ECMA31100 Introduction to Empirical Analysis II

Winter 2022, Week 7: Discussion Session

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Welcome to Week 7

Problem set

- Please submit the problem sets by the deadline
- Make sure that everything has been compiled
- Submit your code as a separate script

Today's plan

- Continue our discussion on monotone instrumental variables
- Empirical example on the effect of parental schooling on their children's schooling

Contents

de Haan (2011)

Overview

This paper

- Look at the effect of parents' schooling on the schooling of their child
- Used a sample from the Wisconsin Longitudinal Study

Notations

- Let t be level of schooling of the parent and y be the years of schooling of the child
- $y_i(\cdot) : \mathcal{T} \longrightarrow \mathcal{Y}$ be the response function where $\mathcal{T} \equiv \text{supp}(t)$ and $\mathcal{Y} \equiv \text{supp}(y)$
- For each child i, we observe parental schooling z_i and the child's schooling $y_i \equiv y_i(z_i)$
- Let $\underline{y}$ and $\overline{y}$ be the lowest and highest possible level of education
- Target parameter: ATE of increased parental schooling $\Delta(s,t) \equiv \mathbb{E}[y_i(t)] - \mathbb{E}[y_i(s)]$

de Haan (2011)

Table 1: Summary statistics (table 1 of de Haan (2011))

	Mean	SD
Years of schooling child	14.50	2.322
College degree child	.458	.498
College degree mother	.180	.384
College degree father	.280	.449
Gender child (female = 1)	.495	.500
Age child	38.34	5.501
Schooling level mother:		
1. Less than high school	.035	.183
2. High school	.627	.484
3. Some college	.158	.365
4. Bachelor's degree	.131	.338
5. Master's degree or more	.048	.215
Schooling level father:		
1. Less than high school	.082	.275
2. High school	.495	.500
3. Some college	.142	.349
4. Bachelor's degree	.141	.348
5. Master's degree or more	.140	.346
Schooling level grandparent (mother's parent):		
1. Elementary school	.147	.354
2. Middle school	.343	.475
3. Some high school	.101	.301
4. High school	.274	.446
5. More than high school	.136	.343
Schooling level grandparent (father's parent):		
1. Elementary school	.143	.350
2. Middle school	.359	.480
3. Some high school	.092	.289
4. High school	.268	.443
5. More than high school	.138	.345
N	21,545	

NOTE.—Number of observations on schooling grandparent is smaller: $N = 16{,}912$ for mother's parent and $N = 14{,}614$ for father's parent.

de Haan (2011)

Partial identification

Identification problem

- We observe $y_i(z_i)$, but not $y_i(t)$ for $t \in \mathcal{T} \backslash \{z_i\}$
- This paper considers the no-assumption, MTR, MTR-MTS, and MIV bounds

No-assumption bounds

- Using the law of iterated expectations, we can write

$$\mathbb{E}[y_i(t)] = \mathbb{E}[y_i(t) | t = z_i]\mathbb{P}[t = z_i] + \mathbb{E}[y_i(t) | t \neq z_i]\mathbb{P}[t \neq z_i]$$

- The no-assumption bounds of $\mathbb{E}[y_i(t)]$ is

$$\left[\mathbb{E}[y_i | t = z_i]\mathbb{P}[t = z_i] + \underline{y}\mathbb{P}[t \neq z_i], \mathbb{E}[y_i | t = z_i]\mathbb{P}[t = z_i] + \overline{y}\mathbb{P}[t \neq z_i]\right]$$

de Haan (2011)

Monotone treatment response

Monotone treatment response (MTR) assumption

- $t \geq t' \implies y_i(t) \geq y_i(t')$
- Intuition: $\uparrow$ parents' schooling weakly $\uparrow$ child's schooling
- Rationale of the paper: Better help with homework, more income for education etc.
- MTR does not rule out the possibility that there is no causal impact

MTR bounds

- The MTR bounds for $\mathbb{E}[y_i(t)]$ is $[\underline{\tau}_{\mathrm{R}}, \overline{\tau}_{\mathrm{R}}]$, where

$$\underline{\tau}_{\mathrm{R}} = \mathbb{E}[y_i|z_i < t]\mathbb{P}[z_i < t] + \mathbb{E}[y_i|z_i = t]\mathbb{P}[z_i = t] + \underline{y}\mathbb{P}[z_i > t],$$
$$\overline{\tau}_{\mathrm{R}} = \overline{y}\mathbb{P}[z_i < t] + \mathbb{E}[y_i|z_i = t]\mathbb{P}[z_i = t] + \mathbb{E}[y_i|z_i > t]\mathbb{P}[z_i > t]$$

de Haan (2011)

Monotone treatment selection

Monotone treatment selection (MTS) assumption

- $u \geq u' \implies \mathbb{E}[y_i(t)|z_i = u] \geq \mathbb{E}[y_i(t)|z_i = u']$
- Intuition: Children with higher-school parents have weakly higher mean schooling
- Rationale of the paper: Higher-educated parents have higher-ability child on average

MTR-MTS bounds

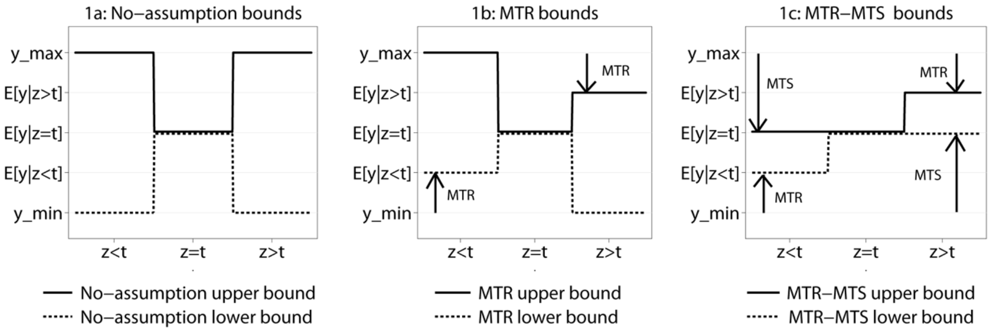
- The MTR-MTS bounds for $\mathbb{E}[y_i(t)]$ is $[\underline{\tau}_{\text{RS}}, \overline{\tau}_{\text{RS}}]$, where

$$\underline{\tau}_{\text{RS}} = \mathbb{E}[y_i|z_i < t]\mathbb{P}[z_i < t] + \mathbb{E}[y_i|z_i = t]\underbrace{(\mathbb{P}[z_i = t] + \mathbb{P}[z_i > t])}_{\mathbb{P}[z_i \geq t]},$$

$$\overline{\tau}_{\text{RS}} = \mathbb{E}[y|z_i = t]\underbrace{(\mathbb{P}[z_i < t] + \mathbb{P}[z_i = t])}_{\mathbb{P}[z_i \leq t]} + \mathbb{E}[y_i|z_i > t]\mathbb{P}[z_i > t]$$

de Haan (2011)

Figure 1: Impact of the assumptions on the bounds (figure 1 of de Haan (2011))



de Haan (2011)

Monotone instrumental variables

Monotone instrumental variables (MIV) assumption

- $m_1 \leq m \leq m_2 \implies \mathbb{E}[y_i(t)|v_i = m_1] \leq \mathbb{E}[y_i(t)|v_i = m] \leq \mathbb{E}[y_i(t)|v_i = m_2]$, where $m \in \mathcal{M}$
- Motivation: Not easy to find v_i that satisfies mean-independence $\mathbb{E}[y_i(t)|v_i] = \mathbb{E}[y_i(t)]$ $\implies$ Allows a weaker version of the assumption

MIVs used in the paper

- Schooling of grandparent
- Schooling of the other parent

IV bounds

- $\max_{m \in \mathcal{M}} \text{LB}_{\mathbb{E}[y(t)|v=m]} \leq \mathbb{E}[y(t)] \leq \min_{m \in \mathcal{M}} \text{UB}_{\mathbb{E}[y(t)|v=m]}$

de Haan (2011)

Monotone instrumental variables

MIV bounds

- The MIV bounds for $\mathbb{E}[y_i(t)]$ is $[\underline{\tau}_{\text{MIV}}, \overline{\tau}_{\text{MIV}}]$, where

$$\underline{\tau}_{\text{MIV}} = \sum_{m \in \mathcal{M}} \mathbb{P}[v_i = m] \cdot \max_{m_1 \leq m} \text{LB}_{\mathbb{E}[y(t)|v_i = m_1]},$$

$$\overline{\tau}_{\text{MIV}} = \sum_{m \in \mathcal{M}} \mathbb{P}[v_i = m] \cdot \max_{m_2 \geq m} \text{UB}_{\mathbb{E}[y(t)|v_i = m_2]},$$

Using two MIVs simultaneously

- The assumption can be modified as follows:

$$u_1 \geq u_1' \text{ and } u_2 \geq u_2' \implies \mathbb{E}[y_i(t)|(v_{1i}, v_{2i}) = (u_1, u_2)] \geq \mathbb{E}[y(t)|(v_{1i}, v_{2i}) = (u_1', u_2')]$$

de Haan (2011)

Estimation and inference

Bias-corrected bounds (Kreider and Pepper, 2007)

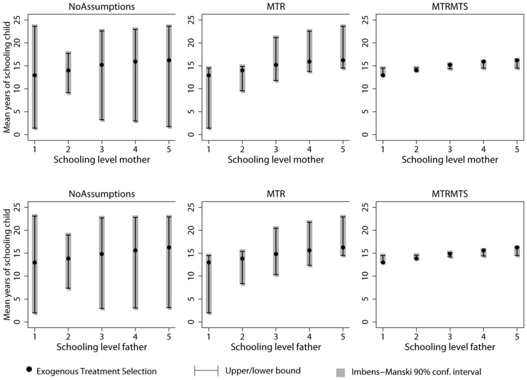
- MIV uses max. and min. of nonparametric regression estimates $\Longrightarrow$ Biased bounds
- Let $\widehat{\tau}$ be the estimate and $\{\widehat{\tau}_b\}_{b=1}^B$ be the bootstrap estimates of the upper bound
- Subtract $\widehat{\text{Bias}} \equiv \frac{1}{B}\sum_{b=1}^B \widehat{\tau}_b - \widehat{\tau}$ from the upper bound for bias-correction
- Do the same for the lower bound

Confidence intervals (Imbens and Manski, 2004)

- Imbens and Manski (2004) covers the target parameter with fixed probability
- Let $\widehat{\tau}_i$ be the estimated bound and $\widehat{\sigma}_i$ be its bootstrap standard error, with $i \in \{\text{lb}, \text{ub}\}$
- The $(1-\alpha)\%$ confidence interval is $[\widehat{\tau}_{\text{lb}} - c\widehat{\sigma}_{\text{lb}}, \widehat{\tau}_{\text{ub}} + c\widehat{\sigma}_{\text{ub}}]$
- c is obtained from $\Phi(c + \frac{\widehat{\tau}_{\text{ub}} - \widehat{\tau}_{\text{lb}}}{\max\{\widehat{\sigma}_{\text{lb}}, \widehat{\sigma}_{\text{ub}}\}}) - \Phi(-c) = 1 - \alpha$

de Haan (2011)

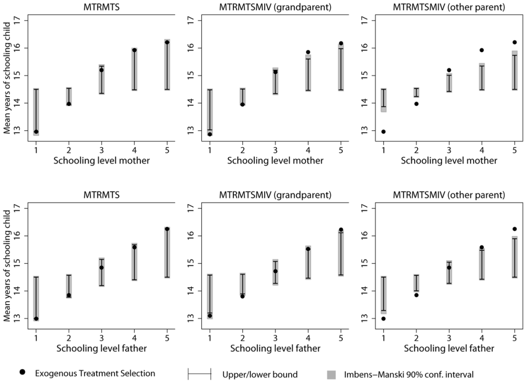
Figure 2: Impact of the assumptions on the bounds (figure 3 of de Haan (2011))



(1) less than high school, (2) high school, (3) some college, (4) bachelor's degree, and (5) master's degree or more

de Haan (2011)

Figure 3: Impact of the assumptions on the bounds (figure 4 of de Haan (2011))



(1) less than high school, (2) high school, (3) some college, (4) bachelor's degree, and (5) master's degree or more

de Haan (2011)

Table 2: Impact of increasing parental education (table 3 of de Haan (2011))

	ETS	MTR-MTS		MTR-MTS-MIV Grandparent				MTR-MTS-MIV Other Parent			
						Bias Corrected				Bias Corrected	
	β	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
	Effect of Mother's Schooling										
$\Delta(1, 2)$	1.021	0	1.578	0	1.483	0	1.535	0	.658	0	.655
	(.847, 1.196)	(0	1.714)	(0	1.690)	{0	1.741}	(0	.844)	{0	.841}
						[0	1.776]			[0	.877]
$\Delta(2, 3)$	1.218	0	1.399	0	1.236	0	1.273	0	.769	0	.768
	(1.123, 1.313)	(0	1.463)	(0	1.329)	{0	1.366}	(0	.840)	{0	.839}
						[0	1.381]			[0	.860]
$\Delta(3, 4)$	.731	0	1.586	0	1.259	0	1.262	0	.922	0	.922
	(.622, .841)	(0	1.650)	(0	1.410)	{0	1.412}	(0	1.019)	{0	1.019}
						[0	1.423]			[0	1.041]
$\Delta(4, 5)$	.284	0	1.725	0	1.515	0	1.569	0	1.252	0	1.270
	(.136, .432)	(0	1.831)	(0	1.674)	{0	1.728}	(0	1.408)	{0	1.427}
						[0	1.739]			[0	1.475]
$\Delta(1, 5)$	3.254	0	3.254	0	2.951	0	3.053	0	1.867	0	1.882
	(3.039, 3.469)	(0	3.422)	(0	3.204)	{0	3.306}	(0	2.111)	{0	2.126}
						[0	3.323]			[0	2.185]
	Effect of Father's Schooling										
$\Delta(1, 2)$	.850	0	1.573	0	1.406	0	1.516	0	1.278	0	1.291
	(.735, .964)	(0	1.661)	(0	1.618)	{0	1.728}	(0	1.397)	{0	1.410}
						[0	1.727]			[0	1.449]
$\Delta(2, 3)$	1.001	0	1.372	0	1.179	0	1.190	0	1.036	0	1.034
	(.902, 1.099)	(0	1.433)	(0	1.267)	{0	1.279}	(0	1.102)	{0	1.100}
						[0	1.300]			[0	1.118]
$\Delta(3, 4)$	.740	0	1.481	0	1.243	0	1.260	0	1.199	0	1.201
	(.629, .852)	(0	1.542)	(0	1.374)	{0	1.391}	(0	1.273)	{0	1.276}
						[0	1.396]			[0	1.289]
$\Delta(4, 5)$	.669	0	1.850	0	1.652	0	1.684	0	1.472	0	1.473
	(.568, .770)	(0	1.912)	(0	1.743)	{0	1.775}	(0	1.555)	{0	1.556}
						[0	1.787]			[0	1.582]
$\Delta(1, 5)$	3.260	0	3.260	0	2.918	0	3.048	0	2.610	0	2.624
	(3.132, 3.387)	(0	3.359)	(0	3.144)	{0	3.275}	(0	2.751)	{0	2.765}
						[0	3.258]			[0	2.810]

de Haan (2011)

Table 3: Impact of increasing parental education: $<$ college to college (table 4 of de Haan (2011))

		MTR-MTS-MIV Grandparent				MTR-MTS-MIV Other Parent				MTR-MTS-MIV Grandparent + Other Parent			
				Bias Corrected				Bias Corrected				Bias Corrected	
	ETS β	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound	Lower Bound	Upper Bound
	Effect on Child's Years of Schooling												
Mother with college degree	1.809	0	1.523	0	1.525	0	1.088	0	1.086	.048	.873	.025	.997
	(1.726, 1.892)	(0	1.649)	{0	1.651}	(0	1.183)	{0	1.181}	(.014	1.018)	{0	1.141}
				[0	1.671]			[0	1.200]			[.005	1.073]
Father with college degree	1.943	.008	1.702	0	1.716	0	1.437	0	1.437	.072	1.162	.052	1.269
	(1.865, 2.021)	(0	1.800)	{0	1.814}	(0	1.509)	{0	1.510}	(.028	1.289)	{.008	1.396}
				[0	1.840]			[0	1.527]			[.017	1.342]
	Effect on Probability Child Has College Degree												
Mother with college degree	.365	0	.306	0	.307	0	.214	0	.214	.010	.171	.001	.209
	(.347, .383)	(0	.335)	{0	.336}	(0	.236)	{0	.236}	(.001	.210)	{0	.248}
				[0	.340]			[0	.241]			[.001	.214]
Father with college degree	.393	.001	.347	0	.351	0	.300	0	.301	.017	.234	.010	.257
	(.376, .409)	(0	.367)	{0	.372}	(0	.316)	{0	.317}	(.007	.263)	{.0002	.285}
				[0	.375]			[0	.323]			[.003	.273]

References 1

de Haan, M. (2011): "The Effect of Parents' Schooling on Child's Schooling: A Nonparametric Bounds Analysis," *Journal of Labor Economics*, 29, 859–892.

Imbens, G. and C. Manski (2004): "Confidence Intervals for Partially Identified Parameters," *Econometrica*, 72, 1845–1857.

Kreider, B. and J. Pepper (2007): "Disability and employment: Reevaluating the evidence in light of reporting errors," *Journal of the American Statistical Association*, 102, 432–441.