

# Career Cost of Parenthood, Selective Fertility, and Dynamic Effects

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# Motivation

Parenthood is often said to be the main cause of gender inequality in the labor market

- ▶ “Not surprisingly, children are the **main contributors** to women’s labor supply changes.” (Goldin, 2014)
- ▶ “...the **remaining gender disparities** in labor market outcomes are related to the fact that **children** impose significantly larger penalties on the career trajectories of women compared to men.” (Cortés & Pan, 2023)
- ▶ “The **effects of parenthood** (...) account for **most** of the observed **gender inequality** in labor market outcomes” (Kleven et al., 2023)

# Causal Identification Has Proven Challenging

Fertility is endogenous

- ▶ Human capital, wealth, health, career prospects, the cost of parenthood

Effects of parenthood are dynamic

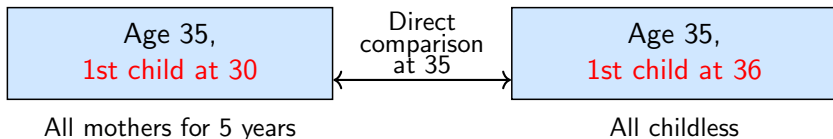
- ▶ Time spent in parenthood, career stage and age at the time of becoming a parent

**Leading methods address one or the other**

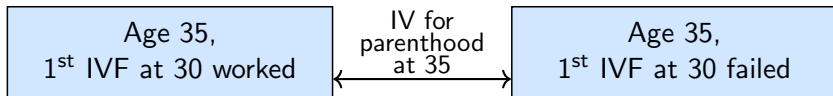
## ES and IV-IVF

“Some of the most compelling evidence of the crucial role children (...) has been produced over the past few years” (Bertrand, 2020)

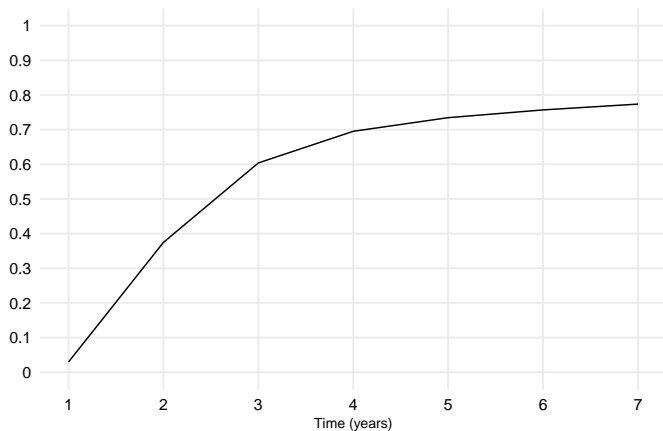
Event study (Kleven, Landais, & Sørensen, 2019):



IV-IVF (Lundborg et al., 2017):



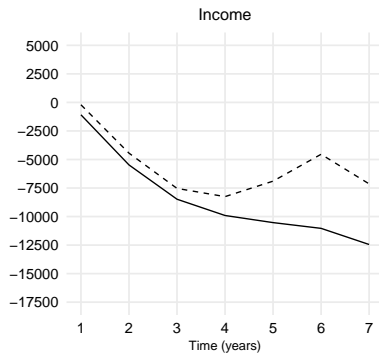
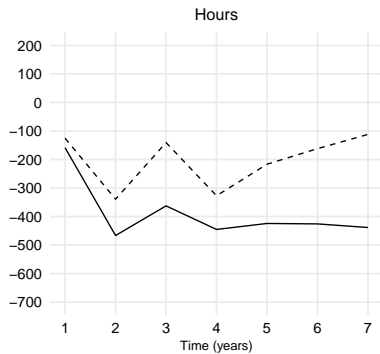
# Motherhood After 1<sup>st</sup> Procedure Fails



$$\tau_{RF} = 0.25\tau_{Parenthood} + 0.75\tau_{Earlier}$$

$$\tau_{IV} = \tau_{Parenthood} + 3\tau_{Earlier}$$

# IV vs ES



-- IV — ES

ES extern.

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  - ▶ Challenge: childless women are a selective group

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2. Empirical evidence using Dutch data
  - ▶ 1<sup>st</sup> success mothers vs 1<sup>st</sup> fail & childless
  - ▶ Challenge: childless women are a selective group
    1. Use full ACP histories to account for selection via ACPs
    2. Bounding to address remaining births
  - ▶ Only assumption: (cond.) random ACP outcomes

# Model

- ▶ Particular moment since woman's first ACP
- ▶ Outcome when motherhood begins at first ACP:

$$Y(1)$$

- ▶ Childless outcome:

$$Y(0)$$

- ▶ Outcome when motherhood begins after first ACP:

$$Y(\textit{later})$$

Counterfactuals discussion

## Model (cont.)

Women differ in:

- ▶ Willingness to undergo ACP,  $W$ 
  - ▶ Would try  $W$  times in case all ACPs fail (integer)
- ▶ Reliance on ACP,  $R$ 
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Parameter of interest:

$$\tau_{ATR} = \mathbb{E}[Y(1) - Y(0)|R = 1]$$

# Assumption

## Assumption (Sequential Unconfoundedness)

$$(Y(1), Y(0), R, W) \perp D_j | A \geq j$$

- ▶  $A$  - number of attempts
- ▶  $D_j$  - success of attempt  $j$

In words: once sperm/embryo at ACP  $j$  are implanted, whether this results in a conception is as-good-as-random

- ▶  $e = \Pr(D_j = 1 | A \geq j)$  for all  $j$  for illustration.

## Intuition: Childless Outcome $Y(0)$

1. Childless women  $\subset$  reliers
2. Not represent. (only) due to unobs. het. in will. to try ACPs

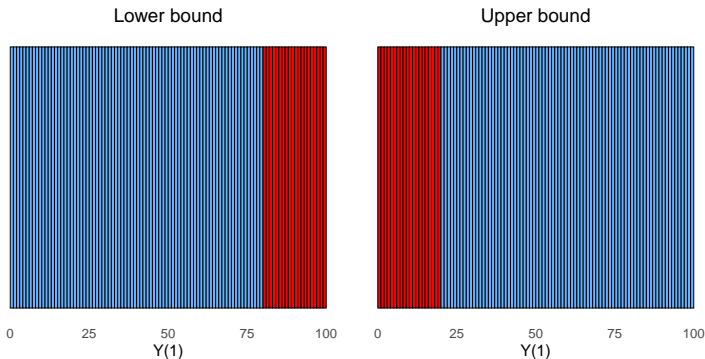
$$\Pr(C = 0 | R = 1, W = w) = (1 - e)^W$$

3. Observed number of ACPs is sufficient to account for it
  - ▶ Among childless  $A = W$
  - ▶ Higher weights to women who tried more

$$\mathbb{E} \left[ Y \frac{(1 - C)}{(1 - e)^A} \right] = \mathbb{E} [Y(0) | R = 1] \Pr(R = 1)$$
$$\mathbb{E} \left[ \frac{(1 - C)}{(1 - e)^A} \right] = \Pr(R = 1)$$

## Intuition: Motherhood Outcome $Y(1)$

1. Treated group is a rep. sample but their types are unobserved
2. Identify  $\Pr(R = 1) = 0.8$  on control group
3. Assume most extreme distributions of types in treated group
4. Bound  $\mathbb{E}[Y(1)|R = 1]$





# Background

## Assisted conception procedures

- ▶ IUI (primary procedure): sperm injected into uterus
- ▶ IVF (secondary procedure): embryo inserted into uterus

## Data

- ▶ Dutch administrative data
- ▶ Labor market outcomes from 2011 to 2022

ACPs

Data

# Results: Bounds

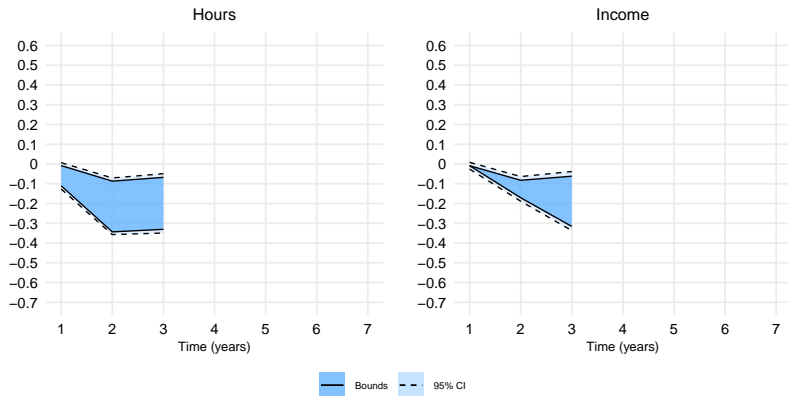


Figure 1: Bounds - short run

Baseline Lee bounds

Absolute effects

# Results: Bounds

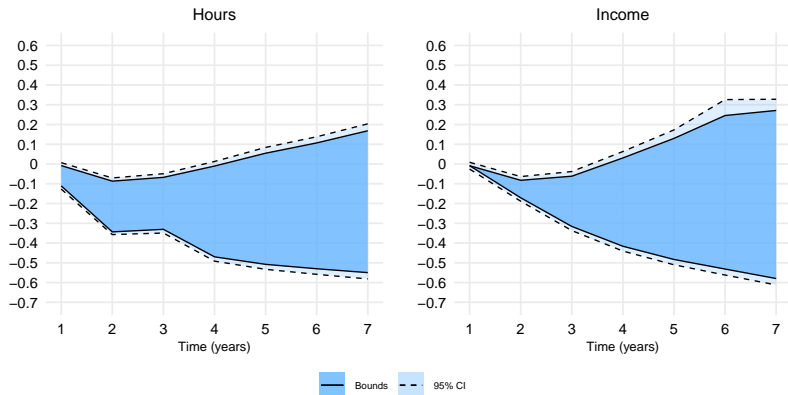


Figure 2: Bounds - medium run

Baseline Lee bounds

Absolute effects

# Monotonicity

- ▶ Some women whose first ACP succeeds eventually conceive more children without ACP
- ▶ It may be reasonable to assume that they would have eventually conceived at least one child if all ACPs had failed

Plausibility discussion

Benefit of monotonicity

Graphic intuition

# Bounds with Monotonicity

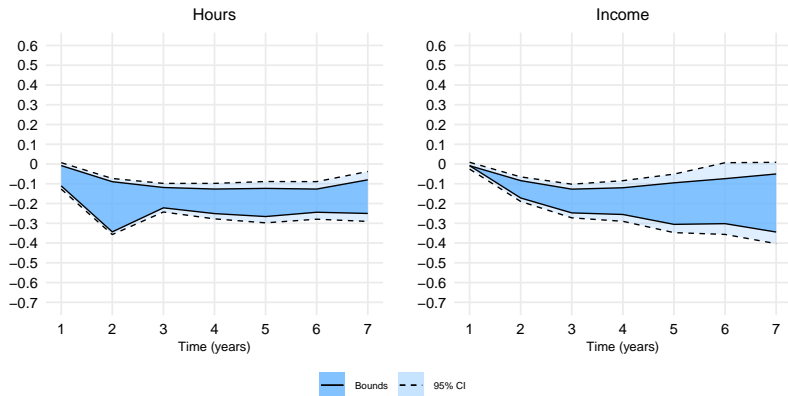


Figure 3: Bounds for percent effects

Absolute

How wide?

# Bounds with Monotonicity - Gender Inequality

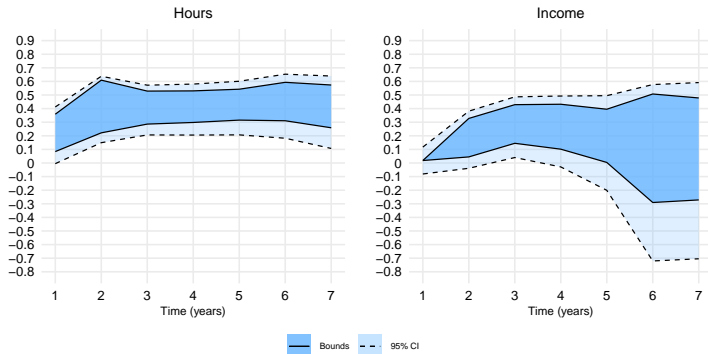


Figure 4: Share of gender inequality caused by parenthood

# Conclusion

- ▶ Method for evaluating the career cost of children robust to selective fertility and dynamic effects
  - ▶ Applicable to settings with sequential treatment assignment and non-compliance
- ▶ Application to Dutch data:
  - ▶ Sizable career impacts of motherhood
  - ▶ Parenthood causes at most 56% (44%) of gender inequality in post-child work hours (earnings)
- ▶ Comparison to existing approaches
  - ▶ IV-IVF might overstate penalty in the short run
  - ▶ ES might overstate penalty in both short and medium run

# Extensions

## Outcomes:

- ▶ Fatherhood Absolute Percentage
- ▶ Decomposing gender inequality Share explained by children
- ▶ Effect of delaying motherhood Absolute Cumulative

## Existing estimators:

- ▶ Are existing estimates biased? Naive IV-IVF equiv. Plac. ES Place. ineq.
- ▶ Are estimates less informative than existing? Confidence intervals

## Robustness:

- ▶ Bias due to depression Counterfact. Depr. effect Bounds non-depr. Arguments
- ▶ Inequality correcting for age De-aging partners
- ▶ Stable complier group Childless final period
- ▶ Estimator without DML Identification Effects
- ▶ Relaxing monotonicity Direction Partnered only

## Other:

- ▶ Heterogeneity Covariates Willingness to try
- ▶ Population imputation\* ES pop. Mother. imp. Childless imp. Effect imp. Gap



# Appendix

Literature

Identification Math

Treatment Success

Balance

Type Shares

Trimming Shares

Monotonicity

Bound Width

Extensions

Application to Other Settings

References

## Related Literature

Gender inequality in labor market outcomes.

- ▶ Bertrand (2011); Blau & Kahn (2017) for review.

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Main methodological ideas closely related to:

- ▶ Van den Berg & Vikström (2022): sequential treatment assignment.
- ▶ Lee (2005); Zhang & Rubin (2003): bounds with missing data.

[Back](#) [Literature](#)

## Bensnes et al. (2023); Gallen et al. (2023)

Main idea:

1. Estimate effect in first period after treatment (while there are no later-mothers)
2. For individuals who are treated in second period, plug in estimate from the first
3. Repeat for all periods . . .

Required (intuitive) assumptions:

1. Effect must be similar between women who do and who do not enter motherhood later
2. Effect cannot vary over the life-cycle

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## Literature (cont.)

Parenthood, labor market outcomes, and gender equality:

- ▶ Event studies: Angelov et al. (2016); Chung et al. (2017); Kleven, Landais, Posch, et al. (2019); Eichmeyer & Kent (2022),
- ▶ Abortion access: Miller (2011); Brooks & Zohar (2021)
- ▶ Infertility: Agüero & Marks (2008); Cristia (2008)
- ▶ Sibling sex mix: Angrist & Evans (1996); Iacovou (2001); Cruces & Galiani (2007); Maurin & Moschion (2009); Hirvonen (2009)
- ▶ Twins: Rosenzweig & Wolpin (1980); Bronars & Grogger (1994); Jacobsen et al. (1999); Vere (2011)
- ▶ Miscarriages: Hotz et al. (2005)

Methodological paper on dynamic compliance and treatment effects:

- ▶ Heckman et al. (2016); Han (2021); Van den Berg & Vikström (2022)

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Extrapolation requires carefully addressing mental health consequences of failure (and medical procedures)

[Back \(model\)](#) [Back \(extensions\)](#) [Depr. effect](#) [Bounds non-depr.](#) [Arguments](#)

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# Estimator Intuition: Math with Coins

- ▶ Each individuals flips a coin once
- ▶ Some may chose to flip again if heads come up
- ▶ Number of flips ( $P$ ) observed
- ▶  $Y$  only revealed for those who never flip heads

$$\mathbb{E}[Y] = \mathbb{E}\left[\frac{1}{(1/2)^P} Y \mathbf{1}_{\{\text{no heads}\}}\right]$$

Back

# Formal Identification

$$\Delta_L = \mu_L - \mu_C$$

$$\Delta_U = \mu_U - \mu_C$$

$$\mu_C = \mathbb{E} \left[ \frac{Y}{\prod_j^P (1 - p_j(X_j))} \middle| \mathbf{1}_{Child} = 0 \right] \mathbb{E} \left[ \prod_j^P (1 - p_j(X_j)) \middle| \mathbf{1}_{Child} = 0 \right]$$

$$\mu_L = \mathbb{E} \left[ \frac{Y}{p_1(X_1)} \middle| D_1 = 1, Y < y(1 - s) \right] \mathbb{E} [p_1(X_1) | D_1 = 1, Y < y(1 - s)]$$

$$\mu_U = \mathbb{E} \left[ \frac{Y}{p_1(X_1)} \middle| D_1 = 1, Y > y(s) \right] \mathbb{E} [p_1(X_1) | D_1 = 1, Y > y(s)]$$

$$y(q) = G^{-1}(q)$$

$$G(q) = \mathbb{E} \left[ \frac{\mathbf{1}(Y \leq q)}{p_1(X_1)} \middle| D_1 = 1 \right] \mathbb{E} [p_1(X_1) | D_1 = 1]$$

$$s = \mathbb{E} \left[ \frac{\mathbf{1}_{Child}}{\prod_j^P (1 - p_j(X_j))} \middle| W = 0 \right] \mathbb{E} \left[ \prod_j^P (1 - p_j(X_j)) \middle| W = 0 \right],$$

where  $W = 1 - \prod_{j=1}^P (1 - D_j)$ .

# Narrowing the Bounds with Covariates (cont.)

Alternative extension of Lee bounds (to my knowledge)

- ▶ Take some function  $g(x)$
- ▶  $\mathbb{E}[g(X_1)|R = 1]$  can be identified on women who remain childless
- ▶ Take  $\mathbb{E}[Y(1)|R = 1] = \mathbb{E}[g(X_1) + \varepsilon|R = 1]$
- ▶ Only need to bound  $\mathbb{E}[\varepsilon|R = 1]$
- ▶  $g(X_1)$  can be directly chosen to minimize the spread in residuals, e.g. OLS of  $Y$  on  $X_1$  for women with  $D_1 = 1$ .
- ▶ Since residuals typically have a narrower distribution, this gives narrower bounds.
- ▶ Also, likely to improve asymptotic efficiency: only need to compare residuals in both groups,  $\mathbb{E}[g(X_1)|R = 1]$  is the same for treated and control.

[Back \(DML\)](#)

[Back \(extensions\)](#)

# Assisted Conception Procedures

## In vitro fertilization (IVF)

- ▶ Relatively invasive procedure performed under sedation/anesthesia
- ▶ ~25% success rate

## Intrauterine insemination (IUI)

- ▶ Sperm injected directly into the uterus.
- ▶ ~10% success rate
- ▶ First-line infertility treatment in most countries

I use the moment embryos/sperm are transferred into the uterus

Is success as-good-as-random?

Background

# Data

- ▶ Administrative data from Statistics Netherlands
  - ▶ Data on fertility treatments from 2013 to 2017
  - ▶ Labor market outcomes from 2011 to 2021
- ▶ Unlimited IUI and first 3 IVF attempts covered by mandatory insurance (later IVF attempts cost 2500-5000 Eur per cycle)
- ▶ Sample of opposite sex couples cohabiting before first IUI attempt

Balance

Treatment success

Success prob. change

Background

# Randomness in IUI and IVF

Treatment success is not completely random.



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Other (medical) factors relevant for IVF success appear to be largely unrelated to labor market outcomes (Lundborg et al., 2017).

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# Treatment Success

- ▶ I impute treatment success as having a child born within 10 months after treatment without subsequent treatments in between.
  - ▶ Validated to reflect medical records of treatment success (Lundborg et al., 2017).

Back

**Table 1:** First treatment outcomes and descriptives

	Success (1)	Fail (2)	Difference (1)-(2)	Dif. cond. age FE (1)-(2) cond. age
Work (W)	0.881 [0.324]	0.863 [0.344]	0.018 (0.009)	0.008 (0.009)
Work (P)	0.884 [0.320]	0.865 [0.341]	0.019 (0.009)	0.014 (0.009)
Hours (W)	1239.696 [605.070]	1208.255 [634.840]	31.441 (16.168)	17.578 (15.812)
Hours (P)	1473.383 [658.917]	1438.880 [695.345]	34.502 (17.699)	22.690 (17.587)
Income 1000s € (W)	28.049 [19.559]	27.434 [20.232]	0.615 (0.516)	0.942 (0.496)
Income 1000s € (P)	37.173 [26.484]	36.959 [29.443]	0.214 (0.746)	0.896 (0.732)
Bachelor deg. (W)	0.608 [0.488]	0.605 [0.489]	0.002 (0.013)	0.018 (0.012)
Bachelor deg. (P)	0.593 [0.491]	0.598 [0.490]	-0.004 (0.013)	0.008 (0.012)
Age (W)	31.643 [4.016]	32.384 [4.383]	-0.741 (0.111)	
Age (P)	34.672 [5.527]	35.459 [5.993]	-0.787 (0.152)	
Observations	1,716	13,788		
Joint <i>p</i> -val.			0.000	0.536

*Note:* Labor market outcomes measured year before first treatment. (W) - woman, (P) - partner. Standard deviations in brackets. Standard errors in parentheses.

# Balance in Later Treatments

Table 2: Balance in later treatments

	D2	D3	D4	D5	D6	D7	D8	D9	D10
Work (W)	0.013 (0.009)	-0.002 (0.010)	0.023 (0.011)	0.008 (0.012)	0.030 (0.013)	0.007 (0.014)	-0.008 (0.017)	0.016 (0.019)	0.041 (0.026)
Work (P)	0.011 (0.010)	0.014 (0.010)	0.005 (0.011)	0.014 (0.012)	-0.004 (0.013)	-0.008 (0.014)	0.001 (0.017)	0.016 (0.020)	0.040 (0.027)
Hours (W)	37.050 (17.373)	-0.615 (18.648)	45.477 (20.127)	39.327 (21.930)	68.596 (24.489)	25.780 (26.043)	-5.734 (31.176)	81.149 (36.869)	29.860 (49.101)
Hours (P)	29.074 (19.336)	28.347 (20.807)	18.441 (22.614)	35.597 (24.685)	-7.332 (27.215)	-15.344 (28.618)	0.360 (34.381)	47.511 (41.158)	49.279 (55.440)
Income 1000s € (W)	1.786 (0.548)	0.283 (0.592)	1.123 (0.647)	1.672 (0.710)	1.380 (0.786)	0.489 (0.831)	0.417 (1.030)	1.839 (1.240)	-0.297 (1.714)
Income 1000s € (P)	0.221 (0.820)	1.277 (0.846)	1.588 (0.923)	1.125 (1.018)	-0.542 (1.123)	-0.370 (1.212)	1.567 (1.423)	1.001 (1.666)	-0.202 (2.277)
Bachelor deg. (W)	0.002 (0.013)	0.026 (0.014)	-0.020 (0.015)	0.001 (0.017)	-0.003 (0.019)	0.003 (0.020)	0.023 (0.024)	-0.012 (0.028)	0.045 (0.038)
Bachelor deg. (P)	0.005 (0.013)	0.010 (0.014)	0.011 (0.016)	0.007 (0.017)	-0.003 (0.019)	0.013 (0.020)	0.020 (0.024)	0.012 (0.029)	-0.014 (0.039)
Age (W)	0.001 (0.011)	-0.007 (0.015)	-0.040 (0.019)	0.024 (0.023)	0.013 (0.026)	-0.001 (0.028)	-0.046 (0.036)	-0.027 (0.043)	-0.017 (0.059)
Age (P)	0.001 (0.011)	-0.007 (0.015)	-0.040 (0.019)	0.024 (0.023)	0.013 (0.026)	-0.001 (0.028)	-0.046 (0.036)	-0.027 (0.043)	-0.017 (0.059)
Observations	12,955	10,759	8,714	6,969	5,403	3,938	2,718	1,848	1,173
Joint <i>p</i> -val.	0.071	0.737	0.057	0.439	0.420	0.991	0.836	0.508	0.437

Note: Each column describes the differences between those treated successfully and those treated unsuccessfully at the respective treatment attempt conditional on fixed effects for age-at-treatment interacted with fixed effects for treatment type. Labor market outcomes and age measured year before first treatment. (W) - woman, (P) - partner. Standard errors in parentheses.

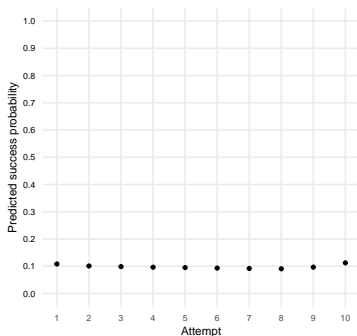
# Representative and Relevant Treatment group

Table 3: Full sample, relier sample, and representative sample

	Success (1)	Fail (2)	Reliers (3)	Representative (4)	Success vs rep. (1)-(4)	Rel. vs rep. (3)-(4)
Work (W)	0.882 [0.323]	0.863 [0.344]	0.820 [0.335]	0.800 [0.400]	0.082 (0.010)	0.020 (0.005)
Work (P)	0.884 [0.320]	0.865 [0.342]	0.849 [0.345]	0.782 [0.413]	0.103 (0.010)	0.068 (0.005)
Hours (W)	1240.315 [604.666]	1207.860 [635.194]	1117.711 [584.369]	1068.897 [698.712]	171.418 (16.915)	48.815 (8.442)
Hours (P)	1474.530 [658.231]	1438.590 [695.692]	1390.699 [663.944]	1242.166 [794.776]	232.364 (19.241)	148.533 (9.591)
Income 1000s € (W)	28.065 [19.559]	27.418 [20.219]	24.976 [15.080]	20.846 [17.990]	7.219 (0.436)	4.130 (0.218)
Income 1000s € (P)	37.205 [26.482]	36.952 [29.452]	35.299 [23.982]	27.471 [28.686]	9.734 (0.694)	7.828 (0.346)
Bachelor deg. (W)	0.480 [0.500]	0.451 [0.498]	0.398 [0.411]	0.411 [0.492]	0.069 (0.012)	-0.012 (0.006)
Bachelor deg. (P)	0.394 [0.489]	0.381 [0.486]	0.329 [0.397]	0.345 [0.475]	0.049 (0.012)	-0.015 (0.006)
Age (W)	31.638 [4.015]	32.388 [4.383]	33.480 [3.896]	28.375 [4.657]	3.263 (0.113)	5.105 (0.056)
Age (P)	34.675 [5.513]	35.461 [5.996]	36.580 [3.927]	28.375 [4.663]	6.300 (0.113)	8.205 (0.057)
Observations	1,714	13,809	4,882	376,157		

Note: Labor market outcomes measured year before first treatment for main sample and year and 9 months before birth of first child for representative sample. Representative sample selected to match main sample by year of conception. Relier sample consists of women who remain childless 7 years after their first ART attempt with weights described under implementation. (W) - woman, (P) - partner. Standard deviations in brackets. Standard errors in parentheses.

# Predicted Success Prob. per Treatment



**Figure 5:** Predicted success probability holding  $X$  fixed at first attempt average

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# Attempts

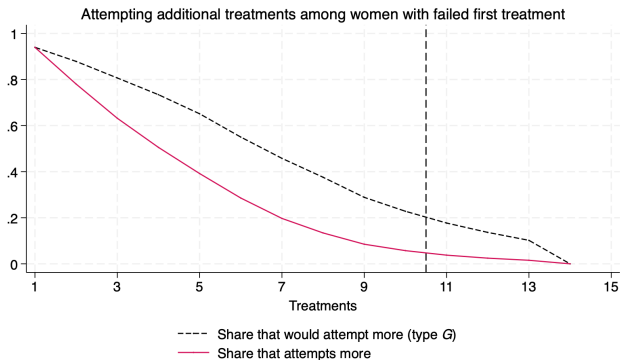


Figure 6: Number of treatments and type

# Non-treatment Conception by Type

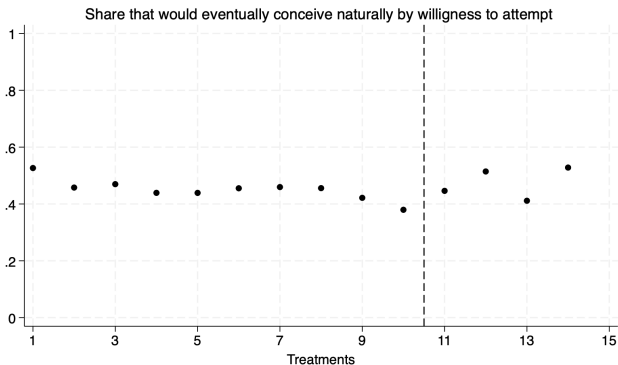


Figure 7: Conceiving naturally and willingness to attempt

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# Trimming shares

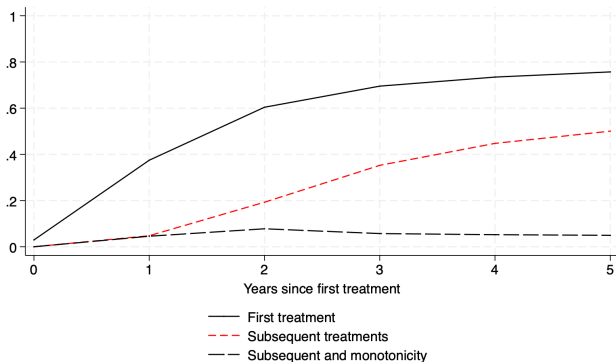


Figure 8: Trimming share under different information

# Correction Term

$$\begin{aligned} \text{corr}_L(\text{data}, \eta_0) &= q_1(s_0(X_1), X_1) \prod_{j=1}^P \frac{1 - D_j}{1 - e_j(X_j)} (S - s(0, X_1)) \\ &\quad - q_1(s_0(X_1), X_1) \frac{D_1}{e_1(X_1)} (1_{\{Y < q_1(s_0(X_1), X_1)\}} - s_0(X_1)) \\ &\quad - \frac{D_1 - e_1(X_1)}{e_1(X_1)} z_L^+(1, X_1) s(0, X_1) \\ &\quad + \sum_k \mathbb{1}_{P \geq j} \prod_j^{k-1} \frac{1 - D_j}{1 - e_j(X_j)} \frac{e_k(X_k) - D_k}{1 - e_k(X_k)} (s_k(0, X_k) \beta_k(0, X_k)) \\ &\quad + \sum_k \mathbb{1}_{P \geq j} \prod_j^{k-1} \frac{1 - D_j}{1 - e_j(X_j)} \frac{e_k(X_k) - D_k}{1 - e_k(X_k)} q_1(s_0(X_1), X_1) (s(0, X_1) - s_k(0, X_k)) \end{aligned}$$

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# Bounds: Absolute

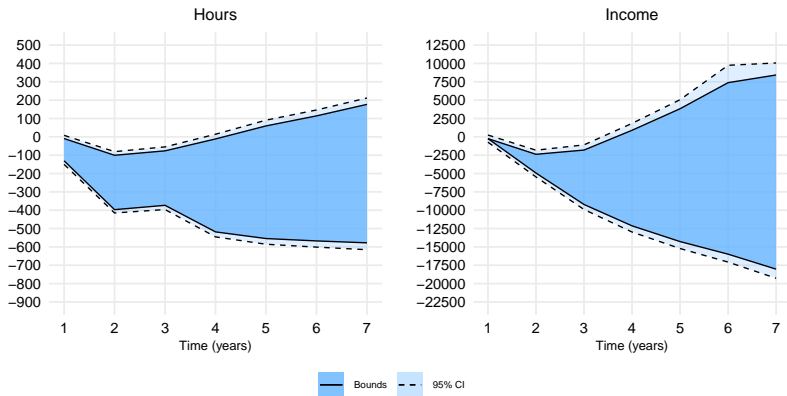


Figure 9: Bounds effects

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# Bounds: Hours - Comparison to Baseline Lee Bounds

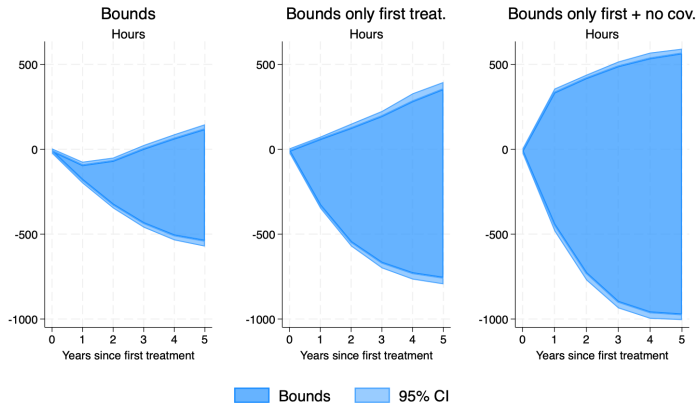


Figure 10: Comparison with baseline Lee: hours

# Bounds: Income - Comparison to Baseline Lee Bounds

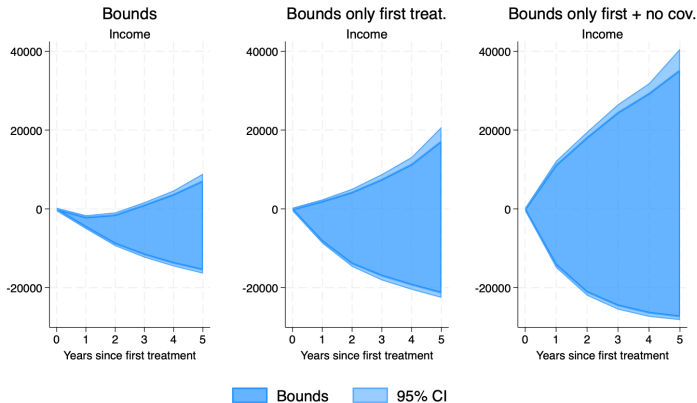


Figure 11: Comparison with baseline Lee: income

# Monotonicity (cont.)

Is monotonicity realistic?



## Monotonicity (cont.)

Is monotonicity realistic?

- ▶ Yes, if families are determined to have at least one child.
  - ▶ Decreasing marginal returns to children.
  - ▶ Stronger sufficient assumption: success cannot increase total (natural) births.

# Monotonicity (cont.)

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- ▶ Yes, if families are determined to have at least one child.
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  - ▶ Stronger sufficient assumption: success cannot increase total (natural) births.
- ▶ No, if first treatment success increases the likelihood of attempting to conceive naturally.

# Monotonicity (cont.)

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  - ▶ Couples may realize they are fertile and try more.

# Monotonicity (cont.)

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  - ▶ Couples may realize they are fertile and try more.
  - ▶ First child may “save the relationship” resulting in more attempts to conceive.

# Monotonicity (cont.)

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- ▶ Yes, if families are determined to have at least one child.
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  - ▶ Stronger sufficient assumption: success cannot increase total (natural) births.
- ▶ No, if first treatment success increases the likelihood of attempting to conceive naturally.
  - ▶ Couples may realize they are fertile and try more.
  - ▶ First child may “save the relationship” resulting in more attempts to conceive.
- ▶ Robustness: restrict to only couples that stay together

Effects

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Benefit of monotonicity

Graphic intuition

# Benefit of Monotonicity

- ▶ Women who conceive a second child naturally are not the women who would remain childless.

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- ▶ This restricts which women among successfully treated could have remained childless had all treatment attempts failed.

# Benefit of Monotonicity

- ▶ Women who conceive a second child naturally are not the women who would remain childless.
- ▶ This restricts which women among successfully treated could have remained childless had all treatment attempts failed.
- ▶ Narrower bounds.

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# Monotonicity: Intuition (1)

Identify distribution of motherhood outcomes from group whose first treatment succeeds:

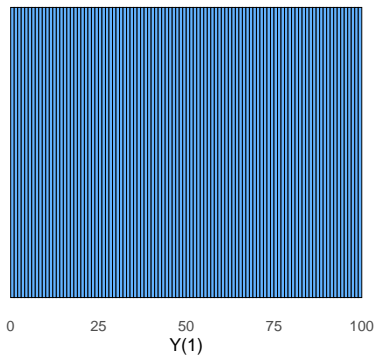


Figure 12: Distribution of potential motherhood outcomes

## Monotonicity: Intuition (2)

Without monotonicity: 20 with highest/lowest outcomes:

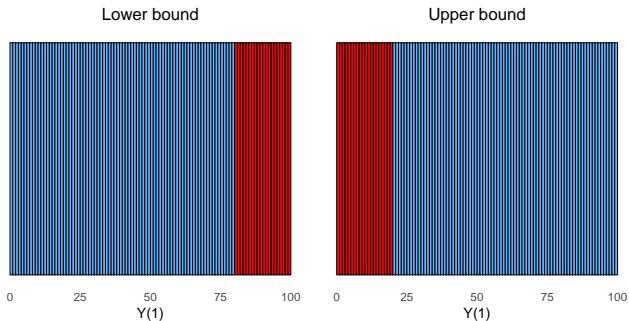


Figure 13: Distribution of potential motherhood outcomes

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## Monotonicity: Intuition (3)

With monotonicity: first, drop 10 who conceive again naturally:

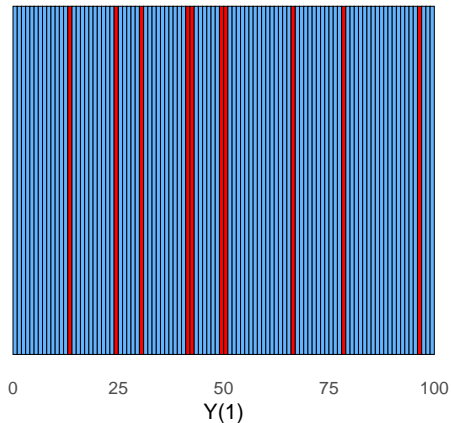


Figure 14: Distribution of potential motherhood outcomes

## Monotonicity: Intuition (4)

With monotonicity: second, drop another 10 with highest/lowest outcomes:

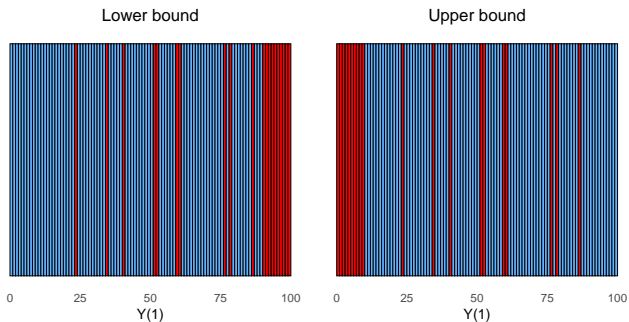


Figure 15: Distribution of potential motherhood outcomes

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# Monotonicity: Intuition (5)

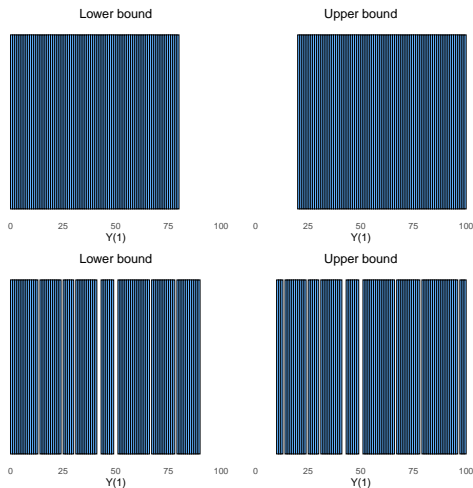


Figure 16: Distribution of potential motherhood outcomes

# Monotone Bounds: Absolute

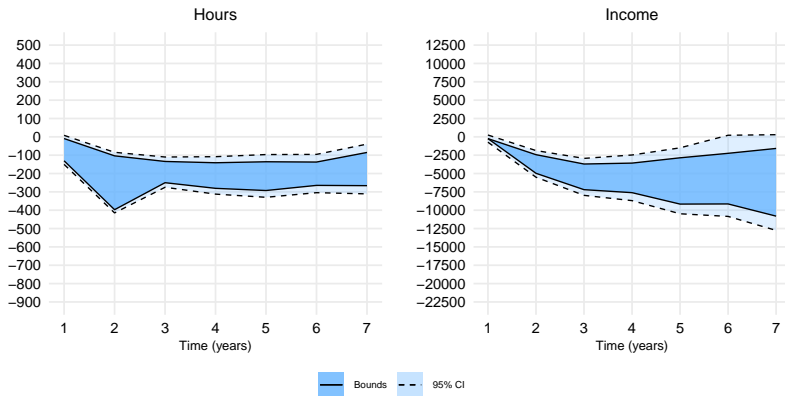


Figure 17: Monotone bounds: absolute terms

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# How Wide are the Bounds?

6 years after first treatment:

- ▶ Bounds:
  - ▶ 1 SD of pre-treatment hours
  - ▶ 1 SD of pre-treatment earnings
- ▶ Monotone bounds:
  - ▶ 0.15 SD of pre-treatment hours
  - ▶ 0.25 SD of pre-treatment earnings

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# Extensions

## Outcomes:

- ▶ Fatherhood Absolute Percentage
- ▶ Decomposing gender inequality Share explained by children
- ▶ Effect of delaying motherhood Absolute Cumulative

## Existing estimators:

- ▶ Are existing estimates biased? Naive IV-IVF equiv. Plac. ES Place. ineq.
- ▶ Are estimates less informative than existing? Confidence intervals

## Robustness:

- ▶ Bias due to depression Counterfact. Depr. effect Bounds non-depr. Arguments
- ▶ Correcting for parental leave Max leave
- ▶ Inequality correcting for age De-aging partners
- ▶ Stable complier group Childless final period
- ▶ Estimator without DML Identification Effects
- ▶ Relaxing monotonicity Direction Partnered only

## Other:

- ▶ Heterogeneity Covariates Willingness to try
- ▶ Population imputation\* ES pop. Mother. imp. Childless imp. Effect imp. Gap



# Monotone Bounds: Women who Remain Childless

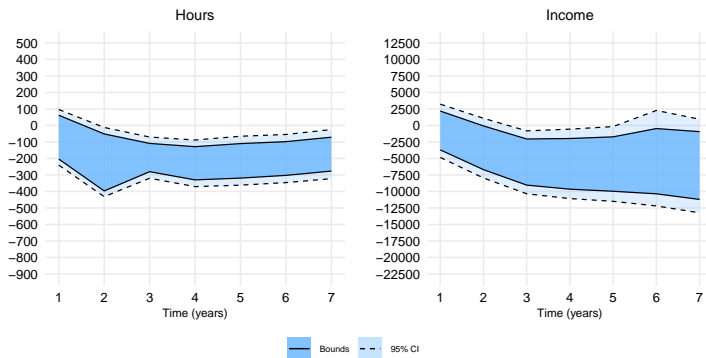


Figure 18: Monotone bounds using final status

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# Event Study: Population vs IUI Sample

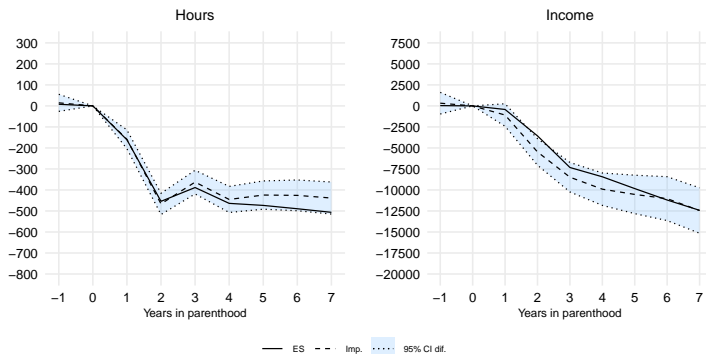


Figure 19: ES for population and women with first IUI success

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[Back \(intro\)](#)

# Imputing Population Motherhood Outcomes Using IUI Sample

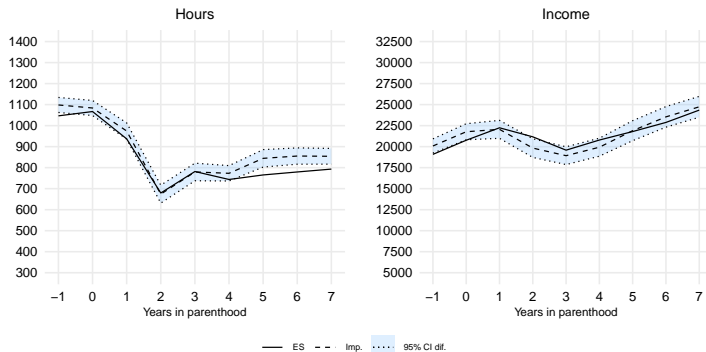


Figure 20: Population Outcomes vs IUI-imputation (age & education)

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# Imputing Population Childless Outcomes Using IUI Sample

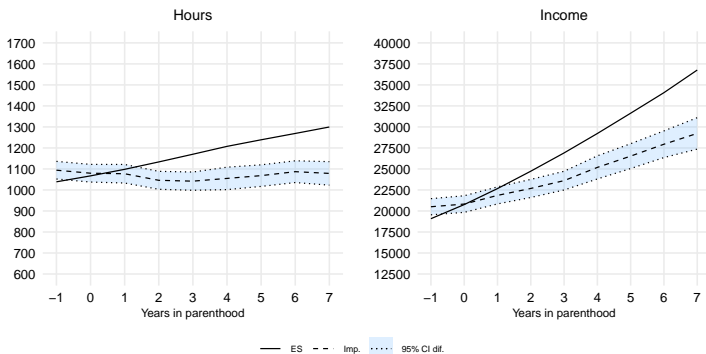


Figure 21: Population Outcomes vs IUI-imputation (age & education)

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# Event Study vs IUI-imputation for Population

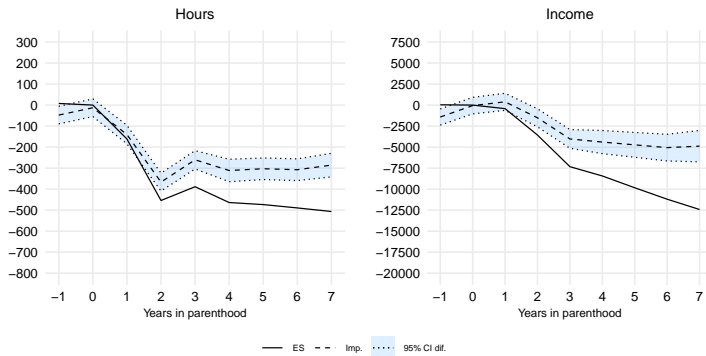


Figure 22: Event study vs IUI-imputation for population (age & education)

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## Event Study vs IUI-imputation: Inequality

$$\text{Ineq. cause by children} = \frac{\tau}{\text{Ineq. w/o children} + \tau}$$

## Event Study vs IUI-imputation: Inequality

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$$\text{Ineq. cause by children} = \frac{\tau}{\text{Ineq. w/o children} + \tau}$$

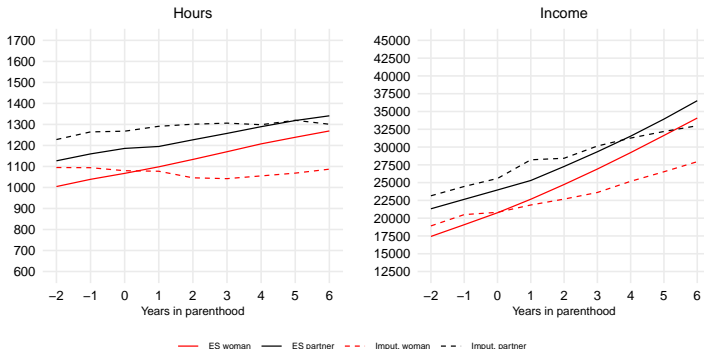
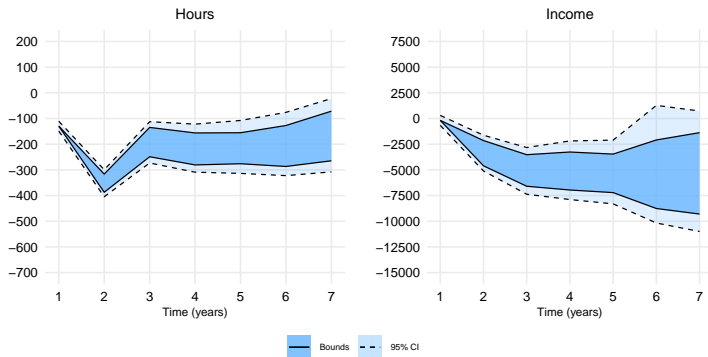


Figure 23: Event study vs IUI-imputation for population gaps (age & education), partner outcomes shifted 3 years

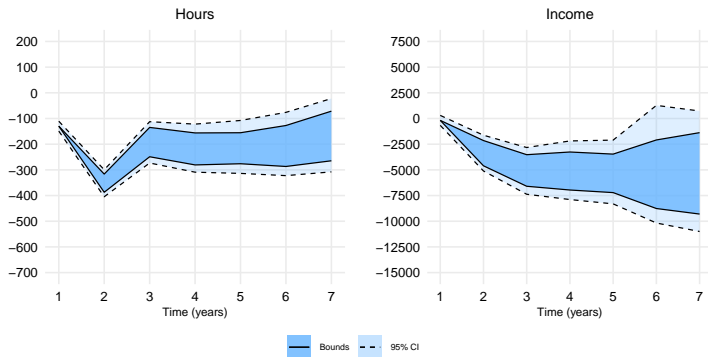


# Simple estimator



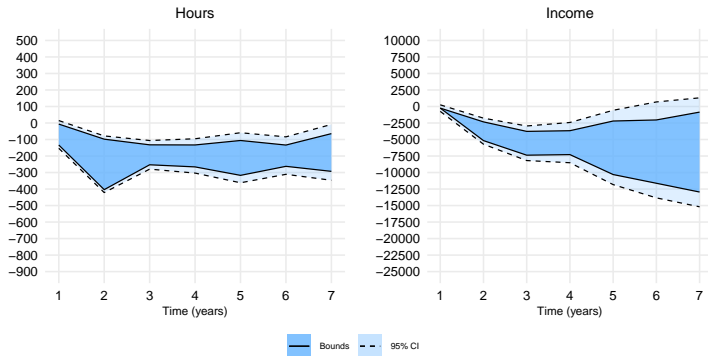
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# Simple estimator



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# Relaxing Monotonicity Direction



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# Heterogeneity by Covariates

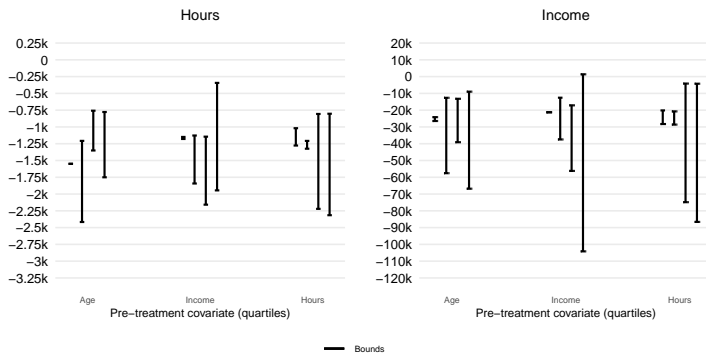


Figure 24: Cumulative outcomes after 6 years, pre-treatment covariates

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# Heterogeneity by Willingness to Undergo Procedures

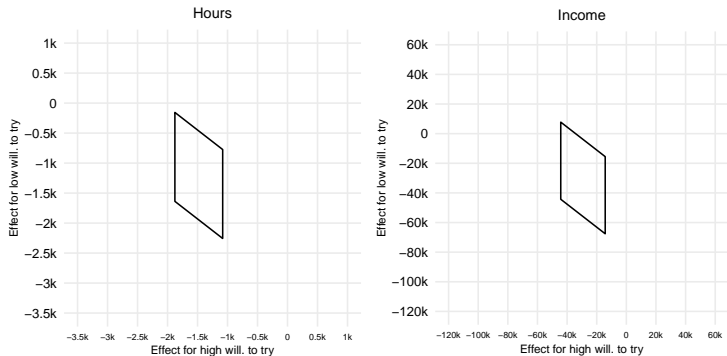


Figure 25: Cumulative outcomes 6 years after,  $G$  above or below 6

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# Monotone Bounds: Excluding Depression

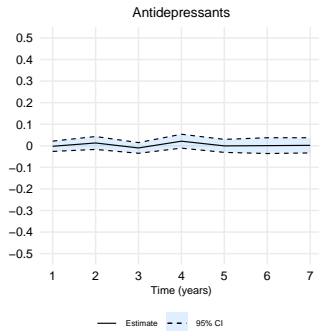
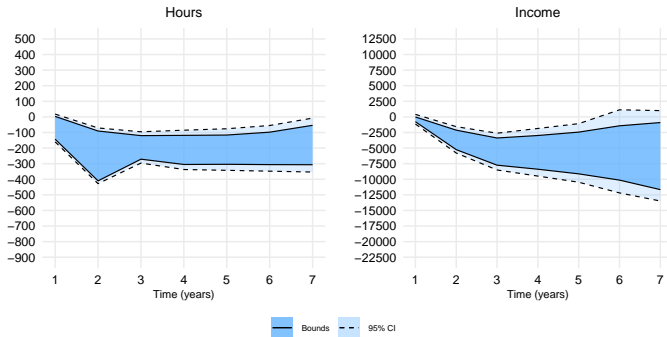


Figure 26: Sequential-IV estimates for effect on antidepressant take-up

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# Monotone Bounds: Excluding Depressed



**Figure 27:** Monotone bounds for women who would not start antidepressants if they were to remain childless

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# Arguments Regarding Mental Health

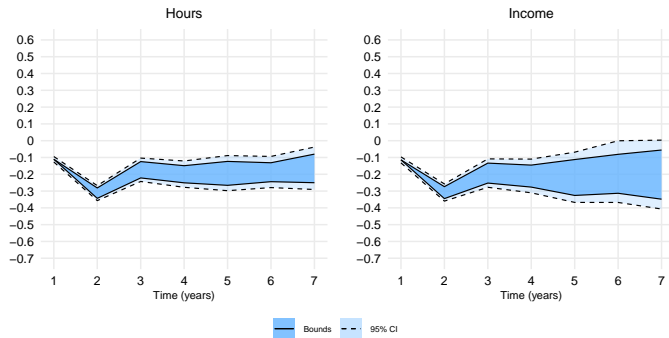
- ▶ Mental health consequences of not having a child are arguably a part of the relevant counterfactual
- ▶ IUI is significantly less invasive than IVF
- ▶ “Effects” of severe health shocks (including mental health shocks and psychical shocks that are followed by invasive treatments) are “relatively” small
- ▶ Partners’ mental health might also suffer, which could alleviate concerns for inequality estimates

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# Monotone Bounds: Assuming Maximum Leave



**Figure 28:** Monotone bounds scaling outcomes in years with childbirth by max. leave fraction

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# Monotone Bounds: Correcting for Partner's age

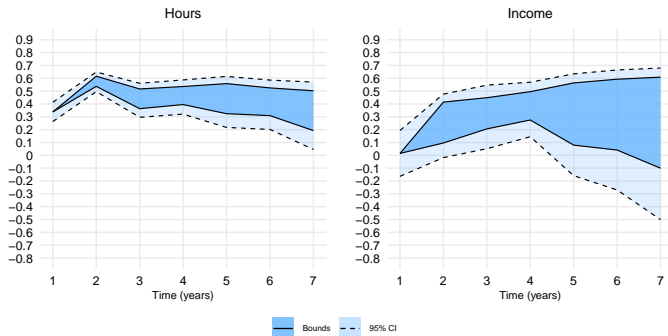


Figure 29: Monotone bounds using male income at same age as female

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# Monotone Bounds: Fatherhood Penalty

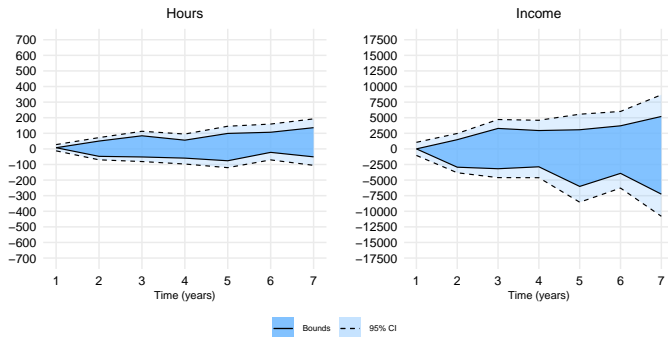


Figure 30: Monotone bounds for partners

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# Monotone Bounds: Fatherhood Penalty in Percent

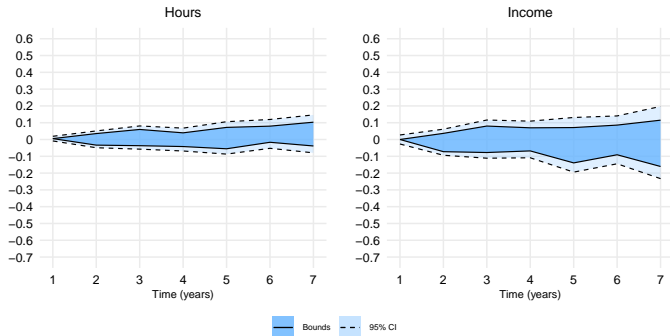


Figure 31: Monotone bounds for partners in percent

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# Monotone Bounds: Explaining Gender Inequality

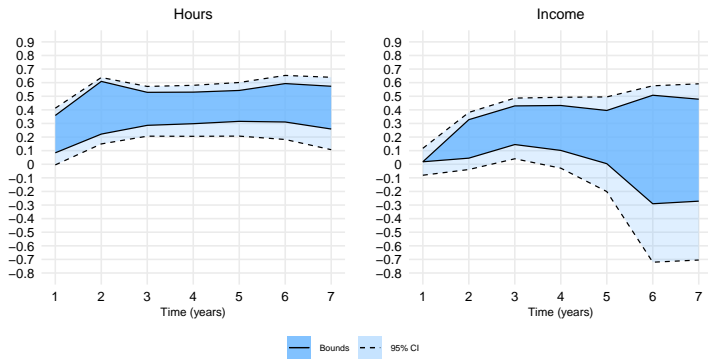


Figure 32: Share of gender inequality explained by parenthood

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# Are Bounds Less Informative?

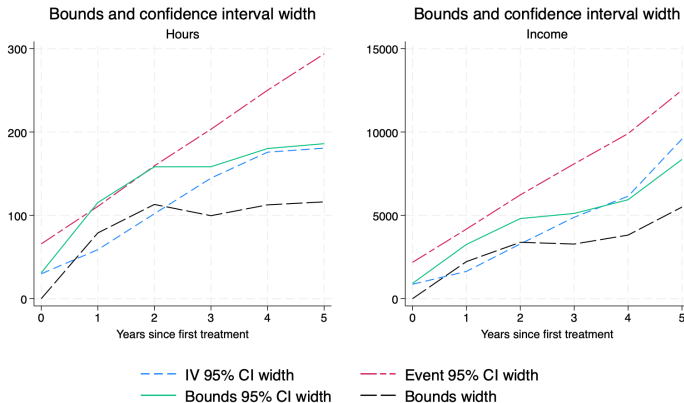


Figure 33: Confidence intervals for different methods

# Naive Comparison

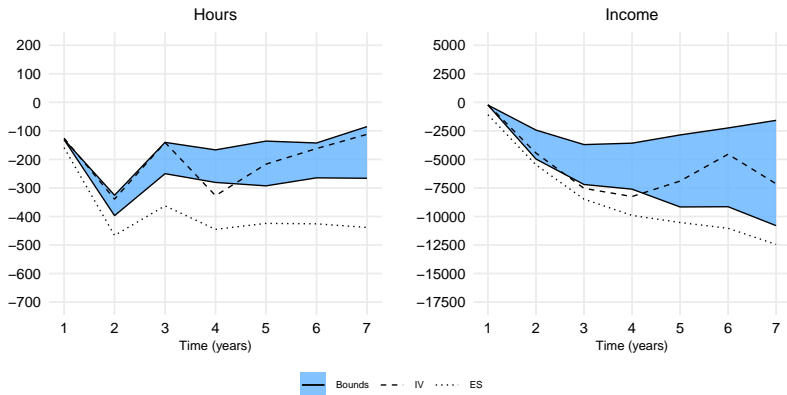


Figure 34: Estimates based on different methods

IV→women with lowest treated hours get children after ACPs fail [Back](#)

# Monotone Bounds and IV

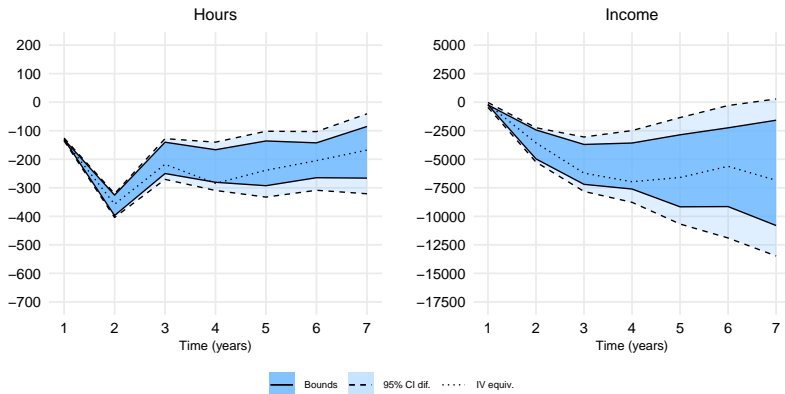


Figure 35: Bounds and IV equivalent for the same population

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# Placebo Event

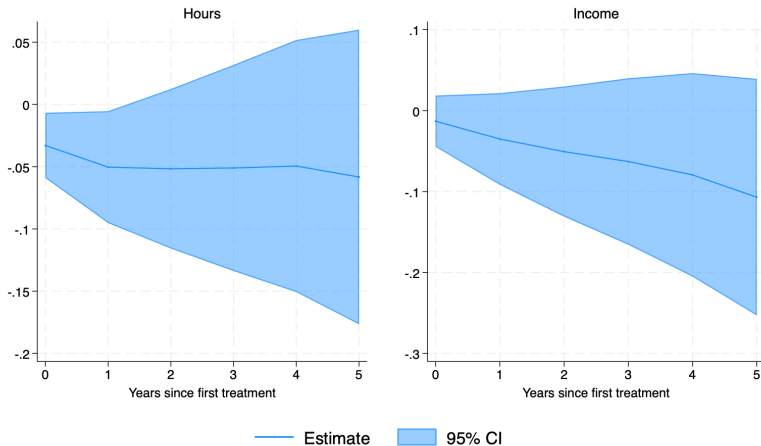


Figure 36: Placebo event study

# Inequality treating ES bias as causal

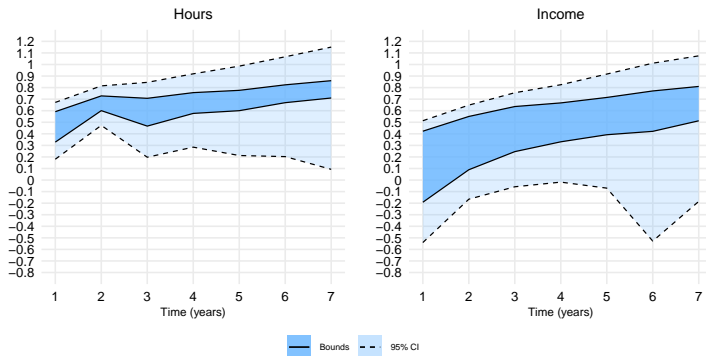


Figure 37: Placebo effects as share of bounds for the same population

Two possible interpretations:

- ▶ Event study severely overstates the penalty
- ▶ Large share of penalty is due to trying to conceive not parenthood per se

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# Yearly effect of Delaying Motherhood

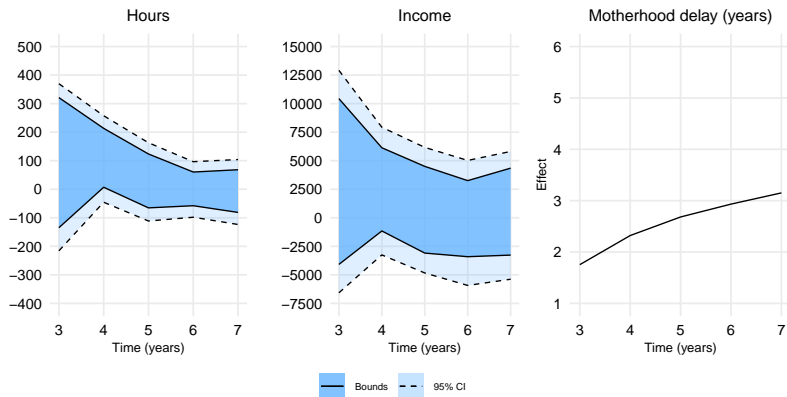


Figure 38: Effect of delaying relative to motherhood at first attempt

**Opposite of what is frequently assumed!**

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# Cumulative effect of Delaying Motherhood

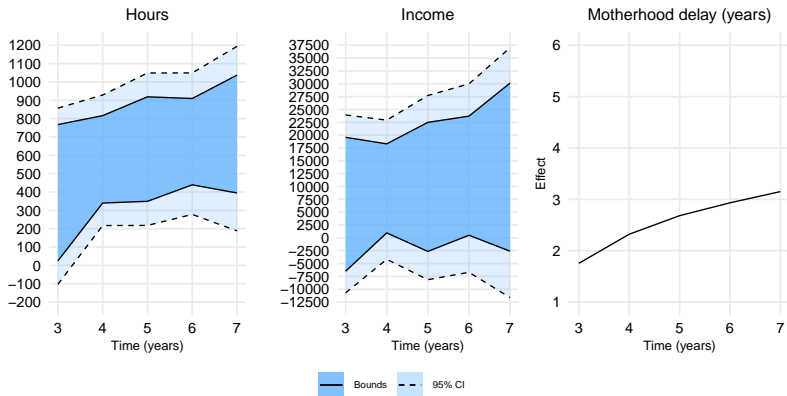


Figure 39: Effect of delaying relative to motherhood at first attempt

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# Monotone Bounds: Women who Remain Childless

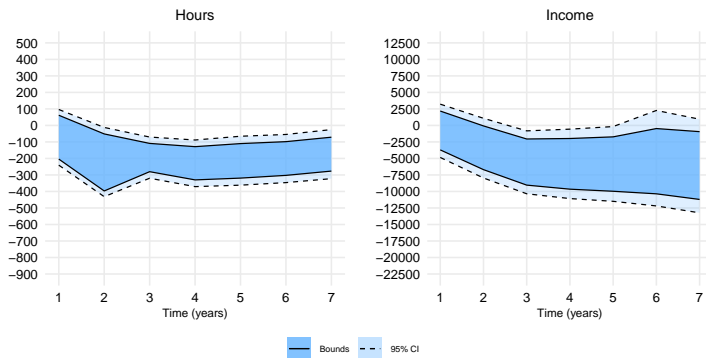


Figure 40: Monotone bounds using final status

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# Relaxing Monotonicity to Partnered Women

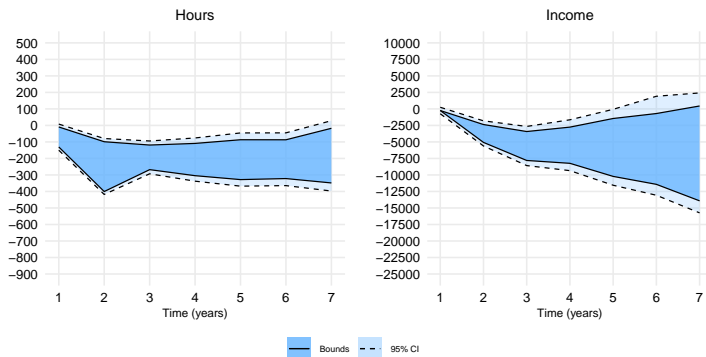


Figure 41: Monotone bounds using women who stay partnered

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[Back \(monotonicity\)](#)

# Testing the Plug-in Approach

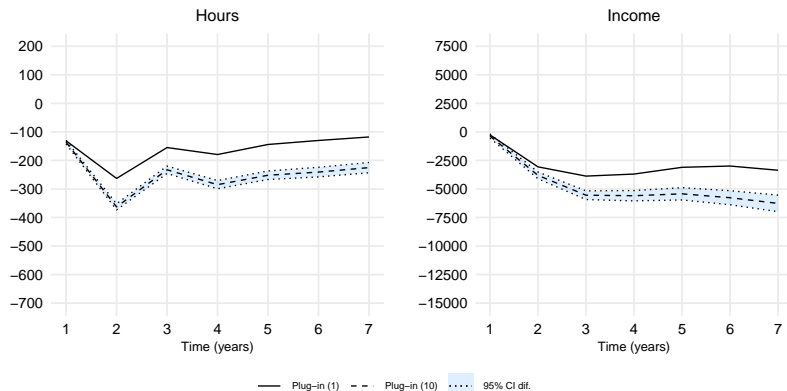


Figure 42: Plug-in estimators exploiting different number of treatments

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# Application to Other Settings

Key features:

1. Dynamic treatment effects.
2. Individuals (may choose to) “re-apply” for random treatment assignment.
3. Some may obtain treatment endogenously.



# Application to Other Settings

Key features:

1. Dynamic treatment effects.
2. Individuals (may choose to) “re-apply” for random treatment assignment.
3. Some may obtain treatment endogenously.

Few examples:

- Education, medical trials, research grants, job training.

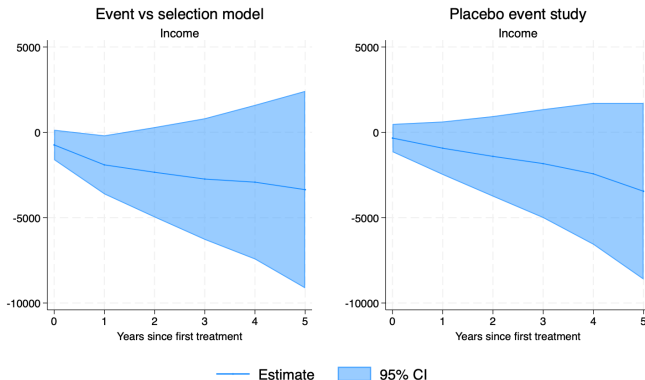
Examples

# Application to Other Settings (Examples)

- ▶ Education: grade retention, school admission lotteries, special and gifted education programs.
- ▶ Medical trials: individuals assigned to control may eventually choose to participate in other medical trials or selectively receive a different treatment.
- ▶ Research grants: after unsuccessful application can apply for another or receive funding other ways.
- ▶ Job training: those not assigned to training may re-apply, some assignments may be non-random.

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# Estimated Bias and Placebo Event Study



**Figure 43:** Difference between selection model estimate and event study estimate compared to placebo event study estimate

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