?												5

Why did you give this answer? Briefly explain.