Econometrics
of Human
Capital

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Material available on





### Parameters of Interest

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### Heckman (2008) sets out three tasks for us:

- ▶ Defining the Set of Hypotheticals or Counterfactuals⇒ A Scientific Theory
- Identifying Causal Parameters from Hypothetical Population Data
  - ⇒ Mathematical Analysis of Data Point or Set Identification
- Identifying Parameters from Real Data
  - ⇒ Estimation and Testing Theory

### **Parameters of Interest**

- conventional average effects
- policy-relevant average effects
- marginal effects
- distributional effects
- effects on distributions

## Setup

### The Generalized Roy Model

Potential Outcomes

$$Y_1 = \mu_1(X) + U_1$$

$$Y = DY_1 + (1 - D)Y_0$$

$$Y_0 = \mu_0(X) + U_0$$

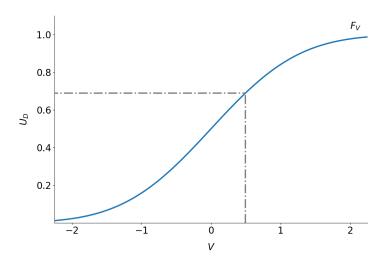
Choice

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

### **Useful Notation**

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

### Figure: First-state unobservable



## Individual Heterogeneity

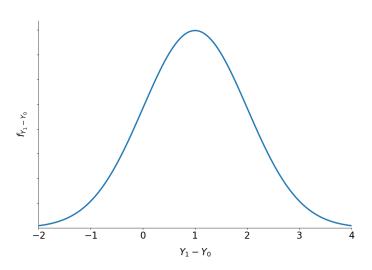
### Individual-specific Benefit of Treatment

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

### **Sources of Heterogeneity**

- Difference in Observable Characteristics
- Difference in Unobservable Characteristics
  - Uncertainty
  - Private Information

Figure: Distribution of Benefits



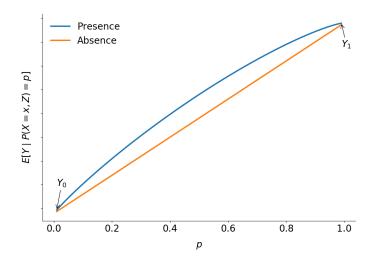
### **Essential Heterogeneity**

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

$$Y_1 - Y_0 \not\perp \!\!\!\perp D \mid X = x.$$

⇒ consequences for 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**

$$\begin{split} E[Y \mid D = 1] - E[Y \mid D = 0] &= \underbrace{E[Y_1 - Y_0]}_{B^{ATE}} \\ + \underbrace{E[Y_1 - Y_0 \mid D = 1] - E[Y_1 - Y_0]}_{\text{Selection on gains}} \\ + \underbrace{E[Y_0 \mid D = 1] - E[Y_0 \mid D = 0]}_{\text{Selection on levels}} \end{split}$$

$$\begin{split} E[Y \mid D=1] - E[Y \mid D=0] = \underbrace{E[Y_1 - Y_0 \mid D=1]}_{B^{TT}} \\ + \underbrace{E[Y_0 \mid D=1] - E[Y_0 \mid D=0]}_{\text{Selection on levels}} \end{split}$$

⇒ the bias depends on the parameter of interest

Figure: Distribution of Effects with Essential Heterogeneity

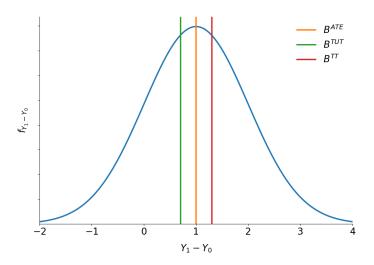
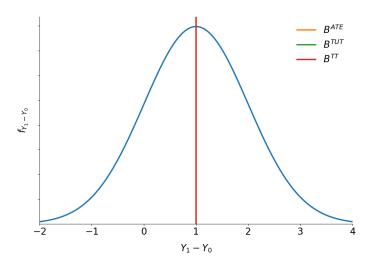


Figure: Distribution of Effects without Essential Heterogeneity



# 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**

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

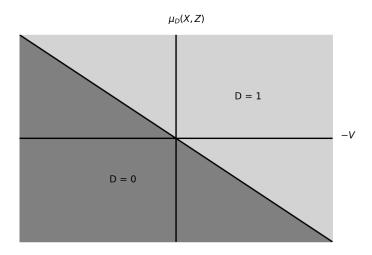
## Marginal Effect of Treatment

### **Marginal Benefit of Treatment**

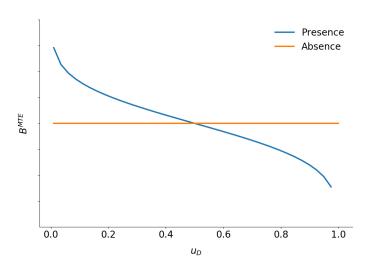
$$B^{MTE}(x, u_D) = E[Y_1 - Y_0 \mid X = x, U_D = u_D]$$

**Intuition:** Mean gross return to treatment for persons at quantile  $u_D$  of the first-stage unobservable V

### Figure: Margin of Indifference



### Figure: Marginal Benefit of Treatment



Effects of Treatment as Weighted Averages Parameter  $\Delta_j$ , 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.

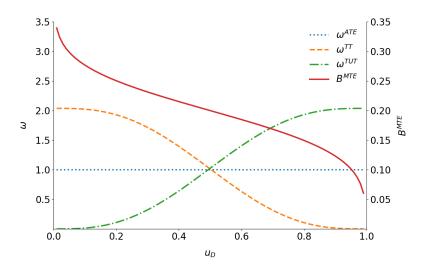
### Weights

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

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

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

Figure: Effects of Treatment as Weighted Averages



## Local Average Treatment Effect

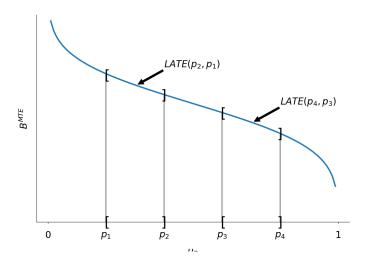
### **Local Average Treatment Effect**

- ► 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

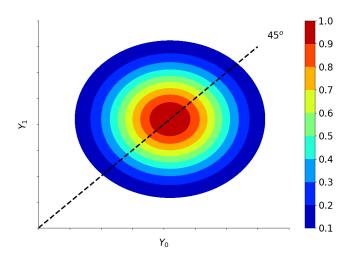
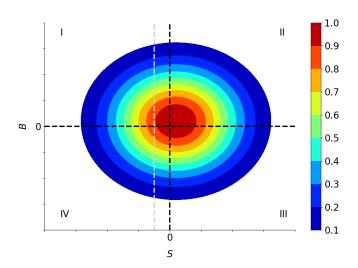


Figure: Distribution of Benefits and Surplus



## **Appendix**

### References

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