

A Tale of Two Samples: Observations and Counterfactuals for the Evaluation of Economic Policy

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This Talk

- 1 Describe the canonical selection problem
 - Examine Roy's model within the context of research standing
 - Outline the selection problem and consider cases
 - Consider causality and counterfactuals
 - Develop the standard treatment effects analysis
 - Examine a few recent solutions to the selection problem
- 2 Contextualize evaluation for department objectives
 - Describe the recent departmental review
 - Outline the department's response
 - Return to treatment effects in relation to a few goals
- 3 Summarize
 - Review
 - Outline future challenges
 - Consider some limitations

CANONICAL SELECTION PROBLEM

Thoughts on the Distribution of Earnings, Roy (1951)

- 1 Workers can either hunt or fish
- 2 Choices affected by:
 - Fundamental distribution of skills
 - Correlations of skills amongst the population
 - Technologies related to these skills
 - Consumer tastes for meat and fish
- 3 $\bar{y}_h - \bar{y}_f$ does not reflect the true earnings gain from switching from fishing to hunting
- 4 Comparative advantage
 - Workers select the occupation with the highest expected earnings
 - Only the marginal worker is indifferent to employment sector
 - A (some) worker(s) expect same earnings in each sector

Borjas (1987) - Research Standing Context

- Consider two universities: University 0 and the UP (1)
- Research output: $s_j = \mu_j + \varepsilon_j$, $j = \{0, 1\}$
- Assume: $\varepsilon_j \sim \mathcal{N}(0, \sigma_j^2)$
- ε_j is *demeaned* research standing
- Cost of switching institutions: $\pi = C/s_0$
- Each researcher knows C , μ_0 , μ_1 , ε_0 and ε_1
- Analyst can only observe a researcher in one institution, so only know ε_0 or ε_1 for one researcher
- Questions
 - ① What is research output for University 0 researchers that moved to UP, if they had stayed at University 0?
 - ② What would research output be for non-leavers of University 0 if they had, in fact, left for UP?

Formalizing Answers to those Questions

Start with some definitions:

- ① $\sigma_{01} = \text{cov}(\varepsilon_0, \varepsilon_1)$
- ② $\rho = \sigma_{01} / (\sigma_0 \sigma_1)$
- ③ Self-selection to UP:
 - Comparative Advantage
 - $(\mu_1 - \mu_0 - \pi) + (\varepsilon_1 - \varepsilon_0) > 0$
- ④ $\mathcal{J} = 1$ if $(\mu_1 - \mu_0 - \pi) + (\varepsilon_1 - \varepsilon_0) > 0$
- ⑤ $\nu = \varepsilon_1 - \varepsilon_0$

Selection Rule Applied

University choice probability (UP):

$$\begin{aligned}
 P &= \text{Prob}[\mathcal{J} = 1] \\
 &= \text{Prob}[\nu > (\mu_0 - \mu_1 + \pi)] \\
 &= \text{Prob}\left[\frac{\nu}{\sigma_\nu} > \frac{\mu_0 - \mu_1 + \pi}{\sigma_\nu}\right] \\
 &= 1 - \Phi\left(\frac{\mu_0 - \mu_1 + \pi}{\sigma_\nu}\right) \\
 &= 1 - \Phi(z)
 \end{aligned} \tag{1}$$

Therefore:

$$\frac{\partial P}{\partial \mu_0} < 0 \quad \frac{\partial P}{\partial \mu_1} > 0 \quad \frac{\partial P}{\partial \pi} < 0 \tag{2}$$

Effect of Self-selection on Research Output

Define: $E_0 = E(\varepsilon_0 | \mathcal{J} = 1)$ and $E_1 = E(\varepsilon_1 | \mathcal{J} = 1)$

Assume: $\mu_0 \approx \mu_1$

- Case 1: Positive Sorting $E_0 > 0$ and $E_1 > 0$
 - $\sigma_1/\sigma_0 > 1$
 - Research output more dispersed at UP
 - Higher research return to skill at UP
 - $\rho > \min(\sigma_1/\sigma_0, \sigma_0/\sigma_1)$
 - Correlation between skills at universities is high enough
 - High-skill at University 0 would not leave, if skills not valued at UP
- The best and the brightest go to UP
- A university with low research variance *taxes* the research output of high skills workers and *insures* the research output of low skills workers

Two Other Cases

- Case 2: Negative Sorting $E_0 < 0$ and $E_1 < 0$
 - Opposite of Case 1
 - Low skill researchers want to migrate
- Case 3: Mixed Sorting $E_0 < 0$ and $E_1 > 0$
 - Leave lower tail to arrive at upper tail
 - Discrimination at University 0 against certain types of research
 - $\rho < \min(\sigma_1/\sigma_0, \sigma_0/\sigma_1)$
- Case 4: Does not exist $E_0 > 0$ and $E_1 < 0$
 - Leave the top for the bottom
 - Does not make sense if research output has value to the individual

Policy Conclusions

- ① Policy Conclusion: Raise E_1
 - Research Incentives
 - Increased subsidy passthrough
 - Other research bonuses
 - Research support
 - Easily accessed software
 - Dedicated computer labs
 - Increased congress support
 - Other factors
 - Economies of scale and scope
 - Reduced administrative burdens
- ② A similar argument related to teaching
 - Quality teaching must be recognized/incentivized
 - Technological solutions
 - Economies of scale and scope

Causality

So far, we have shown how selection affects choices. When examining policy, we must keep that in mind. Policies are expected to affect outcomes, but are also likely to affect choices.

- “We may define a cause to be an object followed by another, and where all the objects, similar to the first, are followed by objects similar to the second.” - David Hume (1748)
- “Where c and e are two distinct possible events, e causally depends on c if and only if, if c were to occur e would occur; and if c were not to occur e would not occur.” - David Lewis (1973)

Counterfactuals

- “We think of a cause as something that makes a difference, and the difference it makes must be a difference from what would have happened without it. Had it been absent, its effects - some of them, at least, and usually all - would have been absent as well.” - David Lewis (1973)
- A counterfactual is “what would have happened without it”.
- Underlying principles of causal dependence:
 - Here, refers to events
 - Events must be distinct
 - Backtracking - underlying common cause - not consistent

Treatment and Potential Outcomes Framework

Let us begin by defining a binary treatment outcome:

$$D_i = \begin{cases} 1, & \text{If "agent" receives treatment} \\ 0, & \text{If "agent" does not receive treatment} \end{cases} \quad (3)$$

We can now define treatment potential outcomes:

$$\begin{aligned} Y_i &= \begin{cases} Y_{1i}, & \text{Outcome, if "agent" receives treatment} \\ Y_{0i}, & \text{Outcome, if "agent" does not receive treatment} \end{cases} \\ &= Y_{0i} + D_i (Y_{1i} - Y_{0i}) \\ &= \alpha + \beta D_i + u_i \end{aligned} \quad (4)$$

The Standard Regression Framework

Recall:

$$\begin{aligned} Y_i &= Y_{0i} + D_i (Y_{1i} - Y_{0i}) \\ &= \alpha + \beta D_i + u_i \end{aligned} \tag{5}$$

If treatment is randomly assigned:

$$E[D_i u_i] = 0 \tag{6}$$

$\hat{\beta}$ is an unbiased estimate:

$$E[\hat{\beta}] = E[Y_{1i} - Y_{0i}] \tag{7}$$

- Selection effect is zero
- **Counterfactual:** sample of non-treated

The Identification Problem

But... treatment is rarely randomly assigned. In other words:

$$E[D_i u_i] \neq 0 \quad (8)$$

Therefore, selection effect is not zero:

$$\begin{aligned}
 & \underbrace{E[Y_i | D_i = 1] - E[Y_i | D_i = 0]}_{\text{Observed difference in average}} = \overbrace{E[Y_{1i} | D_i = 1]}^{\text{a. observed}} - \overbrace{E[Y_{0i} | D_i = 1]}^{\text{b. unobserved}} \\
 & \quad \quad \quad 1. \text{ Average treatment on the treated} \\
 & \quad \quad \quad \underbrace{+ E[Y_{0i} | D_i = 1] - E[Y_{0i} | D_i = 0]}_{\text{2. Selection effect}} \\
 & \quad \quad \quad \text{b. unobserved} \quad \text{a. observed} \\
 & \quad \quad \quad (9)
 \end{aligned}$$

Observations and Counterfactuals

- 1 We observe $Y_{0i}|D_i = 0$ and $Y_{1i}|D_i = 1$
- 2 Therefore, not difficult to get:
 - $E[Y_{0i}|D_i = 0]$
 - $E[Y_{1i}|D_i = 1]$
- 3 We do not observe $Y_{0i}|D_i = 1$ or $Y_{1i}|D_i = 0$
- 4 Therefore, must create counterfactuals to get:
 - $E[Y_{0i}|D_i = 1]$
 - $E[Y_{1i}|D_i = 0]$
- 5 Observation and counterfactual
 - Observation is readily available
 - Counterfactual must be constructed
 - Counterfactual accounts for selection & comparative advantage
 - People often “seek” treatment, and there is a reason for it

A Few Examples

- 1 Earnings gain from completing undergraduate education
 - Easy to observe average difference in earnings
 - Undergraduate entry is not attained by all
 - Better students tend to be punctual, organized...
 - These (unobservable) skills are also liked by employers
 - Difficult to separate education effect from them
- 2 Improvement in health from hospitalization
 - Easy to observe average difference in health
 - Not all people visit hospital
 - Less healthy people tend to “seek” hospitalization
 - Difficult to observe underlying health before hospitalization
 - Difficult to separate hospitalization from underlying health
- 3 Below, we consider options for redress

Brief Highlights

In evaluating the effects of treatments:

- 1 We can observe participant outcomes
- 2 We can observe non-participant outcomes
- 3 We cannot observe participant outcome for non-participants
- 4 We cannot observe non-participant outcomes for participants

Therefore, we need to create a counterfactual sample:

- 1 Exogenous participation
 - Randomized Controlled Trials
 - Matching
- 2 Endogenous participation
 - Exclusion restriction affecting participation, but not outcome
 - Arbitrary enforcement rule

Randomization or Pure Exogeneity

Recall:

$$\begin{aligned} E[Y_i|D_i = 1] - E[Y_i|D_i = 0] &= E[Y_{1i}|D_i = 1] - E[Y_{0i}|D_i = 1] \\ &\quad + E[Y_{0i}|D_i = 1] - E[Y_{0i}|D_i = 0] \end{aligned} \quad (10)$$

Under exogeneity:

$$E[Y_{0i}|D_i = 1] = E[Y_{0i}|D_i = 0] \quad (11)$$

Therefore:

$$\begin{aligned} E[Y_i|D_i = 1] - E[Y_i|D_i = 0] &= E[Y_{1i}|D_i = 1] - E[Y_{0i}|D_i = 1] \\ &= E[Y_{1i}|D_i = 1] - E[Y_{0i}|D_i = 0] \\ &= E[Y_{1i} - Y_{0i}] = E[\hat{\beta}] \end{aligned} \quad (12)$$

Counterfactual: the non-treated sample.

Selection on Observables: Matching

Theorem : Propensity Score Matching.

Suppose $\{Y_{0i}, Y_{1i}\} \perp\!\!\!\perp D_i | X_i$. Then, $\{Y_{0i}, Y_{1i}\} \perp\!\!\!\perp D_i | p(X_i)$.

$$E[Y_{1i} - Y_{0i} | D_i = 1] = E\left(E[Y_i | p(X_i), D_i = 1] - E[Y_i | p(X_i), D_i = 0] \middle| D_i = 1\right) \quad (13)$$

- 1 Conditional exogeneity: no selection problem
- 2 **Counterfactual**: matched sample of non-treated

Instrumental Variables: Refining Potential Outcomes Framework

Recall:

$$E[Y_i|D_i = 1] - E[Y_i|D_i = 0] = E[Y_{1i}|D_i = 1] - E[Y_{0i}|D_i = 1] + E[Y_{0i}|D_i = 1] - E[Y_{0i}|D_i = 0] \quad (14)$$

Potential treatments framework:

$$D_i = \begin{cases} D_{1i}, & \text{Treatment outcome, if } z_i = 1 \\ D_{0i}, & \text{Treatment outcome, if } z_i = 0. \end{cases} \quad (15)$$
$$= D_{0i} + z_i (D_{1i} - D_{0i})$$

Instrumental Variables: Assumptions

Randomly assigned IV:

$$[\{Y_i(d, z); \forall d, z\}, D_{1i}, D_{0i}] \perp\!\!\!\perp z_i \quad (16)$$

Exclusion restriction:

$$Y_i(d, 0) = Y_i(d, 1) \equiv Y_{di}; d = \{0, 1\} \quad (17)$$

In practical terms:

$$\begin{aligned} E[Y_i|z_i = 1] - E[Y_i|z_i = 0] & \\ &= E[Y_i(D_{1i}, 1)|z_i = 1] - E[Y_i(D_{0i}, 0)|z_i = 0] \\ &= E[Y_i(D_{1i}, 1)] - E[Y_i(D_{0i}, 0)] \\ E[D_i|z_i = 1] - E[D_i|z_i = 0] & \\ &= E[D_{1i}|z_i = 1] - E[D_{0i}|z_i = 0] \\ &= E[D_{1i} - D_{0i}] \end{aligned} \quad (18)$$

Instrumental Variables: LATE

Theorem : Local Average Treatment Effects.

Assume:

- 1 Independence. $[\{Y_i(d, z); \forall d, z\}, D_{1i}, D_{0i}] \perp\!\!\!\perp z_i$,
- 2 Exclusion. $Y_i(d, 0) = Y_i(d, 1) \equiv Y_{di}; d = \{0, 1\}$,
- 3 First-stage. $E[D_{1i} - D_{0i}] \neq 0$, and
- 4 Monotonicity. Either $D_{1i} \geq D_{0i} \forall i$ or $D_{1i} \leq D_{0i} \forall i$.

Then, the average effect of treatment on the affected group is:

$$\frac{E[Y_i|z_i = 1] - E[Y_i|z_i = 0]}{E[D_i|z_i = 1] - E[D_i|z_i = 0]} \quad (19)$$

Counterfactual: should have been treated, but weren't

Regression Discontinuity: Similar to IV

Treatment is a discontinuous function of a “running” variable:

$$D_i = \begin{cases} 1 & \text{If } z_i \geq z_0 \\ 0 & \text{If } z_i < z_0 \end{cases} \quad (20)$$

Rules are arbitrary; therefore the selection effect is constant:

$$\begin{aligned} E[Y_{0i}|D_i = 1] &= E[Y_{0i}|D_i = 0] \\ E[Y_{0i}|z_0 \leq z_i \leq z_0 + \epsilon] &= E[Y_{0i}|z_0 - \epsilon \leq z_i < z_0] \\ &= k \end{aligned} \quad (21)$$

Counterfactual: on the other side, but “near” the cutoff

Regression Discontinuity Treatment Effect

If the rule is applied perfectly, the causal effect can be directly estimated:

$$E[Y_{1i}|D_i = 1] - E[Y_{0i}|D_i = 1] = \lim_{\epsilon \rightarrow 0} \left(E[Y_{1i}|z_0 \leq z_i \leq z_0 + \epsilon] - E[Y_{0i}|z_0 - \epsilon \leq z_i < z_0] \right) \quad (22)$$

If the rule is imperfectly applied, the causal effect follows IV estimate:

$$E[Y_{1i}|D_i = 1] - E[Y_{0i}|D_i = 1] = \lim_{\epsilon \rightarrow 0} \frac{\left(E[Y_{1i}|z_0 \leq z_i \leq z_0 + \epsilon] - E[Y_{0i}|z_0 - \epsilon \leq z_i < z_0] \right)}{\left(E[D_{1i}|z_0 \leq z_i \leq z_0 + \epsilon] - E[D_{0i}|z_0 - \epsilon \leq z_i < z_0] \right)} \quad (23)$$

True Panels: Fixed Effects

With multiple observations on i , it is possible to assume:

$$E[Y_{0it}|A_i, t, D_{it}] = E[Y_{0it}|A_i, t] \quad (24)$$

Treatment status is “as good as randomly assigned”.

Requires time-invariant individual unobserved variable, A_i .

If it is also possible to assume constant treatment effects:

$$E[Y_{1it}|A_i, t] = E[Y_{0it}|A_i, t] + \gamma \quad (25)$$

Then fixed effects estimation yields an unbiased estimate of γ

Counterfactual: earlier or later observation on same individuals

Quasi-Panels: Differences-in-Differences

Consider fixed effects on aggregate data. John Snow (1855) - two groups and two time periods, one group is treated, the other is not.

Define the first difference as:

$$d_1 = E[Y_{igt}|g = 1, t = 2] - E[Y_{igt}|g = 1, t = 1] \quad (26)$$

$$d_2 = E[Y_{igt}|g = 2, t = 2] - E[Y_{igt}|g = 2, t = 1] \quad (27)$$

If group 2 received the treatment, the treatment effect is simply the difference-in-differences:

$$\tau = d_2 - d_1 \quad (28)$$

Counterfactual: earlier or later observation on same groups

CONTEXTUALIZE EVALUATION FOR DEPARTMENTAL OBJECTIVES

External Evaluation Review Team

External Review of Department: August 2010

- Prof Stephen Miller, HOD: Economics, University of Nevada-Las Vegas
- Prof Carolyn Heinrich, Director: LaFollette School of Public Affairs, University of Wisconsin
- Prof Stan du Plessis, President: Economic Society of South Africa
- Prof Rashad Cassim, Director of Research, South African Reserve Bank

External Evaluation Highlights

Paraphrased Summary of Recommendations:

- 1 Review and strengthen all components of the department's curriculum, from first-year through the PhD
- 2 Develop and improve management goals and structures for classes, students and staff.
- 3 Develop a coherent human resources plan to strengthen and broaden the department's skills base.
- 4 Develop a coherent and representative marketing plan.

Department Bosberaad

- 1 Factors over which we have no control
 - Geo-politics
 - Cultural environment
 - Demographics
- 2 Factors over which we have limited control
 - University policy and priorities
 - Our competition
 - Demand for economics, econometrics and economic policy
 - Student quality and numbers
 - Resources
- 3 Factors over which we have much control
 - Quality and relevance of our programs
 - Staff quality and happiness
 - Research strategy

Pillars of Focus and Policies

- 1 Quality research
 - Networking and collaboration
 - Align focus areas within the department
 - Develop stronger mentoring programs for both students and staff
- 2 Quality teaching
 - Align focus areas to the expertise in the department
 - Improve mentoring activities
 - Interrogate quality teaching
 - Revisit subject content for consistency and complementarity
- 3 Impactful marketing
 - Disseminate research results, collaboration efforts and opinions to wide audiences
 - Set up and maintain an effective website
 - Aggressive fund raising activities

The Educational Anchor: Undergraduate

- ① Economically literate
- ② Describe and analyse economic problems and assumptions
- ③ Communicate - written and oral:
 - Advantages and disadvantages
 - Potential economic solutions
- ④ Interested and capable of reading the *Business Day*

Our undergraduate economists will be capable of using economics to appropriately separate good economic arguments and information from bad economic arguments and information.

The Education Anchor: Honours

- 1 Everything undergraduates can do, only better
- 2 Incorporate a larger and more technical toolbox into analysis
- 3 Interested and capable of reading *The Economist* and/or *The Financial Times*

Our honours economists will be capable of applying economic analysis to develop and present good economics arguments and information, as well as inform the discussion about why other economics arguments and information might be bad.

The Education Anchor: Masters

- 1 Everything an honours graduate can do, only better
- 2 Should be interested and capable of reading specialist journals
- 3 Capable of explaining complex ideas to specialist audiences
- 4 Capable of explaining complex ideas to non-specialists

Our Masters economists will be critical thinkers that are capable of testing their hypotheses, as well as hypotheses presented by others.

The Education Anchor: PhD

- 1 Everything a Masters graduate can do, only better
- 2 Capable of locating gaps in specialist economics literature
- 3 Capable of critiquing the economics literature
- 4 Become specialists within an area of economics
- 5 Contribute to knowledge creation

Our PhD graduates will be able to synthesize, critique and rebuild economic knowledge for the benefit of knowledge creation and/or the development of society.

Research Standing

Measurable objectives with regard to research standing:

- Citations or h factor
- Number/proportion of publications in ISI/IBSS journals
- Number of former students appointed in other universities

Policy options or treatments:

- Extend networking and collaboration
- Further focus area alignment
- Improved Mentoring
- Active grant funding pursuit
- Create incentive bonuses
- Fight for increased research subsidy passthrough (at least to department)
- Require individual research plans

Evaluation of Treatments

Suppose $x\%$ of the Performance Management Contract was specifically tied to an increase in h factor.

Advantage: Bonus partially tied to measure of research quality.

Disadvantage: Bonuses dispersed yearly, and measure has a lengthy time horizon.

Evaluation options:

- ① Randomized Controlled Trial 1
 - Draw staff members out of a hat
 - Examine increase in h factor over three-year window
 - Requires an additional difference-in-difference estimate
- ② Randomized Controlled Trial 2
 - Draw x values out of a hat
 - Examine increase in h factor over three-year window
 - Allows for a panel estimate

Teaching Performance

Measurable objectives in teaching:

- Student evaluations
- Pass rates
- Number of students switching major
- Time to degree

Policy options or treatments:

- Aligning focus areas and course content
- Improve mentoring
- Interrogating quality teaching
- Interrogating student performance

Evaluation of Treatments

Suppose we wanted to know the effect of *hereksamen*, i.e, by how much does it improve graduation times.

Advantage: Appear to improve overall throughput.

Disadvantage: Requires significant teaching resources.

Evaluation option:

- 1 Regression Discontinuity
 - Re-exams are granted based on a set of well-specified rules
 - Therefore, it is possible to compare students on either side
 - These students can be followed over their UP career
 - Compare total number of re-exams offered to both groups of students
 - Compare completion times for both groups of students
 - Compare drop-out rates for both groups of students
- 2 Randomized Controlled Trial - Ethically complicated

Marketing Impact

Measurable objectives in marketing:

- Media appearances
- Total funds raised
- Web access and downloads

Policy options or treatments:

- Increased research dissemination
- Uploading (and announcing) focused policy briefs
- Developing alumni relations
- Appointing an advisory board

Evaluation of Treatments

Suppose every researcher posted a short research/media brief for their favourite published paper(s).

Advantage: Potential increased exposure

Disadvantage: Not all good research is directly relevant, and proper briefs are time consuming to prepare.

Evaluation options:

- Briefs would be self-selected
- Selection would likely be driven by marketability
- Selection would also be driven by interest in consulting
- Could consider a Local Average Treatment Effect
 - Must learn how the requestor learned of our activities
 - Could be across availability of briefs
 - Would be adjusted by proportion of briefs available

SUMMARIZE

Brief Summary

- 1 Presented an object-based output model
 - Leads to sorting based on comparative advantage
 - Success derived from *positive* sorting
 - Suggests policies affecting positive sorting
- 2 Considered policy evaluation
 - Policies impact comparative advantage
 - Exogenous policy impact is difficult to identify
 - Yet, there are options related to identification
- 3 Contextualized the Department of Economics
 - Described the recent external review
 - Outlined the response of the department
 - Considered some policies and evaluations
- 4 But, we have sidestepped a few important issues...

Challenges Ahead

“The method of postulating what we want has many advantages. They are the same as the advantages of theft over toil.” -
Bertrand Russell

- 1 Policy evaluation is predicated on objective measures
 - If the measures are wrong, there are unintended consequences
 - Evaluation lends itself to micromanagement
 - It is important to entitle and entrust staff to do their job
 - Organizational architecture matters
 - Responsibility to match accountability and incentives
 - Some decentralization is needed
- 2 Many academic outcomes are subjective
 - Quality often based on others' opinions
 - Opinions can sometimes be influenced
 - Marketing can help
 - Politics also matter

Some Final Thoughts

- 1 The job of academics has not really changed
 - We challenge ourselves to think beyond what is already known
 - We challenge ourselves to refute or support what is hypothesized
 - We challenge our students to do likewise
 - This must remain the core of our activities
- 2 However, the environment has changed
 - Rankings and ratings are the rage
 - Information - even misinformation - is easily obtained
 - Reading competes with other forms of entertainment
- 3 It is now necessary to think beyond what is already known to appropriately deal with the changing environment, to maintain our core activities, while simultaneously raising our contribution.

Lyrical Poetry

Beyond your tunnel vision, reality fades;
Like shadows into the night.
- David Gilmour

Emancipate yourself from mental slavery;
None but ourselves can free our mind.
- Bob Marley

THANKS