Liu–Mogstad–Salvanes: The reduced-form strategy

Applied Microeconomics

Hans-Martin von Gaudecker & Florian Zimmermann

What this screencast covers

- The **reduced-form** half of LMS (i.e., Section 3 of the paper)
- Norwegian setting and the compulsory schooling reform
- The Imbens–Rubin identification argument: how IV recovers $E[h(\mathbf{Y}(d)) \mid \text{compliers}]$, *not just the mean LATE*
- What is identified (and what is not) without further parametric structure
- The selection-into-employment complication for log earnings

The structural step (Sections 4–5) is the subject of the in-class exercise. See also the short companion screencast on what structural estimation is.

Setting: Norway, 1943–1963 birth cohorts

- Population panel data linked across registers: every Norwegian, 1967–2013
- Earnings, employment, family income, ability test scores (military draft, ≈ age 18)
- 69,651 individuals with 7 or 9 years of schooling
- *Males only*, ages 17–60, to avoid selection issues from women's labour-market entry over the period

The Norwegian reform: compulsory schooling raised from 7 → 9 years, rolled out between 1959 and 1974 *by municipality and birth cohort*.

$$Z_i = \mathbb{I}[\text{individual } i \text{ subject to the 9-year regime}]$$

The treatment, the instrument, the outcomes

- $D_i \in \{0, 1\}$: observed schooling, 7 years ($D = 0$) or 9 years ($D = 1$)
- Z_i: under the reform or not (binary instrument)
- $\mathbf{Y}_i = \{Y_{i1}, \ldots, Y_{iT}; H_{i1}, \ldots, H_{iT}\}$: a **vector**

  of life-cycle outcomes:

  - Y_{it}: earnings at age t
  - H_{it}: employed ($\geq$ 2× substantial-gainful-activity threshold) at age t
- Potential outcome vectors $\mathbf{Y}_i(0), \mathbf{Y}_i(1)$, one per schooling level

Key difference from earlier weeks: $\mathbf{Y}$ is a **vector** of outcomes over the life cycle, not a single number.

IV assumptions

LMS impose the **standard LATE assumptions** (Imbens–Angrist 1994):

1. **Random assignment** (conditional on cohort × municipality FEs): $Z_i \perp (\mathbf{Y}_i(0), \mathbf{Y}_i(1), D_i(0), D_i(1)) \mid \delta_c, \delta_m$
2. **Uniformity**: $D_i(1) \geq D_i(0)$, i.e. nobody is forced *out* of schooling by the reform
3. **Exclusion**: Z_i affects $\mathbf{Y}_i$ only through D_i
4. **Relevance**: $\Pr(D = 1 \mid Z = 1) \neq \Pr(D = 1 \mid Z = 0)$

Note: LMS do **not** impose the Roy assumption of utility maximisation in D. The choice of D_i may be driven by anything: selection on levels, on gains, on tastes, on parental pressure.

Compliance types and shares

Imbens–Rubin (1997) partition the population:

	$D_i(0) = 0$	$D_i(0) = 1$
$D_i(1) = 0$	never-takers	(ruled out by monotonicity)
$D_i(1) = 1$	compliers	always-takers

Shares identified directly from a first stage:

$$\pi_c = \Pr(D = 1 \mid Z = 1) - \Pr(D = 1 \mid Z = 0)$$

$$\pi_a = \Pr(D = 1 \mid Z = 0), \quad \pi_n = \Pr(D = 0 \mid Z = 1)$$

Estimated by a difference-in-differences linear probability model with cohort + municipality fixed effects.

e Imbens–Rubin identification step

identify $E[h(\mathbf{Y}_i(1)) \mid \text{compliers}]$ for arbitrary h (mean, variance, autocovariance, employment,

ngredients:

e $(Z = 1, D = 1)$ subpopulation is a **mixture** of compliers and always-takers (in known proporti
$/(\pi_c + \pi_a)$ and $\pi_a/(\pi_c + \pi_a)$):

$$h(\mathbf{Y}) \mid Z = 1, D = 1] = \frac{\pi_c}{\pi_c + \pi_a} E[h(\mathbf{Y}(1)) \mid \text{compliers}] + \frac{\pi_a}{\pi_c + \pi_a} E[h(\mathbf{Y}(1)) \mid \text{always-ta}$$

e $(Z = 0, D = 1)$ subpopulation is **only** always-takers:

$$E[h(\mathbf{Y}) \mid Z = 0, D = 1] = E[h(\mathbf{Y}(1)) \mid \text{always-takers}]$$

itute the second into the first → solve for the complier moment. Done.

What this gets you

For **any** function h and **any** age t:

- $E[Y_{it}(d) \mid \text{compliers}]$: mean potential earnings
- $\text{Var}(Y_{it}(d) \mid \text{compliers})$: variance of potential earnings
- $E[H_{it}(d) \mid \text{compliers}]$: potential employment probability
- $\text{Cov}(H_{it}(d), H_{it-k}(d) \mid \text{compliers})$: employment autocovariance

All of Panel A of Table 1 falls out of this single identification argument applied to different h's.

Powerful: Entire **joint distribution** of life-cycle potential outcomes for compliers, from one instrument.

Endogenous-selection test (Section 3.5)

If education were *exogenous*, then potential outcomes would be independent of D:

$$E[h(\mathbf{Y}(1)) \mid \text{compliers}] = E[h(\mathbf{Y}(1)) \mid \text{always-takers}]$$

LMS test this. Result: **rejected at any conventional level**, for mean earnings, variance, and employment. Self-selection into schooling is real, and the instrument is doing work.

Headline results from the reduced form

- At age 50, an extra two years of compulsory schooling raises mean earnings by **6.3%** and the variance of earnings by **10.5%**
- Effects on employment: small but generally positive (≈ 1.4 pp average)
- Effects on **family** income (after spouses, taxes, transfers): roughly **half** the gross-earnings effect on means; the progressive tax-transfer system is doing substantial insurance work

These are all *complier* statements: they describe the marginal individuals induced by the compulsory schooling reform, not the whole population.

The selection-into-employment wrinkle (Panel B)

So far we have analysed earnings *levels* (including zeros for the unemployed). To get at the **earnings process** (Section 4), LMS need:

- $E[\log Y_{it}(d) \mid \text{compliers}, H_{it}(d) = 1]$
- Autocovariances of $\log Y_{it}(d)$ for the employed compliers

But $\log Y$ is only observed when $H = 1$, and H is itself endogenous (education affects it).

$$E[h(\mathbf{Y}(d)) \mid D(1) > D(0), H(d) = 1] = E[h(\mathbf{Y}(d)) \mid D(1) > D(0)] + \underbrace{\text{selection bias}}_{\text{may differ by } d}$$

The IV step *alone* cannot disentangle this; it needs the **structural employment equation** (eq. (12)) for identification.

This is the joint that the in-class exercise will dig into.

What the reduced form *does not* give you

Things you will **not** get from Section 3 alone:

- Decomposition of the variance of earnings into **risk** (within-individual) versus **heterogeneity** (between-individual): needs the earnings process
- The role of **latent ability** (α_i) in shaping returns: needs the measurement system