
title: "Parity-two multiple birth, attained fertility, and maternal wage income"
subtitle: "Outcome-blind preregistration report" **date:** "2026-09-04T20:00:00Z"

Registration boundary

- Research ID: `restricted42_twin_birth_iv`
- Mode: `schema_first`
- Version: 1
- Knowledge cutoff: 2026-09-04T20:00:00Z
- Outcome data accessed: **no**

Research scope

Question. Among validated Danish mothers at a parity-two live-birth delivery, what is the effect of attained parity ten years later, as shifted by a multiple rather than singleton index delivery, on mean nominal maternal wage income in calendar years six through ten after the index year?

Primary estimand. Individual-level LATE, in nominal DKK per one-parity increase, of parity attained by ten years on the arithmetic mean of `LOENMV_13` in years six through ten among mothers whose ten-year parity is increased by index multiplicity.

Population and setting. Mothers with a validated maternal PNR and exactly one classifiable parity-two live-birth delivery in 1995-2009, complete ten-year LPR coverage, and IND observation in every outcome year. Unit: Mother indexed at one parity-two delivery.. Setting: Danish administrative records restricted to the 42-table schema boundary.. Period: Index admissions in 1995-2009; fertility through ten years after index date; wage income in calendar years six through ten after index year..

Inferential ceiling. A horizon-specific LATE for validated observed parity-two compliers only if all construction, exchangeability, relevance, monotonicity, and exclusion gates pass; otherwise a bundled multiple-delivery contrast, descriptive contrast, feasibility claim, or no claim as registered below.

Theory and contribution

Focal mechanism. A multiple parity-two delivery increases attained parity at ten years for some mothers; the added child-care burden can reduce later maternal wage income.

Rival mechanisms.

- Twin gestation, delivery morbidity, and simultaneous infant care may affect later wages directly, violating exclusion.
- Maternal age, fecundity, health, prenatal condition, and assisted reproduction may jointly predict twinning and wages.
- Differential survival, migration, or tax-register presence may select the fully observed sample.

Contribution. A bounded Danish horizon-specific implementation that makes construction, weak-IV, direct-path, and observation failures explicit rather than treating twins as automatically ran-

dom.

Question-to-output map

Question

Effect of ten-year attained parity shifted by index multiplicity on mean maternal wage income in years six through ten.
Whether individual multiple assignment is credible in the validated parity-two risk set.
Whether multiple birth shifts attained parity at ten years strongly and consistently.

Execution governance

Authority. This YAML, the four hashed upstream artifacts, and hashed authoritative codebooks jointly govern execution; the YAML controls conflicts.

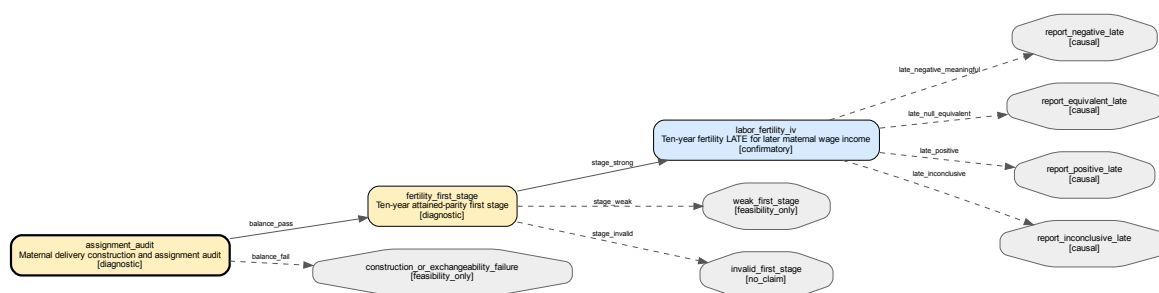
Execution order. assignment_audit -> fertility_first_stage -> labor_fertility_iv

Environment. R 4.5.1; arrow 20.0.0, data.table 1.17.8, fixest 0.13.2, ivreg 0.6-5, sandwich 3.1-1. Capture: Write sessionInfo and renv.lock SHA-256 before data access. Seed: Set RNGkind L'Ecuyer-CMRG and seed 420904 for randomization tests and synthetic data. Time zone: Europe/Copenhagen. Locale: en_DK.

Data-access sequence. Hash codebooks and run synthetic dry run; read birth/contact and baseline fields; close gates; construct fertility; only after activation read LOENMV_13 outcome years.

Failure policy. Any failed assertion follows its declared route; no proxy field, estimator, cohort, threshold, or outcome substitution is permitted.

Experiment graph



assignment_audit: Maternal delivery construction and assignment audit

Epistemic role: **diagnostic**. Establish a valid individual risk set and test pre-index balance without reading post-index wages.

Activation. Run when Always first.; skip when Never..

Hypothesis. Multiple and singleton groups satisfy the frozen construction and balance gates.

Design and estimand. other; Construction pass indicator, maximum absolute standardized difference, and joint randomization-test p-value.

Identifying variation. A mother’s own multiple-versus-singleton parity-two pregnancy realization.

Counterfactual. Otherwise comparable validated parity-two singleton pregnancies in the same index-year strata.

Analysis. data.table summaries plus fixest OLS and a 9999-repetition within-index-year permutation test.: For each continuous covariate report (mean_Z1-mean_Z0)/pooled_SD; jointly regress Z on all four covariates and index-year FE and compare the observed robust Wald statistic to permutations of Z within index year.

Pseudocode execution plan

Closed identity. Whether individual multiple assignment is credible in the validated parity-two risk set. -> Construction pass indicator, maximum absolute standardized difference, and joint randomization-test p-value. -> `multiple_birth` -> `max_abs_smd_and_joint_p` -> `balance_result`.

Sources

ID	Resource and tables
<code>births_raw</code>	<code>readable_42_table_schema</code> : LPR_FOEDSLER
<code>adm_raw</code>	<code>readable_42_table_schema</code> : LPR_ADM
<code>ind_baseline</code>	<code>readable_42_table_schema</code> : IND
<code>authoritative_rules</code>	<code>readable_42_table_schema</code> : README.md, LPR_FOEDSLER.md, LPR_ADM.md, IND.

Variable construction `multiple_birth` (instrument, Mother index).

Sources: `V_FLERNR`, `RECNUM`, `plurality_rule`. Time: Index episode only. Missingness: Exclude unclassifiable episodes.

1. Group birth-detail rows by validated delivery `RECNUM`.
2. Apply hashed plurality rule on the same episode and code multiple one versus singleton zero.

`baseline_vector` (covariate, Mother index).

Sources: `V_ALDER`, `D_INDDTO`, `AAR`, `LOENMV_13`. Time: Strictly pre-index wages plus index-contact age. Missingness: Complete-case exclusion before balance.

1. Extract age and calendar year from validated index contact.
2. Select exactly `index_year` minus one and minus two IND rows and retain nominal `LOENMV_13`.

Equation or algorithm

Compute four SMDs and joint Wald statistic from `multiple_birth` on `baseline_vector` plus index-y

Target statistic: `max_abs_smd_and_joint_p`. Estimator/API: `fixest::feols` with `sandwich::vcovHC` and `base::sample.int`

Weights: Equal mother weights. Fixed effects: Index-year indicators in joint regression. References: Singleton Z=0 and earliest index year omitted.

Uncertainty: HC1 Wald statistic and 9999 within-year permutations. Clustering: Mother; one observation each.

Ordered actions **a01 — Freeze documentation and prove the maternal delivery algorithm.**

Consumes: `authoritative_rules`, `births_raw`, `adm_raw`. Produces: `cohort_audit`.

1. Hash all rule files and verify each required rule has one date-valid value.
2. Join RECNUM and apply maternal identity live-birth parity and plurality rules without reading

Assertions: One stable maternal PNR per retained delivery.; Unique classification share meets the registered threshold.; Index chronology is valid.

Failure route: `mark_infeasible` — Stop all experiments and issue `construction_failure`.

a02 — Construct the complete baseline audit sample.

Consumes: `cohort_audit`, `ind_baseline`. Produces: `audit_sample`.

1. Select one earliest eligible parity-two delivery per mother.
2. Join exactly two pre-index IND years and construct `baseline_vector`.

Assertions: One row per mother.; Both assignment groups and at least 100 multiple deliveries exist.

Failure route: `mark_infeasible` — Stop all downstream work and issue `support_failure`.

a03 — Evaluate the frozen assignment-balance gate.

Consumes: `audit_sample`. Produces: `balance_result`.

1. Compute four SMDs and observed joint HC1 Wald statistic.
2. Permute assignment within index year 9999 times and compute the registered Monte Carlo p-value.

Assertions: Exactly 9999 permutation repetitions complete.; Report all four SMDs without suppression.

Failure route: `stop_experiment` — Stop causal sequence and retain feasibility-only cohort audit.

Output contract

Output	Path	Grain	Required fields
<code>cohort_audit</code>	<code>preregistration/results/cohort_audit.parquet</code>	Delivery episode	PNR, RECNUM, index_date
<code>audit_sample</code>	<code>preregistration/results/audit_sample.parquet</code>	Mother index	PNR, index_year, multiple_delivery
<code>balance_result</code>	<code>preregistration/results/balance_result.json</code>	Audit	n_total, n_multiple, unique_delivery

Procedure accounting

- **joint_balance_fit**: 1 calls per unit $\times$ 1 fitted units $\times$ 10000 repetitions = 10000 fits. One observed plus 9999 permuted joint regressions.
- Full-data passes: 4. Largest intermediate: birth_adm joined birth-detail rows.

Synthetic dry run. Generate 1000 fake mothers with duplicate and invalid cases; verify exclusion order, joins, permutations, and decisions without real values.

Reconciliation. Input rows equal retained plus mutually exclusive exclusions at every sample step.

Decision regions.

- **balance_pass** (supports): `unique_share >= unique_direct AND max_abs_smd < smd_pass AND joint_p >= alpha_balance`. — Construction and observed balance pass; activate first stage.
- **balance_fail** (feasibility_failure): Any construction assertion fails OR `max_abs_smd >= smd_pass OR joint_p < alpha_balance`. — Do not claim as-if-random assignment or run outcome models.

fertility_first_stage: Ten-year attained-parity first stage

Epistemic role: **diagnostic**. Determine instrument relevance and directional stability before wage outcomes are read.

Activation. Run when `assignment_audit` returns `balance_pass`.; skip when `assignment_audit` returns `balance_fail`.

Hypothesis. Multiple birth increases ten-year attained parity.

Design and estimand. iv; Adjusted mean difference π in attained parity at ten years between multiple and singleton index deliveries.

Identifying variation. Individual pregnancy-level multiple realization within validated parity-two index-year strata.

Counterfactual. Ten-year parity the same mother would attain after singleton instead of multiple realization.

Analysis. `fixest::feols` OLS first stage with HC1 standard errors.: $\text{parity}_{10y} = \alpha + \pi * \text{multiple_birth} + \text{quadratic centered index age} + \text{wage_lag1} + \text{wage_lag2} + \text{index-year FE}$.

Pseudocode execution plan

Closed identity. Whether multiple birth shifts attained parity at ten years strongly and consistently. -> Adjusted mean difference π in attained parity at ten years between multiple and singleton index deliveries. -> `parity_10y` -> `pi_and_robust_f` -> `first_stage_result`.

Sources

ID	Resource and tables	Fields
audit_cohort	readable_42_table_schema: cohort_audit.parquet	PNR, index_date, index_year, m

ID	Resource and tables	Fields
later_births	readable_42_table_schema: LPR_FOEDSLER, LPR_ADM	RECNUM, PNR, D_INDDTO, V

Variable construction multiple_birth (instrument, Mother index).

Sources: multiple_birth. Time: Index episode only. Missingness: Missing stops the experiment.

1. Read the frozen binary field from audit_cohort.
2. Assert it is unchanged from the cohort digest.

baseline_vector (covariate, Mother index).

Sources: index_age, index_year, wage_lag1, wage_lag2. Time: Frozen pre-index and index values. Missingness: Missing stops the experiment.

1. Read the four frozen terms from audit_cohort.
2. Center age at the sample mean and square the centered value.

parity_10y (treatment, Mother index).

Sources: PNR, D_INDDTO, V_PARITET. Time: D_INDDTO between index date and index date plus ten years inclusive. Missingness: Conflicting or missing parity marks mother unclassifiable and stops if any retained record is affected.

1. Retain validated live-delivery contacts from index through exact tenth anniversary.
2. Sort by date and RECNUM and take maximum authoritative V_PARITET including index value two.

Equation or algorithm

$\text{parity_10y_i} = \alpha + \pi \text{ multiple_birth_i} + b1 \text{ agec_i} + b2 \text{ agec_i}^2 + b3 \text{ wage_lag1_i} + b4 \text{ wage_lag2_i}$

Target statistic: pi_and_robust_f. Estimator/API: fixest::feols

Weights: Equal mother weights. Fixed effects: Index-year fixed effects. References: Singleton and index year 1995.

Uncertainty: HC1 95 percent CI; robust F equals squared HC1 t statistic. Clustering: Mother; one row each.

Ordered actions a01 — Construct ten-year attained parity.

Consumes: audit_cohort, later_births. Produces: first_stage_sample.

1. Apply identical hashed maternal and live-birth rules to later contacts.
2. Sort valid contacts and take maximum parity through exact tenth anniversary.

Assertions: Cohort cardinality unchanged.; Parity is integer at least two and chronological.

Failure route: mark_infeasible — Stop fertility and outcome experiments because treatment is undefined.

a02 — Estimate strength and directional stability.

Consumes: first_stage_sample. Produces: first_stage_result.

1. Fit the registered full-sample first-stage equation and compute HC1 CI and F.
2. Fit the identical equation in four frozen subgroups and record coefficient signs.

Assertions: One primary and four subgroup fits complete.; Output contains no maternal wage outcome from years six through ten.

Failure route: `stop_experiment` — Stop IV and issue `first_stage_failure`.

Output contract

Output	Path	Grain	Required fields
<code>first_stage_sample</code>	<code>preregistration/results/first_stage_sample.parquet</code>	Mother index	PNR, multiple_birth,
<code>first_stage_result</code>	<code>preregistration/results/first_stage_result.json</code>	Diagnostic	pi, se_hc1, ci_low, ci

Procedure accounting

- `first_stage_fits`: 1 calls per unit $\times$ 5 fitted units $\times$ 1 repetitions = 5 fits. One full sample and four frozen subgroup fits.
- Full-data passes: 3. Largest intermediate: linked maternal delivery-contact history.

Synthetic dry run. Simulate monotone and defier-like fertility histories and verify exact-horizon, sign, F, and branch logic.

Reconciliation. First-stage sample count equals balance-pass cohort count exactly.

Decision regions.

- `stage_strong` (supports): $\text{pi} > \text{soe_pi}$ AND $\text{ci_low} > \text{zero_pi}$ AND $\text{robust_f} \geq \text{f_min}$ AND every subgroup_sign is positive. — Relevance passes; IV remains conditional on exclusion approval.
- `stage_weak` (inconclusive): $\text{pi} > \text{zero_pi}$ AND ($\text{robust_f} < \text{f_min}$ OR $\text{ci_low} \leq \text{zero_pi}$) AND every subgroup_sign is nonnegative. — No fertility LATE; report first stage only and terminate at bundled-effect-not-estimated because outcome access is not authorized for a separate unregistered estimand.
- `stage_invalid` (challenges): $\text{pi} \leq \text{zero_pi}$ OR any subgroup_sign is negative. — Terminate fertility claim and do not access wage outcome.

labor_fertility_iv: Ten-year fertility LATE for later maternal wage income

Epistemic role: **confirmatory**. Estimate one fertility LATE for one wage-income outcome family only when every identification gate passes.

Activation. Run when `balance_pass` and `stage_strong` and two recorded exclusion approvals before outcome access.; skip when Any other decision or approval state..

Hypothesis. One additional parity unit induced by multiple birth reduces mean nominal maternal wage income in years six through ten.

Design and estimand. iv; LATE in nominal DKK per parity unit for the five-year mean wage outcome among ten-year parity compliers.

Identifying variation. Own multiple versus singleton parity-two delivery, conditional on frozen covariates and index-year strata.

Counterfactual. A complier mother’s five-year mean wage under parity attained after singleton rather than multiple realization at the same pregnancy.

Analysis. ivreg::ivreg just-identified two-stage least squares.: `wage_mean_y6_y10 ~ parity_10y + agec + agec2 + wage_lag1 + wage_lag2 + factor(index_year) | multiple_birth + same exogenous terms.`

Pseudocode execution plan

Closed identity. Effect of ten-year attained parity shifted by index multiplicity on mean maternal wage income in years six through ten. -> LATE in nominal DKK per parity unit for the five-year mean wage outcome among ten-year parity compliers. -> `wage_mean_y6_y10 -> beta_iv_dkk_per_parity -> iv_result.`

Sources

ID	Resource and tables	Fields
<code>strong_stage_sample</code>	<code>readable_42_table_schema: first_stage_sample.parquet</code>	PNR, <code>multiple_birth</code> , <code>parity_10y</code>
<code>ind_outcome</code>	<code>readable_42_table_schema: IND</code>	PNR, AAR, LOENMV_13, C
<code>exclusion_approval</code>	<code>readable_42_table_schema: exclusion_review.yaml</code>	<code>reviewer_role</code> , <code>decision</code> , <code>signed</code>

Variable construction `multiple_birth` (instrument, Mother index).

Sources: `multiple_birth`. Time: Index episode only. Missingness: Missing stops the experiment.

1. Read frozen instrument from `strong_stage_sample`.
2. Verify against cohort digest.

`parity_10y` (treatment, Mother index).

Sources: `parity_10y`. Time: Through exact tenth anniversary. Missingness: Missing stops the experiment.

1. Read frozen ten-year parity from `strong_stage_sample`.
2. Verify against first-stage digest.

`baseline_vector` (covariate, Mother index).

Sources: `index_age`, `index_year`, `wage_lag1`, `wage_lag2`. Time: Pre-index and index only. Missingness: Missing stops the experiment.

1. Read frozen baseline terms.
2. Center age and square centered age identically to first stage.

`wage_mean_y6_y10` (outcome, Mother index).

Sources: PNR, AAR, LOENMV_13. Time: Exactly five calendar years six through ten after index year. Missingness: Exclude any mother with a missing duplicate or non-finite annual value; do not impute.

1. Retain AAR equal to index_year plus 6 7 8 9 or 10 on the same linked mother.
2. Assert one eligible row per year and calculate arithmetic mean of the five nominal LOENMV_13 values.

Equation or algorithm

First stage $\text{parity}_{10y_i} = X_i \gamma + \pi Z_i + u_i$; second stage $Y_i = X_i \delta + \beta \text{fitted_parity}_{10y_i}$

Target statistic: `beta_iv_dkk_per_parity`. Estimator/API: `ivreg::ivreg`; `sandwich::vcovHC` type HC1; manual Anderson-Rubin inversion using `fixest::feols`

Weights: Equal mother weights. Fixed effects: Index-year indicators. References: Singleton instrument and index year 1995.

Uncertainty: HC1 conventional 95 percent CI and two-sided AR 95 percent set with alpha 0.05. Clustering: Mother; one observation each.

Ordered actions **a01 — Enforce the exclusion and outcome-access gate.**

Consumes: `strong_stage_sample`, `exclusion_approval`. Produces: `authorized_sample`.

1. Verify both reviewer roles have signed yes decisions with timestamps before outcome access.
2. Hash approval file and compare cohort digest to first-stage output.

Assertions: Exactly two affirmative role decisions.; No `ind_outcome` access appears earlier in run log.

Failure route: `stop_experiment` — Do not access outcomes; terminate at `exclusion_not_credible`.

a02 — Construct the single registered wage outcome.

Consumes: `authorized_sample`, `ind_outcome`. Produces: `iv_sample`.

1. Join only exact years six through ten and apply hashed OMFANG eligibility.
2. Require five unique rows and compute arithmetic mean nominal wage.

Assertions: Five annual rows per mother.; One row per mother after aggregation.; Cohort exclusions reconcile.

Failure route: `mark_infeasible` — Stop IV and issue `outcome_observation_failure`.

a03 — Estimate the registered fertility LATE and uncertainty.

Consumes: `iv_sample`. Produces: `iv_result`.

1. Fit one just-identified 2SLS model and HC1 covariance.
2. Fit reduced form and invert AR tests on the deterministic expanding grid.

Assertions: Target coefficient maps to `parity_10y` exactly.; All fit counts and AR endpoint status are recorded.

Failure route: `stop_experiment` — Report `estimation_failure` with no replacement model.

Output contract

Output	Path	Grain	Required field
authorized_sample	preregistration/results/authorized_sample.parquet	Mother index	PNR, cohort_
iv_sample	preregistration/results/iv_sample.parquet	Mother index	PNR, multipl
iv_result	preregistration/results/iv_result.json	Confirmatory analysis	n, beta_iv, se

Procedure accounting

- **primary_2sls**: 1 calls per unit $\times$ 1 fitted units $\times$ 1 repetitions = 1 fits. One primary IV model.
- **reduced_form**: 1 calls per unit $\times$ 1 fitted units $\times$ 1 repetitions = 1 fits. One registered diagnostic reduced form.
- **ar_grid**: 1 calls per unit $\times$ 32001 fitted units $\times$ 1 repetitions = 32001 fits. Maximum deterministic grid from minus to plus 16 million DKK inclusive by 1000.
- Full-data passes: 4. Largest intermediate: five-row-per-mother IND outcome panel.

Synthetic dry run. Generate data with known negative zero and positive LATEs plus weak instruments; verify aggregation, 2SLS, AR inversion, and decisions.

Reconciliation. Sum of complete cohort and mutually exclusive exclusions equals authorized cohort; 2SLS first stage matches diagnostic equation on the IV sample.

Decision regions.

- **late_negative_meaningful** (supports): `ar_set` upper endpoint $<$ `minus_soe` AND `beta_iv` $<$ `minus_soe`. — Supports a negative economically meaningful fertility LATE subject to all IV assumptions.
- **late_null_equivalent** (null_equivalent): `ar_set` is bounded and entirely within [`minus_equiv`, `plus_equiv`]. — LATE is statistically compatible only with effects smaller than the registered meaningful band.
- **late_positive** (challenges): `ar_set` lower endpoint $>$ `zero_beta`. — Challenges the negative prediction and supports a positive LATE conditional on assumptions.
- **late_inconclusive** (inconclusive): None of `late_negative_meaningful`, `late_null_equivalent` or `late_positive` holds, including unbounded or disconnected `ar_set`. — Precision or sign is insufficient for a directional or equivalence conclusion.

Synthesis worlds

world_construction_failure

Trigger. `balance_fail` due to construction assertion.

Interpretation. Restricted data cannot define the maternal quasi-experiment.

Allowed claim. Feasibility failure only; no plurality or wage comparison.

world_exchangeability_failure

Trigger. `balance_fail` after coherent construction.

Interpretation. Observed imbalance undermines as-if-random multiplicity.

Allowed claim. Describe cohort construction only; no causal assignment claim.

world_relevance_failure

Trigger. stage_weak or stage_invalid.

Interpretation. Multiple birth does not provide a strong stable shift in registered ten-year parity.

Allowed claim. Report the diagnostic first stage only and no fertility effect.

world_exclusion_failure

Trigger. stage_strong but either exclusion reviewer does not approve.

Interpretation. Direct twin burdens prevent a fertility-only interpretation.

Allowed claim. Report gates and first stage only; no wage outcome is accessed.

world_negative

Trigger. late_negative_meaningful.

Interpretation. Additional ten-year parity lowers later maternal nominal wages for compliers.

Allowed claim. Conditional causal LATE for the registered population window and scale.

world_equivalent

Trigger. late_null_equivalent.

Interpretation. Meaningful effects outside the equivalence band are excluded for compliers.

Allowed claim. Conditional causal equivalence conclusion for the registered LATE.

world_positive

Trigger. late_positive.

Interpretation. The complier wage effect is positive contrary to prediction.

Allowed claim. Conditional positive causal LATE without post hoc mechanism attribution.

world_inconclusive

Trigger. late_inconclusive.

Interpretation. Data do not distinguish meaningful negative null-range or positive effects.

Allowed claim. Report conditional IV estimate and uncertainty without directional conclusion.

Frozen machine-readable preregistration

This appendix is authoritative and contains the complete registered plan.

```

schema_version: '1.1'
artifact: preregistration
registration:
  rq_id: restricted42_twin_birth_iv
  title: Parity-two multiple birth, attained fertility, and maternal wage income
  mode: schema_first
  version: 1
  status: under_review
  generated_at: '2026-09-04T20:00:00Z'
  knowledge_cutoff: '2026-09-04T20:00:00Z'
  outcome_blind: true
  input_digests:
    research_brief: 3c7c45c2e7db2ae8470b85d318263c7c671e0c45c0a89df376808d9c0eb15a5d
    literature_map: 350717cfd64edc01d8ceafd9be99e744a61d02942cff7e38edcd72e5351ba329
    data_feasibility: 8abaf4e94cd595afd386525dcace8c22d2a8d275b30fce8e9c4e3ba6cfb5bf31
    design_space: 71684826a33897dce61351df4551beee13cec82524a4836f85801a9427af3583
scope:
  research_question: Among validated Danish mothers at a parity-two live-birth delivery, what is the effect of attained parity ten years later, as shifted by a multiple rather than singleton index delivery, on mean nominal maternal wage income in calendar years six through ten after the index year?
  population: Mothers with a validated maternal PNR and exactly one classifiable parity-two live-birth delivery in 1995-2009, complete ten-year LPR coverage, and IND observation in every outcome year.
  unit: Mother indexed at one parity-two delivery.
  setting: Danish administrative records restricted to the 42-table schema boundary.
  time_period: Index admissions in 1995-2009; fertility through ten years after index date; wage income in calendar years six through ten after index year.
  primary_estimand: Individual-level LATE, in nominal DKK per one-parity increase, of parity at ten years by ten years on the arithmetic mean of LOENMV_13 in years six through ten among mothers whose parity is increased by index multiplicity.
  inferential_ceiling: A horizon-specific LATE for validated observed parity-two compliers only, under randomization, construction, exchangeability, relevance, monotonicity, and exclusion gates pass; otherwise, no claim as registered, multiple-delivery contrast, descriptive contrast, feasibility claim, or no claim as registered.
  exclusions:
    - Father and child outcomes, lifetime completed fertility, health outcomes, and attributes in common from PNR.
    - Unvalidated maternal identity, parity, live-birth status, plurality, date, duplicates, and attributes in common observation.
theory:
  focal_mechanism: A multiple parity-two delivery increases attained parity at ten years for some mothers, but the added child-care burden can reduce later maternal wage income.
  rival_mechanisms:
    - Twin gestation, delivery morbidity, and simultaneous infant care may affect later wages directly, violating exclusion.
    - Maternal age, fecundity, health, prenatal condition, and assisted reproduction may jointly affect twinning and wages.
    - Differential survival, migration, or tax-register presence may select the fully observed sample.
  directional_predictions:
    - 'The first stage is positive: multiple delivery raises attained parity at ten years.'

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- The fertility LATE for mean nominal wage income in years six through ten is negative.

scope_conditions:

- RECNUM must identify one stable maternal PNR and a live parity-two delivery under authoritative conditions.
- The instrument is the mother's own pregnancy-level multiplicity realization, not a collective one.
- Direct twin burdens must be judged negligible for the registered years-six-through-ten wage income before the IV node activates.

literature_basis:

nearest_work:

- rosenzweig_wolpin_1980
- Angrist_Evans_1998
- cools_markussen_strom_2017

established_knowledge:

- Rosenzweig and Wolpin and Angrist and Evans establish twin-birth IV precedents for fertility and labor supply.
- Angrist and Evans distinguish random assignment from the separate, untestable exclusion restriction.
- Nordic long-run evidence establishes family-size and parental-career analysis as a relevant control while twin validity work warns that maternal condition predicts twinning.

open_questions:

- Maternal identity, live-birth coding, episode plurality, sample size, prevalence, balance, outcome precision, and all effects remain unknown until execution.
- Whether direct twin burdens are negligible in years six through ten remains an unresolved empirical judgment and is a frozen activation gate.

contribution: A bounded Danish horizon-specific implementation that makes construction, weak exclusion, and observation failures explicit rather than treating twins as automatically random.

data_basis:

schema_snapshot_ids:

- readable_42_table_schema

population_construction: Join LPR_FOEDSLER to LPR_ADM on RECNUM, apply authoritative pre-outcome rules, select one maternal parity-two live delivery, require index years 1995-2009 and complete observation, and never infer attributes from PNR.

linkage_plan: Use RECNUM only for birth-detail-to-contact linkage and validated maternal PNR; later LPR birth contacts and IND person-years; all joins and exclusions are audited before data are read.

construct_map:

- **construct_id:** multiple_birth
 - role:** instrument
 - operational_definition:** One if the authoritative V_FLERNR episode algorithm classifies the parity-two live delivery as multiple and zero if singleton.
 - source_fields:**
 - LPR_FOEDSLER.V_FLERNR
 - LPR_FOEDSLER.RECNUM
 - timing:** Index delivery episode
 - alternatives:** []
- **construct_id:** parity_10y
 - role:** treatment
 - operational_definition:** Maximum authoritative valid V_PARITET across the index and later valid maternal live-delivery contacts with admission date no later than index date plus ten years.
 - source_fields:**

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- LPR_FOEDSLER.V_PARITET
- LPR_FOEDSLER.RECNUM
- LPR_ADM.PNR
- LPR_ADM.D_INDDTO
timing: Index date through index date plus ten years
alternatives: []
- construct_id: wage_mean_y6_y10
role: outcome
operational_definition: Arithmetic mean of annual nominal IND.LOENMV_13 across the five calendar years
index_year+6 through index_year+10, requiring one eligible IND row in every year.
source_fields:
- IND.PNR
- IND.AAR
- IND.LOENMV_13
- IND.OMFANG
timing: Calendar years six through ten after index year
alternatives: []
- construct_id: baseline_covariates
role: confounder
operational_definition: Maternal V_ALDER at index, index-year indicators, and nominal LOENMV_13 at
index years minus two and minus one; used for balance and precision, not claimed to close causal
paths.
source_fields:
- LPR_ADM.V_ALDER
- LPR_ADM.D_INDDTO
- IND.AAR
- IND.LOENMV_13
timing: Index contact and two complete pre-index calendar years
alternatives: []
- construct_id: full_observation
role: censoring
operational_definition: IND contains exactly one eligible tax-scope row in each of years index_year+6
through index_year+10 and LPR coverage spans the ten-year fertility horizon; absence is recorded
as zero.
source_fields:
- IND.PNR
- IND.AAR
- IND.OMFANG
- LPR_ADM.D_INDDTO
timing: Ten-year follow-up
alternatives: []
unresolved_quantities:
- Authoritative maternal-identity, live-birth, V_PARITET, V_FLERNR, OMFANG, and duplicate rows must
be supplied, hashed, and pass the registered gates before outcomes.
- Sample size, plurality prevalence, balance, first stage, effective F, precision, and outcomes
are unknown until execution.
no_outcome_data_accessed: true
study_dag:

```

```

source_design_space_sha256: 71684826a33897dce61351df4551beee13cec82524a4836f85801a9427af3583
estimand_context: LATE of ten-year attained parity on mean years-six-through-ten nominal maternal
  income among validated observed parity-two compliers.
nodes:
- node_id: maternal_predisposition
  label: Maternal age, health, fecundity, prenatal condition, and assisted reproduction
  role: confounder
  observed: false
- node_id: observed_preindex
  label: Observed index age, prior wage, and cohort
  role: confounder
  observed: true
- node_id: multiple_birth
  label: Multiple parity-two delivery
  role: instrument
  observed: true
- node_id: horizon_fertility
  label: Attained parity at ten years
  role: treatment
  observed: true
- node_id: direct_twin_burden
  label: Twin gestation delivery and care burden
  role: mediator
  observed: false
- node_id: labor_income
  label: Subsequent maternal employment and income
  role: outcome
  observed: true
- node_id: health_utilization
  label: Maternal health utilization
  role: outcome
  observed: true
- node_id: maternal_observed
  label: Survival residence tax scope and source presence
  role: selection
  observed: false
- node_id: delivery_measurement
  label: RECNUM delivery and plurality classification
  role: measurement
  observed: true
edges:
- from: maternal_predisposition
  to: multiple_birth
  relation: causal
  warrant:
    basis: prior_evidence
    statement: Maternal traits and prenatal conditions predict twinning.
    source_ids:

```

- farbmacher_guber_vikstrom_2018
 - bhalotra_clarke_2019
- from: maternal_predisposition
 - to: horizon_fertility
 - relation: causal
 - warrant:
 - basis: theory
 - statement: Fecundity and preferences affect childbearing.
- from: maternal_predisposition
 - to: labor_income
 - relation: causal
 - warrant:
 - basis: theory
 - statement: Maternal traits affect later wages.
- from: maternal_predisposition
 - to: health_utilization
 - relation: causal
 - warrant:
 - basis: theory
 - statement: Baseline health affects later utilization.
- from: maternal_predisposition
 - to: observed_preindex
 - relation: measurement
 - warrant:
 - basis: maintained_assumption
 - statement: Histories partially proxy predispositions.
- from: multiple_birth
 - to: horizon_fertility
 - relation: causal
 - warrant:
 - basis: prior_evidence
 - statement: Twin births can shift family size.
 - source_ids:
 - Angrist_Evans_1998
 - Rosenzweig_Wolpin_1980
- from: horizon_fertility
 - to: labor_income
 - relation: causal
 - warrant:
 - basis: prior_evidence
 - statement: Family size can change maternal labor supply and earnings.
 - source_ids:
 - Angrist_Evans_1998
 - Cools_Markussen_Strom_2017
- from: multiple_birth
 - to: direct_twin_burden
 - relation: causal
 - warrant:

```

    basis: prior_evidence
    statement: Multiple pregnancy and care create direct burdens.
    source_ids:
      - sheard_et_al_2007
      - van_den_akker_et_al_2016
- from: direct_twin_burden
  to: labor_income
  relation: causal
  warrant:
    basis: theory
    statement: Morbidity and concentrated care can disrupt work.
- from: direct_twin_burden
  to: health_utilization
  relation: causal
  warrant:
    basis: prior_evidence
    statement: Multiple birth can affect maternal health directly.
    source_ids:
      - sheard_et_al_2007
- from: horizon_fertility
  to: health_utilization
  relation: causal
  warrant:
    basis: theory
    statement: Childbearing may affect health care.
- from: maternal_predisposition
  to: maternal_observed
  relation: selection
  warrant:
    basis: theory
    statement: Health and socioeconomic factors affect observation.
- from: multiple_birth
  to: maternal_observed
  relation: selection
  warrant:
    basis: theory
    statement: Twin pregnancy may affect later observation.
- from: maternal_observed
  to: labor_income
  relation: selection
  warrant:
    basis: institution
    statement: Annual wages require tax-register observation.
- from: maternal_observed
  to: health_utilization
  relation: selection
  warrant:
    basis: institution

```

```

    statement: Utilization requires register observation.
- from: multiple_birth
  to: delivery_measurement
  relation: measurement
  warrant:
    basis: institution
    statement: V_FLERNR and RECNUM determine measured plurality.
open_paths:
- multiple_birth <- maternal_predisposition -> labor_income remains open.
- multiple_birth -> direct_twin_burden -> labor_income violates fertility-only exclusion unless gate resolves otherwise.
- Conditioning on maternal_observed can open multiple_birth -> maternal_observed <- maternal_observed -> labor_income.
- multiple_birth -> direct_twin_burden -> health_utilization precludes the rejected health IV.
forbidden_adjustment:
- direct_twin_burden
- maternal_observed
- health_utilization
adjustment_sets:
- experiment_id: assignment_audit
  covariates:
    - observed_preindex
  rationale: Pre-index variables probe assignment balance; they do not close the unobserved path.
  remaining_open_paths:
    - multiple_birth <- maternal_predisposition -> labor_income
- experiment_id: fertility_first_stage
  covariates:
    - observed_preindex
  rationale: Frozen pre-index precision adjustment only.
  remaining_open_paths:
    - multiple_birth <- maternal_predisposition -> horizon_fertility
- experiment_id: labor_fertility_iv
  covariates:
    - observed_preindex
  rationale: Frozen pre-index precision adjustment; IV validity still requires independence
  remaining_open_paths:
    - multiple_birth <- maternal_predisposition -> labor_income
    - multiple_birth -> direct_twin_burden -> labor_income
rationale: This is the full study-specific DAG copied from the design space; the registered effect uses its labor_income node narrowly, and no post-index mediator or observation collider is present for.
question_map:
- question_id: q_fertility_wage
  question_clause: Effect of ten-year attained parity shifted by index multiplicity on mean maternal income in years six through ten.
  experiment_id: labor_fertility_iv
  estimand: LATE in nominal DKK per parity unit for the five-year mean wage outcome among ten-year

```

```

    compliers.
  output_id: iv_result
  claim_ceiling: causal
- question_id: q_assignment
  question_clause: Whether individual multiple assignment is credible in the validated parity
    set.
  experiment_id: assignment_audit
  estimand: Construction pass indicator, maximum absolute standardized difference, and joint r
    p-value.
  output_id: balance_result
  claim_ceiling: feasibility_only
- question_id: q_relevance
  question_clause: Whether multiple birth shifts attained parity at ten years strongly and con
  experiment_id: fertility_first_stage
  estimand: Adjusted mean difference pi in attained parity at ten years between multiple and s
    index deliveries.
  output_id: first_stage_result
  claim_ceiling: feasibility_only
execution_governance:
  authority: This YAML, the four hashed upstream artifacts, and hashed authoritative codebooks
    govern execution; the YAML controls conflicts.
  execution_order:
    - assignment_audit
    - fertility_first_stage
    - labor_fertility_iv
  environment:
    language: R 4.5.1
    software:
      - arrow 20.0.0
      - data.table 1.17.8
      - fixest 0.13.2
      - ivreg 0.6-5
      - sandwich 3.1-1
    environment_capture: Write sessionInfo and renv.lock SHA-256 before data access.
    seed_policy: Set RNGkind L'Ecuyer-CMRG and seed 420904 for randomization tests and synthet
    time_zone: Europe/Copenhagen
    locale: en_DK
  data_access_sequence: Hash codebooks and run synthetic dry run; read birth/contact and basel
    close gates; construct fertility; only after activation read LOENMV_13 outcome years.
  global_invariants:
    - PNR is used only as an opaque linkage key and never parsed.
    - One index row per mother, no outcome read before all pre-outcome gates, and no absent row
      as zero.
    - Action identifiers restart at a01 within each experiment and are contiguous.
  failure_policy: Any failed assertion follows its declared route; no proxy field, estimator,
    threshold, or outcome substitution is permitted.
  deviation_log: preregistration/deviations.yaml
experiments:

```

```

- experiment_id: assignment_audit
  title: Maternal delivery construction and assignment audit
  epistemic_role: diagnostic
  specification_status: conditional
  unresolved_choices:
  - Exact value-label rules for maternal PNR, live birth, parity, plurality, and OMFANG require
    documentation; absence or ambiguity terminates the study.
  purpose: Establish a valid individual risk set and test pre-index balance without reading post-
    wages.
  dependencies: []
  activation:
    when: Always first.
    skip_when: Never.
  hypothesis:
    claim: Multiple and singleton groups satisfy the frozen construction and balance gates.
    'null': At least one construction or balance gate fails.
    alternative: Every gate passes.
    directional: false
  design:
    family: other
    estimand: Construction pass indicator, maximum absolute standardized difference, and joint
      p-value.
    identifying_variation: A mother's own multiple-versus-singleton parity-two pregnancy realia.
    counterfactual: Otherwise comparable validated parity-two singleton pregnancies in the same
      strata.
    assignment_mechanism: Pregnancy-level plurality; it is not presumed random and is audited a
      pre-index measures.
    assumptions:
    - Authoritative metadata identifies maternal PNR and live delivery.
    - Measurement is stable within retained eras.
    - Baseline diagnostics can detect material observed imbalance but cannot prove independence.
    diagnostics:
    - Unique RECNUM linkage share.
    - Standardized differences.
    - Within-year permutation joint balance test.
    downgrade_path: Construction failure yields no claim; moderate uniqueness restricts once to
      consistent eras; balance failure yields descriptive-only ceiling.
    domain_fit: A pre-outcome design audit is required before an individual twin-birth quasi-ex
    method_specific:
      assignment_level: individual
      assignment_unit: maternal_pregnancy
      permutation_repetitions: 9999
    operationalization:
      sample: All 1995-2009 candidate LPR_FOEDSLER records linked to LPR_ADM, reduced to one val
        parity-two live delivery.
      treatment_or_exposure: multiple_birth from V_FLERNR under the hashed authoritative episode
      outcome: Non-outcome baseline vector of age, index year, lag-one wage, and lag-two wage.
      covariates:

```

- index_age
- index_year
- wage_lag1
- wage_lag2

time: Index contact and two calendar years before index year.

exclusions:

- Ambiguous maternal PNR.
- Non-live or unclassifiable episode.
- Invalid parity/plurality/date.
- Duplicate mother index.
- Missing baseline covariate.

analysis:

estimator: data.table summaries plus fixest OLS and a 9999-repetition within-index-year permutation test.

specification: For each continuous covariate report $(\text{mean_Z1} - \text{mean_Z0}) / \text{pooled_SD}$; jointly report on all four covariates and index-year FE and compare the observed robust Wald statistic to the distribution of Z within index year.

uncertainty: Exact Monte Carlo $p = (1 + \text{number permuted statistics at least observed}) / (10000)$.

clustering: Mother; one row per mother.

missingness: Exclude any mother missing one of the four baseline terms and report counts; missingness

multiplicity_family: assignment_gate

robustness: []

prospective_assessment:

expected_direction: unknown

smallest_effect_of_interest:

status: fixed

value: 0.1

unit: absolute standardized difference

rationale: Registered material-balance threshold from upstream gate.

precision_plan: Report covariate-specific standardized differences and Monte Carlo p; gate

absolute difference 0.10 and p 0.05.

weak_data_scenario: Fewer than 100 multiple deliveries or any pooled SD zero marks infeasible

surprising_result: Large imbalance challenges conditional independence and terminates causal

execution:

identity_chain:

question_clause: Whether individual multiple assignment is credible in the validated par

risk set.

estimand: Construction pass indicator, maximum absolute standardized difference, and joint

p-value.

analysis_variable: multiple_birth

target_statistic: max_abs_smd_and_joint_p

primary_output_id: balance_result

sources:

- source_id: births_raw
- resource_id: readable_42_table_schema

tables:

- LPR_FOEDSLER

fields:

- RECNUM
- V_FLERNR
- V_PARITET
- grain: Birth-detail record
- keys:
 - RECNUM
- temporal_semantics: Describes the RECNUM-linked birth contact.
- filters:
 - No value filter before codebook validation.
- source_id: adm_raw
- resource_id: readable_42_table_schema
- tables:
 - LPR_ADM
- fields:
 - RECNUM
 - PNR
 - D_INDDTO
 - D_UDDTO
 - V_ALDER
- grain: Administrative contact
- keys:
 - RECNUM
 - PNR
- temporal_semantics: Admission and discharge dates delimit contact.
- filters:
 - D_INDDTO year 1995 through 2009.
- source_id: ind_baseline
- resource_id: readable_42_table_schema
- tables:
 - IND
- fields:
 - PNR
 - AAR
 - LOENMV_13
 - OMFANG
- grain: Person-year
- keys:
 - PNR
 - AAR
- temporal_semantics: Annual values for two years strictly before index year.
- filters:
 - AAR equals index year minus one or two after linkage.
- source_id: authoritative_rules
- resource_id: readable_42_table_schema
- tables:
 - README.md
 - LPR_FOEDSLER.md
 - LPR_ADM.md

```

- IND.md
fields:
- maternal_identity_rule
- live_birth_codes
- parity_codes
- plurality_rule
- omfang_rule
grain: Versioned documentation rule
keys:
- rule_sha256
temporal_semantics: Rules applicable to each source record date and frozen before outcome
filters:
- Only authoritative documented rules.
joins:
- join_id: birth_adm_join
  left_source: births_raw
  right_source: adm_raw
  keys:
  - left_field: RECNUM
    right_field: RECNUM
  cardinality: many_to_one
  retained_side: inner
  unmatched_rule: Exclude unmatched birth rows and report by year.
  validation: At least 99 percent uniquely classifiable directly or 95 percent after one e
    otherwise stop.
- join_id: baseline_join
  left_source: adm_raw
  right_source: ind_baseline
  keys:
  - left_field: PNR
    right_field: PNR
  cardinality: one_to_many
  retained_side: left
  unmatched_rule: Exclude mothers lacking either required eligible baseline year.
  validation: Exactly two eligible baseline person-years per retained mother.
variables:
- variable_id: multiple_birth
  role: instrument
  grain: Mother index
  source_ids:
  - births_raw
  - authoritative_rules
  source_fields:
  - V_FLERNR
  - RECNUM
  - plurality_rule
  ordered_steps:
  - Group birth-detail rows by validated delivery RECNUM.

```

- Apply hashed plurality rule on the same episode and code multiple one versus singleton
- temporal_rule: Index episode only.
- missing_rule: Exclude unclassifiable episodes.
- output_type: integer zero or one
- validation: Both groups exist and at least 100 multiple deliveries remain.
- variable_id: baseline_vector
 - role: covariate
 - grain: Mother index
 - source_ids:
 - adm_raw
 - ind_baseline
 - source_fields:
 - V_ALDER
 - D_INDDTO
 - AAR
 - LOENMV_13
 - ordered_steps:
 - Extract age and calendar year from validated index contact.
 - Select exactly index_year minus one and minus two IND rows and retain nominal LOENMV_13
 - temporal_rule: Strictly pre-index wages plus index-contact age.
 - missing_rule: Complete-case exclusion before balance.
 - output_type: four numeric columns
 - validation: Finite values and positive pooled SD for every term.
- sample_flow:
 - step_id: s01
 - input_population: All birth-detail rows
 - operation: Inner join to admission and apply hashed maternal/live-birth rules.
 - output_population: Validated maternal live deliveries
 - exclusion_record: Count unmatched and invalid by year and reason.
 - step_id: s02
 - input_population: Validated maternal live deliveries
 - operation: Retain parity two, index years 1995–2009, and uniquely classified singleton or multiple
 - output_population: Candidate index deliveries
 - exclusion_record: Count parity date plurality and ambiguity exclusions.
 - step_id: s03
 - input_population: Candidate index deliveries
 - operation: Retain one earliest qualifying episode per mother and require complete two-year
 - output_population: Audit analysis mothers
 - exclusion_record: Count later duplicate indices and baseline missingness.
- model:
 - model_id: balance_model
 - equation_or_algorithm: Compute four SMDs and joint Wald statistic from multiple_birth on index_year plus index-year fixed effects; permute multiple_birth within index year 9999 times.
 - target_statistic: max_abs_smd_and_joint_p
 - symbol_map:
 - symbol: Z_i
 - meaning: Multiple-birth indicator for mother i.

```

    source_fields:
    - V_FLERNR
    construction_variables:
    - multiple_birth
- symbol: X_i
  meaning: Four-element frozen baseline vector.
  source_fields:
  - V_ALDER
  - D_INDDTO
  - AAR
  - LOENMV_13
  construction_variables:
  - baseline_vector
estimator_api: fixest::feols with sandwich::vcovHC and base::sample.int
weights: Equal mother weights.
fixed_effects: Index-year indicators in joint regression.
reference_levels: Singleton Z=0 and earliest index year omitted.
uncertainty: HC1 Wald statistic and 9999 within-year permutations.
clustering: Mother; one observation each.
diagnostics:
- Unique linkage shares by year.
- Group counts and SMDs.
- Permutation p-value.
actions:
- action_id: a01
  goal: Freeze documentation and prove the maternal delivery algorithm.
  consumes:
  - authoritative_rules
  - births_raw
  - adm_raw
  procedure:
  - Hash all rule files and verify each required rule has one date-valid value.
  - Join RECNUM and apply maternal identity live-birth parity and plurality rules without
    post-index wages.
  produces:
  - cohort_audit
  assertions:
  - One stable maternal PNR per retained delivery.
  - Unique classification share meets the registered threshold.
  - Index chronology is valid.
  on_failure:
    route: mark_infeasible
    detail: Stop all experiments and issue construction_failure.
- action_id: a02
  goal: Construct the complete baseline audit sample.
  consumes:
  - cohort_audit
  - ind_baseline

```

```

procedure:
- Select one earliest eligible parity-two delivery per mother.
- Join exactly two pre-index IND years and construct baseline_vector.
produces:
- audit_sample
assertions:
- One row per mother.
- Both assignment groups and at least 100 multiple deliveries exist.
on_failure:
  route: mark_infeasible
  detail: Stop all downstream work and issue support_failure.
- action_id: a03
goal: Evaluate the frozen assignment-balance gate.
consumes:
- audit_sample
procedure:
- Compute four SMDs and observed joint HC1 Wald statistic.
- Permute assignment within index year 9999 times and compute the registered Monte Carlo
produces:
- balance_result
assertions:
- Exactly 9999 permutation repetitions complete.
- Report all four SMDs without suppression.
on_failure:
  route: stop_experiment
  detail: Stop causal sequence and retain feasibility-only cohort audit.
outputs:
- output_id: cohort_audit
  path: preregistration/results/cohort_audit.parquet
  format: parquet
  grain: Delivery episode
  fields:
    - PNR
    - RECNUM
    - index_date
    - index_year
    - parity
    - multiple_birth
    - rule_sha256
    - exclusion_reason
  produced_by: a01
  consumers:
    - a02
- output_id: audit_sample
  path: preregistration/results/audit_sample.parquet
  format: parquet
  grain: Mother index
  fields:

```

```

- PNR
- index_year
- multiple_birth
- index_age
- wage_lag1
- wage_lag2
produced_by: a02
consumers:
- a03
- output_id: balance_result
  path: preregistration/results/balance_result.json
  format: json
  grain: Audit
  fields:
    - n_total
    - n_multiple
    - unique_share
    - smd_age
    - smd_year
    - smd_wage_lag1
    - smd_wage_lag2
    - max_abs_smd
    - joint_p
    - decision_id
  produced_by: a03
  consumers:
    - balance_pass
    - balance_fail
quality_control:
  synthetic_dry_run: Generate 1000 fake mothers with duplicate and invalid cases; verify ex
    order, joins, permutations, and decisions without real values.
  invariant_checks:
    - One index per PNR.
    - multiple_birth is binary.
    - Baseline years precede index year.
    - Exclusion counts reconcile.
  reconciliation: Input rows equal retained plus mutually exclusive exclusions at every sam
  run_log: preregistration/results/run_log.jsonl
  stop_conditions:
    - Missing authoritative rule.
    - Maternal identity ambiguity.
    - Unique share below threshold.
    - Fewer than 100 multiple deliveries.
compute_plan:
  fit_operations:
    - operation_id: joint_balance_fit
      calls_per_unit: 1
      fitted_units: 1

```

```

    repetitions: 10000
    total_fits: 10000
    justification: One observed plus 9999 permuted joint regressions.
    full_data_passes: 4
    largest_intermediate: birth_adm joined birth-detail rows
    feasibility_note: Streaming projection uses only registered fields; no outcome-year wage
decision_regions:
- decision_id: balance_pass
  condition: unique_share >= unique_direct AND max_abs_smd < smd_pass AND joint_p >= alpha_b
  parameters:
    - name: unique_direct
      value: 0.99
      unit: proportion
      rationale: Upstream unique-link gate.
    - name: smd_pass
      value: 0.1
      unit: absolute SMD
      rationale: Upstream balance gate.
    - name: alpha_balance
      value: 0.05
      unit: probability
      rationale: Frozen joint-test threshold.
  interpretation: Construction and observed balance pass; activate first stage.
  claim_status: supports
- decision_id: balance_fail
  condition: Any construction assertion fails OR max_abs_smd >= smd_pass OR joint_p < alpha_l
  parameters:
    - name: smd_pass
      value: 0.1
      unit: absolute SMD
      rationale: Material imbalance threshold.
    - name: alpha_balance
      value: 0.05
      unit: probability
      rationale: Joint-test threshold.
  interpretation: Do not claim as-if-random assignment or run outcome models.
  claim_status: feasibility_failure
- experiment_id: fertility_first_stage
  title: Ten-year attained-parity first stage
  epistemic_role: diagnostic
  specification_status: frozen
  unresolved_choices: []
  purpose: Determine instrument relevance and directional stability before wage outcomes are r
  dependencies:
    - assignment_audit
  activation:
    when: assignment_audit returns balance_pass.
    skip_when: assignment_audit returns balance_fail.

```

```

hypothesis:
  claim: Multiple birth increases ten-year attained parity.
  'null': pi <= 0.
  alternative: pi > 0.
  directional: true
design:
  family: iv
  estimand: Adjusted mean difference pi in attained parity at ten years between multiple and
    index deliveries.
  identifying_variation: Individual pregnancy-level multiple realization within validated par
    index-year strata.
  counterfactual: Ten-year parity the same mother would attain after singleton instead of mu
  assignment_mechanism: Own delivery plurality at parity two.
  assumptions:
    - Correct fertility measurement.
    - Conditional independence.
    - Monotonicity for LATE.
    - Common observation through ten years.
  diagnostics:
    - Robust first-stage F.
    - Confidence interval.
    - Sign by two age bands and two cohort bands.
  downgrade_path: Weak stable stage activates bundled reduced-form only; null opposite or any
    reversal terminates fertility claims.
  domain_fit: First-stage relevance and monotonicity scrutiny are required for econometric IV
  method_specific:
    instrument: multiple_birth
    first_stage: parity_10y on multiple_birth and frozen X
    first_stage_expected_sign: positive
    independence: Z is independent of potential D and Y conditional on frozen X and year str
    exclusion: Z affects registered wage only through parity_10y.
    monotonicity: No mother has lower parity_10y under multiple than singleton delivery.
    target_population: Validated observed parity-two compliers.
    weak_instrument_rule: Strong only if robust F >= 10, CI excludes zero positively, and su
      do not reverse.
    strong_f_threshold: 10
    subgroups:
      - age_below_30
      - age_at_least_30
      - index_1995_2002
      - index_2003_2009
  operationalization:
    sample: Audit analysis mothers with validated later maternal birth contacts through ten ye
    treatment_or_exposure: multiple_birth instrument.
    outcome: parity_10y, maximum valid V_PARITET through ten years.
    covariates:
      - index_age
      - wage_lag1

```

```

- wage_lag2
- index_year_fe
time: Index date through exact tenth anniversary.
exclusions:
- Any later birth contact with conflicting maternal identity or parity chronology.
- Missing ten-year coverage.
analysis:
estimator: fixest::feols OLS first stage with HC1 standard errors.
specification: parity_10y = alpha + pi*multiple_birth + quadratic centered index age + wage_lag2 + index-year FE.
uncertainty: HC1 95 percent confidence interval and robust Wald  $F=t(\pi)^2$ .
clustering: Mother; one row per mother.
missingness: No imputation; prior complete-case cohort is used and parity ambiguity stops t
multiplicity_family: first_stage_gate
robustness:
- Repeat the same coefficient in four frozen overlapping diagnostic subgroups; these do not
  the primary estimand.
prospective_assessment:
expected_direction: positive
smallest_effect_of_interest:
status: fixed
value: 0.1
unit: parity units
rationale: A smaller shift yields a weak and substantively narrow compliance margin.
precision_plan: Report pi, HC1 CI, robust F, and subgroup signs; strong only if F at least
lower CI above zero.
weak_data_scenario: F below 10 with positive stable signs activates no fertility LATE.
surprising_result: Nonpositive or subgroup-reversing stage terminates fertility interpretation.
execution:
identity_chain:
question_clause: Whether multiple birth shifts attained parity at ten years strongly and
estimand: Adjusted mean difference pi in attained parity at ten years between multiple and
index deliveries.
analysis_variable: parity_10y
target_statistic: pi_and_robust_f
primary_output_id: first_stage_result
sources:
- source_id: audit_cohort
resource_id: readable_42_table_schema
tables:
- cohort_audit.parquet
fields:
- PNR
- index_date
- index_year
- multiple_birth
- index_age
- wage_lag1

```

```

- wage_lag2
grain: Mother index
keys:
- PNR
temporal_semantics: Frozen output from assignment audit.
filters:
- decision_id equals balance_pass.
- source_id: later_births
resource_id: readable_42_table_schema
tables:
- LPR_FOEDSLER
- LPR_ADM
fields:
- RECNUM
- PNR
- D_INDDTO
- V_PARITET
grain: Maternal delivery contact
keys:
- RECNUM
- PNR
temporal_semantics: Validated contacts from index through exact tenth anniversary.
filters:
- Same hashed maternal and live-birth rules as assignment audit.
joins:
- join_id: later_birth_join
left_source: audit_cohort
right_source: later_births
keys:
- left_field: PNR
  right_field: PNR
cardinality: one_to_many
retained_side: left
unmatched_rule: Retain index parity two only when LPR has full calendar coverage; absence
  delivery then leaves parity at two.
validation: Later valid parity never decreases and dates are chronological.
variables:
- variable_id: multiple_birth
role: instrument
grain: Mother index
source_ids:
- audit_cohort
source_fields:
- multiple_birth
ordered_steps:
- Read the frozen binary field from audit_cohort.
- Assert it is unchanged from the cohort digest.
temporal_rule: Index episode only.

```

```

missing_rule: Missing stops the experiment.
output_type: integer zero or one
validation: Binary and nonmissing.
- variable_id: baseline_vector
  role: covariate
  grain: Mother index
  source_ids:
    - audit_cohort
  source_fields:
    - index_age
    - index_year
    - wage_lag1
    - wage_lag2
  ordered_steps:
    - Read the four frozen terms from audit_cohort.
    - Center age at the sample mean and square the centered value.
  temporal_rule: Frozen pre-index and index values.
  missing_rule: Missing stops the experiment.
  output_type: numeric vector
  validation: Complete and finite.
- variable_id: parity_10y
  role: treatment
  grain: Mother index
  source_ids:
    - audit_cohort
    - later_births
  source_fields:
    - PNR
    - D_INDDTO
    - V_PARITET
  ordered_steps:
    - Retain validated live-delivery contacts from index through exact tenth anniversary.
    - Sort by date and RECNUM and take maximum authoritative V_PARITET including index value
  temporal_rule: D_INDDTO between index date and index date plus ten years inclusive.
  missing_rule: Conflicting or missing parity marks mother unclassifiable and stops if any
    record is affected.
  output_type: integer parity
  validation: parity_10y is integer at least two and nondecreasing over contacts.
sample_flow:
- step_id: s01
  input_population: balance-pass audit cohort
  operation: Link all validated maternal live-delivery contacts through tenth anniversary.
  output_population: Maternal fertility histories
  exclusion_record: Record chronology and identity failures.
- step_id: s02
  input_population: Maternal fertility histories
  operation: Take maximum valid parity and retain the unchanged audit cohort.
  output_population: First-stage sample

```

```

    exclusion_record: Any ambiguity stops rather than silently excludes.
model:
  model_id: first_stage_model
  equation_or_algorithm: parity_10y_i = alpha + pi multiple_birth_i + b1 agec_i + b2 agec_i
    wage_lag1_i + b4 wage_lag2_i + index_year_FE + e_i.
  target_statistic: pi_and_robust_f
  symbol_map:
    - symbol: parity_10y_i
      meaning: Attained parity at ten years.
      source_fields:
        - V_PARITET
        - D_INDDTO
      construction_variables:
        - parity_10y
    - symbol: multiple_birth_i
      meaning: Index multiple indicator.
      source_fields:
        - multiple_birth
      construction_variables:
        - multiple_birth
    - symbol: X_i
      meaning: Frozen age wage and cohort precision terms.
      source_fields:
        - index_age
        - index_year
        - wage_lag1
        - wage_lag2
      construction_variables:
        - baseline_vector
  estimator_api: fixest::feols
  weights: Equal mother weights.
  fixed_effects: Index-year fixed effects.
  reference_levels: Singleton and index year 1995.
  uncertainty: HC1 95 percent CI; robust F equals squared HC1 t statistic.
  clustering: Mother; one row each.
  diagnostics:
    - Four subgroup coefficient signs.
    - Parity chronology.
    - Effective F.
actions:
  - action_id: a01
    goal: Construct ten-year attained parity.
    consumes:
      - audit_cohort
      - later_births
    procedure:
      - Apply identical hashed maternal and live-birth rules to later contacts.
      - Sort valid contacts and take maximum parity through exact tenth anniversary.

```

```

produces:
- first_stage_sample
assertions:
- Cohort cardinality unchanged.
- Parity is integer at least two and chronological.
on_failure:
  route: mark_infeasible
  detail: Stop fertility and outcome experiments because treatment is undefined.
- action_id: a02
  goal: Estimate strength and directional stability.
  consumes:
  - first_stage_sample
  procedure:
  - Fit the registered full-sample first-stage equation and compute HC1 CI and F.
  - Fit the identical equation in four frozen subgroups and record coefficient signs.
  produces:
  - first_stage_result
  assertions:
  - One primary and four subgroup fits complete.
  - Output contains no maternal wage outcome from years six through ten.
  on_failure:
    route: stop_experiment
    detail: Stop IV and issue first_stage_failure.
outputs:
- output_id: first_stage_sample
  path: preregistration/results/first_stage_sample.parquet
  format: parquet
  grain: Mother index
  fields:
  - PNR
  - multiple_birth
  - parity_10y
  - index_age
  - index_year
  - wage_lag1
  - wage_lag2
  produced_by: a01
  consumers:
  - a02
- output_id: first_stage_result
  path: preregistration/results/first_stage_result.json
  format: json
  grain: Diagnostic
  fields:
  - pi
  - se_hc1
  - ci_low
  - ci_high

```

```

- robust_f
- subgroup_signs
- decision_id
produced_by: a02
consumers:
- stage_strong
- stage_weak
- stage_invalid
quality_control:
  synthetic_dry_run: Simulate monotone and defier-like fertility histories and verify exact
    sign, F, and branch logic.
  invariant_checks:
    - Same mothers as audit sample.
    - No parity decrease.
    - No post-index wage field loaded.
  reconciliation: First-stage sample count equals balance-pass cohort count exactly.
  run_log: preregistration/results/run_log.jsonl
  stop_conditions:
    - Any parity ambiguity.
    - Cohort cardinality change.
    - Model failure.
compute_plan:
  fit_operations:
    - operation_id: first_stage_fits
      calls_per_unit: 1
      fitted_units: 5
      repetitions: 1
      total_fits: 5
      justification: One full sample and four frozen subgroup fits.
  full_data_passes: 3
  largest_intermediate: linked maternal delivery-contact history
  feasibility_note: Fertility is constructed before any outcome-year wage access.
decision_regions:
- decision_id: stage_strong
  condition:  $\pi > \text{soe}_{\pi}$  AND  $\text{ci}_{\text{low}} > \text{zero}_{\pi}$  AND  $\text{robust}_f \geq f_{\text{min}}$  AND every subgroup_sign
  parameters:
    - name: soe_pi
      value: 0.1
      unit: parity units
      rationale: Fixed relevance magnitude.
    - name: zero_pi
      value: 0
      unit: parity units
      rationale: Expected positive direction.
    - name: f_min
      value: 10
      unit: F statistic
      rationale: Registered weak-instrument gate.

```

```

    interpretation: Relevance passes; IV remains conditional on exclusion approval.
    claim_status: supports
- decision_id: stage_weak
    condition:  $\pi > \text{zero\_pi}$  AND ( $\text{robust\_f} < \text{f\_min}$  OR  $\text{ci\_low} \leq \text{zero\_pi}$ ) AND every subgroup_sign
    parameters:
      - name: zero_pi
        value: 0
        unit: parity units
        rationale: Stable expected direction.
      - name: f_min
        value: 10
        unit: F statistic
        rationale: Weak-instrument threshold.
    interpretation: No fertility LATE; report first stage only and terminate at bundled-effect
      because outcome access is not authorized for a separate unregistered estimand.
    claim_status: inconclusive
- decision_id: stage_invalid
    condition:  $\pi \leq \text{zero\_pi}$  OR any subgroup_sign is negative.
    parameters:
      - name: zero_pi
        value: 0
        unit: parity units
        rationale: Nonpositive or reversed relevance defeats LATE.
    interpretation: Terminate fertility claim and do not access wage outcome.
    claim_status: challenges
- experiment_id: labor_fertility_iv
    title: Ten-year fertility LATE for later maternal wage income
    epistemic_role: confirmatory
    specification_status: conditional
    unresolved_choices:
      - Before outcome access, named reproductive-epidemiology and labor-domain reviewers must both
        yes that direct twin gestation delivery and concentrated-care effects are negligible for m
        in years six through ten; any no or missing answer routes to exclusion_not_credibile.
    purpose: Estimate one fertility LATE for one wage-income outcome family only when every ident
      gate passes.
    dependencies:
      - fertility_first_stage
    activation:
      when: balance_pass and stage_strong and two recorded exclusion approvals before outcome ac
      skip_when: Any other decision or approval state.
    hypothesis:
      claim: One additional parity unit induced by multiple birth reduces mean nominal maternal v
        in years six through ten.
      'null':  $\beta \geq 0$ .
      alternative:  $\beta < 0$ .
      directional: true
    design:
      family: iv

```

estimand: LATE in nominal DKK per parity unit for the five-year mean wage outcome among compliers.
identifying_variation: Own multiple versus singleton parity-two delivery, conditional on first birth and index-year strata.
counterfactual: A complier mother's five-year mean wage under parity attained after singleton rather than multiple realization at the same pregnancy.
assignment_mechanism: Individual pregnancy-level plurality.
assumptions:

- Relevance.
- Conditional independence.
- Exclusion for registered late wage window.
- Monotonicity.
- SUTVA and no cross-mother interference.
- Coherent complete observation.

diagnostics:

- Anderson-Rubin confidence set.
- Conventional 2SLS CI.
- Reduced-form sign.
- First-stage residual checks.

downgrade_path: Any pre-outcome gate failure prevents outcome access and yields the named treatment; ceiling; no alternative estimator is selected.
domain_fit: Just-identified 2SLS and weak-IV-robust inference match a canonical labor-economy model with IV.
method_specific:

- assignment_level:** individual
- instrument:** multiple_birth
- first_stage:** parity_10y on multiple_birth and frozen X
- first_stage_expected_sign:** positive
- independence:** Z is independent of potential D and Y conditional on frozen X and year strata
- exclusion:** Z affects registered wage only through parity_10y.
- monotonicity:** No mother has lower parity_10y under multiple than singleton delivery.
- target_population:** Validated observed parity-two compliers.
- weak_instrument_rule:** Activation requires robust F >= 10 and stable positive subgroup sign
- inference:** Anderson-Rubin inference.
- instrument_count:** 1
- endogenous_regressor_count:** 1
- weak_iv_method:** Anderson_Rubin

operationalization:

- sample:** Exactly the strong-stage mothers with one eligible IND row in every outcome year.
- treatment_or_exposure:** parity_10y.
- outcome:** wage_mean_y6_y10 in nominal DKK.
- covariates:**
 - index_age_centered
 - index_age_centered_squared
 - wage_lag1
 - wage_lag2
 - index_year_fe
- time:** Fertility through ten years; wage in calendar years index_year plus six through plus

```

exclusions:
- Any missing or duplicate eligible IND outcome-year row.
- Non-finite LOENMV_13.
- Failed exclusion approval.
analysis:
estimator: ivreg::ivreg just-identified two-stage least squares.
specification: wage_mean_y6_y10 ~ parity_10y + agec + agec2 + wage_lag1 + wage_lag2 + fact
| multiple_birth + same exogenous terms.
uncertainty: HC1 95 percent conventional CI plus inverted two-sided Anderson-Rubin 95 perc
set.
clustering: Mother; one row each.
missingness: Complete five-year outcome required; missing is exclusion with observed-sampl
and no imputation.
multiplicity_family: primary_wage_late
robustness:
- Report reduced form from the identical sample as a diagnostic only; it does not create a
confirmatory claim.
prospective_assessment:
expected_direction: negative
smallest_effect_of_interest:
status: fixed
value: -25000
unit: nominal DKK per parity unit per year
rationale: Fixed economically meaningful annual wage decrement; equivalence band is plus
25000 DKK.
precision_plan: Report point estimate and both confidence procedures; classify using the AR
set relative to zero and the fixed equivalence band.
weak_data_scenario: Unbounded or disconnected AR set is inconclusive regardless of 2SLS sig
surprising_result: AR set wholly above zero supports a positive effect contrary to theory a
mechanism reconsideration without changing the estimand.
execution:
identity_chain:
question_clause: Effect of ten-year attained parity shifted by index multiplicity on mean
wage income in years six through ten.
estimand: LATE in nominal DKK per parity unit for the five-year mean wage outcome among
parity compliers.
analysis_variable: wage_mean_y6_y10
target_statistic: beta_iv_dkk_per_parity
primary_output_id: iv_result
sources:
- source_id: strong_stage_sample
resource_id: readable_42_table_schema
tables:
- first_stage_sample.parquet
fields:
- PNR
- multiple_birth
- parity_10y

```

```

- index_year
- index_age
- wage_lag1
- wage_lag2
grain: Mother index
keys:
- PNR
temporal_semantics: Frozen strong-stage cohort before outcome access.
filters:
- first_stage decision equals stage_strong.
- source_id: ind_outcome
resource_id: readable_42_table_schema
tables:
- IND
fields:
- PNR
- AAR
- LOENMV_13
- OMFANG
grain: Person-year
keys:
- PNR
- AAR
temporal_semantics: Annual nominal wage values in index_year plus six through plus ten.
filters:
- OMFANG satisfies hashed eligible tax-scope rule.
- source_id: exclusion_approval
resource_id: readable_42_table_schema
tables:
- exclusion_review.yaml
fields:
- reviewer_role
- decision
- signed_at
- evidence
- sha256
grain: Reviewer decision
keys:
- reviewer_role
temporal_semantics: Created and hashed before ind_outcome is accessed.
filters:
- One reproductive epidemiology and one labor-domain review.
joins:
- join_id: wage_join
left_source: strong_stage_sample
right_source: ind_outcome
keys:
- left_field: PNR

```

```

    right_field: PNR
cardinality: one_to_many
retained_side: inner
unmatched_rule: Exclude mother unless exactly five eligible target-year rows exist; never
    as zero.
validation: Exactly one row per required mother-year and five rows per retained mother.
variables:
- variable_id: multiple_birth
  role: instrument
  grain: Mother index
  source_ids:
  - strong_stage_sample
  source_fields:
  - multiple_birth
  ordered_steps:
  - Read frozen instrument from strong_stage_sample.
  - Verify against cohort digest.
  temporal_rule: Index episode only.
  missing_rule: Missing stops the experiment.
  output_type: integer zero or one
  validation: Binary and nonmissing.
- variable_id: parity_10y
  role: treatment
  grain: Mother index
  source_ids:
  - strong_stage_sample
  source_fields:
  - parity_10y
  ordered_steps:
  - Read frozen ten-year parity from strong_stage_sample.
  - Verify against first-stage digest.
  temporal_rule: Through exact tenth anniversary.
  missing_rule: Missing stops the experiment.
  output_type: integer parity
  validation: Integer at least two.
- variable_id: baseline_vector
  role: covariate
  grain: Mother index
  source_ids:
  - strong_stage_sample
  source_fields:
  - index_age
  - index_year
  - wage_lag1
  - wage_lag2
  ordered_steps:
  - Read frozen baseline terms.
  - Center age and square centered age identically to first stage.

```

```

temporal_rule: Pre-index and index only.
missing_rule: Missing stops the experiment.
output_type: numeric vector
validation: Complete and finite.
- variable_id: wage_mean_y6_y10
  role: outcome
  grain: Mother index
  source_ids:
    - strong_stage_sample
    - ind_outcome
  source_fields:
    - PNR
    - AAR
    - LOENMV_13
  ordered_steps:
    - Retain AAR equal to index_year plus 6 7 8 9 or 10 on the same linked mother.
    - Assert one eligible row per year and calculate arithmetic mean of the five nominal LOE
temporal_rule: Exactly five calendar years six through ten after index year.
missing_rule: Exclude any mother with a missing duplicate or non-finite annual value; do
output_type: numeric nominal DKK
validation: Exactly five contributors and mean equals sum divided by five.
sample_flow:
- step_id: s01
  input_population: Strong-stage cohort
  operation: Verify two signed pre-outcome exclusion approvals and then unlock registered
    fields.
  output_population: Outcome-access-authorized cohort
  exclusion_record: If approval absent no records are read and terminal is logged.
- step_id: s02
  input_population: Outcome-access-authorized cohort
  operation: Inner join five exact outcome years and require one eligible record in each.
  output_population: Complete observed wage cohort
  exclusion_record: Count missing duplicate invalid and tax-scope failures by assignment w
model:
  model_id: wage_iv_model
  equation_or_algorithm: First stage parity_10y_i=X_i gamma+pi Z_i+u_i; second stage Y_i=X
    fitted_parity_10y_i+e_i; invert AR tests H0 beta=b over deterministic grid -1000000 to
    by 1000 DKK, extending endpoints by factors of two until acceptance is bounded or abso
    reaches 16000000 DKK.
  target_statistic: beta_iv_dkk_per_parity
  symbol_map:
    - symbol: Y_i
      meaning: Five-year mean nominal wage outcome.
      source_fields:
        - AAR
        - LOENMV_13
  construction_variables:
    - wage_mean_y6_y10

```

- symbol: D_i
 - meaning: Attained parity at ten years.
 - source_fields:
 - parity_10y
 - construction_variables:
 - parity_10y
- symbol: Z_i
 - meaning: Index multiple-birth instrument.
 - source_fields:
 - multiple_birth
 - construction_variables:
 - multiple_birth
- symbol: X_i
 - meaning: Frozen age prior-wage and year terms.
 - source_fields:
 - index_age
 - index_year
 - wage_lag1
 - wage_lag2
 - construction_variables:
 - baseline_vector

estimator_api: ivreg::ivreg; sandwich::vcovHC type HC1; manual Anderson-Rubin inversion

weights: Equal mother weights.

fixed_effects: Index-year indicators.

reference_levels: Singleton instrument and index year 1995.

uncertainty: HC1 conventional 95 percent CI and two-sided AR 95 percent set with alpha 0

clustering: Mother; one observation each.

diagnostics:

- First-stage statistics reconciled.
- Reduced-form coefficient.
- AR grid endpoint flag.

actions:

- action_id: a01
 - goal: Enforce the exclusion and outcome-access gate.
 - consumes:
 - strong_stage_sample
 - exclusion_approval
 - procedure:
 - Verify both reviewer roles have signed yes decisions with timestamps before outcome access
 - Hash approval file and compare cohort digest to first-stage output.
 - produces:
 - authorized_sample
 - assertions:
 - Exactly two affirmative role decisions.
 - No ind_outcome access appears earlier in run log.
 - on_failure:
 - route: stop_experiment
 - detail: Do not access outcomes; terminate at exclusion_not_credible.

```

- action_id: a02
  goal: Construct the single registered wage outcome.
  consumes:
    - authorized_sample
    - ind_outcome
  procedure:
    - Join only exact years six through ten and apply hashed OMFANG eligibility.
    - Require five unique rows and compute arithmetic mean nominal wage.
  produces:
    - iv_sample
  assertions:
    - Five annual rows per mother.
    - One row per mother after aggregation.
    - Cohort exclusions reconcile.
  on_failure:
    route: mark_infeasible
    detail: Stop IV and issue outcome_observation_failure.
- action_id: a03
  goal: Estimate the registered fertility LATE and uncertainty.
  consumes:
    - iv_sample
  procedure:
    - Fit one just-identified 2SLS model and HC1 covariance.
    - Fit reduced form and invert AR tests on the deterministic expanding grid.
  produces:
    - iv_result
  assertions:
    - Target coefficient maps to parity_10y exactly.
    - All fit counts and AR endpoint status are recorded.
  on_failure:
    route: stop_experiment
    detail: Report estimation_failure with no replacement model.
outputs:
- output_id: authorized_sample
  path: preregistration/results/authorized_sample.parquet
  format: parquet
  grain: Mother index
  fields:
    - PNR
    - cohort_sha256
    - approval_sha256
  produced_by: a01
  consumers:
    - a02
- output_id: iv_sample
  path: preregistration/results/iv_sample.parquet
  format: parquet
  grain: Mother index

```

```

fields:
- PNR
- multiple_birth
- parity_10y
- wage_mean_y6_y10
- index_age
- index_year
- wage_lag1
- wage_lag2
produced_by: a02
consumers:
- a03
- output_id: iv_result
path: preregistration/results/iv_result.json
format: json
grain: Confirmatory analysis
fields:
- n
- beta_iv
- se_hc1
- ci_low
- ci_high
- ar_set
- ar_endpoint_flag
- reduced_form
- decision_id
produced_by: a03
consumers:
- late_negative_meaningful
- late_null_equivalent
- late_positive
- late_inconclusive
quality_control:
synthetic_dry_run: Generate data with known negative zero and positive LATEs plus weak IV
  verify aggregation, 2SLS, AR inversion, and decisions.
invariant_checks:
- Exactly five wage years per mother.
- Same treatment instrument and covariates as first stage.
- No health outcome field loaded.
reconciliation: Sum of complete cohort and mutually exclusive exclusions equals authorized
  2SLS first stage matches diagnostic equation on the IV sample.
run_log: preregistration/results/run_log.jsonl
stop_conditions:
- Missing approval.
- Outcome observation failure.
- Estimator mismatch.
- AR grid numerical failure.
compute_plan:

```

```

fit_operations:
- operation_id: primary_2sls
  calls_per_unit: 1
  fitted_units: 1
  repetitions: 1
  total_fits: 1
  justification: One primary IV model.
- operation_id: reduced_form
  calls_per_unit: 1
  fitted_units: 1
  repetitions: 1
  total_fits: 1
  justification: One registered diagnostic reduced form.
- operation_id: ar_grid
  calls_per_unit: 1
  fitted_units: 32001
  repetitions: 1
  total_fits: 32001
  justification: Maximum deterministic grid from minus to plus 16 million DKK inclusive
full_data_passes: 4
largest_intermediate: five-row-per-mother IND outcome panel
feasibility_note: Maximum 32003 fits; the small one-row-per-mother regression design is
  feasible.
decision_regions:
- decision_id: late_negative_meaningful
  condition: ar_set upper endpoint < minus_soe AND beta_iv < minus_soe.
  parameters:
  - name: minus_soe
    value: -25000
    unit: nominal DKK per parity unit
    rationale: Fixed meaningful negative effect.
  interpretation: Supports a negative economically meaningful fertility LATE subject to all
  claim_status: supports
- decision_id: late_null_equivalent
  condition: ar_set is bounded and entirely within [minus_equiv, plus_equiv].
  parameters:
  - name: minus_equiv
    value: -25000
    unit: nominal DKK per parity unit
    rationale: Lower equivalence bound.
  - name: plus_equiv
    value: 25000
    unit: nominal DKK per parity unit
    rationale: Upper equivalence bound.
  interpretation: LATE is statistically compatible only with effects smaller than the registered
    band.
  claim_status: null_equivalent
- decision_id: late_positive

```

```

condition: ar_set lower endpoint > zero_beta.
parameters:
- name: zero_beta
  value: 0
  unit: nominal DKK per parity unit
  rationale: Directional null boundary.
interpretation: Challenges the negative prediction and supports a positive LATE conditional.
claim_status: challenges
- decision_id: late_inconclusive
  condition: None of late_negative_meaningful late_null_equivalent or late_positive holds, in
    unbounded or disconnected ar_set.
  parameters:
  - name: alpha_iv
    value: 0.05
    unit: probability
    rationale: AR confidence-set level is 95 percent.
  interpretation: Precision or sign is insufficient for a directional or equivalence conclusion.
  claim_status: inconclusive
experiment_graph:
  entry_experiments:
  - assignment_audit
  activations:
  - from: assignment_audit
    on_decision: balance_pass
    to: fertility_first_stage
    meaning: Valid construction and observed balance permit relevance audit.
  - from: fertility_first_stage
    on_decision: stage_strong
    to: labor_fertility_iv
    meaning: Strong stable relevance activates IV only if its exclusion approvals also pass.
  terminals:
  - from: assignment_audit
    on_decision: balance_fail
    terminal_state: construction_or_exchangeability_failure
    meaning: No outcome access and at most feasibility reporting.
    claim_ceiling: feasibility_only
  - from: fertility_first_stage
    on_decision: stage_weak
    terminal_state: weak_first_stage
    meaning: No outcome access and no fertility LATE.
    claim_ceiling: feasibility_only
  - from: fertility_first_stage
    on_decision: stage_invalid
    terminal_state: invalid_first_stage
    meaning: No outcome access and no fertility claim.
    claim_ceiling: no_claim
  - from: labor_fertility_iv
    on_decision: late_negative_meaningful

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    terminal_state: report_negative_late
    meaning: Report bounded negative fertility LATE.
    claim_ceiling: causal
- from: labor_fertility_iv
  on_decision: late_null_equivalent
  terminal_state: report_equivalent_late
  meaning: Report bounded equivalence conclusion.
  claim_ceiling: causal
- from: labor_fertility_iv
  on_decision: late_positive
  terminal_state: report_positive_late
  meaning: Report contrary-sign fertility LATE.
  claim_ceiling: causal
- from: labor_fertility_iv
  on_decision: late_inconclusive
  terminal_state: report_inconclusive_late
  meaning: Report estimate and uncertainty without directional conclusion.
  claim_ceiling: causal
completion_rule: Stop at the first terminal reached; labor_fertility_iv approval failure is
  as exclusion_not_credible with no_claim and no outcome access.
synthesis_worlds:
- world_id: world_construction_failure
  triggering_pattern: balance_fail due to construction assertion.
  substantive_interpretation: Restricted data cannot define the maternal quasi-experiment.
  allowed_claim: Feasibility failure only; no plurality or wage comparison.
  next_research: Obtain authoritative birth-register linkage documentation.
- world_id: world_exchangeability_failure
  triggering_pattern: balance_fail after coherent construction.
  substantive_interpretation: Observed imbalance undermines as-if-random multiplicity.
  allowed_claim: Describe cohort construction only; no causal assignment claim.
  next_research: Obtain assisted-reproduction and richer prenatal covariates.
- world_id: world_relevance_failure
  triggering_pattern: stage_weak or stage_invalid.
  substantive_interpretation: Multiple birth does not provide a strong stable shift in registered
    parity.
  allowed_claim: Report the diagnostic first stage only and no fertility effect.
  next_research: Reconsider treatment measurement or another documented instrument in a new reg
- world_id: world_exclusion_failure
  triggering_pattern: stage_strong but either exclusion reviewer does not approve.
  substantive_interpretation: Direct twin burdens prevent a fertility-only interpretation.
  allowed_claim: Report gates and first stage only; no wage outcome is accessed.
  next_research: Separately preregister the bundled multiple-delivery estimand.
- world_id: world_negative
  triggering_pattern: late_negative_meaningful.
  substantive_interpretation: Additional ten-year parity lowers later maternal nominal wages f
  allowed_claim: Conditional causal LATE for the registered population window and scale.
  next_research: Study mechanisms in a separate preregistration.
- world_id: world_equivalent

```

```

triggering_pattern: late_null_equivalent.
substantive_interpretation: Meaningful effects outside the equivalence band are excluded for
allowed_claim: Conditional causal equivalence conclusion for the registered LATE.
next_research: Assess transport to other cohorts.
- world_id: world_positive
  triggering_pattern: late_positive.
  substantive_interpretation: The complier wage effect is positive contrary to prediction.
  allowed_claim: Conditional positive causal LATE without post hoc mechanism attribution.
  next_research: Preregister mechanism tests.
- world_id: world_inconclusive
  triggering_pattern: late_inconclusive.
  substantive_interpretation: Data do not distinguish meaningful negative null-range or positive
  allowed_claim: Report conditional IV estimate and uncertainty without directional conclusion
  next_research: Seek larger or longer compatible cohorts.
synthesis_resolution:
  selection: ordered_precedence
  precedence:
    - world_construction_failure
    - world_exchangeability_failure
    - world_relevance_failure
    - world_exclusion_failure
    - world_negative
    - world_equivalent
    - world_positive
    - world_inconclusive
  unmatched_action: Record synthesis_unmatched, make no substantive claim, and open a deviation
    without changing analysis.
multiplicity:
  families:
    - assignment_gate_four_smgs_and_one_joint_test
    - first_stage_one_primary_and_four_directional_diagnostics
    - primary_wage_late_one_estimand
  correction: Gate thresholds are conjunctive and not adjusted; the sole confirmatory outcome is
    0.05 and AR inference; subgroup stages are sign diagnostics only.
  reporting: Report every registered statistic, fit, confidence set, gate, and failure, including
    and inconclusive results.
deviations:
  permitted:
    - Software patch-version change with identical numerical API after synthetic equivalence.
    - Correction of a coding bug that restores the literal registered rule before results are visible
  prohibited:
    - Outcome substitution.
    - Cohort or horizon search.
    - Covariate or functional-form selection after outcomes.
    - Threshold changes.
    - Unregistered subgroup claims.
    - Parsing PNR.
    - Adding unavailable tables.

```

disclosure: Log every deviation before rerun with timestamp rationale affected outputs outcomes state and code diff; label any nonliteral analysis exploratory and outside the preregistered