Methods for Causal Inference in Educational Research

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UiO : CEMO – Centre for Educational Measurement
University of Oslo

Take-away messages

Group comparison are, in general, “fruitless comparisons” due to selection bias.

Randomised control trials allow us to get rid of selection bias but require samples to be representative and large enough.

Even after a “successful” RCT, we have to be aware of possible threats to validity.

Overview

- Regressions for causal inference
- Preschool example
- Extended R exercise

Regressions for Causal Inference

"Regression-based causal inference is predicated on the assumption that when key observed variables have been made equal across treatment and control groups, selection bias from the things we can't see is also mostly eliminated."

→ assumption that we can control for selection mechanisms by including good set of control variables (ceteris paribus)

→ if control variables do not capture whole selection mechanism, we have *omitted variable bias*, i.e., remaining selection bias

Angrist & Pischke, 2015, p. 47

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Regressions for Causal Inference

We need

1. knowledge about the selection mechanisms at play
2. good observed variables (associated with treatment allocation AND outcome) to capture the selection mechanisms
3. overlaps in characteristics between treatment and control groups
4. large enough datasets
5. appropriate regression model

What are selection mechanisms in private vs. public college attendance in the US?

Regressions for Causal Inference

$$Y_i = \alpha + \beta D_i + \gamma_1 A_{1i} + \cdots + \gamma_k A_{ki} + e_i$$

Outcome Y (in this case wage) is regressed on

- treatment D (in this case 0 = *public* and 1 = *private*) and
- set of *k* control variables A
  - SAT scores, parental income, gender, race, high-school rank, athlete
  - 150 selectivity groups (i.e., college types they applied for and were admitted to) → comparing students who were admitted to similar schools and did vs. did not go

Angrist & Pischke, 2015

TABLE 2.2
Private school effects: Barron's matches

	No selection controls			Selection controls		
	(1)	(2)	(3)	(4)	(5)	(6)
Private school	.135	.095	.086	.007	.003	.013
	(.055)	(.052)	(.034)	(.038)	(.039)	(.025)
Own SAT score ÷ 100		.048	.016		.033	.001
		(.009)	(.007)		(.007)	(.007)
Log parental income			.219			.190
			(.022)			(.023)
Female			−.403			−.395
			(.018)			(.021)
Black			.005			−.040
			(.041)			(.042)
Hispanic			.062			.032
			(.072)			(.070)
Asian			.170			.145
			(.074)			(.068)
Other/missing race			−.074			−.079
			(.157)			(.156)
High school top 10%			.095			.082
			(.027)			(.028)
High school rank missing			.019			.015
			(.033)			(.037)
Athlete			.123			.115
			(.025)			(.027)
Selectivity-group dummies	No	No	No	Yes	Yes	Yes

Notes: This table reports estimates of the effect of attending a private college or university on earnings. Each column reports coefficients from a regression of log earnings on a dummy for attending a private institution and controls. The results in columns (4)–(6) are from models that include applicant selectivity-group dummies. The sample size is 5,583. Standard errors are reported in parentheses.

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Log parental income			.219			.190
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Female			−.403			−.395
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→ if other things are controlled for (and hopefully equal), no significant wage premium of private school

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Regressions for Causal Inference

"Regression is a way to make other things equal, but equality is generated only for variables included as controls on the right-hand side of the model. Failure to include enough controls or the right controles still leaves us with selection bias." (p. 69)

→ omitted variable bias (OVB) if a control variable that relates to the treatment and the outcome is not included

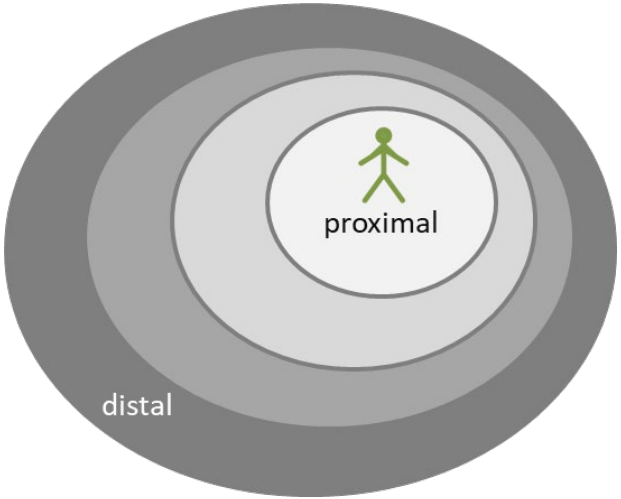
→ "We can't use data to check the consequences of omitting variables that we don't observe, but we can use the OVB formula to make an educated guess as to the likely consequences of their omission." (p. 74)

→ importance of sensitivity checks

Angrist & Pischke, 2015

Preschool example

- Since 1996, three-year-old children in Germany are entitled to attend preschool
- Nowadays, 94.9% do attend preschools (DESTATIS, 2015)
- Main aims of expanding preschool (cf. Hogrebe, 2014):
  - Compatibility of family and career
  - Improvement of preparation for school
- Families and preschools are the most important learning environments for young children (cf. Bronfenbrenner, 1990; Bronfenbrenner & Morris, 2006)
- Preschool is expected to foster later achievement (e.g. Knudsen et al., 2006)



Steinmann et al. (2016)

What could be selection mechanisms?

Preschool example

Selection into preschool

- Family income
- Parental education
- Parental occupation
- Availability of care options in family
- Migration background
- … (cf. Early & Burchinal, 2001; Grogan, 2012; Kim & Fram, 2009)

Steinmann et al. (2016)

Preschool example

- PIRLS 2011: Positive relationship between preschool participation and reading abilities in fourth grade (Mullis et al., 2012)
- Meta-analyses and reviews show substantial but rather mixed effects due to program types and target groups (Barnett, 2011; Burger, 2010; Camilli et al., 2010; Chambers et al., 2010; Duncan & Magnuson, 2013; Pianta et al., 2009)
- Experimental studies: High/Scope Perry Preschool Project (Schweinhart et al., 2005) or Abecedarian Program (Campbell & Ramey, 1995)
  - Ca. 100 children with disadvantaged backgrounds
  - High intensity and quality of programs
  - Beneficial long-term effects on several outcomes in school age

→ Generalizability?

Steinmann et al. (2016)

Preschool example

- More recent international studies could not (fully) replicate these promising findings (cf. Barnett, 2011)
  - Head Start study: No significant effects on later achievement (Puma et al., 2012)
  - Early Head Start study: Only reading ability effects for low risk students (Vogel et al., 2010)
  - Effective Provision of Preschool Education project: effects for high risk students (Sylva et al., 2008)
  - Effects for disadvantaged students in two out of nine countries (Hogrebe & Strietholt, 2016)
- Basically no robust findings in Germany (Anders & Roßbach, 2014)

Steinmann et al. (2016)

Preschool example

What is the effect of attending preschool for 3 years or more (D = 1) on reading achievement in grade 4 in Germany, as compared to not attending or attending for less than 3 years (D = 0)?

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We need

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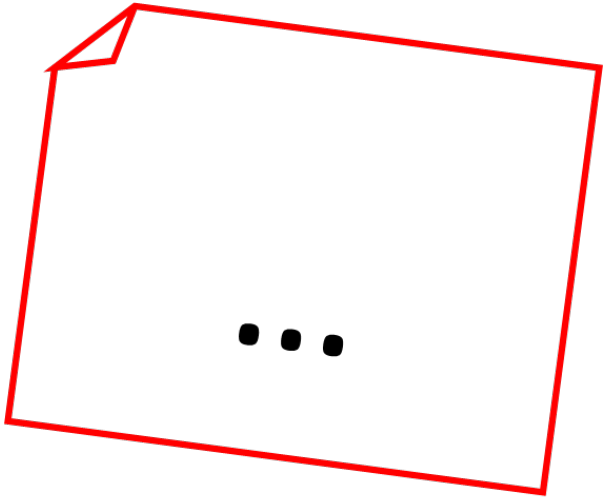
Extended R example



see

- CausalInference_Session5_Material1.R
- PIRLS2016DEU.RData

What can we conclude from this exercise?

What is the causal effect of attending preschool for 3 or more years on reading achievement in grade 4?

What kind of limitations do we have to consider?

Take-away messages

- If selection mechanism is well-known and can be captured with indicators, regressions can control for selection mechanisms (in social sciences, this is usually not the case)
- Omitted variable bias (i.e., selection bias) if control variables do not capture whole selection mechanism
- If regressions used for causal research questions, importance of justification of control strategy, balance checks, and sensitivity analyses

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