Panel data models: case study

Instructor: Mengcen Qian
School of Public Health
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Case material

Heather Royer, 2009. "**Separated at Girth: US Twin Estimates of the Effects of Birth weight**," *American Economic Journal: Applied Economics*, vol. 1., no. 1.

Motivation

The fetal origins hypothesis

"A fetus faced with a compromised intrauterine environment not only would ***slow down*** *its growth to reduce nutritional requirements but also might* ***make developmental adaptations*** *by modifying its structure and physiology in a durable fashion, leading to a higher risk of developing* ***chronic diseases*** *in later life."*

Economic implication

programs that aim to improve prenatal environment ⇒ large returns for both current & future generations on { long-run health; human capital; wage }

↓

often ignored

underinvestment in these programs

Motivation (cont.)

Empirical difficulties

fetal origins effects are unobserved → What about observed birth weight?

not casual effect!!!

strongly associated with socioeconomic status (SES) & genetic makeup

Two empirical strategies

Approach 1

exploiting historical events, which altered the in utero environment through starvation, stress, and/or sickness

natural experiment

Approach 2

twin or sibling comparisons, relating with-in-twin or with-in-sibling pair differences in birth weight to differences in the twins' (siblings') long-run outcome

twin is a near ideal counterfactual

Motivation (cont.)

Random assignment experiments & natural experiments

Random assignments solve ***selection problems***. When medical researchers want to examine the effect of a new drug, they use a random assignment experiment design. In such experiments, two groups are chosen ***randomly***:

Grouping is not based on the characteristics of individuals.

① Treatment group: receives the treatment (say, a specific medicine)
② Control group: receives a harmless, ineffective placebo

Then, we would be able to estimate the causal effect of the treatment by

$$\text{Outcome}_i = \beta_0 + \boldsymbol{\beta_1}\text{Treatment}_i + \varepsilon_i$$

where "Treatment$_i$" is a dummy variable equal to 1 for individuals in treatment group and 0 for individuals in the control group.

Motivation (cont.)

Random assignment experiments & natural experiments (cont.)

Natural experiments or ***quasi-experiments*** are similar to random assignment experiments, except:

> Observations fall into treatment and control groups "naturally" because of ***an exogenous event*** instead of being randomly assigned by the researcher

> the event must not be under the control of either control or treatment group

Research question

Research objectives

To provide evidence for fetal origins effect, especially on non-health endpoints.

Research question

We use birth weight as a proxy for nutrients intake. This study uses within-twin-pair comparisons to estimate the short- and long-run effects of birth weight.

Several potential threats to the validity of the results

postnatal investment by parents ⇦ hard to measure

- *If **compensating behavior** (invest more on child with lower birth weight child)* → ***underestimate***
- *If **reinforcing behavior** (invest more on child with larger birth weight child)* → ***overestimate***

omitted variable bias

non-random sample selection ⇦ Strong fetal origins effect may lead to early mortality, thus prevents us to observe such individuals in the sample

sample selection issue

Empirical model

As a proxy for fetal nutrient intake, we rely on birth weight, arguably the best measure of fetal nutrients. In order to interpret the results as a test of the fetal origins hypothesis, the assumption that the birth-weight discrepancies result from differences in fetal nutrition intake.

A cross-sectional model

To describe the empirical approach, we begin with a simple linear relationship between birth weight and long-run outcomes

$$\underbrace{y_{ij}}_{\text{outcomes for individual } j \text{ born to mother } i} = \alpha + \underbrace{bw_{ij}}_{\text{birth weight}}\beta + \underbrace{\boldsymbol{x_{ij}}}_{\text{a vector of observable characteristics}}\boldsymbol{\delta} + \varepsilon_{ij}$$

Due to omitted variables issues, cross-sectional estimates are biased. **Family upbringing** and **genetics** are two examples of such confounding influences.

The two factors are unlikely to be changed by policy, thus policies aimed at increasing birth weight would be ineffective.

The interest in birth weight as a policy target is not due to its correlation with other factors but to its direct effect.

Empirical model (cont.)

Suppose that the only confounders leading to an inconsistent estimate of β are family background and genetics. We rewrite the error term as

$$\varepsilon_{ij} = h(f_i, g_{ij}) + u_{ij},$$

a classical error term

where h is a flexible function of family background f_i and genetics g_{ij}.

A fixed-effect model

If identical twins share the same genetic composition and family background, f_i is the same for both twins and g_{i2} equals g_{i1}. Then, by taking twin differences of cross-sectional equation, we can consistently estimate β.

a fixed-effect model

$$y_{i2} - y_{i1} = (bw_{i2} - bw_{i1})\beta + (\boldsymbol{x}_{i2} - \boldsymbol{x}_{i1})\boldsymbol{\delta} + u_{i2} - u_{i1}$$

In the above equation, the effect of birth weight on y_{ij} is identified based on differences in birth weight within each twin pair holding fixed factors that are shared by the twin pair. Such fixed factors include gestational length and maternal prenatal behavior.

Data

The primary twins dataset

California birth records, 1960-2002:

maternal & paternal demographics, infant health, birth order, & plurality;
the mother's and child's name

used for matching

original data

If the individual grew up and gave births during this period, we would also be able to observe her adult outcome as her child's birth record shows her information.

matching condition

This selection is problematic only to the extent that within-twin-pair differences in birth weight are correlated highly with within-twin-pair differences in the probability of later observation.

Same sex, female twins born between 1960-1982.

final sample

Data (cont.)

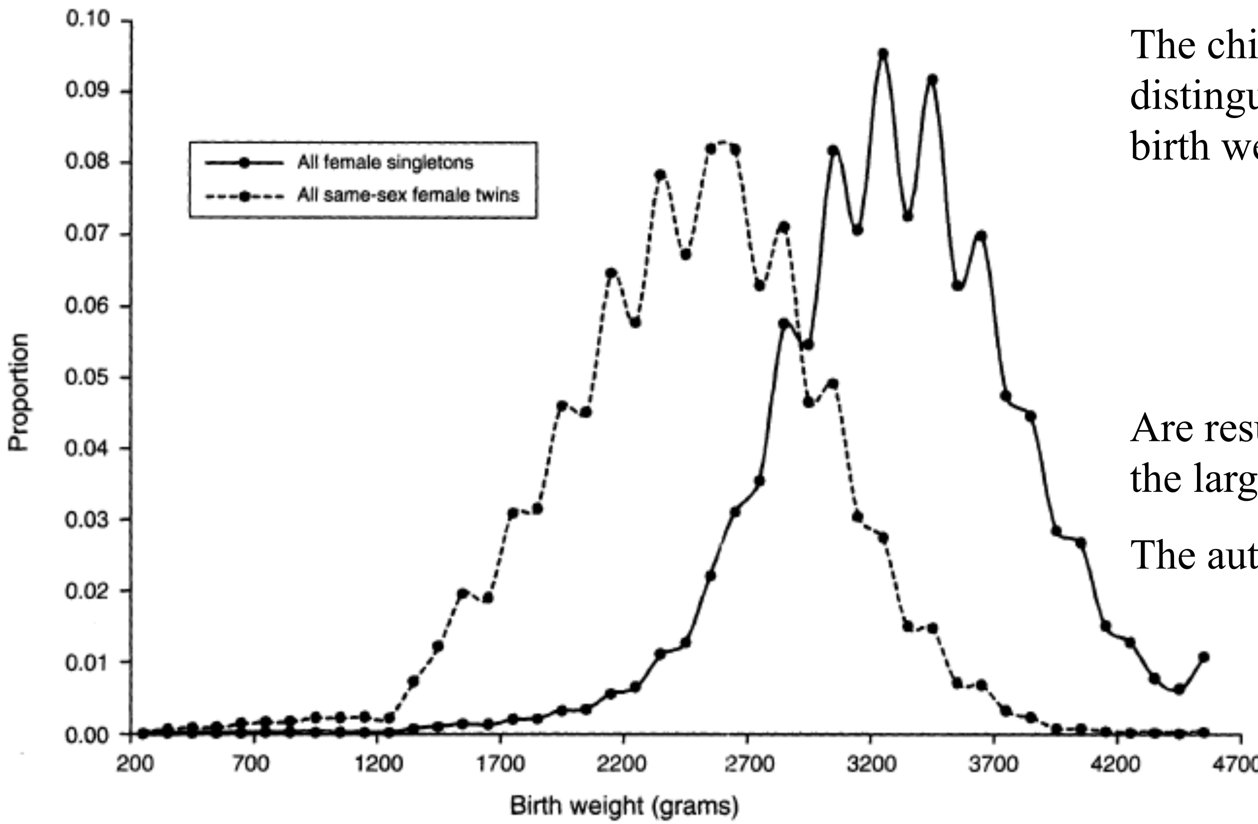


FIGURE 1. DISTRIBUTION OF BIRTH WEIGHT—FEMALE SINGLETONS AND FEMALE TWINS

Notes: The sample includes females born between 1960 and 1982 in California unconditional on whether they had a later observed birth.

The chief characteristic that distinguishes singletons and twins is birth weight.

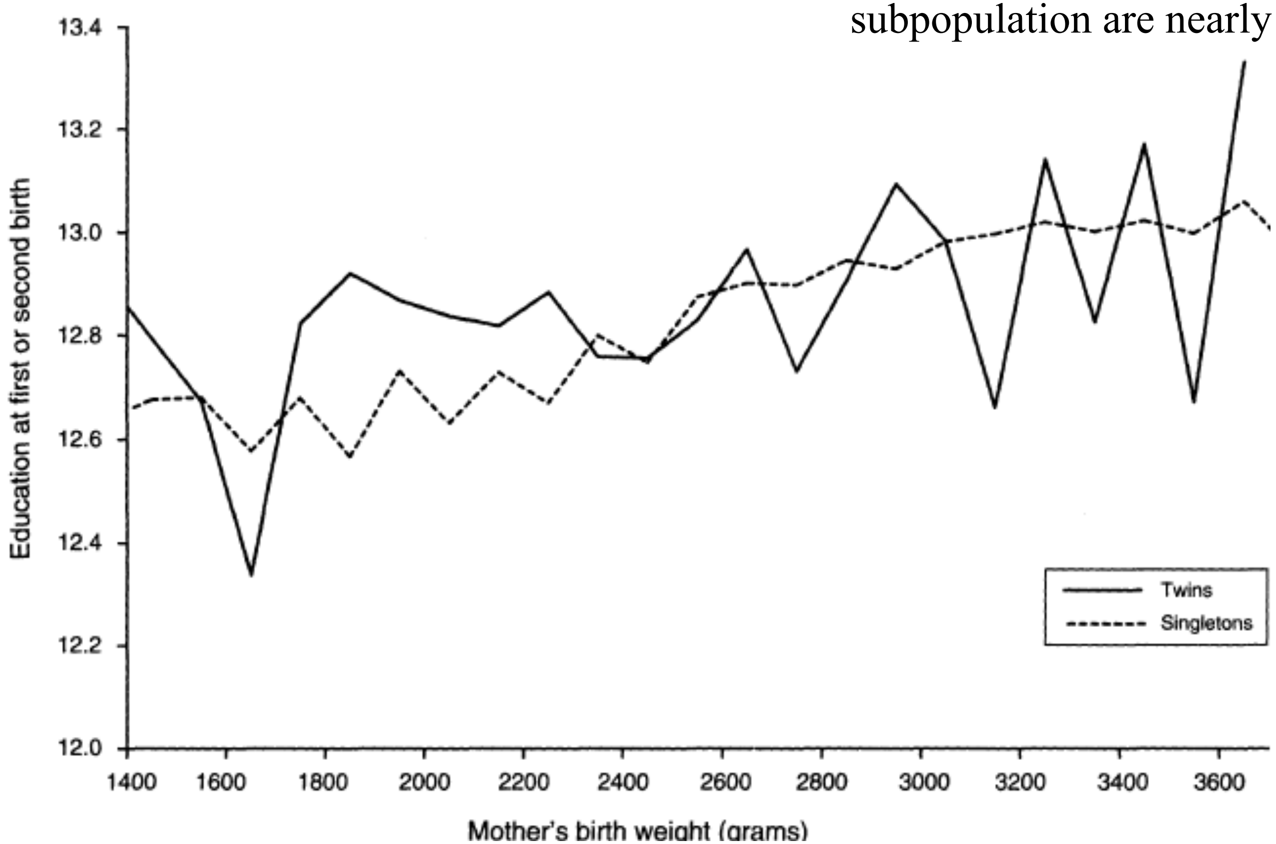
Are results if twins generalizable to the larger non-twin population?

The author also proves that later!!!

Results

Plots of relationships between birth-weight and education

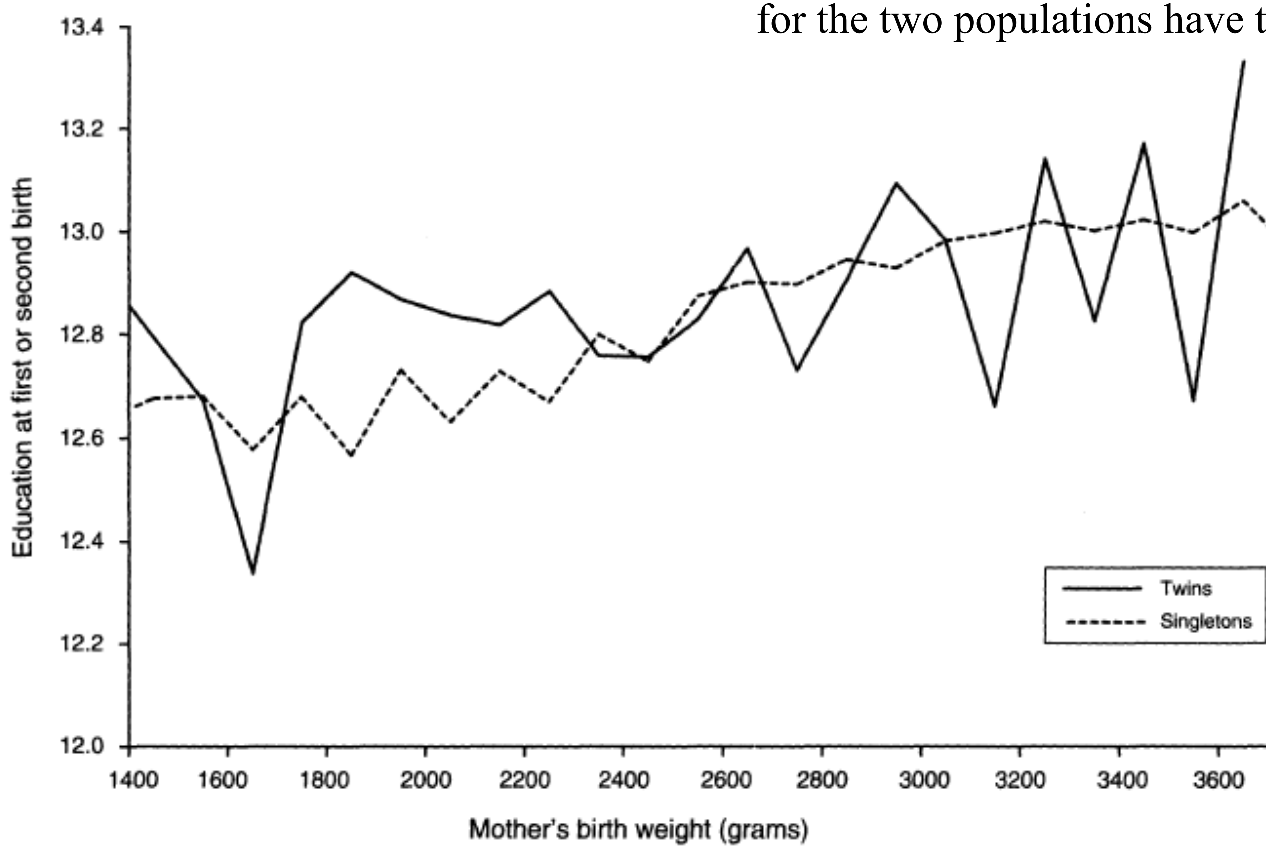
The heavier a female is at birth, the more education she obtains. This is true for both singletons and twins. Moreover, the response functions for each subpopulation are nearly identical.



Results (cont.)

Plots of relationships between birth-weight and birth weight of offspring

Note, that conditional on birth weight, the birth weight of a twin's off spring exceeds the birth weight of a singleton's offspring. Most importantly, however, the response functions for the two populations have the same slopes.

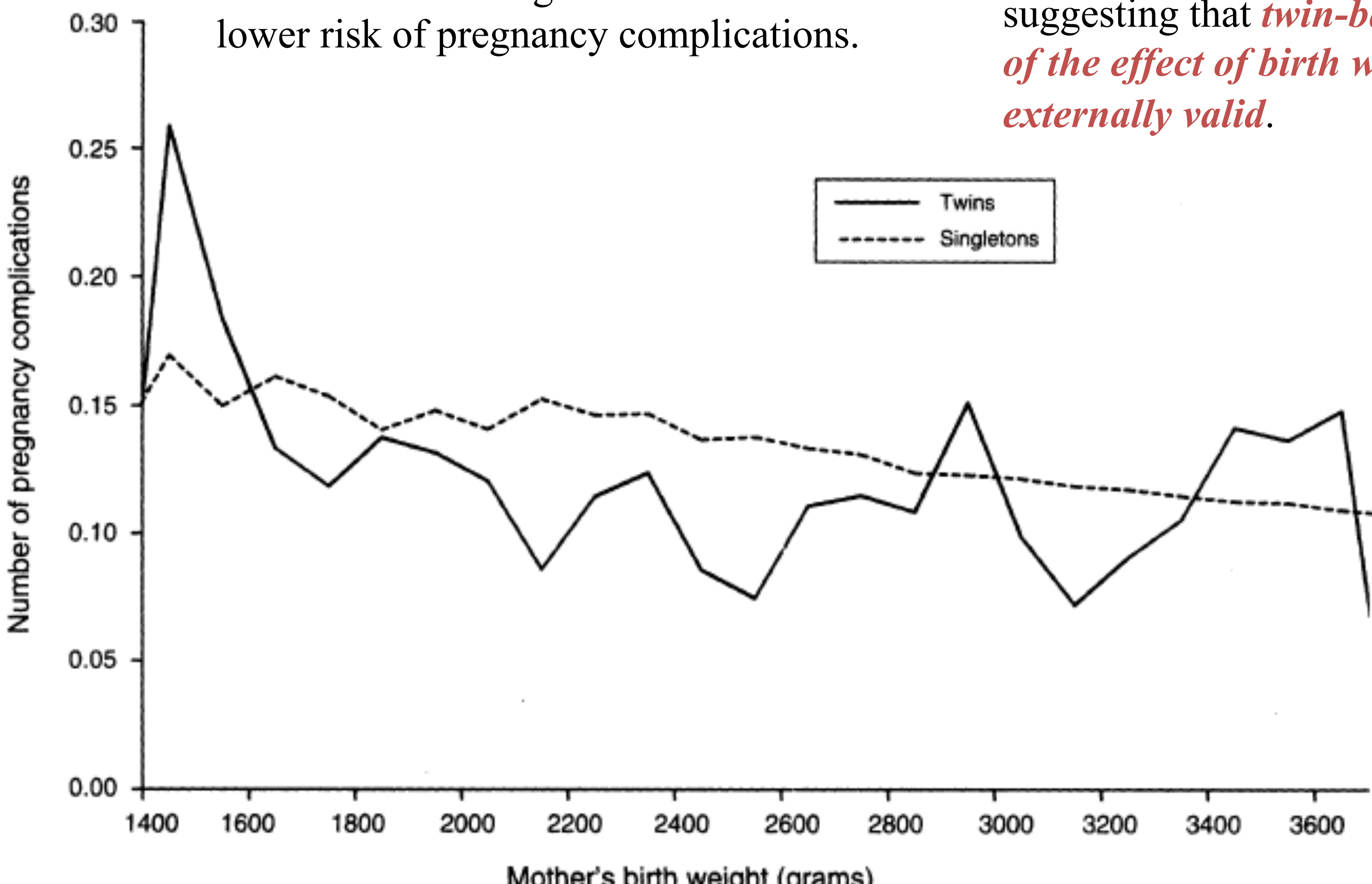


Results (cont.)

Plots of relationships between birth-weight and number of pregnancy complications

A heavier birth weight is associated with a lower risk of pregnancy complications.

Across all three outcomes, these response functions are strikingly alike for both singletons and twins, suggesting that ***twin-based estimates of the effect of birth weight may be externally valid***.



Results (cont.)

Regression estimates

Panel A

Infant mortality		Education					
Death within first year		Maximum education		Mean education		Education at birth	
Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE
−0.18	−0.02	0.19	0.13	0.19	0.16	0.19	0.16
(0.004)	(0.004)	(0.05)	(0.08)	(0.05)	(0.07)	(0.06)	(0.08)
Mean: 0.06		Mean: 13.09		Mean: 12.87		Mean: 12.87	

The twin fixed-effect estimate is one-tenth the size of the cross-sectional estimate.

The fixed-effects estimates for education imply that a one kilogram increase in birth weight leads to a 0.13 to 0.16 of a year increase in educational attainment. These coefficients are 15 to 30 percent smaller than the cross-sectional coefficients. The direction of bias in the cross-sectional estimates is as predicted.

Policy implication: a realistic policy (increase birth weight from 200 to 250 grams) would only lead to a 0.03 to 0.04 in years of schooling, which hardly seems like a cost-effective investment.

Results (cont.)

Regression estimates (cont.)

These outcomes test most directly the fetal origins hypothesis (i.e., the effect of on chronic condition).

Birth and adult health outcomes

Child's birth weight (in grams)		Gestational length (in days)		Hypertension		Diabetes	
Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE
177.87	70.42	2.42	0.87	−0.004	−0.02	−0.005	−0.002
(14.72)	(30.67)	(0.49)	(1.18)	(0.004)	(0.01)	(0.003)	(0.007)
Mean: 3,399.89		Mean: 277.19		Mean: 0.02		Mean: 0.01	
Anemia		**Number of pregnancy complications**		**Number of labor complications**		**Neonatal intensive care unit transfer**	
Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE
0.000	−0.003	−0.01	−0.05	0.01	0.01	−0.004	0.000
(0.0023)	(0.006)	(0.01)	(0.02)	(0.02)	(0.05)	(0.004)	(0.01)
Mean: 0.01		Mean: 0.11		Mean: 0.49		Mean: 0.02	

The cross-sectional estimates imply that a 100 gram increase in a mother's birth weight leads to an 18 gram rise in her child's birth weight.
Meanwhile, the fixed-effects estimates of suggest that this intergenerational transmission is much smaller-- roughly one-third the size of the cross-sectional OLS estimate.

However, it may be too early in the lifecycle to observe the birth weight on chronic conditions

Results (cont.)

Regression estimates (cont.)

Theories of fertility and mating predict: A rise in mother's education level leads to fertility delays and higher "quality" mates.

Improvements in education associated with increases in birth weight would lead to delayed childbearing and maternal selection of older and more educated mates?

Maternal and paternal characteristics

Maternal age (in days)		Father present		Paternal age (in days)		Paternal education	
Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE
−5.83	75.56	0.01	−0.003	24.73	69.34	0.27	0.19
(33.92)	(66.28)	(0.01)	(0.012)	(53.79)	(110.39)	(0.07)	(0.14)
Mean: 9,125.28		Mean: 0.96		Mean: 10,283.04		Mean: 12.89	

None of the effects of birth weight on mate "quality" are significant or large, but the effect of birth weight on paternal education parallels the analogous effect on maternal education, suggesting a large mating market effect of education.

Robustness check

Sample selection issue

A credible empirical test of the fetal origins hypothesis is difficult because of sample selection. In particular, this hypothesis predicts that individuals experiencing unfavorable in utero conditions may not survive into adulthood and thus, would not be observed in the data.

In our case, if a woman's birth weight affects her probability of later observation, the fixed effect estimates could be subject to sample selection bias.

TABLE 5—PROBABILITY OF OBSERVATION OF A LATER BIRTH AS A FUNCTION OF BIRTH WEIGHT

Dependent variable	At least one birth observed		First birth observed		Second birth observed		First or second birth observed	
	Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE	Pooled OLS	FE
Panel A: Linear model								
Birth weight	0.025 (0.004)	0.025 (0.008)	0.022 (0.004)	0.025 (0.008)	0.017 (0.003)	0.013 (0.007)	0.025 (0.004)	0.028 (0.008)
Panel B: Linear spline model								
Birth weight segment:								
<1,500 g	0.12 (0.02)	−0.01 (0.10)	0.13 (0.01)	−0.08 (0.09)	0.01 (0.01)	−0.04 (0.08)	0.12 (0.02)	−0.09 (0.10)
1,500–2,500 g	0.05 (0.01)	0.03 (0.02)	0.04 (0.01)	0.02 (0.01)	0.04 (0.01)	0.02 (0.01)	0.05 (0.01)	0.02 (0.02)
2,500–3,000 g	−0.02 (0.02)	0.04 (0.02)	−0.01 (0.01)	0.05 (0.02)	−0.01 (0.01)	0.02 (0.02)	−0.02 (0.02)	0.04 (0.02)
3,000g+	−0.02 (0.02)	0.002 (0.026)	−0.02 (0.02)	0.01 (0.02)	−0.01 (0.01)	−0.02 (0.02)	−0.01 (0.02)	0.02 (0.03)

Outcome variable is a dummy equal to 1 if the female is observed in the final sample.

A birth weight increase of 200 grams increases the probability of a later observed birth by 0.5 percentage points

Most of the sample selection appears to be the result of low birth weight infants dying in the first year of life.

Robustness check (cont.)

Sample selection issue (cont.)

To measure the extent to which this sample selection potentially biases the twin fixed-effects estimates, I perform a series of "nonparametric" tests.

Methods:

First, I test whether the effect of birth weight on the probability of later observation is the same across birth cohorts.

Then, I test whether the effect of birth weight on the long-run outcomes is identical for these same cohorts.

Intuition:

The intuition is that if I find that the effect of birth weight on the probability of being observed later differs across cohorts, there should be heterogeneous effects of birth weight on long-run outcomes across birth cohorts in the presence of sample selection bias.

If instead the effects of birth weight on long-run outcomes are identical across cohorts but the effects of birth weight on selection into the sample are not, then sample selection bias may not be an issue.

Results:

In this case, I am able to reject strongly that the effect of birth weight on the probability of later observation is the same across cohorts. I am unable to reject the null hypothesis that the long-run effects of birth weight are identical across cohorts.

Conclusion

The results of this nonparametric test suggest that sample selection bias is not problematic.

Robustness check (cont.)

Postnatal investments

The long-run effects of birth weight we estimated represent the effects of birth weight throughout a women's life, including postnatal investment by her parents and her health care providers. Such parental investments may obfuscate identification of the biological effect of birth weight

Methods

Measuring postnatal investments is difficult in the birth records. For this reason, rather than measuring whether investments are responsive to birth weight, I use the birth records to examine whether the effects of birth weight differ across different families that may have varying abilities to invest in one twin versus another.

For instance, it is plausible that the potential for parents to treat each twin differently varies by family size. A large family with limited resources may be unable to treat each twin differently, and thus, estimates based on ***large families*** may be closer to the ***true biological effect of birth weight***.

Define a ***large family dummy***, which equal to 1 if the twins have two elder siblings. ⇨ Add the interaction term ***large family * birth weight*** into the regressions.

Results

Generally, equal resources are devoted to each twin.

Findings & conclusions

The fetal origins hypothesis asserts that nutrient deprivation in utero can raise chronic disease risk. Within economics, this hypothesis has gained acceptance as a leading explanation for the correlations between birth weight, a proxy for fetal nutrient intake, and adult outcomes.

Exploiting birth-weight differences between twins using a newly created dataset of twins from 1960-1982 California birth records, ***I find birth weight is related to educational attainment, later pregnancy complications, and the birth weight of the next generation***. These effects are generally small.