Econometrics

$_{of}$ Human

Capital

Philipp Eisenhauer

UNIVERSITÄT BONN

Parameters of Interest

Philipp Eisenhauer

Heckman (2008) sets out three tasks for us:

- ▶ Defining the Set of Hypotheticals or Counterfactuals
  ⇒ A Scientific Theory

- ▶ Identifying Causal Parameters from Real Data
  ⇒ Mathematical Analysis of Data Point or Set Identification

- ▶ Identifying Parameters from Real Data
  ⇒ Estimation and Testing Theory

Setup

The Generalized Roy Model

Potential Outcomes   Observed Outcome

$Y_1 = \mu_1(X) + U_1$ $Y = DY_1 + (1-D)Y_0$

$Y_0 = \mu_0(X) + U_0$

Choice

$D = \mathrm{I}[\mu_D(X, Z) - V > 0]$

Useful Notation

$$P(X, Z) = \Pr(D = 1 \mid X, Z) = F_V(\mu_D(X, Z))$$
$$U_D = F_V(V)$$

Specification We follow the parameterization in Heckman and Vytlacil (2005):

$$Y_1 = \gamma + \alpha + U_1 \qquad U_1 = \sigma_1 \epsilon \qquad \gamma = 0.670 \qquad \sigma_1 = 0.012$$

$$Y_0 = \gamma + U_0 \qquad U_0 = \sigma_0 \epsilon \qquad \alpha = 0.200 \qquad \sigma_0 = -0.050$$

$$D = I[Z - V > 0] \qquad V = \sigma_V \epsilon \qquad \epsilon \sim \mathbb{N}(0, 1) \qquad \sigma_V = -1.000$$

$$Z \sim \mathbb{N}(-0.0026, 0.2700) \qquad U_D = \Phi\left(\frac{V}{\sigma_V \sigma_\epsilon}\right)$$
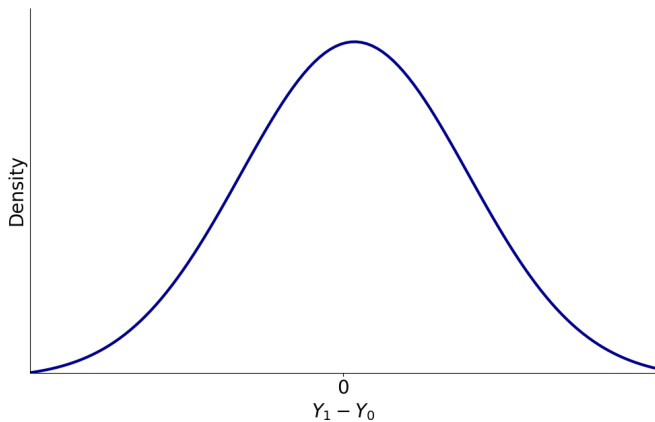
Individual Heterogeneity

Individual-specific Benefit of Treatment

$$Y_1 - Y_0 = (\mu_1(X) - \mu_0(X)) + (U_1 - U_0)$$

Sources of Heterogeneity

▶ Difference in Observable Characteristics

▶ Difference in Unobservable Characteristics

   ▶ Uncertainty

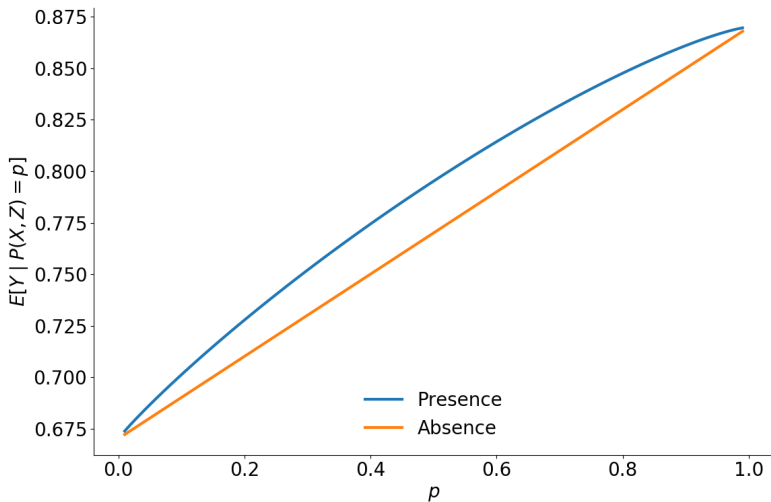   ▶ Private Information

Figure: Distribution of Benefits

Essential Heterogeneity Definition: Individuals select their treatment status based on gains unobservable by the econometrician. More formally,

$$Y_1 - Y_0 \not\perp\!\!\!\perp D \quad | \, X = x.$$

$\Rightarrow$ consequences for the choice of the estimation strategy

Figure: Conditional Expectation and Essential Heterogeneity

Conventional Average Treatment Effects

Conventional Average Treatment Effects

$$B^{ATE} = E[Y_1 - Y_0]$$
$$B^{TT} = E[Y_1 - Y_0 \mid D = 1]$$
$$B^{TUT} = E[Y_1 - Y_0 \mid D = 0]$$

⇒ correspond to *extreme* policy alternatives

Selection Problem

$$E[Y \mid D = 1] - E[Y \mid D = 0] = \underbrace{E[Y_1 - Y_0]}_{B^{ATE}}$$

$$+ \underbrace{E[Y_1 - Y_0 \mid D = 1] - E[Y_1 - Y_0]}_{\text{Sorting Gain}}$$

$$+ \underbrace{E[Y_0 \mid D = 1] - E[Y_0 \mid D = 0]}_{\text{Selection Bias}}$$

$$E[Y \mid D = 1] - E[Y \mid D = 0] = \underbrace{E[Y_1 - Y_0 \mid D = 1]}_{B^{TT}}$$

$$+ \underbrace{E[Y_0 \mid D = 1] - E[Y_0 \mid D = 0]}_{\text{Selection Bias}}$$

$\Rightarrow$ the bias depends on the parameter of interest

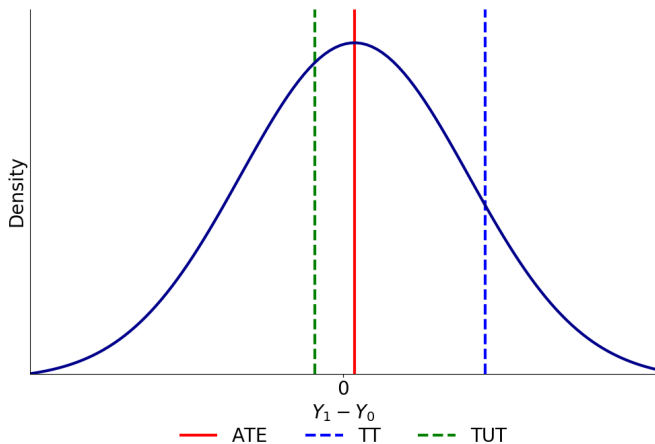Figure: Distribution of Effects with Essential Heterogeneity

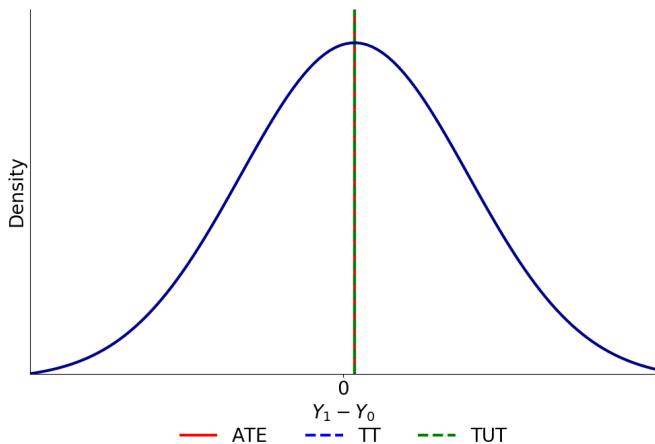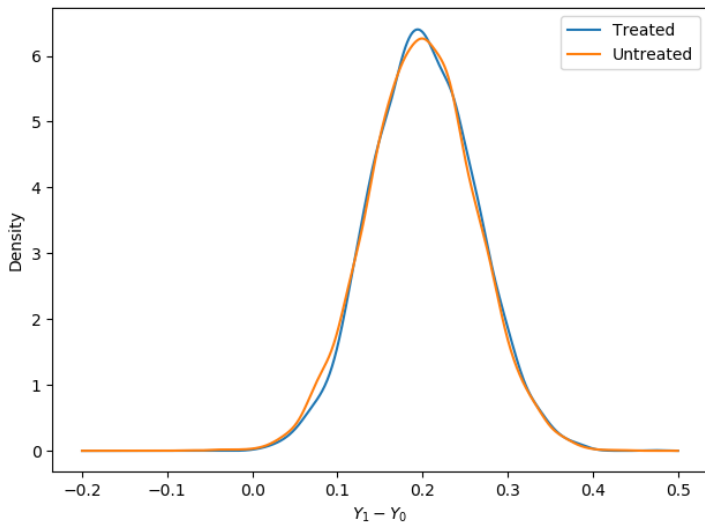# Figure: Distribution of Effects without Essential Heterogeneity

Figure: Distribution of Benefits by Treatment Status

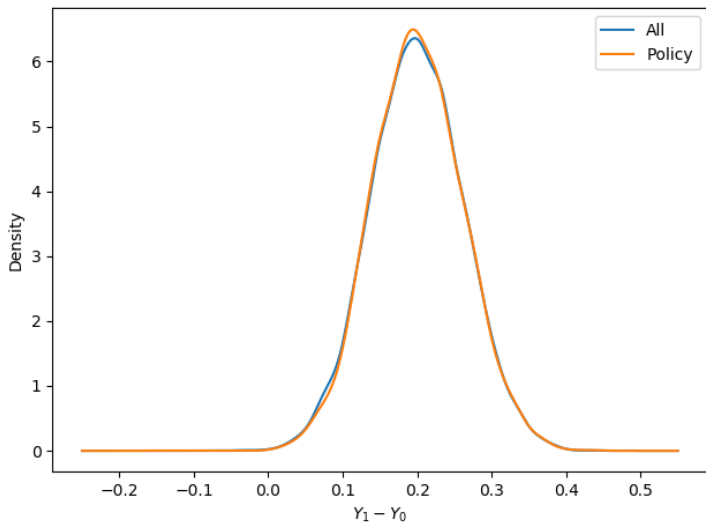# Policy-Relevant Average Treatment Effects

Observed Outcomes

$$Y_B = D_B Y_1 + (1 - D_B) Y_0$$
$$Y_A = D_A Y_1 + (1 - D_A) Y_0$$

Effect of Policy

$$B^{PRTE} = \frac{1}{E[D_A] - E[D_B]} (E[Y_A] - E[Y_B])$$

Figure: Distribution of Benefits for Policy

Marginal Effect of Treatment

Marginal Benefit of Treatment

$$B^{MTE}(x, u_D) = E[Y_1 - Y_0 \mid X = x, U_D = u_D]$$

Intuition: Mean gross return to treatment for persons at quantile u_D of the first-stage unobservable V or a willingness to pay for individuals at the margin of indifference.
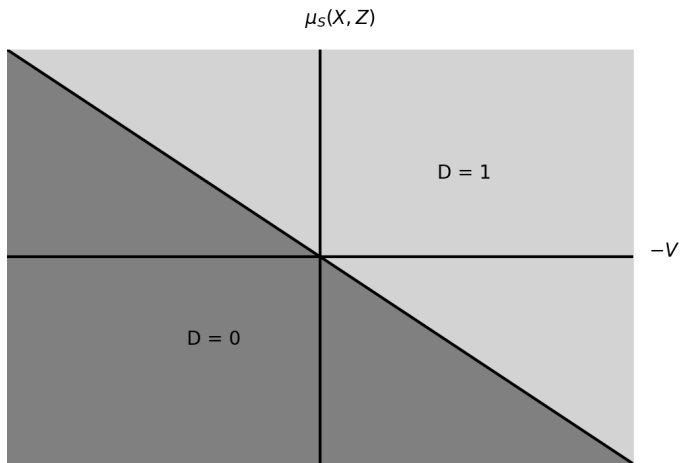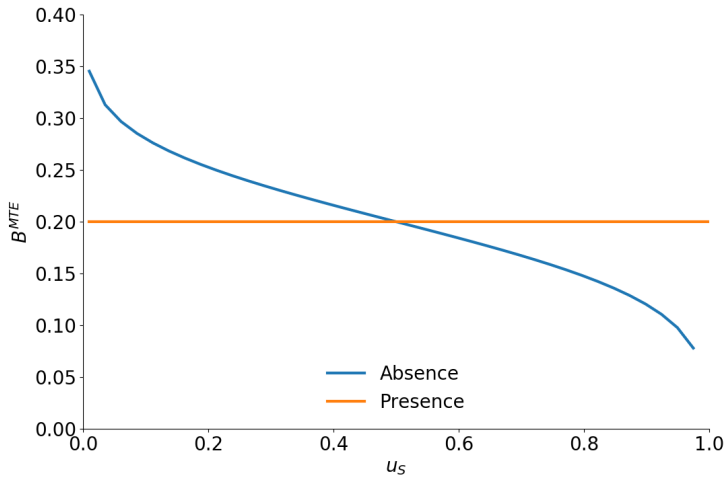
Figure: Margin of Indifference

Figure: Marginal Benefit of Treatment

Effects of Treatment as Weighted Averages Parameter Δ_j, can be written as a weighted average of the $B^{MTE}(x, u_D)$.

$$\Delta_j(x) = \int_0^1 B^{MTE}(x, u_D)\omega^j(x, u_D)du_D,$$

where the weights $\omega^j(x, u_D)$ are specific to parameter j and integrate to one.
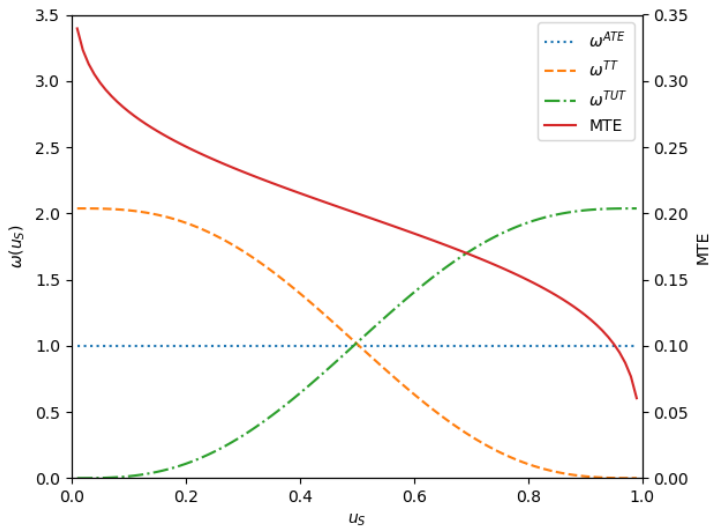
Weights

$$\omega^{ATE}(x, u_D) = 1$$

$$\omega^{TT}(x, u_D) = \frac{1 - F_{P|X=x}(u_D)}{E[P \mid X = x]}$$

$$\omega^{TUT}(x, u_D) = \frac{F_{P|X=x}(u_D)}{E[1 - P \mid X = x]}$$

Figure: Effects of Treatment as Weighted Averages

Local Average Treatment Effect

Local Average Treatment Effect

▶ **Local Average Treatment Effect:** Average effect
for those induced to change treatment because of a
change in the instrument.⇒ instrument-dependent

parameter

▶ **Marginal Treatment Effect:** Average effect for those
individuals with a given unobserved desire to receive
treatment.

⇒ deep economic parameter

$$B^{LATE} = \frac{E(Y \mid Z = z) - E[Y \mid Z = z']}{P(z) - P(z')}$$

$$B^{LATE}(x, u_D, u_{S'}) = \frac{1}{u_D - u_{D'}} \int_{u_D}^{u_{S'}} B^{MTE}(x, u) du,$$

Figure: Local Average Treatment Effect
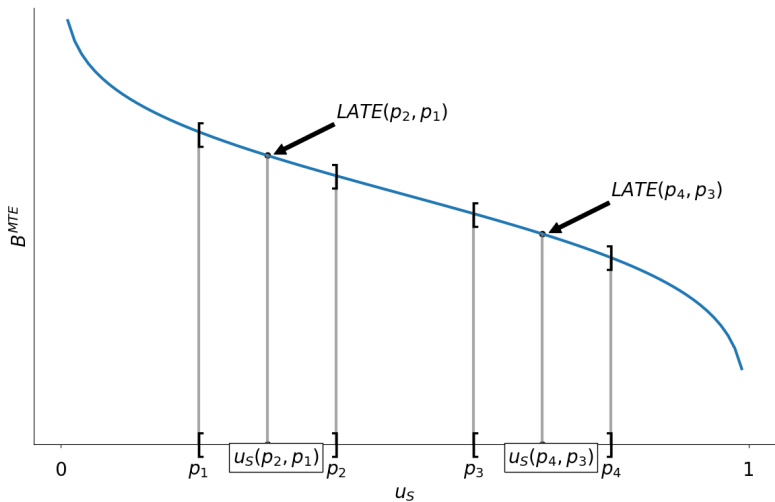
Distributions of Effects
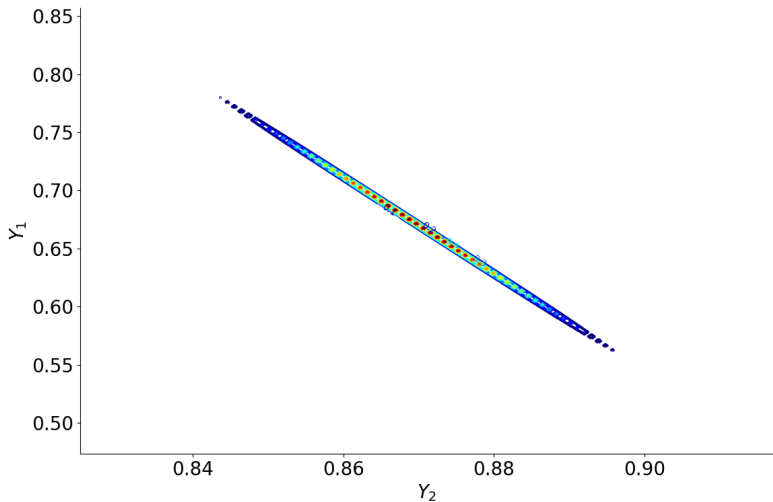
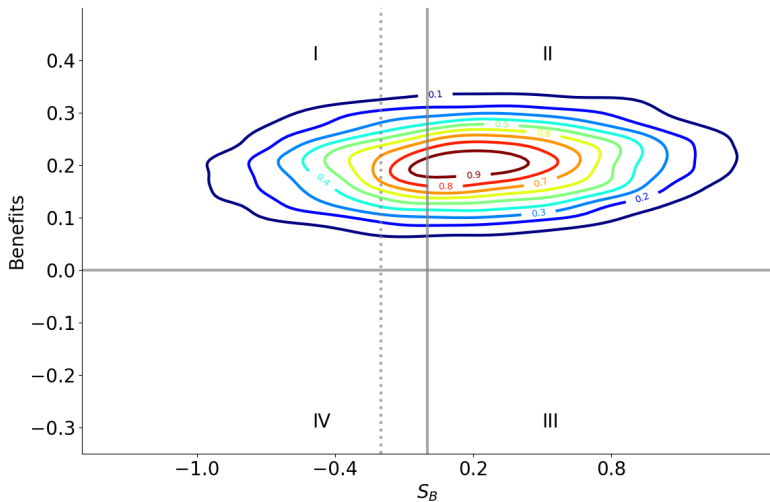# Figure: Distribution of Potential Outcomes

Figure: Distribution of Benefits and Surplus

Appendix

References

Carneiro, P., Heckman, J. J., & Vytlacil, E. J. (2011). Estimating marginal returns to education. *American Economic Review*, *101*(6), 2754–2781.

Heckman, J. J. (1990). Selection bias and self-selection. In J. Eatwell, M. Milgate, & P. Newman (Eds.), *Econometrics* (pp. 201–224). London: Palgrave Macmillan.

Heckman, J. J. (2008). Econometric causality. *International Statistical Review*, *76*(1), 1–27.

Heckman, J. J., & Taber, C. (2010). Roy model. In L. E. Blume & S. N. Durlauf (Eds.), *Microeconometrics* (pp. 221–228). London: Palgrave Macmillan.

Heckman, J. J., & Vytlacil, E. J. (2005). Structural equations, treatment effects, and econometric policy evaluation. *Econometrica*, *73*(3), 669–739.