# Matching Lab

INFO/STSCI/ILRST 3900: Causal Inference

15 Oct 2025

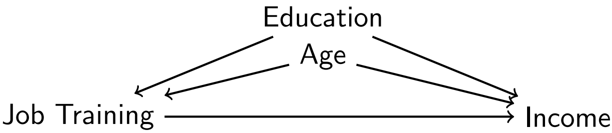
# Reminders and Announcements

- Peer reviews- make sure to review all you're assigned by tomorrow, Oct 16
- In-class quiz 3 tomorrow, Oct 16
- Project Part 1 due Monday, Oct 20
- Office hours:
  - Filippo: Thursday 4-5 pm in 321A CIS Building
  - Shira: Monday 5-6 pm in 329A CIS Building
  - Sam: Tuesday 4-5 pm, in 350 CIS Building
- Check Ed for announcements and use for HW help!

# Matching Review

- Suppose person $i$ is in the treatment group ($A_i = 1$).
- Want to compare their outcome under treatment vs control
- Fundamental problem of causal inference: I can only observe one of these
- Matching: Find a person $j$ in the control group ($A_j = 0$) that is *similar enough* to person $i$ and compare their outcomes
- Reasoning: if people are *similar enough*, then maybe their potential outcomes are also *similar enough*
- How do we define *similar enough*?
- We can use covariates! $\vec{L}$

# What if $\vec{L}$ is multivariate?

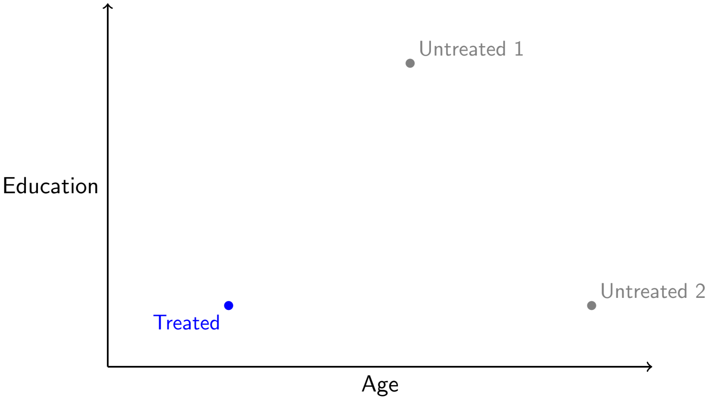



- Conditional exchangeability holds when conditioning on Age and Education!
- Matching: look for a group of untreated units which has a similar distribution of Age and Education to the treated group

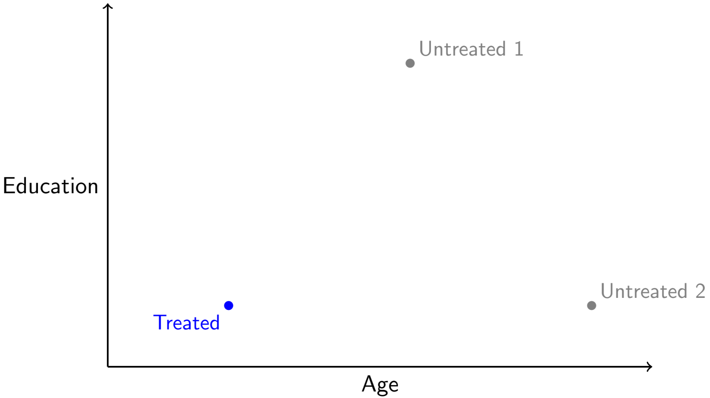
# What if $\vec{L}$ is multivariate?

# What if $\vec{L}$ is multivariate?

# What if $\vec{L}$ is multivariate?

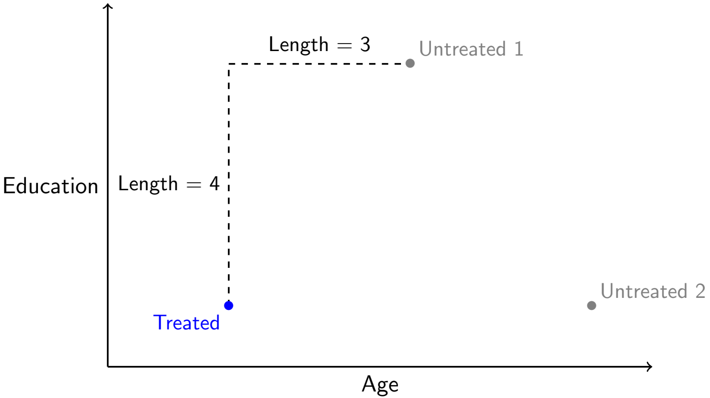


# What if $\vec{L}$ is multivariate?



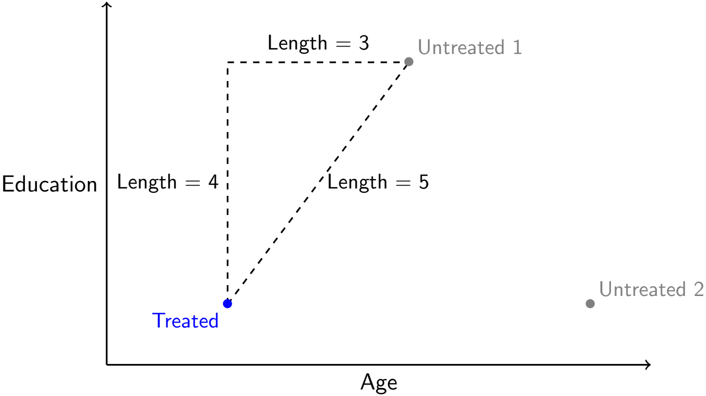

Which untreated unit should be the match?

# What if $\vec{L}$ is multivariate?



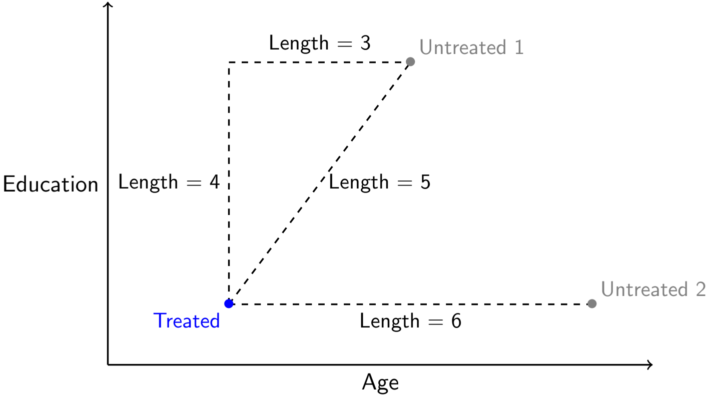

Which untreated unit should be the match?

# What if $\vec{L}$ is multivariate?



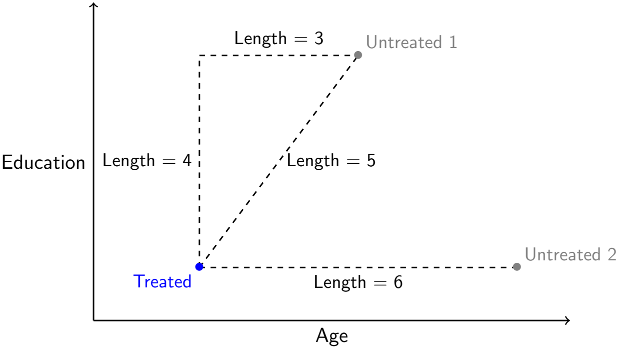

Which untreated unit should be the match?

# What if $\vec{L}$ is multivariate?



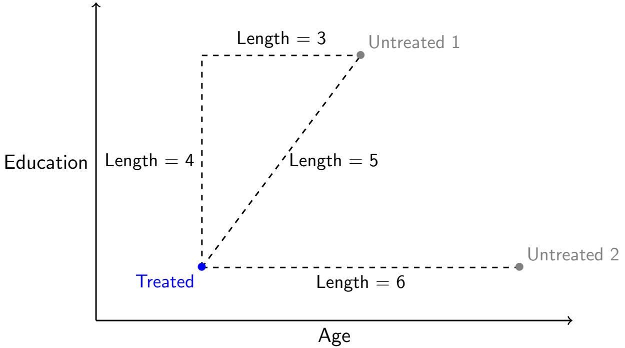

Which untreated unit should be the match?

# What if $\vec{L}$ is multivariate? We need a **distance metric**



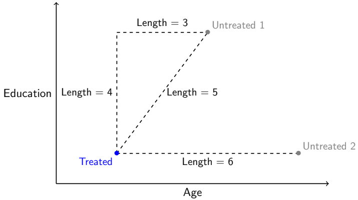

- Define a way to measure "distance" between two individuals as a single number

# What if $\vec{L}$ is multivariate? We need a **distance metric**

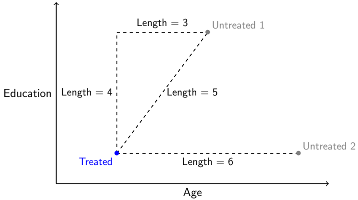



- Define a way to measure "distance" between two individuals as a single number
- Match individuals using that distance!

# What if $\vec{L}$ is multivariate? We need a **distance metric**

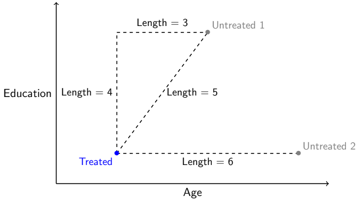


# What if $\vec{L}$ is multivariate? We need a **distance metric**




- Manhattan distance:
  - $d(\text{Treated, Untreated 1}) = 3 + 4 = 7$
  - $d(\text{Treated, Untreated 2}) = 6 + 0 = 6$ ✓
- Euclidean distance: $d(i,j) = \sqrt{\sum_p (L_{pi} - L_{pj})^2}$
  - $d(\text{Treated, Untreated 1}) = \sqrt{3^2 + 4^2} = 5$ ✓
  - $d(\text{Treated, Untreated 2}) = \sqrt{6^2 + 0^2} = 6$
- Which individual to pick depends on the distance metric!

# What if $\vec{L}$ is multivariate? We need a **distance metric**




- Manhattan distance: $d(i,j) = \sum_p |L_{pi} - L_{pj}|$
  - $d(\text{Treated, Untreated 1}) = 3 + 4 = 7$
  - $d(\text{Treated, Untreated 2}) = 6 + 0 = 6$ ✓
- Euclidean distance: $d(i,j) = \sqrt{\sum_p (L_{pi} - L_{pj})^2}$
  - $d(\text{Treated, Untreated 1}) = \sqrt{3^2 + 4^2} = 5$ ✓
  - $d(\text{Treated, Untreated 2}) = \sqrt{6^2 + 0^2} = 6$
- Which individual to pick depends on the distance metric!

# A common distance metric: Mahalanobis distance

Motivated by two principles

- Principle 1: Address unequal variances
  - Age might range uniformly from 18 to 80
  - Education range uniformly from 0 to 16
  - We might correct for this so age doesn't dominate the distance

# A common distance metric: Mahalanobis distance

Motivated by two principles

- Principle 1: Address unequal variances
  - Age might range uniformly from 18 to 80
  - Education range uniformly from 0 to 16
  - We might correct for this so age doesn't dominate the distance
- Principle 2: Address correlations
  - Suppose we included age in years, age in months, and education
  - Suppose we included age in years and age in months are very correlated
  - We should care about a correlation-corrected distance

# Code

Let's try this out in R!

- Section 2 is worked out for you: read through, run the code blocks, and answer the questions
- Section 3 asks you to write some code (will be very similar to the code from Section 2)
- Then move on to the `matching_examples.Rmd` file on the website