Parenthood Timing and Gender Inequality

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Motivation

Gender inequality in OECD labor markets typically emerges with parenthood

Understanding the role of parenthood is crucial for addressing gender inequity

Quantifying the effects of parenthood presents two main challenges:

1. Parenthood may be selective: human capital, wealth, health, or career prospects
2. Effects may vary with timing: age of children or career stage at childbirth

Existing evidence that addresses selection quantifies only a weighted average of parenthood effects (vs. childlessness) and timing effects (earlier vs. later childbearing):

- These forces may work in opposite directions and require distinct policies

This Paper

How much can we say about the separate effects of parenthood and its timing?

- How would outcomes change if parents remained childless or delayed childbirth?

1. New approach to estimate treatment effects
   - Quasi-experiments where unassigned individuals can repeatedly undergo assignment
2. Empirical evidence using novel administrative Dutch data
   - Focus on couples undergoing **intrauterine insemination**
3. Framework to separate selection, parenthood effects, and timing effects
   - Quantify bias in existing methods

Preview of Main Results

- Parenthood persistently reduces women's work hours and income
  - Yearly reductions between 9 and 24 percent
- Parenthood causes a large share, but far from all, of post-child gender inequality
  - Between 36 and 54 percent in work hours and up to 46 percent in income
- Delayed childbearing results in smaller losses
  - Even after childbirth women continue to work and earn more

Literature and Contribution

1. Existing quasi-experimental studies average parenthood and timing effects
   - Hotz et al. (2005); Agüero & Marks (2008); Cristia (2008); Miller (2011); Lundborg et al. (2017); Bensnes et al. (2023); Gallen et al. (2023); Lundborg et al. (2024)

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3. Most gender inequality is explained by gaps between mothers and childless women, but the extent of selection is unknown (Kleven et al., 2019)
   - Patterns are nearly identical among couples undergoing artificial insemination

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I provide a framework to separate causal effects from selection

4. Isolating treatment and timing effects in quasi-experiments is a common challenge
   - Education programs with multiple admission cycles, assignment to judges, promotion tournaments

Method applicable to many other settings with sequential quasi-experiments

Baseline Reduced-Form Setup

Address selection using a quasi-experiment: women undergoing artificial insemination.

- Outcome of the first procedure $Z_1 \in \{0, 1\}$
- Parenthood indicator $D \in \{0, 1\}$
- Potential labor market outcomes $Y_{z_1}(d)$
- Effect of parenthood: $Y_1(1) - Y_0(0)$
- Effect of parenthood timing: $Y_1(1) - Y_0(1)$

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Standard reduced form argument:

1. Assume success of the first procedure is random
2. Compare women whose first procedure succeeds to those whose fails:

$$\mathbb{E}[\text{Parenthood effect} \mid D = 0 \text{ if } Z_1 = 0]c + \mathbb{E}[\text{Timing effect} \mid D = 1 \text{ if } Z_1 = 0](1 - c)$$

- $c = \Pr(\text{no child if } Z_1 = 0) \approx 0.25$ in practice

Model

Women differ in two unobserved characteristics:

- "Willingness" to undergo ACPs, $W \in \{1, \ldots, \overline{w}\}$
  - Would undergo W ACPs for the first child if all ACPs failed
- "Reliance" on ACPs, $R \in \{0, 1\}$
  - No child if all ACPs fail, $R = 1$

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Observables:

- ACP j success indicator, Z_j, for procedures before having any children
- Number of realized ACPs:

$$A = \min\left(\{j : Z_j = 1\} \cup \{W\}\right)$$

- Parenthood indicator:

$$D = \max(Z_A, 1 - R)$$

Sequential Unconfoundedness

Assumption (Sequential Unconfoundedness)

$(Y_1(1), Y_0(0), R, W) \perp\!\!\!\perp Z_j | A \geq j.$

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

- **The decision to undergo the procedure can be endogenous**
- $Y_1(1), Y_0(0), R$ and W can be related
- Main method relaxes to covariate-conditional version: age at procedure, technology

Simple World: Max 2 ACPs, All Reliers

$W = 1$
(willing to try once)

$Z_1 = 1$

$Z_1 = 0$

Simple World: Max 2 ACPs, All Reliers

$W = 1$
(willing to try once)

$Z_1 = 1$

$Z_1 = 0$

$W = 2$
(willing to try twice)

$Z_1 = 1$

$Z_1 = 0, Z_2 = 1$

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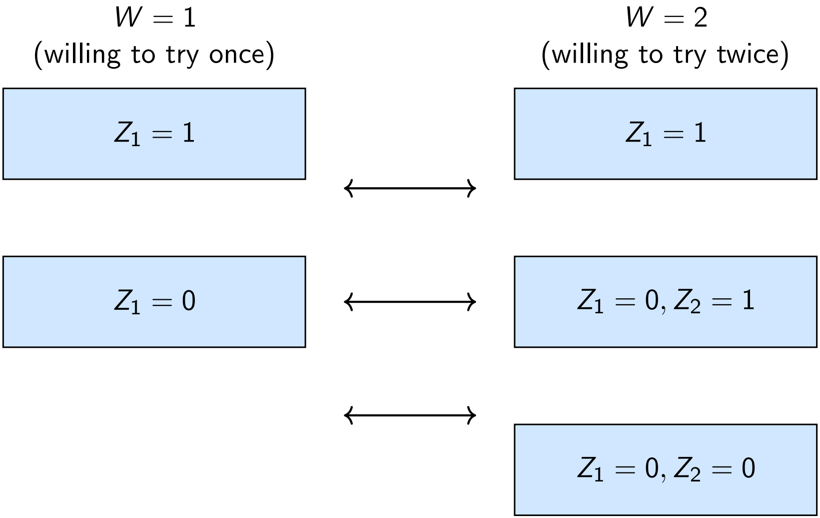
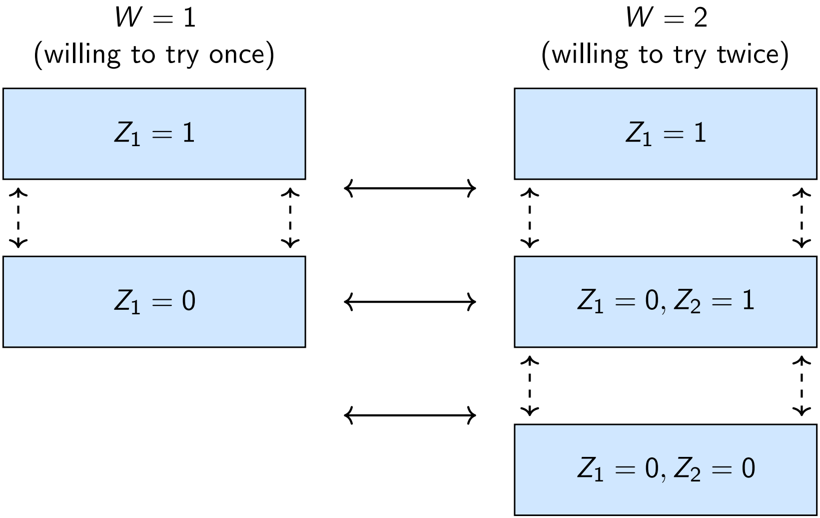
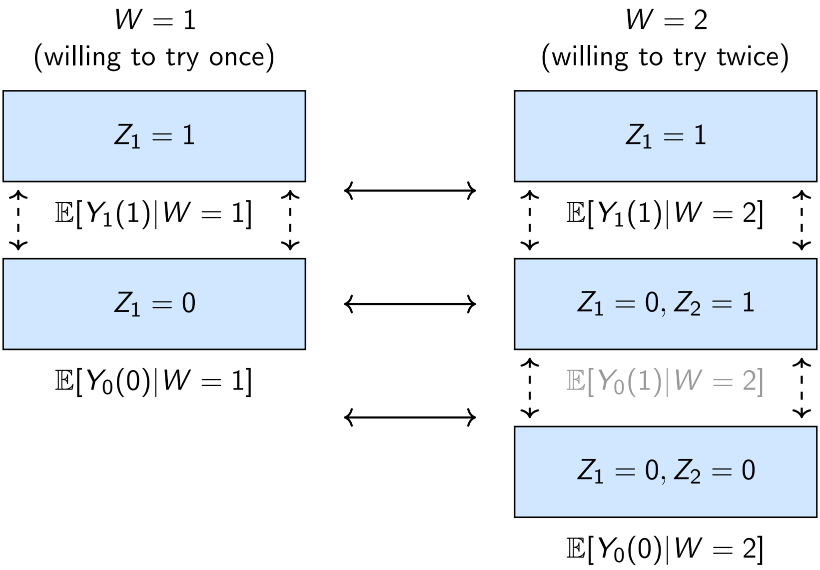
Simple World: Max 2 ACPs, All Reliers



Simple World: Max 2 ACPs, All Reliers



Simple World: Max 2 ACPs, All Reliers



Simple World (Observed): Max 2 ACPs, All Reliers

$W = 1$
(willing to try once)

$W = 2$
(willing to try twice)

$Z_1 = 1$

$Z_1 = 0$

$Z_1 = 0, Z_2 = 1$

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Simple World (Observed): Max 2 ACPs, All Reliers

$W = 1$
(willing to try once)

$W = 2$
(willing to try twice)

$Z_1 = 1$

$\mathbb{E}[Y_1(1)]$

$Z_1 = 0$

$\mathbb{E}[Y_0(0)|W = 1]$

$Z_1 = 0, Z_2 = 1$

$\mathbb{E}[Y_0(1)|W = 2]$

$Z_1 = 0, Z_2 = 0$

$\mathbb{E}[Y_0(0)|W = 2]$

Simple World (Observed): Max 2 ACPs, All Reliers

$W = 1$
(willing to try once)

$W = 2$
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$\mathbb{E}[Y_0(1)|W = 2]$

$Z_1 = 0, Z_2 = 0$

$\mathbb{E}[Y_0(0)|W = 2]$

$Pr(W = 1) =$

Simple World: Max 1 ACP with Non-reliers

$R = 1$	$R = 0$
(no child if fail)	(child if fail)

Simple World: Max 1 ACP with Non-reliers

$R = 1$ (no child if fail)	$R = 0$ (child if fail)

$Z_1 = 1$

Simple World: Max 1 ACP with Non-reliers

$R = 1$ (no child if fail)	$R = 0$ (child if fail)
$Z_1 = 1$	$Z_1 = 1$
$Z_1 = 0, D = 0$	$Z_1 = 0, D = 1$

Simple World: Max 1 ACP with Non-reliers

$R = 1$
(no child if fail)

$R = 0$
(child if fail)

$Z_1 = 1$

Distribution of $Y_1(1)$

$Z_1 = 0, D = 0$

$\mathbb{E}[Y_0(0)|R = 1]$

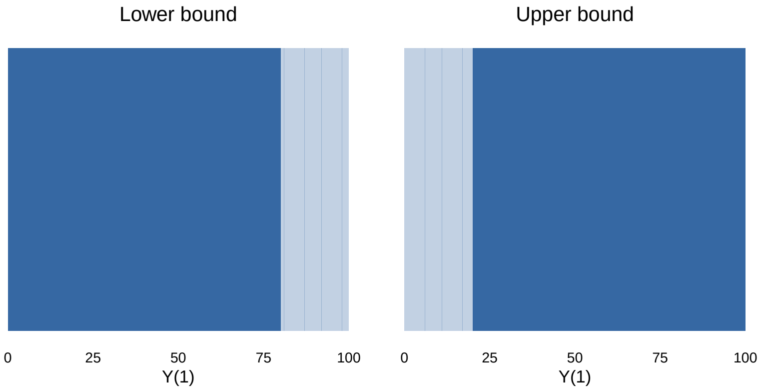
$Z_1 = 0, D = 1$

$\mathbb{E}[Y_0(1)|R = 0]$

$Pr(R = 1) =$

Intuition: Motherhood Outcome $Y_1(1)$

1. Treated group is a representative 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 $\mathbb{E}[Y_1(1)|R = 1]$



Further Details

Compare average relier control outcome to bounds on their treated outcome

- The argument for average timing effects is symmetric:
  - Compare average non-relier later-treated outcome to bounds on the treated outcome

Formal identification →

- Covariate-conditional sequential unconfoundedness: age and procedure type
- Combine the two steps in a semi-parametric moment equation

Using covariates to narrow the bounds →

- The bounds are sharp

Inference complicated by trimming of the outcome distribution →

- Build on a double/debiased machine learning approach by Semenova (2023)
- Construct orthogonal moment functions that are robust to first-stage nonparametric estimation errors in quantile and other nuisance functions

Background and Data

Assisted conception procedures →

- In-vitro fertilization: invasive medical procedure, first 3 free
- Intrauterine insemination: direct sperm injection, minimally invasive, free

Dutch family policies and labor market similar to OECD average →

- 16 weeks maternity + pregnancy leave, 1 week paternity leave

Data combining ACP medical records with tax records →

- Work hours and income include leave; results for hours corrected for uncertainty
- 15,523 cohabiting opposite-sex couples
- Balance: ACP success at each attempt uncorr. with past outcomes cond. on age

Balance in 1st ACP first | Balance in later ACPs | Success probabilities per attempt

Effect of Parenthood: Women

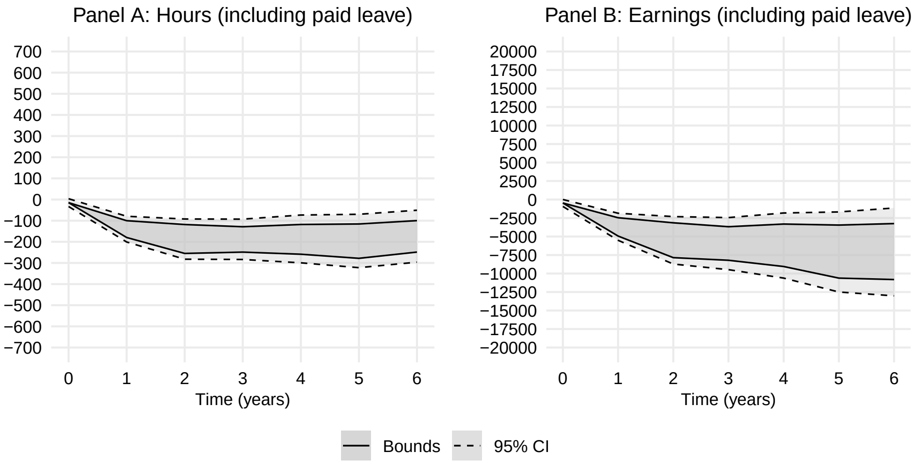


Figure 1: Parenthood Effect Bounds for Women

Effect of Parenthood: Men

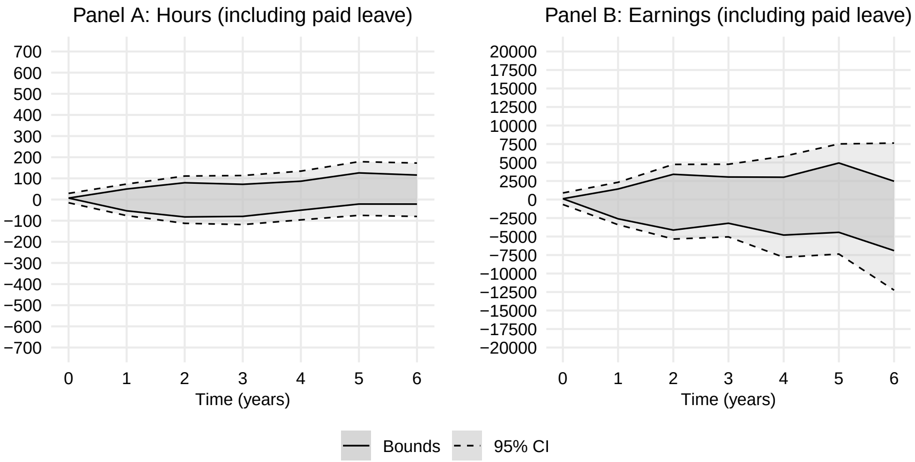


Figure 2: Parenthood Effect Bounds for Men

Share of Gender Inequality Caused by Parenthood

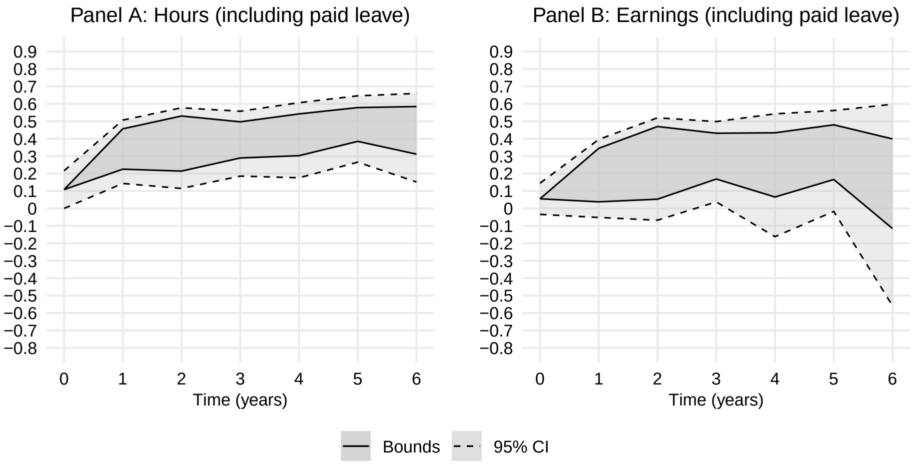


Figure 3: Effect on Gender Gap relative to Gap Under Parenthood

Effect of Parenthood Timing: Women

Figure 4: Parenthood Timing Effect Bounds for Women

Extensions

- **Selection into parenthood** Formal procedure Estimates
- Relation to partial identification literature Comparison
- Robustness Childless final period De-aging partners Mental health Bounds for non-depressed

Conclusion

A method for evaluating treatment and timing effects under dynamic non-compliance:

- Applicable to various settings involving sequential quasi-experiments

Estimate the career cost of parenthood in the Netherlands:

- Motherhood causes up to half of gender inequality in hours and income
- Delayed childbearing mitigates women's losses

Accounting for selection and timing effects helps reconcile findings in the literature:

- Failing to account for either factor leads to bias

External relevance:

- IUI is common, the sample matches population on observables
- Many women would undergo IUI if natural conception failed

Policy:

- Large share of gender inequality may not be due to parenthood per se
- Enabling later childbearing may mitigate gender inequality

Bounding τ_{ATR}

Construct the moment:

$$m^L(G,\eta^0) = Y 1_{\{Y<q(r(X_1),X_1)\}} \frac{Z_1}{e_1(X_1)} - Y(1-D)\prod_{j=1}^{A} \frac{(1-Z_j)}{(1-e_j(X_j))}$$

- G is the observed data vector
- η^0 contains the following:
  - $e_j(X_j) = \Pr(Z_j = 1|X_j)$
  - $q(r(X_1), X_1)$ is the $r(X_1)$-th quantile of Y given X_1 and $Z_1 = 1$
  - $r(X_1)$ identifies the covariate-conditional relier share

Assumption (Conditional Sequential Unconfoundedness)

$(Y(k), R, W) \perp\!\!\!\perp Z_j \mid X_j$ *for all* j, k, *and* $X_j, A \geq j$.

Theorem (Lower Bound)

Under conditional sequential unconfoundedness and regularity, the sharp lower bound on τ_{ATR} *is* $\mathbb{E}[m^L(G,\eta^0)]/\mathbb{E}[r(X_1)]$.

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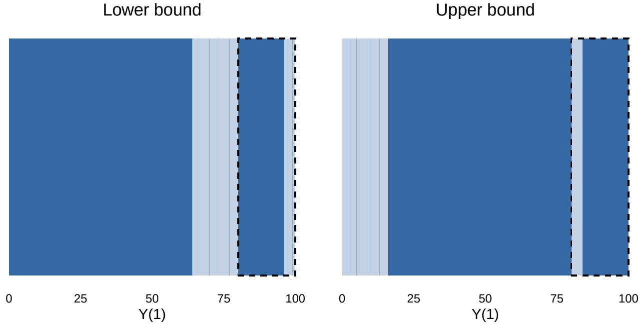
Intuition: Motherhood Outcome $Y_1(1)$—Covariates

Pre-ACP covariates can help narrow the bounds:

- Can identify relier share at each covariate value
- Baseline bounds assume extreme scenarios where reliers have highest or lowest treated outcomes
- These distributions of treated outcomes might be inconsistent with conditional relier shares



Estimating the Bounds

Distribution of $m^L(G, \eta^0)$ is complicated by $q(r(X_1), X_1)$

- Semenova (2023) addresses a closely related inference challenge
- Double/debiased machine learning approach
  1. Adjust $m^L(G, \eta^0)$ to make it insensitive to small error in $q(r(X_1), X_1)$
  2. Sample splitting
- Asymptotic inference as if $q(r(X_1), X_1)$ was known

New moment:

$$\psi^L(G, \xi^0) = m^L(G, \eta^0) + corr(G, \xi^0)$$

Identifies same parameter:

$$\mathbb{E}[\psi^L(G, \xi^0)] = \mathbb{E}[m^L(G, \eta^0)]$$

Insensitive to estimation error in $q(r(X_1), X_1)$:

$$\partial_{q(.)} \mathbb{E}[\psi^{L+}(G, \xi_r)|X_1]|_{\xi_r = \xi_r^0} = 0 \ a.s.$$

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Assisted Conception Procedures

- IUI (main procedure): sperm injected into uterus
  - Minimally invasive, primary ACP in most countries
  - "Free" in NL
- IVF (secondary procedure): embryo inserted into uterus
  - Invasive treatment, performed under sedation/anesthesia
  - Eggs retrieved through the vaginal wall using a specialized needle
  - In NL, first 3 free; each subsequent costs between 1000 and 4000 EUR

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Institutions

- Dutch family friendly polices similar to OECD average
  - 16 weeks of fully paid pregnancy+maternity leave
  - 1 week of paternity leave
  - Average time in child care similar to OECD average
  - Net child care cost 10% median household income
- Dutch employment intensity similar to OECD average
  - Employment among parents and non-parents relatively high
  - Part time work much more common
  - Approximately 15% two-parent families have both partners working part-time

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Data

Administrative data from Statistics Netherlands

- Comprehensive hospital records cover fertility treatments from 2012 to 2017: procedure date and type
  - Success imputed as having child born within 10 months
- Tax records cover work hours and income from 2011 to 2023
  - Include maternity leave and pay
  - Main bounds account for uncertainty around actual work hours
- Birth dates, legal family connections, cohabitation
- Dispensed medication registry

Main sample: cohabiting opposite-sex couples undergoing IUI for their first child between 2013 and 2016: 15,523

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Balance in 1^{st} ACP Back

Table 1: First IUI Outcomes and Descriptives

	Success (1)	Fail (2)	Dif. (1)-(2)	IPW dif. (1)-(2) cond.	Rep. (5)	Suc. vs rep. (1)-(5)
Work (W)	0.912	0.916	-0.004	-0.009	0.936	-0.024
	[0.283]	[0.277]	(0.008)	(0.008)	[0.244]	(0.007)
Work (P)	0.894	0.885	0.009	0.002	0.897	-0.002
	[0.307]	[0.319]	(0.009)	(0.009)	[0.304]	(0.008)
Hours (W)	1300.012	1298.876	1.136	-1.951	1310.923	-10.911
	[547.832]	[558.316]	(15.730)	(16.119)	[544.468]	(14.554)
Hours (P)	1513.337	1494.541	18.796	3.345	1497.603	15.734
	[635.121]	[656.050]	(18.457)	(19.041)	[651.043]	(17.403)
Earn. 1000s EUR (W)	29.358	29.648	-0.290	0.203	26.555	2.803
	[18.000]	[18.911]	(0.531)	(0.561)	[15.989]	(0.427)
Earn. 1000s EUR (P)	38.082	38.060	0.022	0.322	33.862	4.220
	[25.425]	[26.525]	(0.745)	(0.774)	[24.148]	(0.646)
Bachelor deg. (W)	0.512	0.494	0.018		0.518	-0.007
	[0.500]	[0.500]	(0.014)		[0.500]	(0.013)
Bachelor deg. (P)	0.425	0.410	0.014		0.430	-0.005
	[0.494]	[0.492]	(0.014)		[0.495]	(0.013)
Age (W)	31.373	32.060	-0.687		28.840	2.533
	[3.889]	[4.265]	(0.119)		[3.896]	(0.104)
Age (P)	34.088	34.856	-0.768		31.415	2.673
	[4.968]	[5.500]	(0.154)		[4.803]	(0.128)
Observations	1,411	11,323			171,180	
Joint *p*-val.			0.001	0.955		0.000

Note: *Success* – average among women whose first IUI succeeded; *Fail* – average among women whose first IUI failed; *Dif.* – difference between *Success* and *Fail*; *IPW dif.* – difference adjusted for age and education using inverse probability weights from the baseline specification; *Rep.* – average in representative sample of women who conceived their first child without assisted conception procedures; *Suc. vs rep* – difference between *Success* and *Rep.*. Reference year: year of first IUI (IUI sample); 9 months before first birth (representative sample). IUI sample: women who underwent intrauterine insemination for their first child between 2013 and 2016, with no prior assisted conception procedures, cohabiting with a male partner in the year prior to the reference year. Representative sample: women with no assisted conception procedures before first birth, cohabiting with a male partner in the year prior to the reference year, with reference year between 2013 and 2016. Labor market outcomes measured in the year before the reference year; age measured in the reference year. *Bachelor deg.* – indicator for completing a bachelor's degree. *Earn.* – earnings, (W) – woman, (P) – partner. Standard deviations in brackets. Standard errors in parentheses.

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Balance in Subsequent ACPs

Table 2: Balance in Later ACPs

	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9	Z_{10}
Work (W)	0.009	-0.004	0.022	0.014	0.039	-0.003	-0.011	0.022	0.030
	(0.010)	(0.011)	(0.011)	(0.012)	(0.012)	(0.017)	(0.018)	(0.019)	(0.024)
Work (P)	0.006	0.016	0.012	0.020	-0.004	-0.004	-0.019	0.017	0.030
	(0.010)	(0.010)	(0.012)	(0.012)	(0.015)	(0.015)	(0.019)	(0.020)	(0.027)
Hours (W)	32.885	-4.482	52.999	41.332	81.957	11.894	-18.836	72.659	24.819
	(18.721)	(20.032)	(21.045)	(22.686)	(25.131)	(31.187)	(32.937)	(38.210)	(48.490)
Hours (P)	21.655	24.730	23.756	38.965	9.666	-6.580	-28.458	30.525	43.722
	(21.018)	(21.089)	(23.574)	(25.255)	(30.585)	(31.513)	(37.976)	(44.856)	(52.821)
Income 1000s € (W)	1.481	-0.015	1.685	1.802	2.086	0.150	-0.043	0.866	-0.444
	(0.615)	(0.624)	(0.767)	(0.830)	(0.913)	(1.000)	(1.092)	(1.234)	(1.629)
Income 1000s € (P)	-0.749	1.002	2.040	0.800	0.774	0.025	0.259	-0.324	0.149
	(0.835)	(0.912)	(1.066)	(1.115)	(1.424)	(1.424)	(1.563)	(1.737)	(2.203)
Observations	12,974	10,774	8,726	6,977	5,411	3,944	2,723	1,850	1,174
Joint *p*-val.	0.175	0.976	0.234	0.303	0.140	1.000	0.956	0.704	0.917

Note: Each column describes the difference in average characteristics between women for whom the respective ACP succeeds and those for whom it fails, among those who undergo the procedure, using inverse probability weights for each ACP following the main specification. Labor market outcomes and age measured year before first treatment. (W) - woman, (P) - partner. Standard errors in parentheses.

Estimated Success Probabilities

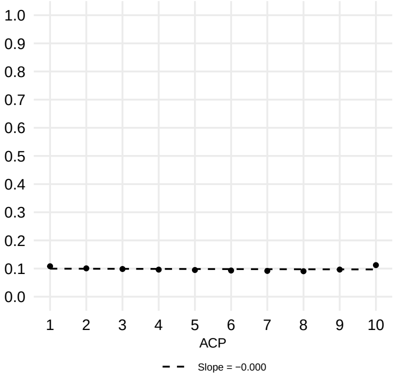

Figure 5: Estimated Success Probabilities

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Comparison with Lee (2009)

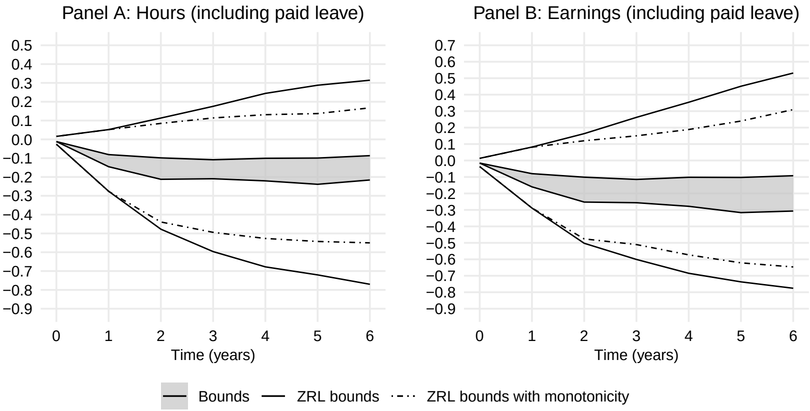

Figure 6: Comparison with Lee (2009) Bounds for Effects on Women

Back (extensions) Conclusion
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Quantifying Selection Using the Event Study Approach

Kleven et al. (2024) compare mothers t years after childbirth to women one year before

- Most gender inequality is explained by these differences between women
- Event study estimates may be biased due to selective timing
- But differences from IV/bounds need not imply bias, even in the same sample

1. I proxy fertility timing using the timing of first ACP
2. Compare the actual trajectories of women who attempted conception but remained childless with those imputed from women who are about to attempt conception but ultimately remain childless

- **Event study comparison of women with different timing absent children**
- **Same population as bounds: selection vs causal effects directly comparable**

Back (extensions) Conclusion

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Placebo Event Study

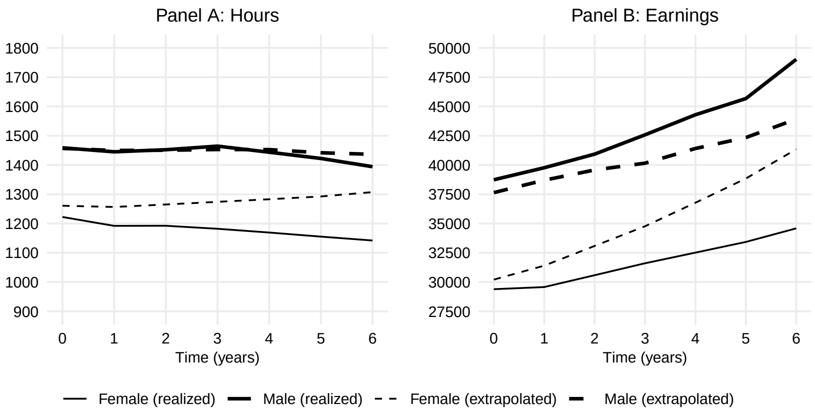

Figure 7: Placebo Event Study

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ToC

Gender Inequality: Causal vs Selection

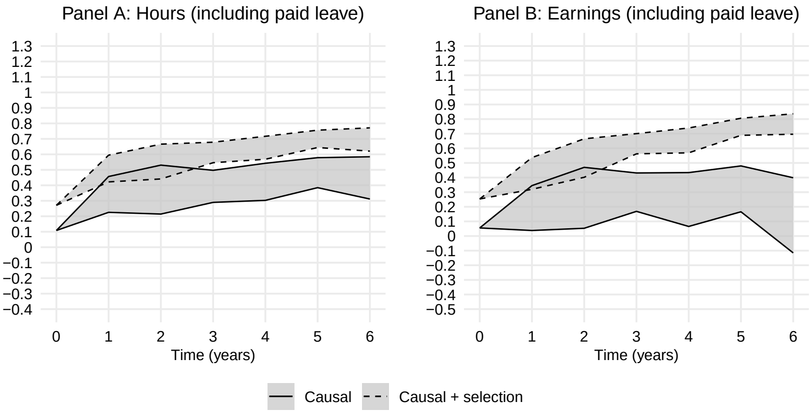

Figure 8: Share of Gender Inequality Explained by Selection and Parenthood

Back (extensions) Conclusion
ToC

Mental Health and ACPs

Mental health consequences associated with failure to conceive are a part of the story:

- Unmet fertility goals may negatively impact mental health, and in turn, labor market outcomes

There are, however, additional concerns:

- Mental health issues caused specifically by failed conception or ACPs (external)
  - Focusing on artificial insemination helps mitigate this
- Large impacts unique to ACP families (external)
- Worsened mental health by threatening monotonicity (internal)

In practice, these impacts are likely small (Lundborg et al., 2024)

Antidepressant uptake Back (extensions) Conclusion

ToC

Monotone Bounds for Non-depressed Childless Women

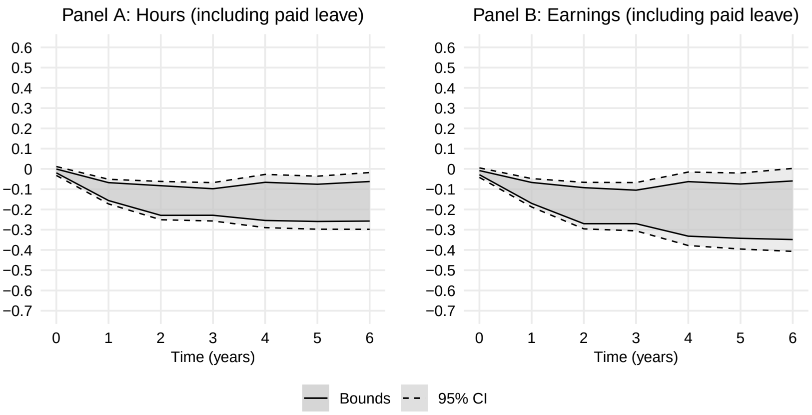

Figure 9: Monotone Bounds for Women Who Would Not Uptake Antidepressants if They Were to Remain Childless

Back (extensions) Conclusion

ToC

Monotone Bounds: Women Who Remain Childless

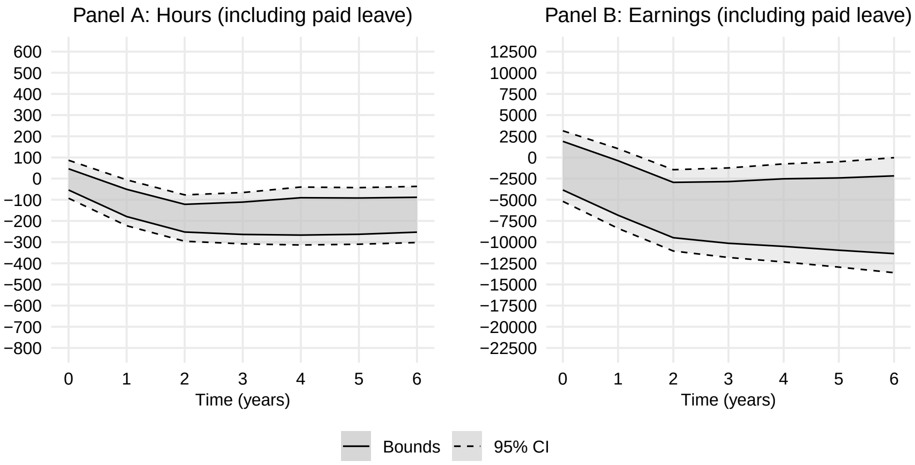

Figure 10: Monotone Bounds Using Completed Fertility

Parenthood Effect Bounds: Correcting for Partner's age

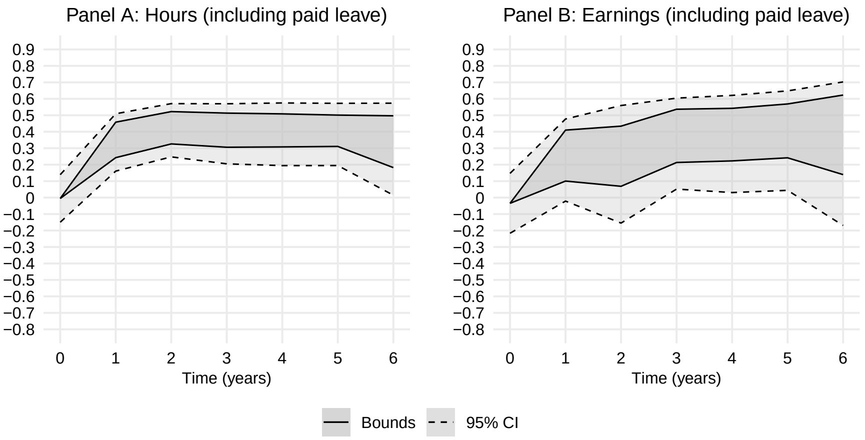

Figure 11: Bounds Measuring Male Income at Same Age as Female

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