Long-Term Causal Effects of Access to Institutional Delivery on Dementia Risk

Martin Fischer
(joint work with Martin Karlsson, Nikolaos Prodromidis,
Therese Nilsson and Martin Lövdén)

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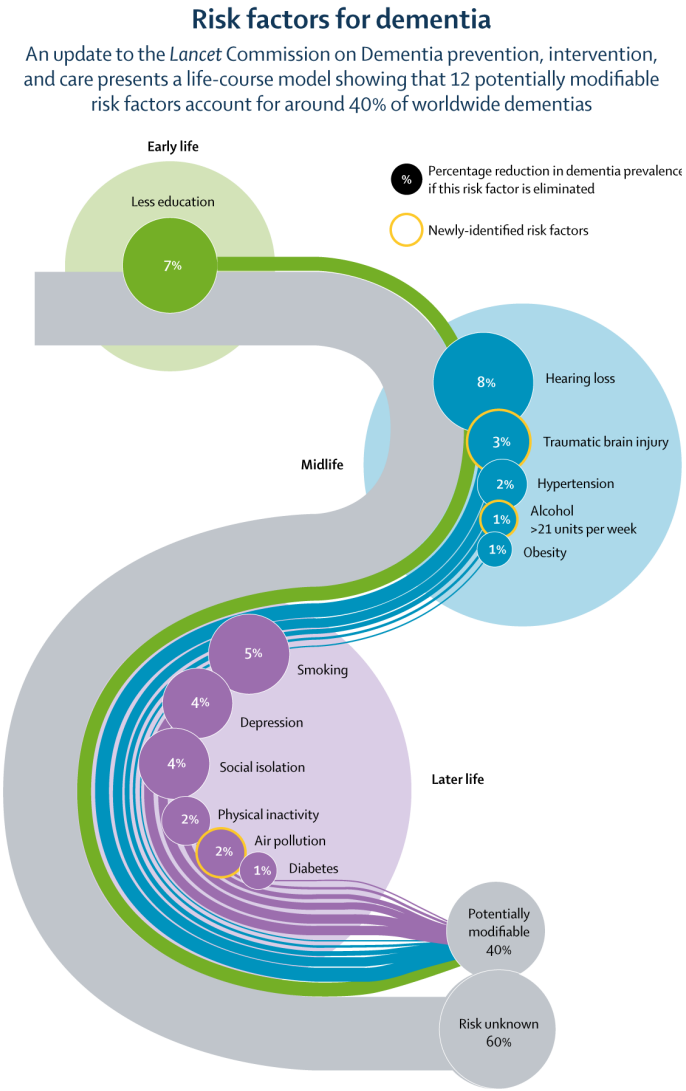
Risk Factors for Dementia (Lancet Commission)



- 40% of known risk factors potentially preventable.
- 60% either unknown or considered non-preventable.
- Known risk factors represent associations, not causal relationships.
- **Very early life period under-explored**.

Path Diagram

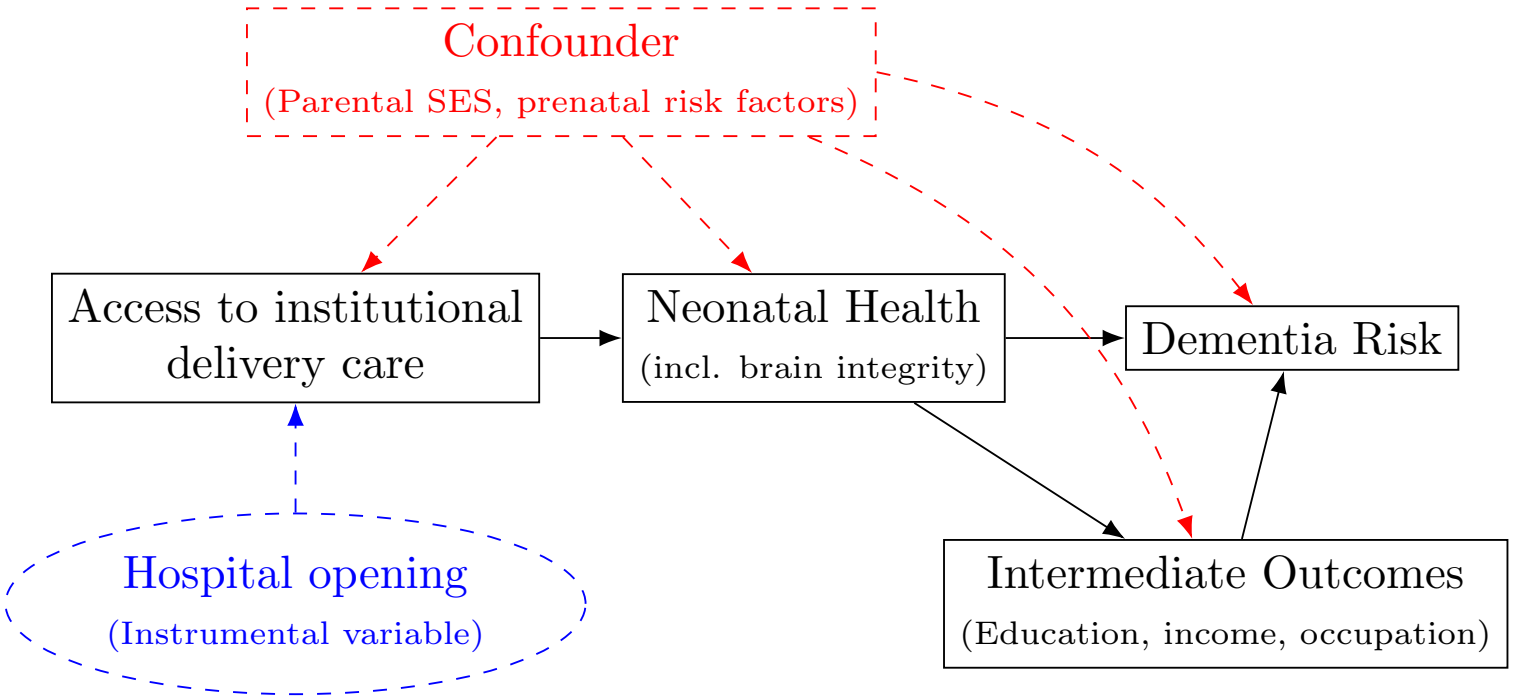


Figure: Path Diagram.

Reserve – Threshold Models

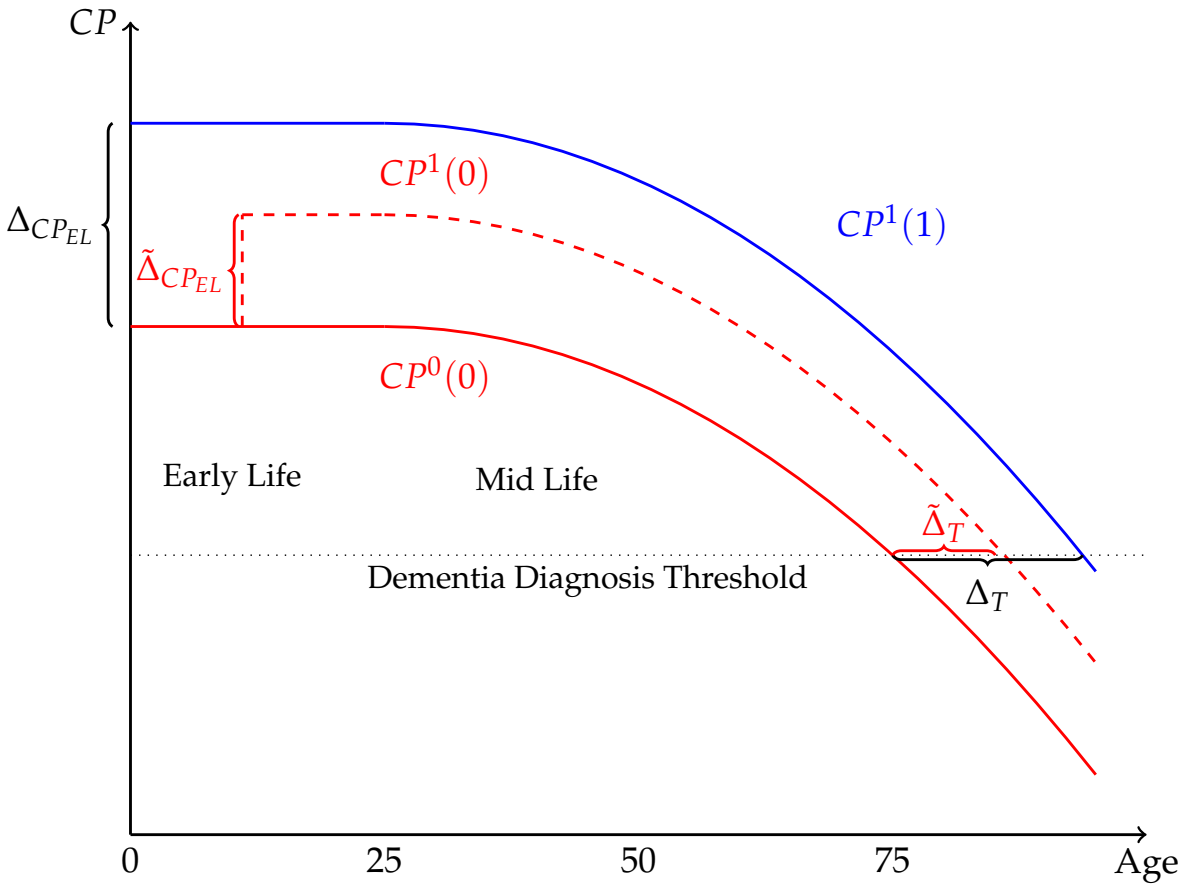
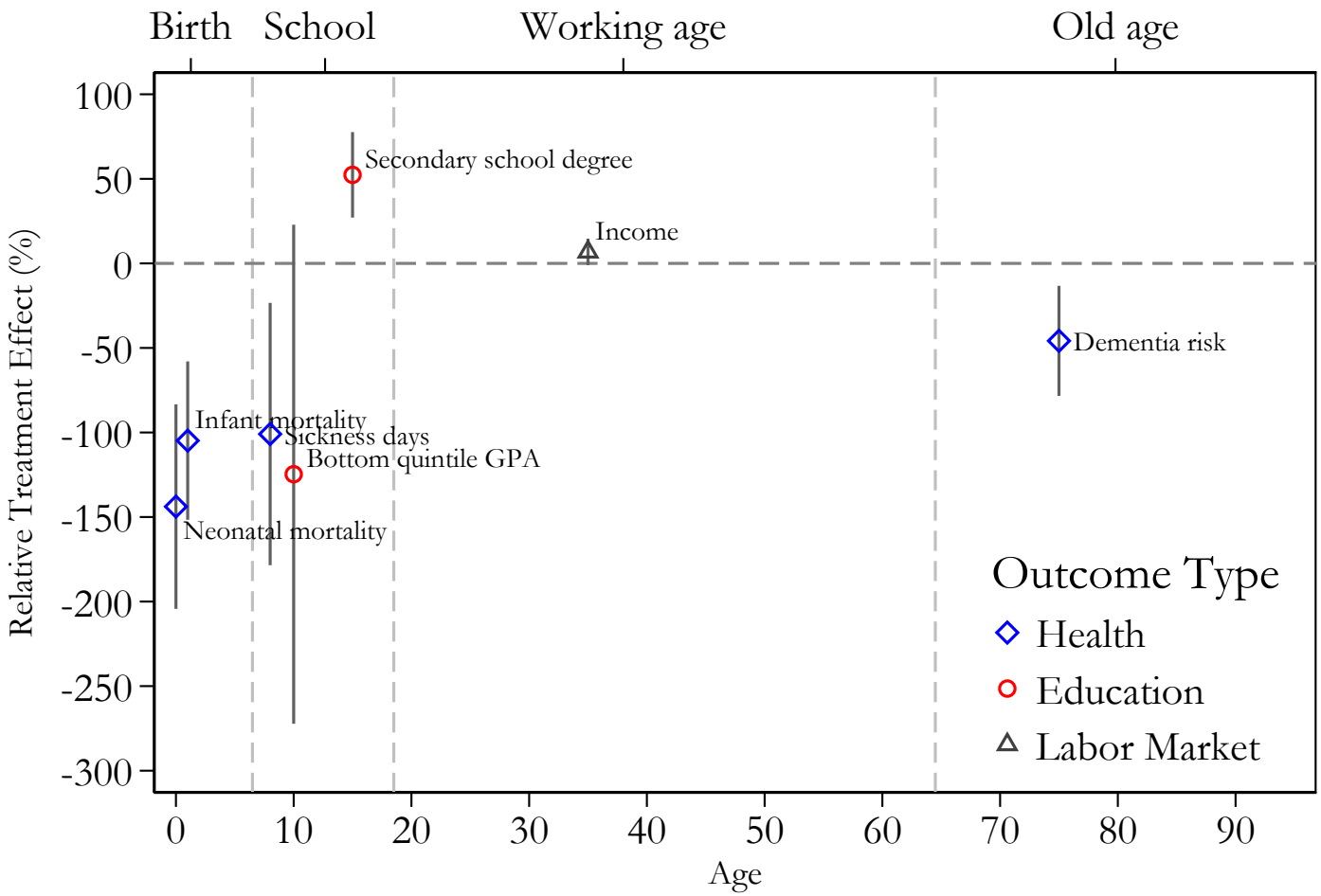


Figure: Cognitive Reserve – Potential Outcomes.

Treatment effects from being born in hospital estimated by instrumental variable



How to interpret the results – running LATE

- Estimated treatment effects from IV VERY large.
- Suggests that born in maternity ward eradicates infant mortality, the risk of getting dementia and doubles educational attainment. Note very reasonable…And also not in line with aggregated trends.
- Know that IV under **heterogenous treatment effects** estimates effect on **subpopulation of compliers**.
- Put effects into perspective by
  a) using marginal treatment framework to explain the large effects stemming from **selection into treatment**,
  b) present evidence that compliers were chosen through **sophisticated risk selection by midwifes**,
  c) realign large treatment effects with general aggregated trends,
  d) Consequences for external validly and policy implications.

Transition from Home to Hospital Births

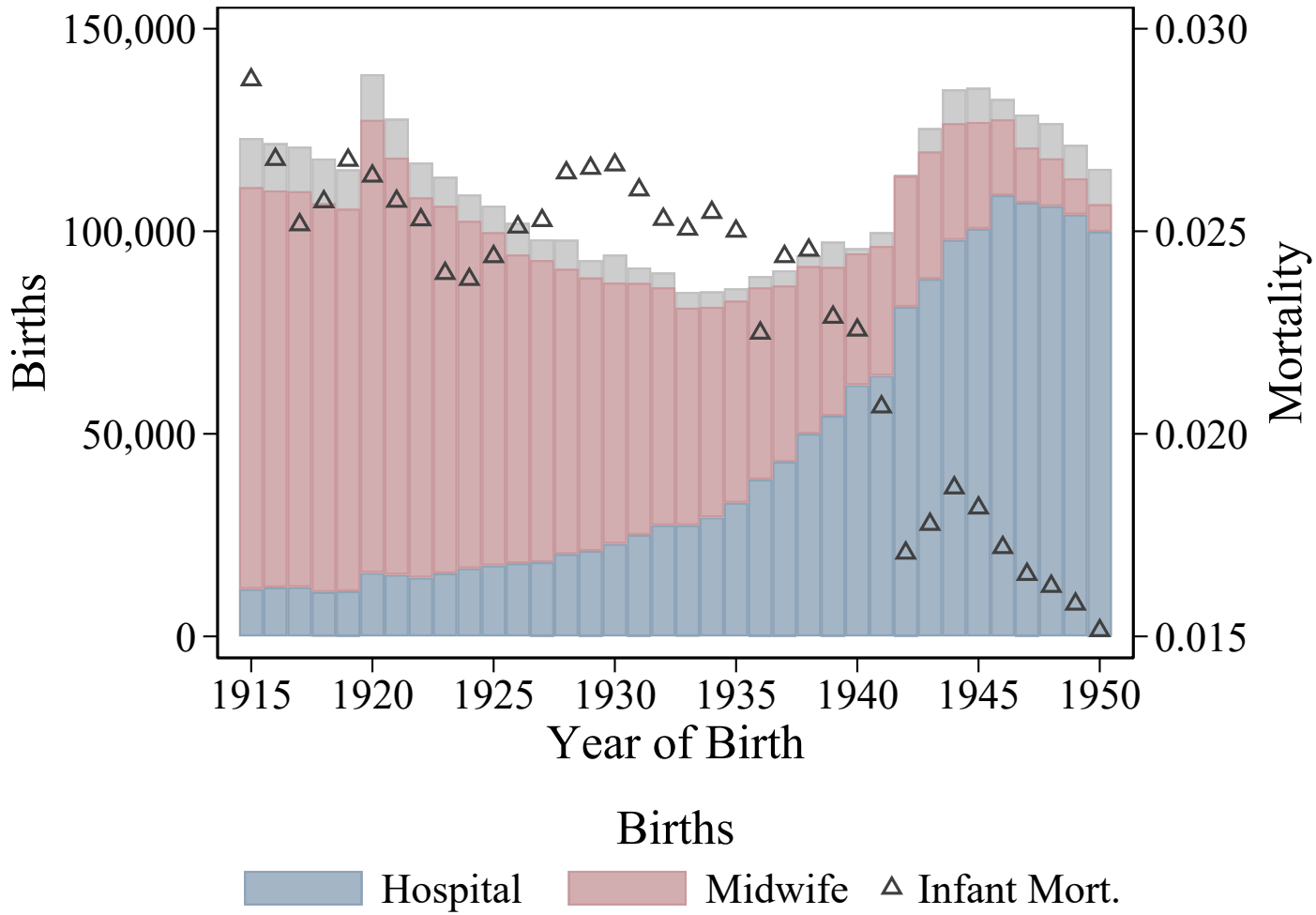


Figure: Live Births and Neonatal Mortality in Sweden, 1915–50.

Transition from Home to Hospital Births

- **Changing preferences** to give births in maternity wards.
- Transition **earlier** than in other Nordic countries.
- Swedish **midwifes** generally well-educated but not for births with serious complications.
- Excess demand for giving birth in maternity wards $\Rightarrow$ hospitals operated at capacity constraint.
- Supply shifts as *natural experiments*:
  - Establishment of **new hospitals**.
  - **Extensions** of existing institutions.

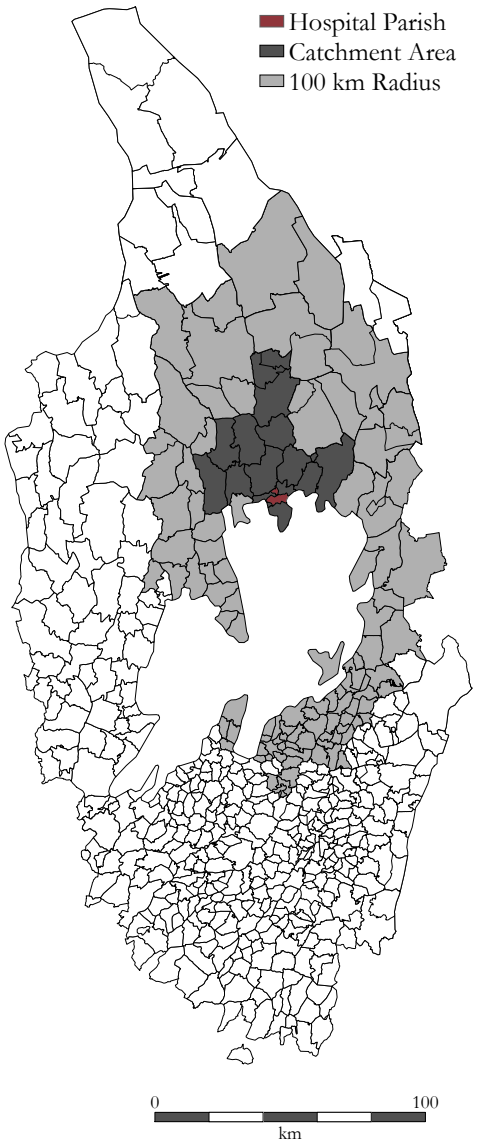
Data Sources

1. Swedish **Administrative Data** (SIP, individual level)
   - Censuses (1950, 1970)
   - Outcome: Dementia
     - Cause of Death Register
     - Inpatient Register
   - Mediators: Income, Education, Occupation
2. **Intervention Data** (expansions in the hospital sector)
   - 51 hospital openings or extensions.
   - Requirements for in sample:
     - Historical records on openings or extensions
     - Presence of a birthbook
   - Identification of **catchment area** around hospital (parishes which contributed to births at the hospital $\sim$30–40 km).

Data Sources, Ctd.

3. **School Performance Data** (individual level)
   - Digitised from exam catalogues for subsample ($N = 10,965$)
   - Includes performance years 1 and 4 (ages 7–11).
   - Read/speak, write, math, religion, physical education.
   - Sickness absence (pct of school days).
4. **Midwife Data** (universe of home births)
   - Entire population 1928–38.
   - Data on mothers, complications, procedures, parity...
   - Available at **health district** level ($N = 400$).

Catchment Area Karlstad (1937)



1. Start with radius 60km (120 km in the 5 northern counties).
2. Data-driven approach to identify parishes within radius which contribute to maternity ward births.
3. Typical radius 30-40km.
4. Radius is in line with historical sources on travel distances, using quite sophisticated modes of transportation for 1930s (cars, sometimes even planes!).

Empirical Strategy: Instrumental Variables

First Stage:

$$H_i = \beta_0 + \beta_1 Z_i + \beta_2' x_i + \mu_c + \delta_t + \eta_i,$$

H_i hospital birth

Z_i born after an extension/opening

μ_c catchment area fixed effects

δ_t fixed effects birth year

Second stage:

$$Y_i = \gamma_0 + \gamma_1 \hat{H}_i + \gamma_2' x_i + \mu_c + \delta_t + \epsilon_i,$$

Empirical Models

1. Pooled Regression Discontinuity (before and after)
2. Two-way fixed effects (DiD) (with 2-year window around opening)
3. Difference-in-Discontinuity (with 2-year window around opening)

- Linear regression models
- Survival models (time of first diagnosis of dementia).
  - Control function
  - G-estimation

Local average treatment effect

- With our binary instrument and under the assumptions of
  - **Independence**
  - **Exclusion**
  - and **Monotonicity**...
- γ_1 identifies a LATE for those being *born in a hospital due to a supply side shift*.

$$\gamma_1^{LATE} = \mathbb{E}\left(Y_i^1 - Y_i^0 \mid H_i^1 > H_i^0\right)$$

- **Not** necessarily

$$\gamma_1^{LATE} = \mathbb{E}\left(Y_i^1 - Y_i^0\right)$$

$$\gamma_1^{LATE} = \mathbb{E}\left(Y_i^1 - Y_i^0 \mid H_i = 1\right)$$

$$\gamma_1^{LATE} = \mathbb{E}\left(Y_i^1 - Y_i^0 \mid H_i = 0\right)$$

First Stage

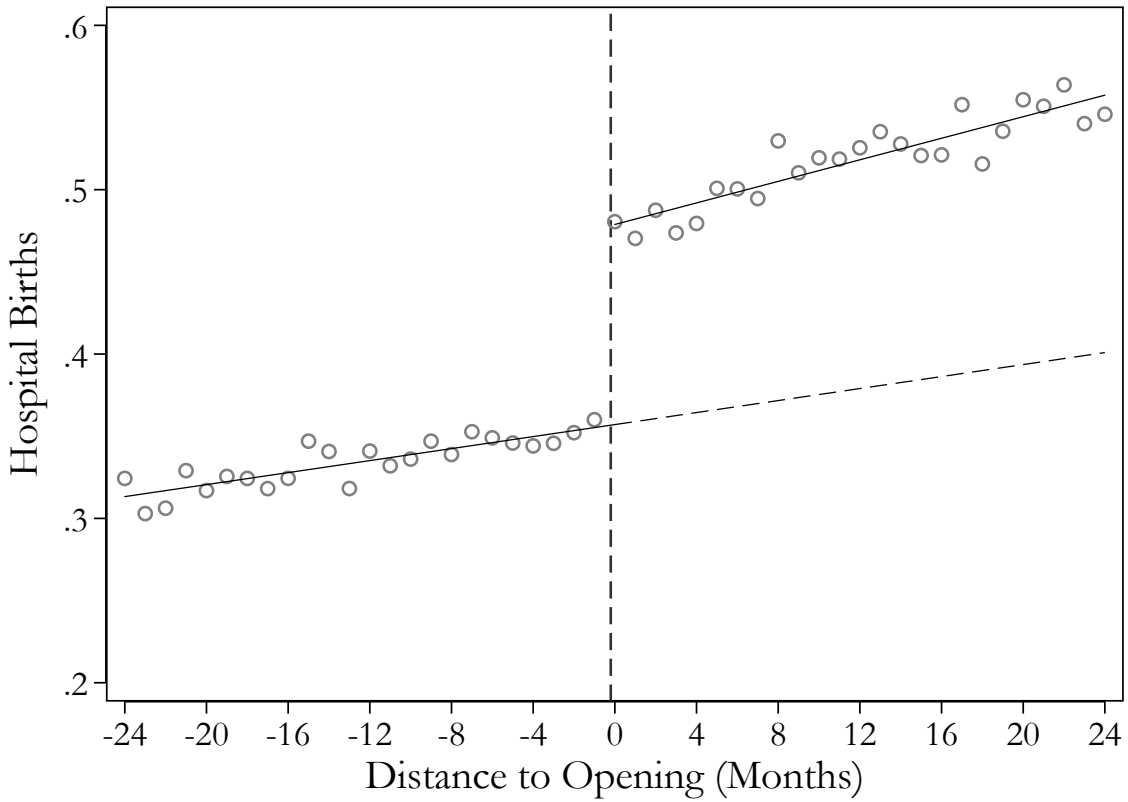


Figure: The First Stage: Hospital Birth

First Stage

Table: First Stage

	RDD	DiDisc
Maternity Ward Opening/Extension (p.p.)	12.42	12.51
[95% CI]	[10.69,14.16]	[9.06,15.97]
Mean Dep. Var	37.37	37.37
F-Statistic	218.46	53.59

Notes: Robust standard errors are clustered at the level of the running variable.

Early Life and Mid-life Outcomes

Table: Instrumental Variable Estimates

	Neonatal mortality	Life-Cycle Earnings	Years of education	Secondary school
Born in Maternity Ward				
RDD	-0.041**	11225.51	1.48***	0.18***
	(0.017)	(16808.78)	(0.39)	(0.04)
Mean dep. var.	0.028	175,944.46	9.42	0.24
DiD	-0.045***	19457.92**	1.35***	0.17***
	(0.009)	(8280.75)	(0.33)	(0.05)
Mean dep. var.	0.028	175,944.46	9.42	0.24

Main Results

Table: Effects of Hospital Delivery on Dementia Risk

	RDD	**DiDisc**
Proportional Hazard Model		
ITT	0.876	0.883
[95% CI]	[0.774,0.990]	[0.798,0.976]
IV	0.339	0.462
	[0.130,0.885]	[0.218,0.979]
N	43,512	86,675
Cluster	24	48

Notes: Robust standard errors are clustered at the level of the running variable. Significance levels: $*$ 0.10 $**$ 0.05 $***$ 0.01.

Untreated Outcomes Test

- Subpopulation of individuals who were **not** born in hospital
  - before a supply-side expansion: compliers (C) and never-takers (N)
  - after supply-side expansion only never-takers (N)
- any change in outcomes or in control variables $W^0 \epsilon \{Y^0, X^0\}$ within the untreated group which coincides with the intervention Z must be a result of selection.
- Use two different data source:
  1. Midwife diaries on homes births (by construction conditioning on no treamtment).
  2. Individual level data conditioning on **not** being treated.

Untreated Outcomes Test (UOT)

- Restrict analysis to **untreated**.
- **Before a supply-side expansion** the mean in the non-treated group is the weighted average between compliers and never-takers

$$\mathbb{E}(W^0|Z=0) = \frac{\mathbb{P}(C)}{\mathbb{P}(C)+\mathbb{P}(N))}\mathbb{E}(W^0|C) + \frac{\mathbb{P}(C)}{\mathbb{P}(C)+\mathbb{P}(N))}\mathbb{E}(W^0|N). \quad (1)$$

- **After the supply-side expansion** simply the mean of never-takers $\mathbb{E}(W^0|Z=1) = \mathbb{E}(W^0|N)$.
- We can quantify selection by

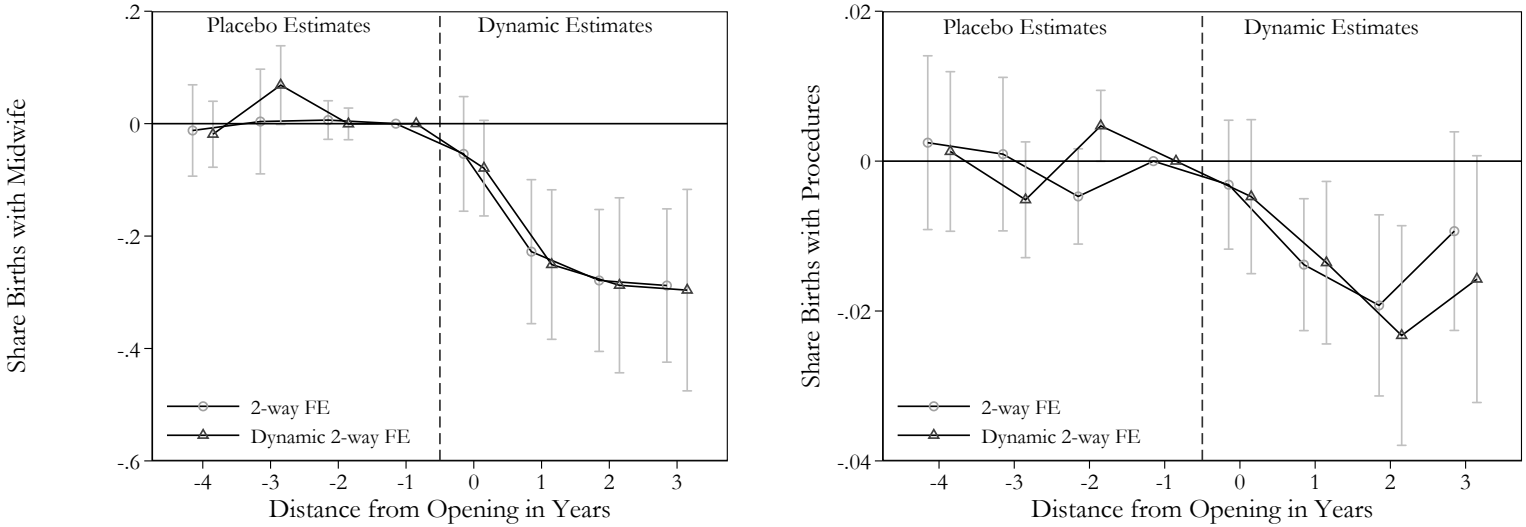
$$\begin{aligned}\Delta^0 &= \mathbb{E}(W^0|C) - \mathbb{E}(W^0|N) \\ &= (-1)\frac{\mathbb{P}(C)+\mathbb{P}(N)}{\mathbb{P}(C)}\left[\underbrace{\mathbb{E}(W^0|Z=1) - \mathbb{E}(W^0|Z=0)}_{\theta_0}\right],\end{aligned}$$

with θ_0 the reduced form estimand (ITT) of the supply-side expansion **based on untreated only**.

Untreated Outcomes Test (UOT)

- Testing whether there is **non-random uptake of treatment**.
- Δ^0 represents the mean difference between compliers and never-takers prior to treatment.
- Note that this difference cannot be due to the treatment itself, as all are untreated.
- We will use Δ^0 to investigate to which extent compliers are a selected group in terms of health risk and socio-economic status.
- Statistical inference is based on the delta method or bootstrapping.

Event Study Midwife Data (UOT)



(a) (b)

Figure: Event Study: (**a**) Births with Midwife; (**b**) Midwife Birth with Procedure

UOT on Midwife Assisted Home Births

	(1)	(2)	(3)	(4)	(5)
	Panel A: DiD (2-way FE)				
	Births with Midwife	Births with Procedures	Births with Complications	Mother ill / diseased	Twins
Hospital Opening θ^0	-0.284***	-0.013***	-0.003**	-0.006***	-0.001
	(0.054)	(0.004)	(0.001)	(0.002)	(0.001)
N	791,755	622,930	622,930	622,930	622,930
Health Districts	397	413	413	413	413
	Untreated outcome test (Selection)				
$\mathbb{E}(W^0\|N)$	0.513	0.029	0.003	0.011	0.012
Δ^0		0.055	0.011	0.027	0.003
Relative Risk		2.916	4.730	3.529	1.252
	Robust DiD Estimator (Dynamic 2-Way FE)				
Robust Effect	-0.232	-0.012	-0.002	-0.008	-0.000
SE Robust Effect	(0.061)	(0.004)	(0.001)	(0.007)	(0.002)

Notes: Table shows effects of the a hospital opening or extension in a given health district.
Source: Midwife Diaries. Own calculations.

Transition from Home to Hospital Births

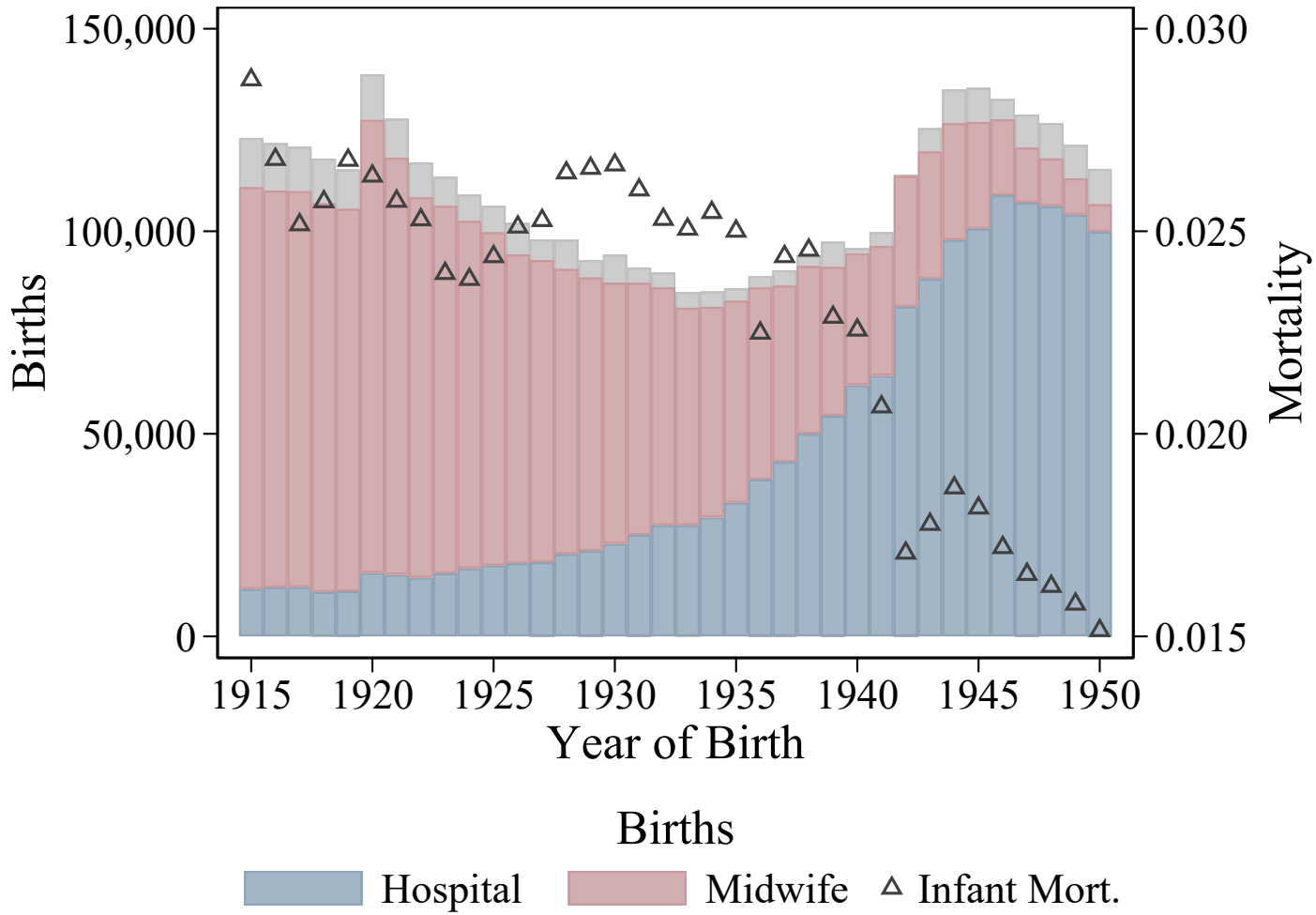


Figure: Live Births and Neonatal Mortality in Sweden, 1915–50.

Treated and Untreated Outcomes: Neonatal Mortality

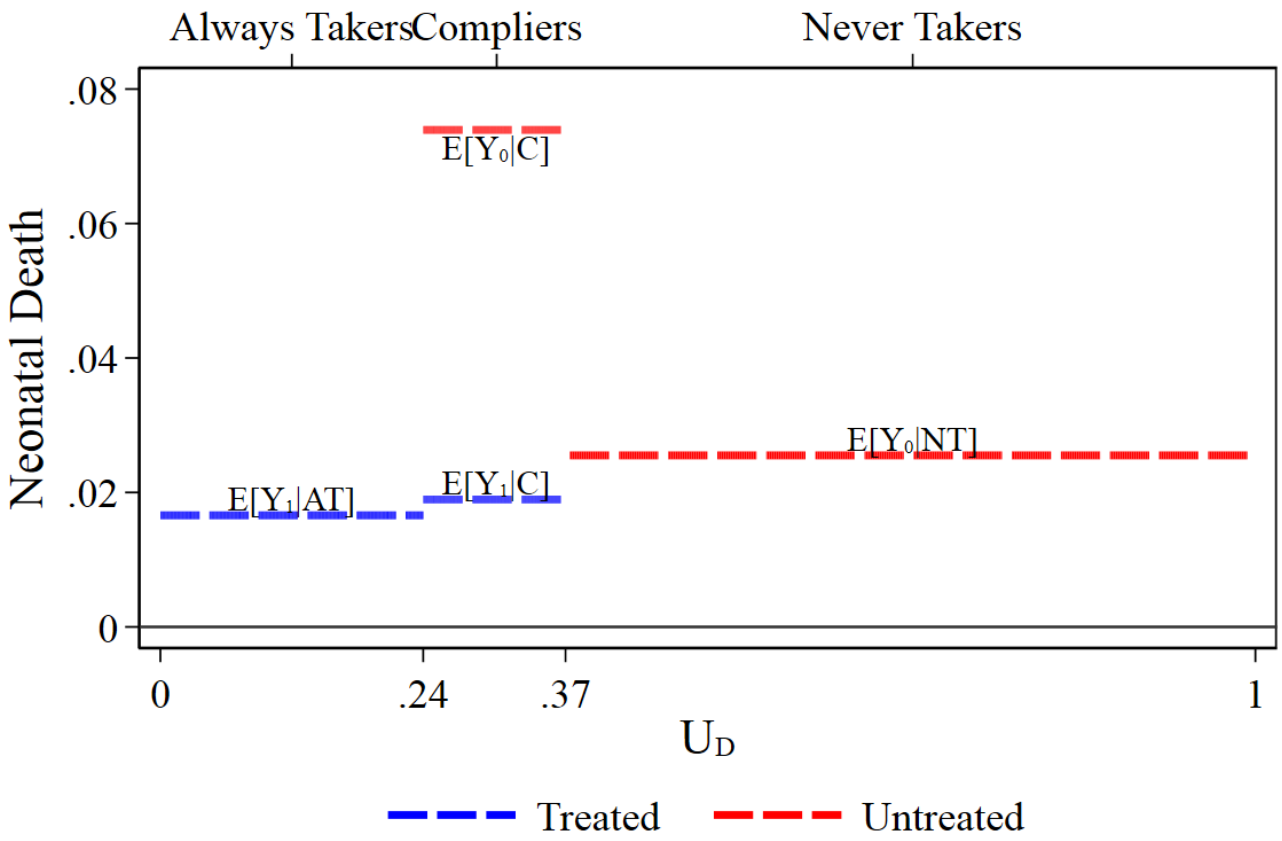
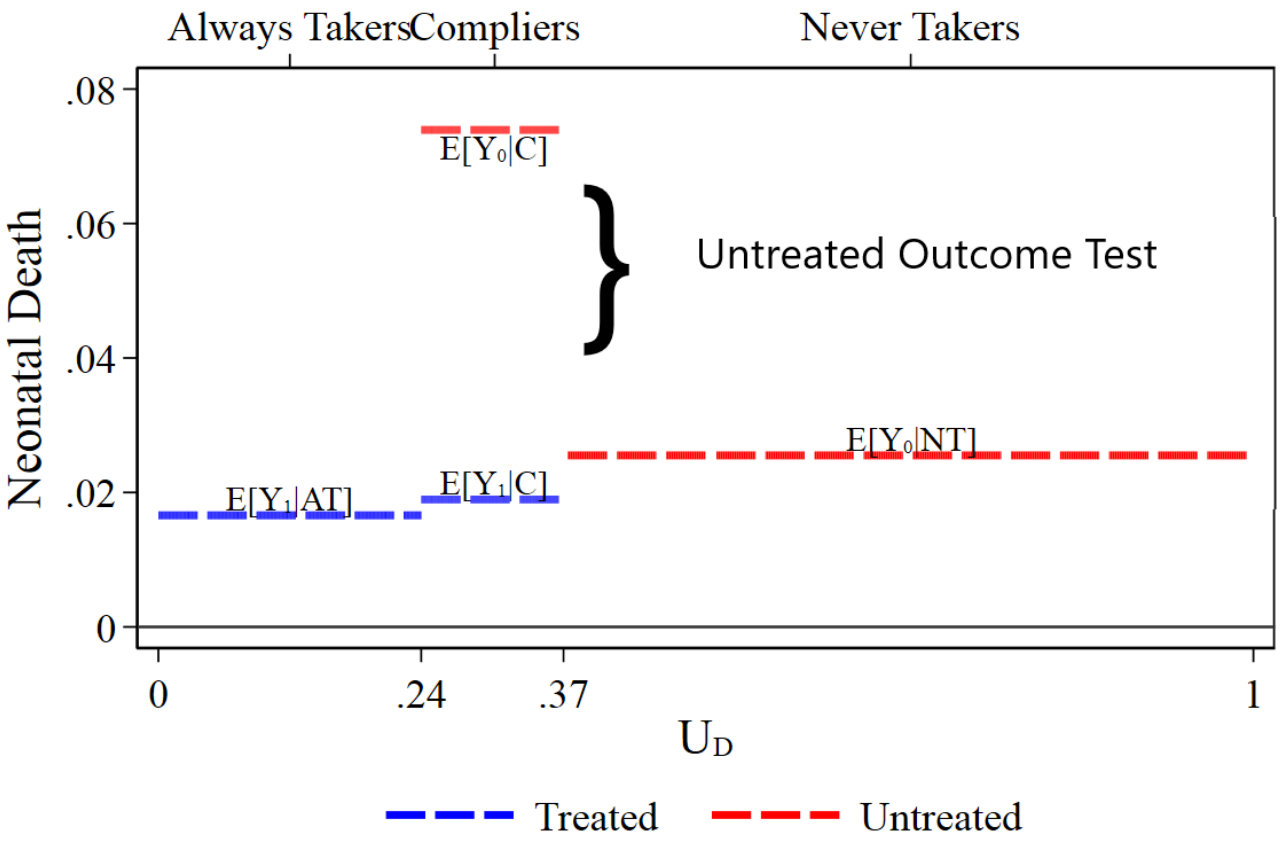


Figure: Treated and Untreated Outcomes by Group.

Treated and Untreated Outcomes: Neonatal Mortality



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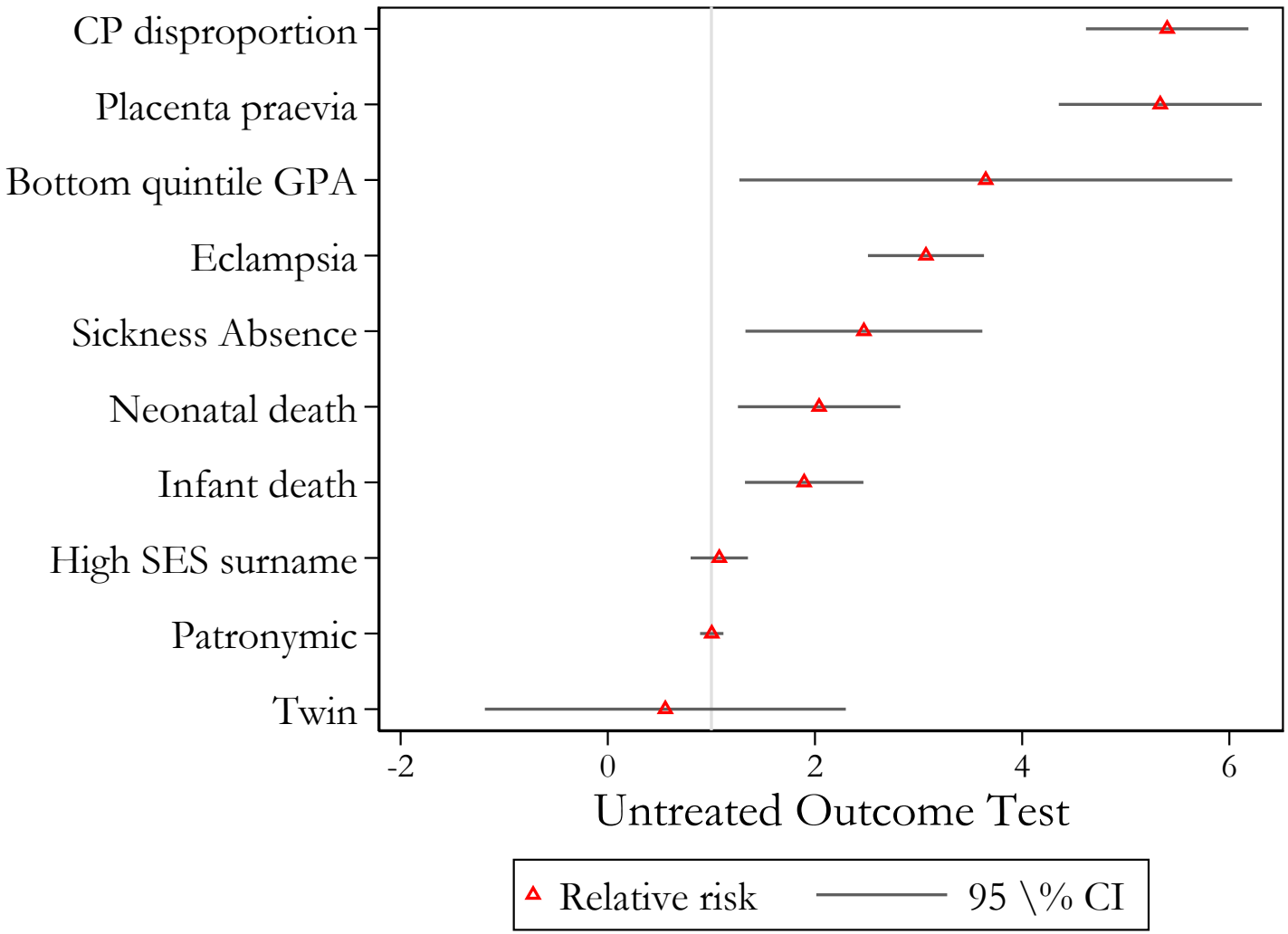
Selection: Summary



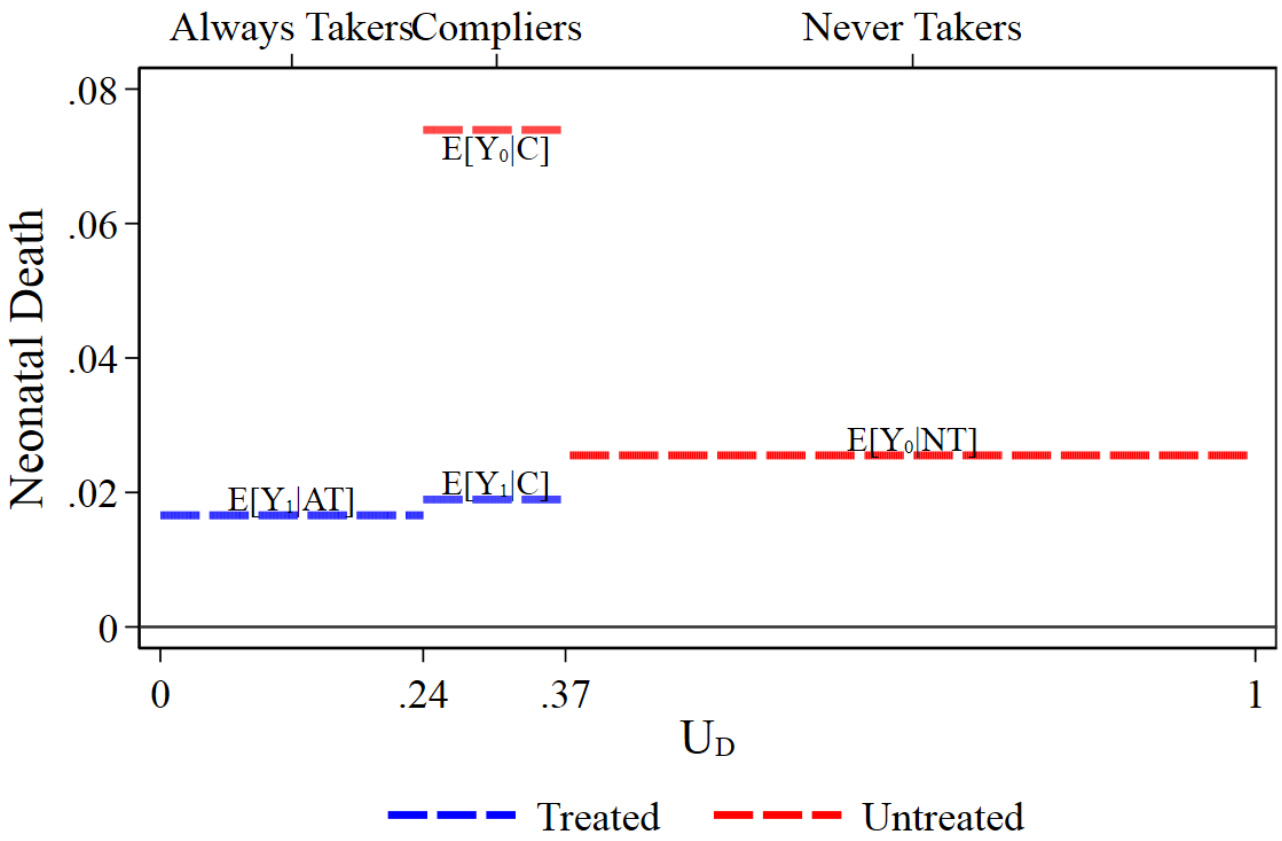
Is strong risk selection in line with historical sources?

- General
  - By law (SFS 1919:798) the midwife had to contact a doctor in case of complications during child birth.
  - The National healthcare committee (1928): hospitals should be for complicated cases.
- Related to specific complications
  - Midwifes not allowed to do surgery or use sharp instruments.
  - Only doctors allowed to give medicine (pitocin 1927, ergometrin 1935, heparin 1937).
  - Eclampsia could be identified by urine test by 1923.
  - Hospitals had instruments to initiate contractions and from 1927 doctors could provide pitocin.

Can we do more? External validity?

- Until now only binary instrument.
- Estimates of IV restricted to compliers.
- How well do our IV estimates extrapoLATE?
- Important question, when decision whether extending a programme based on (self-)selection into treatment.
- Imposing more structure
  - Impose linearity in unobserved heterogeneity / *resistance* to being born in a hospital U_D
  - Continuous instrument - distance to next hospital from families place of residence.

Linear MTE: Neonatal mortality



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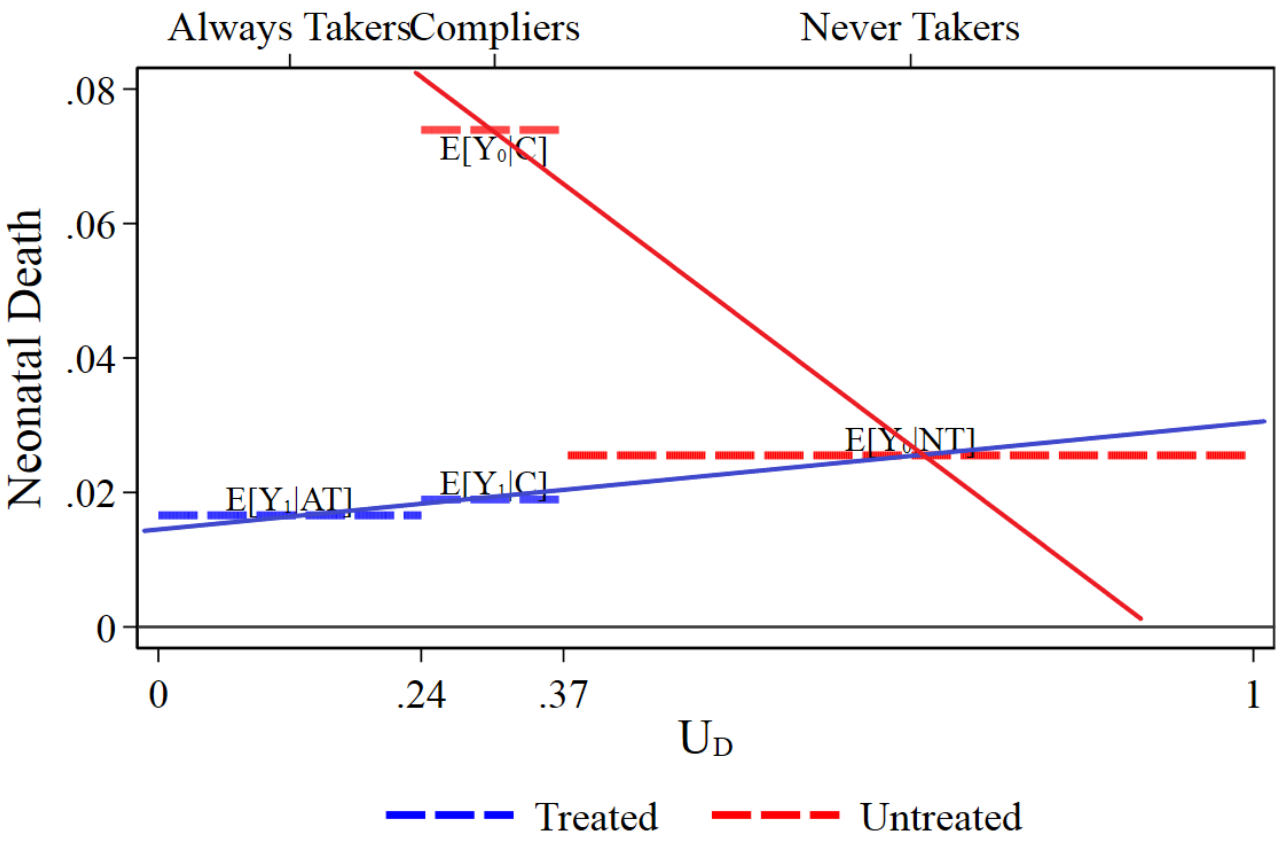

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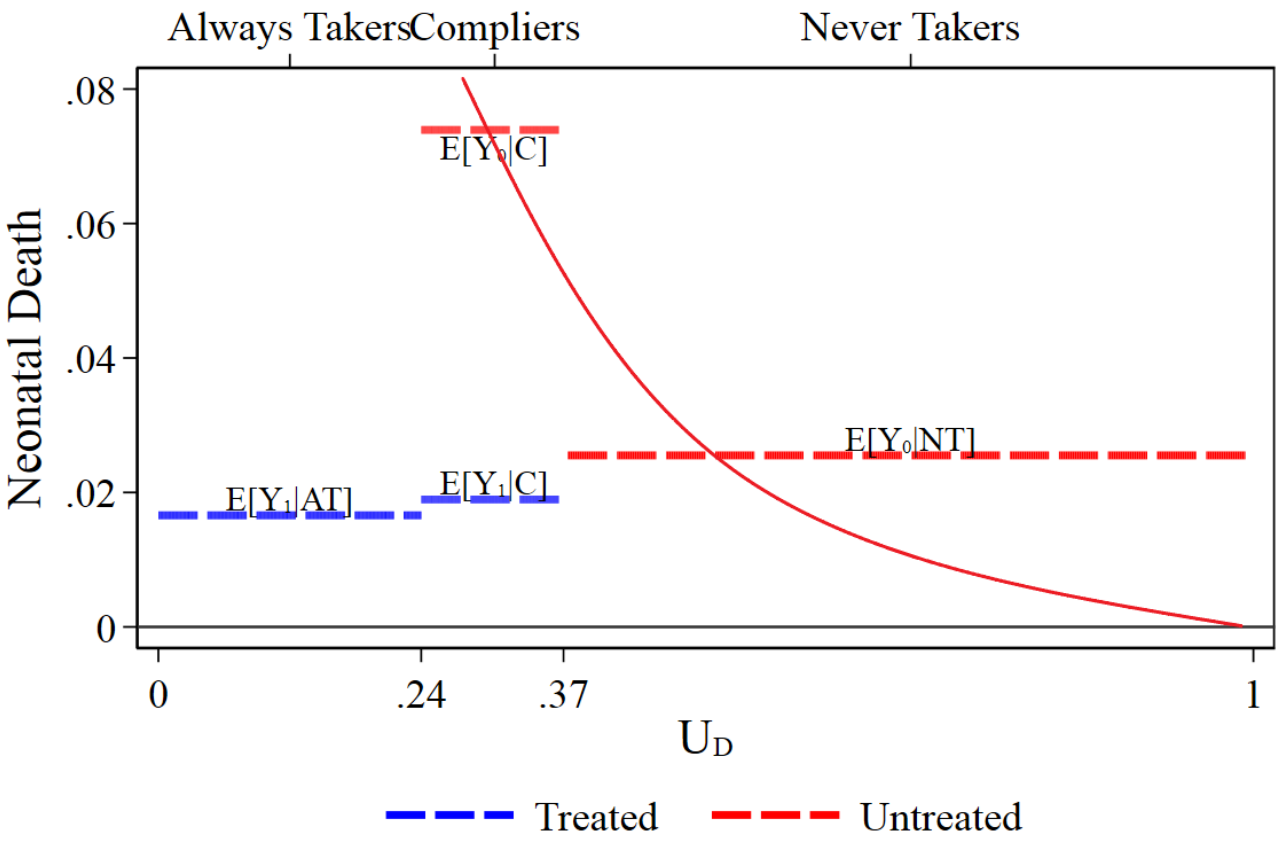

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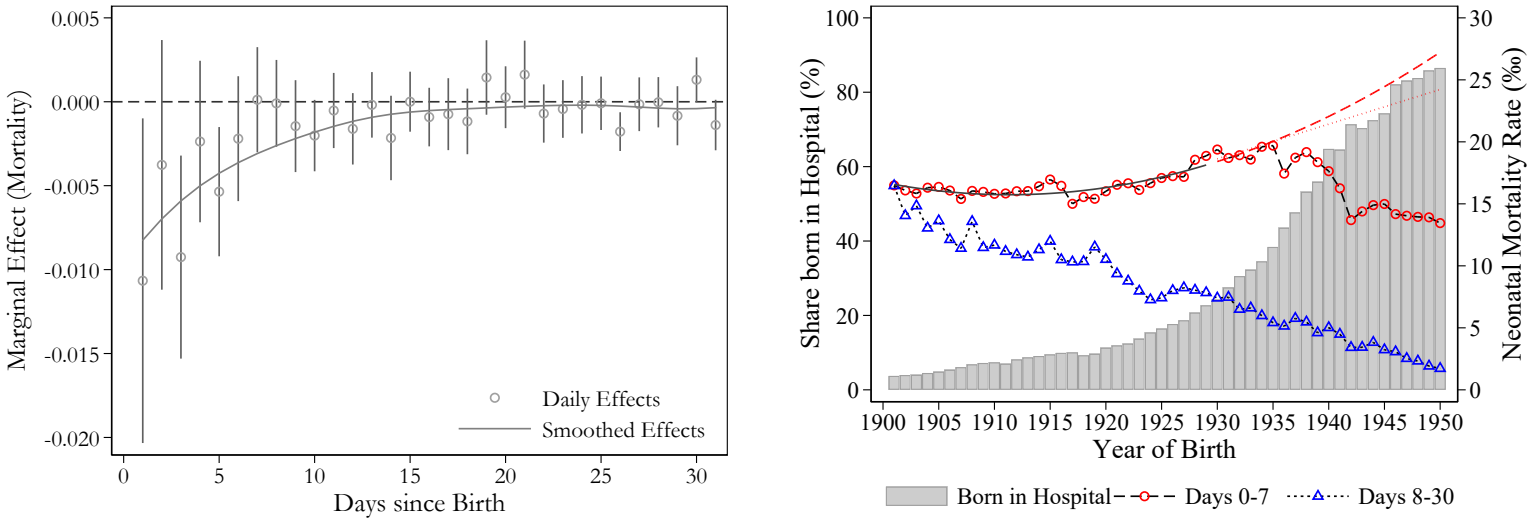
Reconciliation Effects and Trends



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Conclusions

- Critical births seem to have **shifted to hospitals**.
- **Better care** in case of (severe) **complications**.
- Find substantial decrease in the relative dementia risk of **10-15% from improved access** to services.
- Parts of the effect runs through **education** and **income**.
- Unexplored potential to address the **early-life origins** of dementia.
- Potential for large policy leverage in developing countries...
- However strong **self-selection** suggests $ATE << LATE$.