Potential Outcomes

USAID MENA Advanced MEL Workshop

Session 1

2024-05-01

Welcome!

- Who we are
- What we do
- How we hope to help you

Objectives of impact evaluation sessions

- Understand the need for impact estimation of USAID activities
- Understand how impact estimation fits into the Agency performance management framework
- Gain practical knowledge about impact evaluation to help USAID staff better manage and support IEs

Benchmarks for success

By the end of this session, participants will be able to:

- Explain the fundamental problem of causal inference
- Explain how impact estimation can be seen as a problem of missing data
- Relive unpleasant schoolhood memories of having to learn algebra

Benchmarks for success

Bonus content:

- Is causal inference a two-body or three-body problem?
- How has causal inference developed out of traditions from MENA region?

The Fundamental Problem

Measuring social benefit

We want to know the causal effect of a project on its beneficiaries

- Job training on earnings and employment
- Teacher qualifications on student outcomes
- Humanitarian assistance on food security

Identifying a treatment assignment

- Consider an indicator for a *potential* beneficiary, D_i
- D tells us whether there is an activity, or a "treatment"
- The subscript i denotes a single individual who is either treated or not treated
  - D_i = 1 means participation in an activity
  - D_i = 0 means no participation in an activity

Identifying an outcome

Now consider an indicator for the outcome of a potential beneficiary, Y_i, where i denotes each person or unit under study.

- ${Y_i}^1$ is the outcome after activity participation ($D_i = 1$)
- ${Y_i}^0$ is the outcome without the activity ($D_i = 0$)
- Note that Y_1 and Y_0 denote *possibilities* for the *same person*, unit i!

Switching across treated and untreated outcomes

We use what is called a 'switching equation' to connect a treatment assignment to a realized outcome

- $Y_i = D_i Y_i^1 + (1 - D_i) Y_i^0$

(Plug in $D_i = 1$ and $D_i = 0$ and see what you end up with)

ALGEBRA ALERT

$Y_i = D_i Y_i^1 + (1 - D_i) Y_i^0$ where $D_i = 1$

- $Y_i = 1 * Y_i^1 + 1 * Y_i^0 - 1 * Y_i^0$
- $Y_i = Y_i^1 + Y_i^0 - Y_i^0$
- $Y_i = Y_i^1$

ALGEBRA ALERT

$Y_i = D_i Y_i^1 + (1 - D_i) Y_i^0$ where $D_i = 0$

- $Y_i = 0 * Y_i^1 + 1 * Y_i^0 - 0 * Y_i^0$
- $Y_i = 0 + Y_i^0 - 0$
- $Y_i = Y_i^0$

Difference between assignment and mechanism

- The switching equation determines where (to whom) treatment is assigned
- We call this the treatment assignment
- The switching equation does **NOT** address **HOW** treatment is assigned
- We call this the treatment assignment *mechanism*

From assignment to treatment effect

We can also write the switching equation this way:

- $Y_i = Y_i^0 + (Y_i^1 - Y_i^0)D_i$
- Notice our treatment effect $Y_i^1 - Y_i^0$, or the difference between the treated and untreated outcome
- We call the difference $Y_i^1 - Y_i^0$ $delta$, or δ_i
- Remember that the treatment effect δ_i refers to the *same* individual!

Recap:

- The effect of the activity (treatment effect) on person i is the difference between the two potential outcomes
- Treatment effect = $Y_i^1 - Y_i^0$, or δ_i
- This is the difference in potential outcomes for the *same person*
- A person participates in an activity, and then goes back in time and does not participate in the activity

You ask the impossible

- But how can one person be both treated and untreated?
- In the real world, person i experiences one of the potential outcomes, but not both
- If $D_i = 1$, the potential outcome of Y_i becomes Y_i^1 in fact and the potential outcome of Y_i^0 is unobserved
- If $D_i = 0$, the potential outcome of Y_i becomes Y_i^0 in fact and the potential outcome of Y_i^1 is unobserved

The fundamental problem of causal inference

- This is the fundamental problem of causal inference
- We observe only one outcome, but we need both outcomes to describe the effect of the project
- We refer to the outcome that didn't happen as the *counterfactual*, or what would have happened in the absence of the project

The Missing Data Problem

Something is missing

Group	Yi1	Yi0
Treatment	Observed	Counterfactual
Control	Counterfactual	Observed

- Researchers sometimes refer to impact evaluation as a "missing data problem"
- We are missing two pieces of information about what happens with or without the treatment

What do we do now?

- How do we estimate the effect of a project, if we cannot observe the same person go through both potential outcomes?
- We must compare a person who was treated with a person who was not treated
- But, what are the differences between those two people? How do we know that project participation is the only difference between them?

CLIFFHANGER

Tune into the next session for a resolution of the Fundamental Problem of Causal Inference!

Teaser:

- Experimental impact evaluation
- Quasi-experimental impact evaluation
- Prediction via machine learning
- Artificial General Intelligence (AGI)

Bonus content

- Causal inference as a two-body or a three-body problem
- Causal inference from traditions in Middle East and North Africa

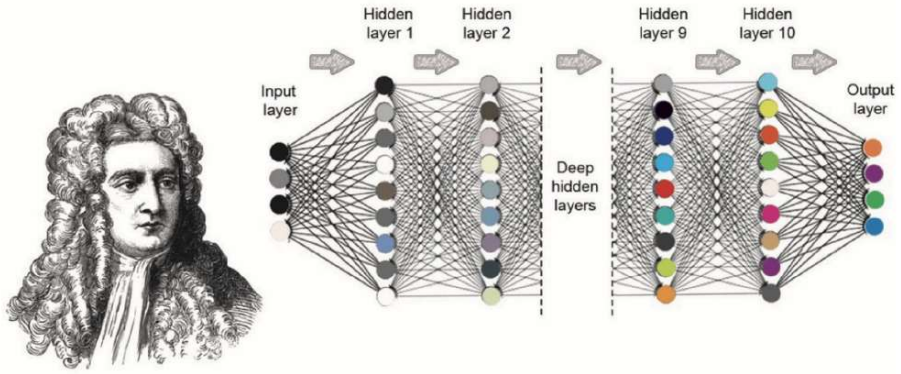
The Three-Body Problem

Science

Why Is the Three-Body Problem Unsolvable?

Let's break down the chaos.

BY CAROLINE DELBERT PUBLISHED: NOV 06, 2019 2:08 PM EST



Philip G. Breen, Christopher N. Foley, Tjarda Boekholt, Simon Portegies Zwart

- Researchers have **solved a set of simple examples** of the chaotic three-body problem.
- Space travel and most real-life systems **are chaotic**, making this research valuable.
- Neural networks have the potential to solve, or at least model, chaotic problems better than traditional supercomputers.

Causal inference in the MENA tradition