

Economics of Human Capital

Static model of educational choice

Philipp Eisenhauer

Housekeeping

Lecture plan

- ▶ Static model of educational choices
- ▶ OpenSourceEconomics
- ▶ grmpy
- ▶ Estimating Marginal Returns to Education (Carneiro, Heckman, & Vytlačil, 2011)

Course program

- ▶ economics of human capital
- ▶ econometrics of human capital
- ▶ research seminar

?

Introduction

Figure: Motivation

American Economic Review (October 2011): 1794-2201
<http://www.aeaweb.org/articles.php?doi=10.1257/aer.101.6.2294>

Estimating Marginal Returns to Education

By PEDRO CARNEIRO, JAMES J. HECKMAN, AND EDWARD J. VYTLACIL

Estimating marginal returns to policies is a central task of economic cost-benefit analysis. A comparison between marginal benefits and marginal costs determines the optimal size of a social program. For example, to evaluate the optimality of a policy that promotes expansion in college attendance, analysts need to estimate the return to college for the marginal student and compare it to the marginal cost of the policy.

This is a relatively simple task (i) if the effect of the policy is the same for everyone (conditional on observed variables) or (ii) if the effect of the policy varies across individuals given observed variables but agents either do not know their idiosyncratic returns to the policy, or if they know them, they do not act on them. In these cases, individuals do not choose their schooling based on their realized idiosyncratic individual returns, and thus the marginal and average ex post returns to schooling are the same.¹

Under these conditions, the mean marginal return to college can be estimated using conventional methods applied to the following Mincer equation:

$$(1) \quad Y = \alpha + \beta S + \epsilon,$$

where Y is the log wage, S is a dummy variable indicating college attendance, β is the return to schooling (which may vary among persons), and ϵ is a residual. The standard problem of selection bias (S correlated with ϵ) may be present, but this problem can be solved by a variety of conventional methods (instrumental variables (IV), regression discontinuity, and selection models).

*Carneiro: Department of Economics, University College London, Gower Street, London WC1E 6BT, United Kingdom; Institute for Fiscal Studies and Centre for Microdata Methods and Practice (e-mail: p.carneiro@ucl.ac.uk); Heckman: Department of Economics, University of Chicago, 1108 E. 59th Street, Chicago, IL 60637; American Bar Foundation, Georgetown University College Dublin (e-mail: jh.heckman@ucd.ie); Vytlacil: Department of Economics and Center for Population, Not University, Box 208141, New Haven, CT 06520-8141 (e-mail: edward.vytlacil@yale.edu). Carney acknowledges the support of ESRC (RES-060-22-2542) and ESRC-RES-060-22-2541 through the Centre for Microdata Methods and Practice. Heckman thanks the National Institutes of Health (R01-DE05902), the JPM and MK Prater Family Foundation, the Buffett Early Childhood Fund, the American Bar Foundation, and the Committee for Economic Development with a grant from The Charles and Johanna Perryman for America's Economic Success. Heckman also thanks the Cowles Foundation at Yale University, which supported a visit that facilitated completion of this research. Vytlacil thanks NSF (EIO-052345) and Rhineland University, at which he was a visiting professor while the research in part was conducted. He thanks Michael Greenhouse and Ben Williams for comments. The views expressed in this paper are those of the authors and not necessarily those of these funders.

1. To view additional materials, visit the article page at <http://www.aeaweb.org/articles.php?doi=10.1257/aer.101.6.2294>.

See Heckman and Vytlacil (2007b).

2754

INTERNATIONAL ECONOMIC REVIEW

May 2003
Vol. 44, No. 2

2001 LAWRENCE R. KLEIN LECTURE

ESTIMATING DISTRIBUTIONS OF TREATMENT EFFECTS WITH AN APPLICATION TO THE RETURNS TO SCHOOLING AND MEASUREMENT OF THE EFFECTS OF UNCERTAINTY ON COLLEGE CHOICE*

By PEDRO CARNEIRO, KARSTEN T. HANSEN, AND JAMES J. HECKMAN¹

Department of Economics, University of Chicago; Kellogg School of Management, Northwestern University; Department of Economics, University of California and The American Bar Foundation

This article uses factor models to identify and estimate the distributions of counterfactuals. We extend LEJOLLE, from works to a dynamic treatment effect setting, extending matching to account for unobserved conditioning variables. Using these models, we can identify all pairwise and joint treatment effects. We apply these models to a study of schooling and determine the returns, uncertainty facing agents at the time they make their decisions about enrollment in school. We go beyond the "test of ignorance" in evaluating educational policies and determine who benefits and who loses from commonly proposed educational reforms.

* Manuscript received October 2000; revised January 2003.

Previous versions of the paper were given at the Midwest Econometrics Group, Chicago, October 2000; Washington University in St. Louis, May 2001; the Nordic Econometrics Meetings, May 2001 and workshops at Chicago, August 2001 and Stanford, January 2003. A shorter version of this paper is presented at Caracas, Hansen, and Heckman (2001). A version of this paper was presented by Heckman at the Klein Lectures at the University of Pennsylvania, September 28, 2001 and also at the IFAI conference in Stockholm, Sweden, October 2002. We are grateful to all workshop participants. We especially thank Mark Duggan, Oreste Trionfetti, and Michael Kremer for comments on earlier drafts of this paper. We have benefited from discussions with Ricardo Barro, Richard Blundell, Francisco Buera, Peter Cahn, Mark Duggan, Oreste Trionfetti, Lars Ljungqvist, and Sergio Torres on subsequent drafts. We gratefully acknowledge Roberto and Edward Vytlacil for especially helpful comments. We are grateful to Peter Cahn and Roberto Barro for exceptional research assistance and hard work. This research is supported by NSF (75-06-071, EIO-0000001), and NSF (EIO-01-00040). Heckman's work was also supported by the American Bar Foundation and the Deutsche Forschungsgemeinschaft. Please address correspondence to James J. Heckman, Department of Economics, University of Chicago, 1108 E. 59th Street, Chicago, IL 60637, USA; fax: +1 773 762 6064; fax: +1 773 762 6060; E-mail: jh@econ.uchicago.edu.

361

Carneiro & al. (2011)

Carneiro & al. (2003)

J. Heckman (2008) defines three policy evaluation tasks:

- ▶ Evaluating the impact of historical interventions on outcomes including their impact in terms of well-being of the treated and the society at large.
- ▶ Forecasting the impact of historical interventions implemented in one environment in other environments, including their impact in terms of well-being.
- ▶ Forecasting the impacts of interventions never historically experienced to various environments, including their impact on well-being.

Econometrics of policy evaluation

- ▶ is important
- ▶ is complicated
- ▶ is multifaceted

Numerous applications

- ▶ labor economics
- ▶ development economics
- ▶ industrial economics
- ▶ health economics

Numerous effects

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

Numerous estimation strategies

- ▶ instrumental variables
- ▶ (quasi-)experimental methods
- ▶ matching

Model

Generalized Roy model

Potential Outcomes

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

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

Cost

$$C = \mu_C(Z) + U_C$$

Observed Outcomes

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

Choice

$$S = Y_1 - Y_0 - C$$

$$D = I[S > 0]$$

Individual Heterogeneity

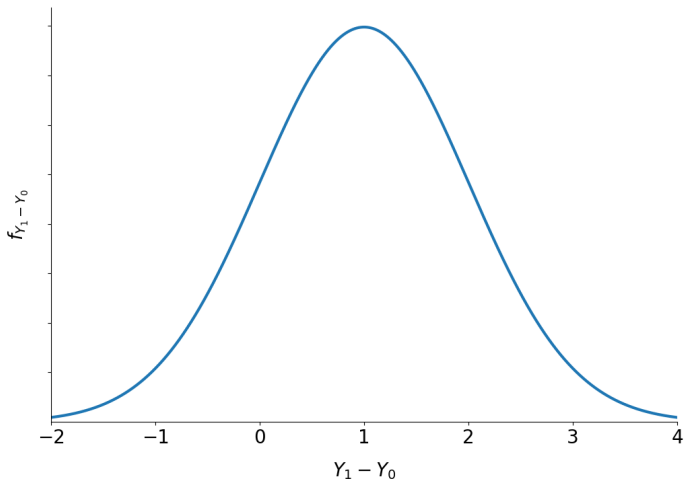
Individual-specific Benefit of Treatment

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

Sources of Heterogeneity

- ▶ Difference in observables
- ▶ Difference in unobservables
 - ▶ Uncertainty
 - ▶ Private information

Figure: Distribution of benefits



Observed outcome

$$Y_i = Y_{0i} + D_i(Y_{1i} - Y_{0i}) = \begin{cases} Y_{1i} & \text{if } D_i = 1 \\ Y_{0i} & \text{if } D_i = 0 \end{cases}$$

Econometric problems

- ▶ **Evaluation problem**, we only observe an individual in either the treated or untreated state.
- ▶ **Selection problem**, individuals that select into treatment differ from those that do not.

Essential Heterogeneity

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

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

⇒ consequences for the choice of the estimation strategy

Objects of interest

Useful Notation

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

$$U_D = F_V(V)$$

Figure: First-stage unobservable

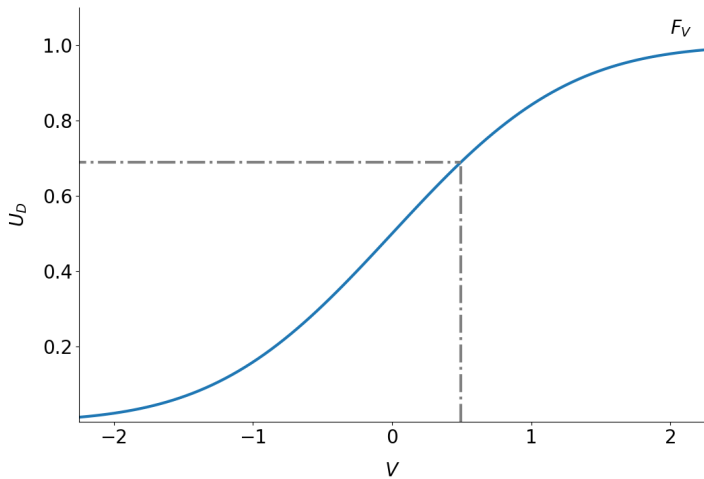


Figure: Support

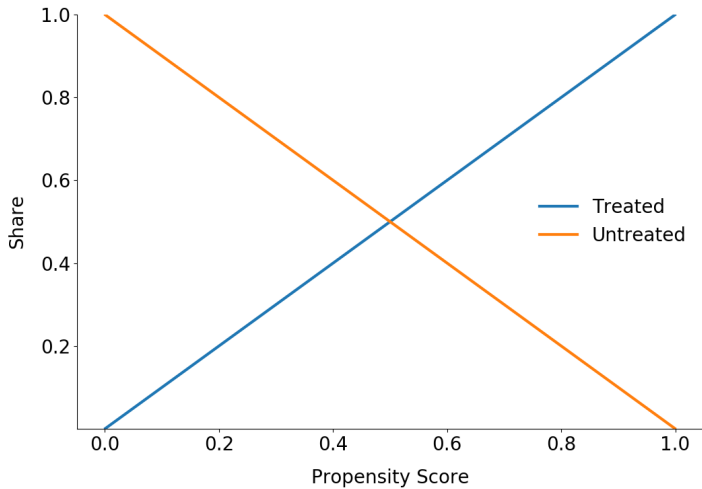


Figure: Distribution of benefits

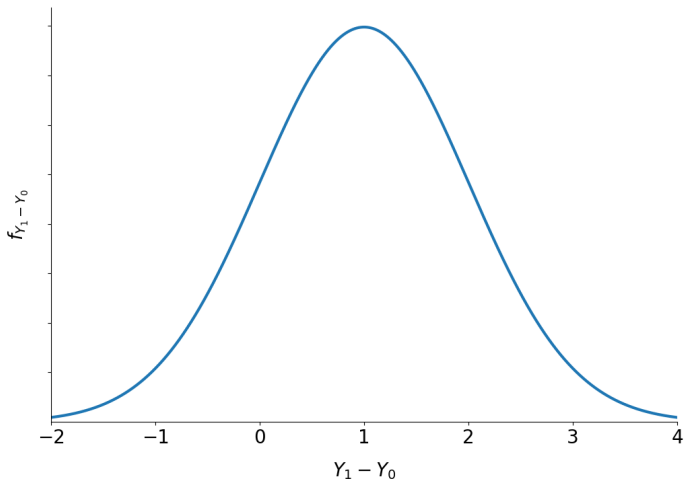
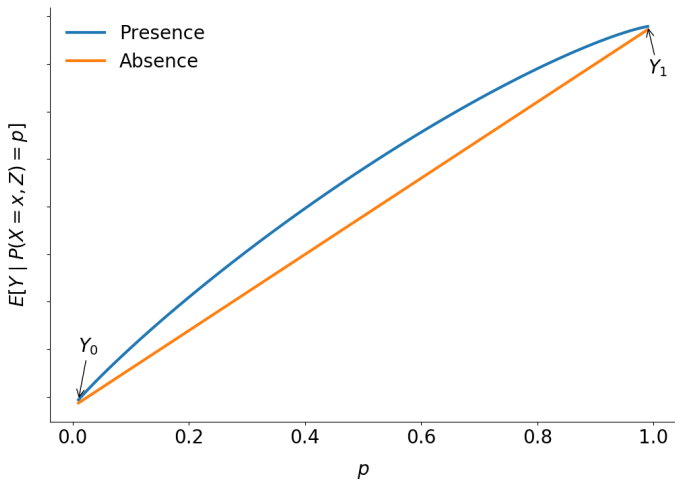


Figure: Conditional expectation and essential heterogeneity



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

$$\begin{aligned} E[Y | D = 1] - E[Y | D = 0] &= \underbrace{E[Y_1 - Y_0]}_{B^{ATE}} \\ &+ \underbrace{E[Y_1 - Y_0 | D = 1] - E[Y_1 - Y_0]}_{\text{Sorting Gain}} \\ &+ \underbrace{E[Y_0 | D = 1] - E[Y_0 | D = 0]}_{\text{Selection Bias}} \end{aligned}$$

$$\begin{aligned}
 E[Y \mid D = 1] - E[Y \mid D = 0] &= \underbrace{E[Y_1 - Y_0 \mid D = 1]}_{B^{TT}} \\
 &\quad + \underbrace{E[Y_0 \mid D = 1] - E[Y_0 \mid D = 0]}_{\text{Selection Bias}}
 \end{aligned}$$

⇒ the bias depends on the parameter of interest

Figure: Distribution of effects with essential heterogeneity

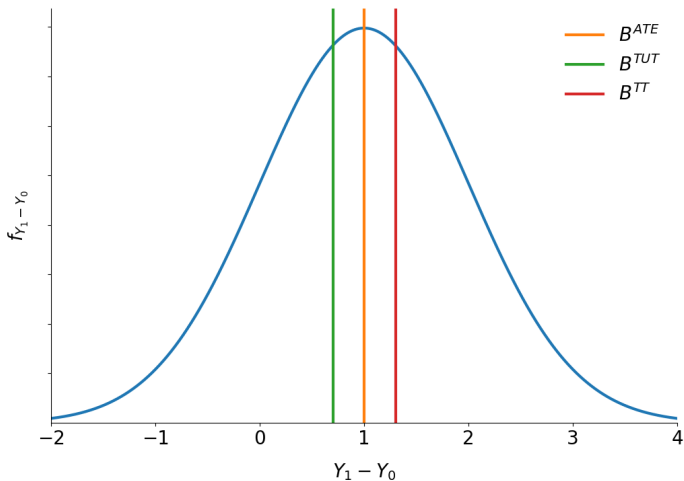
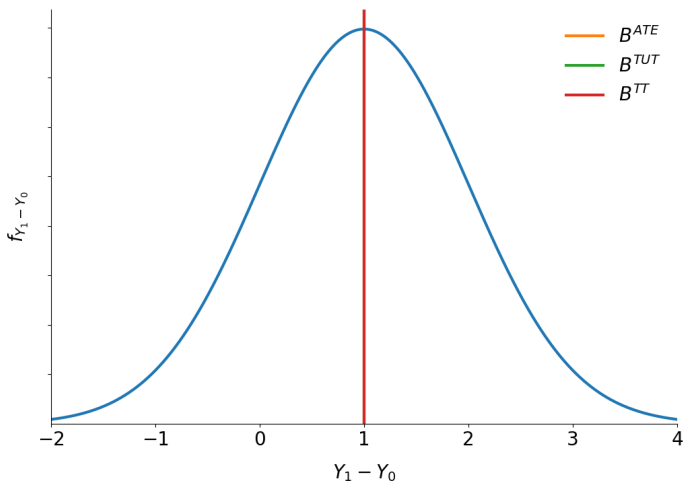


Figure: Distribution of effects without essential heterogeneity



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 or a willingness to pay for individuals at the margin of indifference.

Figure: Margin of indifference

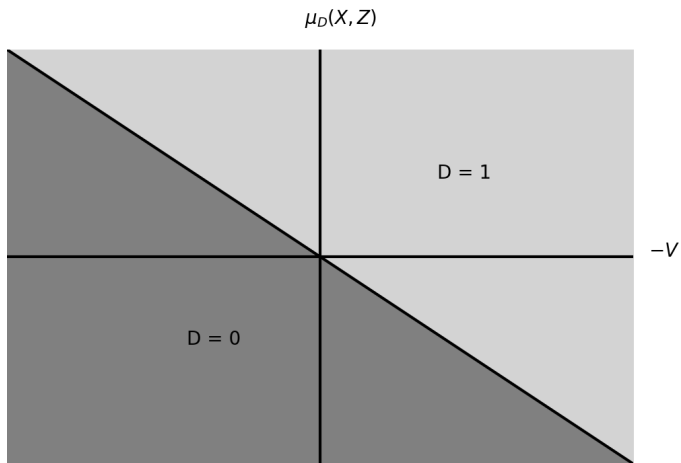
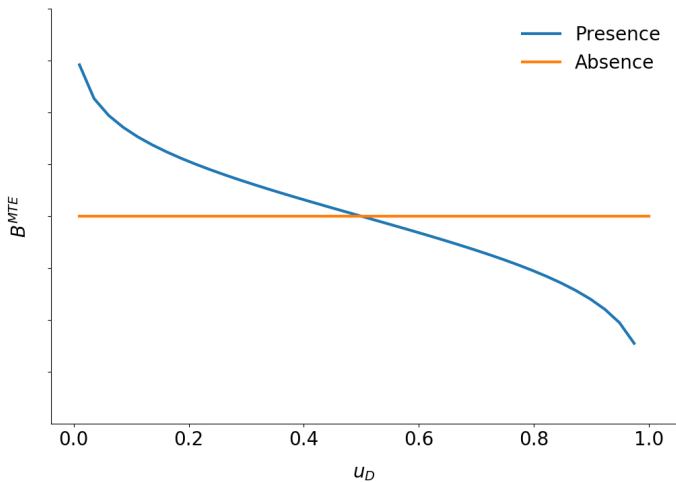


Figure: B^{MTE} and essential heterogeneity



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.

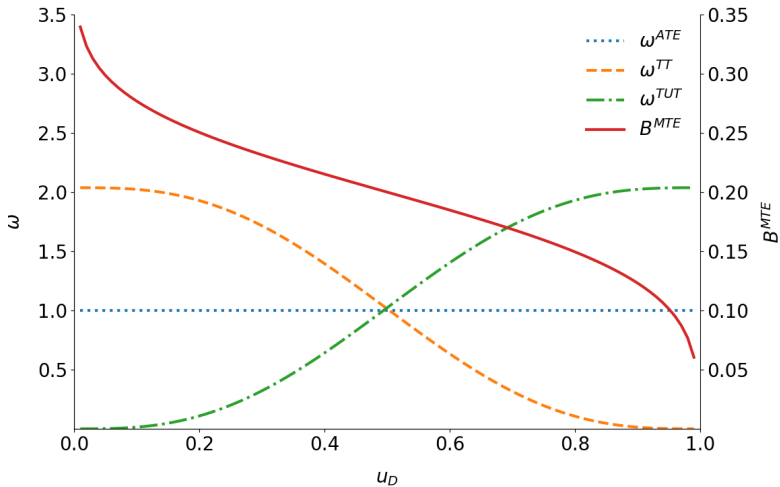
Weights

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

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

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

Figure: Effects of treatment as weighted averages



Local Average Treatment Effect

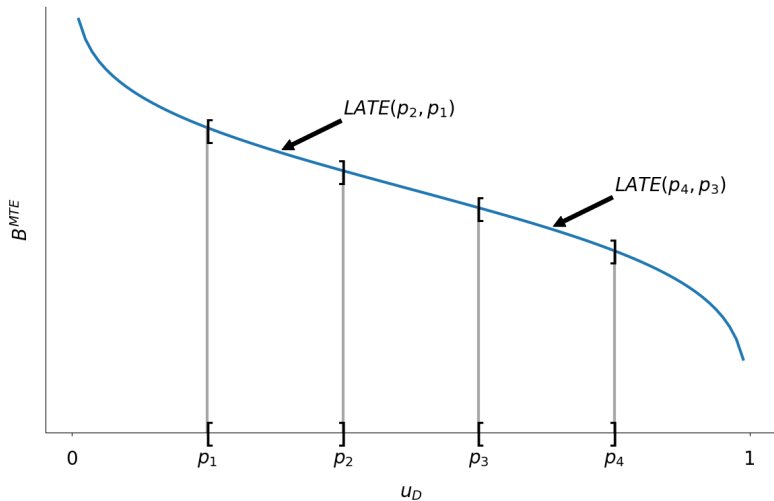
Local Average Treatment Effect

- ▶ **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

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

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

Figure: Local average treatment effect



Distributions of Effects

Distributions of Effects

- ▶ marginal distribution of benefits
- ▶ joint distribution of potential outcomes
- ▶ joint distribution of benefits and surplus

Figure: Distribution of benefits

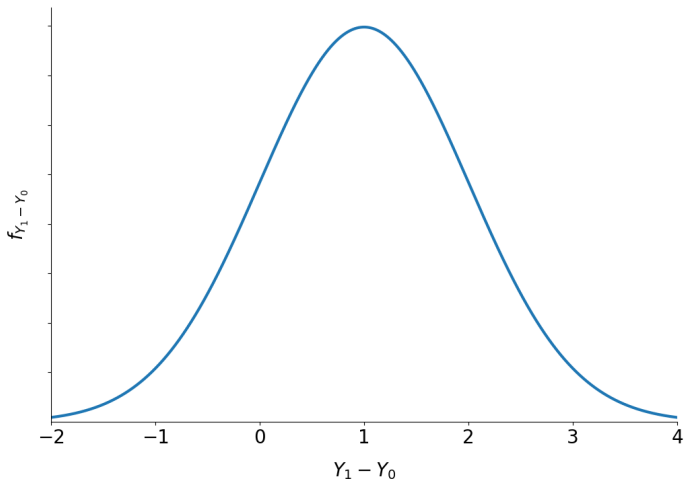


Figure: Distribution of potential outcomes

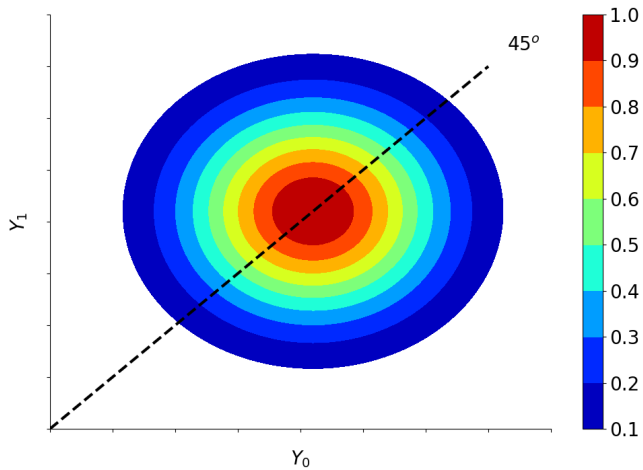
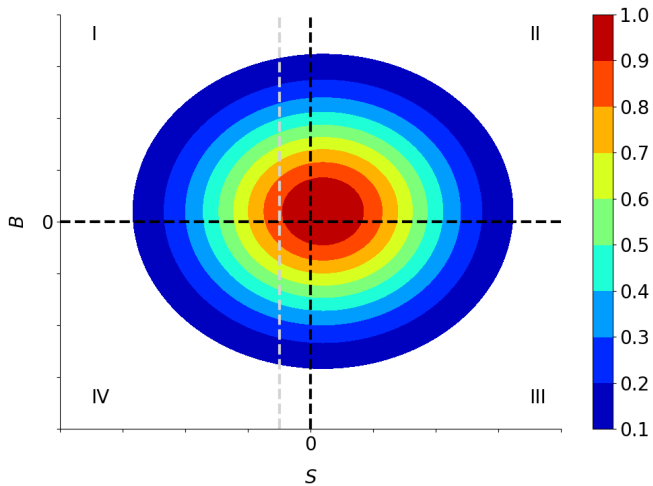


Figure: Distribution of benefits and surplus



Conclusion

Appendix

References

- Carneiro, P., Hansen, K. T., & Heckman, J. J. (2003). Estimating distributions of treatment effects with an application to the returns to schooling and measurement of the effects of uncertainty on college choice. *International Economic Review*, 44(2), 361–422.
- Carneiro, P., Heckman, J. J., & Vytlačil, E. J. (2011). Estimating marginal returns to education. *American Economic Review*, 101(6), 2754–2781.
- Heckman, J. (2008). Schools, skills, and synapses. *Economic Inquiry*, 46, 289–324.

Heckman, J. J., & Vytlačil, E. J. (2007a). Econometric evaluation of social programs, part I: Causal effects, structural models and econometric policy evaluation. In J. J. Heckman & E. E. Leamer (Eds.), *Handbook of econometrics* (Vol. 6B, pp. 4779–4874). Amsterdam, Netherlands: Elsevier Science.

Heckman, J. J., & Vytlačil, E. J. (2007b). Econometric evaluation of social programs, part II: Using the marginal treatment effect to organize alternative economic estimators to evaluate social programs and to forecast their effects in new environments. In J. J. Heckman & E. E. Leamer (Eds.), *Handbook of econometrics* (Vol. 6B, pp. 4875–5144). Amsterdam, Netherlands: Elsevier Science.