Discussion of
“Measuring Heterogeneity in the Returns to Education in Norway Using Educational Reforms”
by Arild Aakvik, Kjell Salvanes and Kjell Vaage

Justin Wolfers
The Wharton School, University of Pennsylvania & NBER
http://bpp.wharton.upenn.edu/jwolfers
Contribution of the Paper

- Examine 1960’s expansion of compulsory high school in Norway
- Estimate plausibly exogenous returns to education, taking selection seriously
- Look for heterogeneity in returns to education
  - Estimating a range of treatment parameters
The Norwegian School System

- Initially 7 years of required (primary) education ("Level 1")
- Choose to pursue 2 years of further education ("Level 2")
- Can then choose Vocational OR Academic
  - Vocational track
    » Finish first year ("Level 3")
    » Continue to 2nd and 3rd year ("Level 4")
  - Academic track
    » Upper secondary for 2-3 years ("Level 5")
    » Choose College OR University
      - Regional colleges ("Level 6")
      - University track
        - Continue to University II (undergraduate) ("Level 7")
        - Continue to University III (Grad school) ("Level 8")

Policy Intervention: Level 2 became compulsory between 1960 and 1970, with 750 different municipalities changing laws at different times.
Experiment #1: The Reform

Distribution of Qualifications

<table>
<thead>
<tr>
<th>Final Qualification Level</th>
<th>Change Due to Reform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>Compulsory Secondary</td>
<td></td>
</tr>
<tr>
<td>Vocational I</td>
<td></td>
</tr>
<tr>
<td>Vocational II</td>
<td></td>
</tr>
<tr>
<td>Upper Secondary</td>
<td></td>
</tr>
<tr>
<td>University I</td>
<td></td>
</tr>
<tr>
<td>University II</td>
<td></td>
</tr>
<tr>
<td>University III</td>
<td></td>
</tr>
</tbody>
</table>

Pre-Reform  Post-Reform

Justin Wolfers, Wharton & NBER: “Discussion of Aakvik et. al”
## Experiment #1: Results (Table 13)

**Dependent Variable: Log(Wage)**

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>“IV” (b)</th>
<th>“IV with Het.” (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Education (a)</strong></td>
<td>.075 (.0005)</td>
<td>.1026 (.0024)</td>
<td>.0634</td>
</tr>
<tr>
<td><strong>Inverse Mills Ratio (c)</strong></td>
<td>.0522 (.0043)</td>
<td>.0320 - .0138*Ed (.0044) (.0005)</td>
<td></td>
</tr>
<tr>
<td><strong>Controls</strong></td>
<td>Experience, Experience², Tenure, Tenure², Parent’s college, Family income quartiles, Cohort and Municipality Fixed Effects</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

a) “Education” is not years of education (Coefficient on years is closer to 0.04)

b) “IV” models are sample correction models (not IV)

c) Inverse Mills Ratio from first stage ordered probit
   \[ Schooling = Reform_{Cohort,Municipality} + Cohort + Municipality + Controls \]
Three Sources of Variation

Share of Population with at least 9 Years of Schooling

- Municipality B
- Municipality A

Long diffs
DD-estimate

\[
\frac{\phi(\text{Reform+Controls})}{\Phi(\text{Reform+Controls})} - \beta \cdot \text{Controls}
\]

Differences in the timing of reform

Justin Wolfers, Wharton & NBER: “Discussion of Aakvik et. al”
Does Selection or Mis-Specification Vary?

Changes in Qualifications

- Actual Change (Table 7)
- Ordered Probit Estimate (Table 10)

Change, Due to Reform (%population)

Final Qualification Level

Justin Wolfers, Wharton & NBER: “Discussion of Aakvik et. al”
Experiment #2: Access to Education

Access to Types of Education

<table>
<thead>
<tr>
<th>Type of Education</th>
<th>Pre-Reform Cohort</th>
<th>Mid-Reform Cohort</th>
<th>Post-Reform Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory 9-years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocational</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Secondary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University II</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Justin Wolfers, Wharton & NBER: “Discussion of Aakvik et. al”
Wage Equations

For each level of terminal education, regress wages on:
- Tenure and experience
- Family background
- Municipal characteristics
- County and Cohort fixed effects
  » Cohort
  » County
- Inverse Mills Ratio from Selection equation

Allows one to construct counterfactual wage distributions for individuals who differ on both observables and unobservables
- Identifying a family of treatment effects
Sequential Probit Selection Equation

Choose whether to do Lower Secondary (level 1):
- \[ \Pr(D_1=1) = \Phi(\beta_1 Q + \theta_1 Z) \]

Then choose grade level 2 (vocational training), given choice of lower secondary:
- \[ \Pr(D_2=1|Q,Z) = \Phi(\beta_2 Q + \theta_2 Z) \Phi(\beta_1 Q + \theta_1 Z) \]
- …and so on…
Observations

▼ You can’t do graduate work without an undergraduate degree (and you can’t do either without a university)
  – Independence of error terms across selection equations?
▼ Choose between vocational track and academic track
  – A series of sequential choices?
▼ There are 4½ million Norwegians in 750 municipalities (Ave. size =6,000 people, and 40 boys per municipality-cohort)
  – These seem small: Is the municipality the right level to think about distance from college?
  – County fixed effects exacerbate this problem
▼ Solves a problem in most binary choice models
  – Intensity of treatment no longer varies with selection into treatment
Marginal Effects of Higher Qualifications (Table 15)

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Wage Premium (Log points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Secondary (2yrs)</td>
<td>-10%</td>
</tr>
<tr>
<td>Vocational I (1 year)</td>
<td>0%</td>
</tr>
<tr>
<td>Vocational II (2-3 years)</td>
<td>10%</td>
</tr>
<tr>
<td>Upper secondary (2-3 years)</td>
<td>20%</td>
</tr>
<tr>
<td>University I (1-2 yrs)</td>
<td>30%</td>
</tr>
<tr>
<td>University II (3-4 yrs)</td>
<td>20%</td>
</tr>
<tr>
<td>University III (5+ yrs)</td>
<td>30%</td>
</tr>
</tbody>
</table>

Legend:
- Orange: Average Treatment Effect
- Blue: Conditional Cumulative Treatment Effect
- Red: Effect of Treatment on the Treated
Conclusions

- Pre-1960 variation in schooling levels ensures that compulsory schooling laws have very different effects
  - Arguably “cleanest” source of variation
  - Moving from selection control to IV methods will aid
    » Transparency
    » Robustness
  - With 750 municipalities, effectively 750 instruments, which can provide evidence on the heterogeneity of treatment effects

- Heterogeneity of treatment effects