Propensity techniques

Aleš Vomáčka

The Plan

- How to estimate propensity scores
- How to apply the scores
  - Propensity scores matching
  - Propensity score weighting
- Advantages and Disadvantages, assumptions

Estimating propensity scores

Pre-election Debates & Opinion Change

- How effective are pre-election debates at changing voter preferences?
- Data from the last presidential elections, shorty before the 2nd round.
- Variables of interest:
  - debate - have the respondent seen the last debate?
  - change - have the respondent changed candidate after debate?
  - election_cand_before - which candidate preferred before debate?

The Problem

- Who sees the debate isn't random.

- Potential Outcome Framework
  - Ignorability may be violated

- Directed Acyclic Graphs Framework
  - There may be a backdoor path from debate to change.

The (Potential) Solution

- We can try estimating probability of receiving treatment and…
  - …achieve conditional ignorability
  - …close the backdoor path

  - How do we do it?
    - One option are propensity techniques

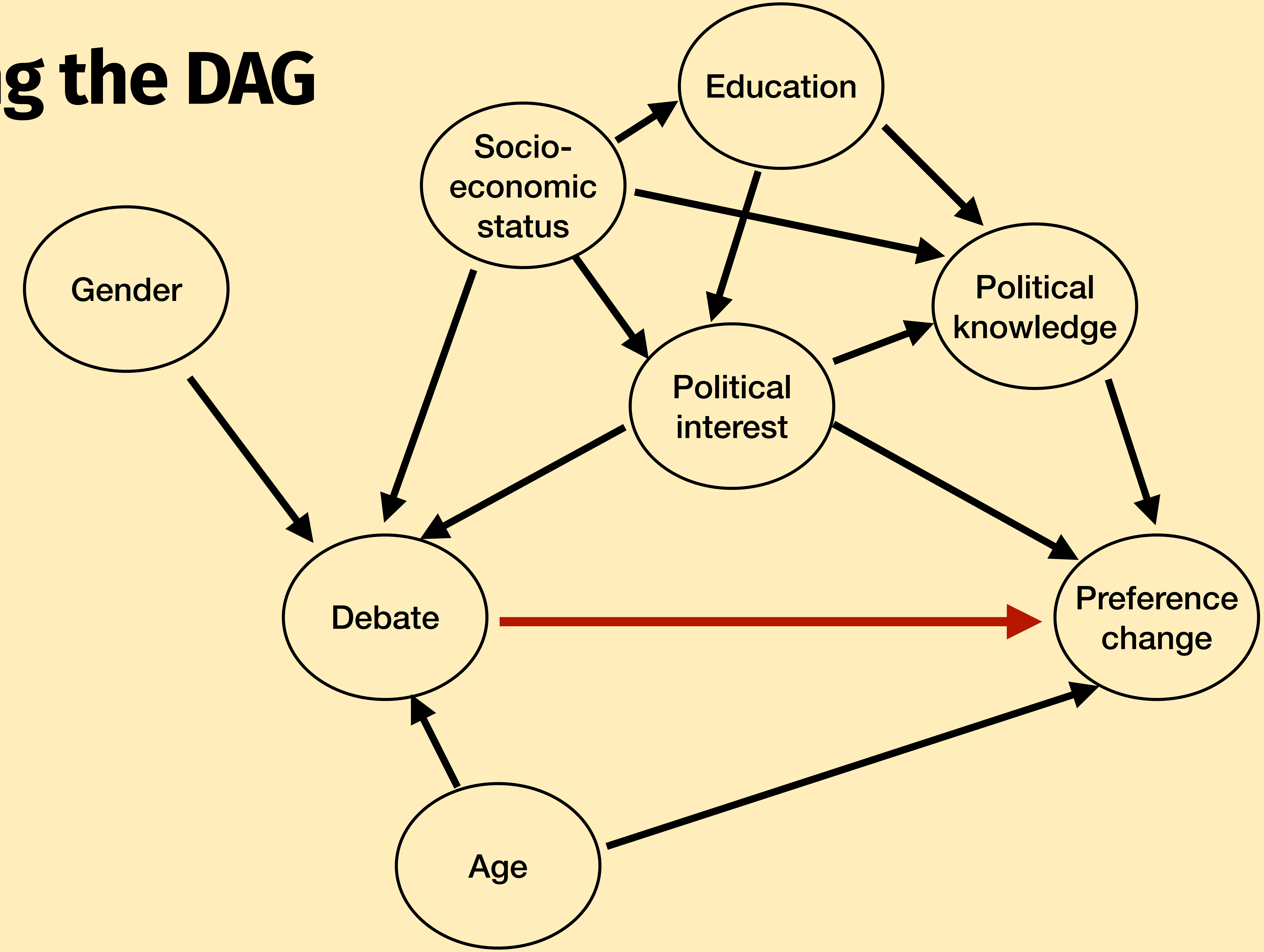
Propensity Scores Techniques

- Zhao, Q.-Y., Luo, J.-C., Su, Y., Zhang, Y.-J., Tu, G.-W., & Luo, Z. (2021). Propensity score matching with R: Conventional methods and new features. *Annals of Translational Medicine*, *9*(9), 812. https://doi.org/10.21037/atm-20-3998
- Chesnaye, N. C., Stel, V. S., Tripepi, G., Dekker, F. W., Fu, E. L., Zoccali, C., & Jager, K. J. (2022). An introduction to inverse probability of treatment weighting in observational research. *Clinical Kidney Journal*, *15*(1), 14–20. https://doi.org/10.1093/ckj/sfab158

Propensity Scores

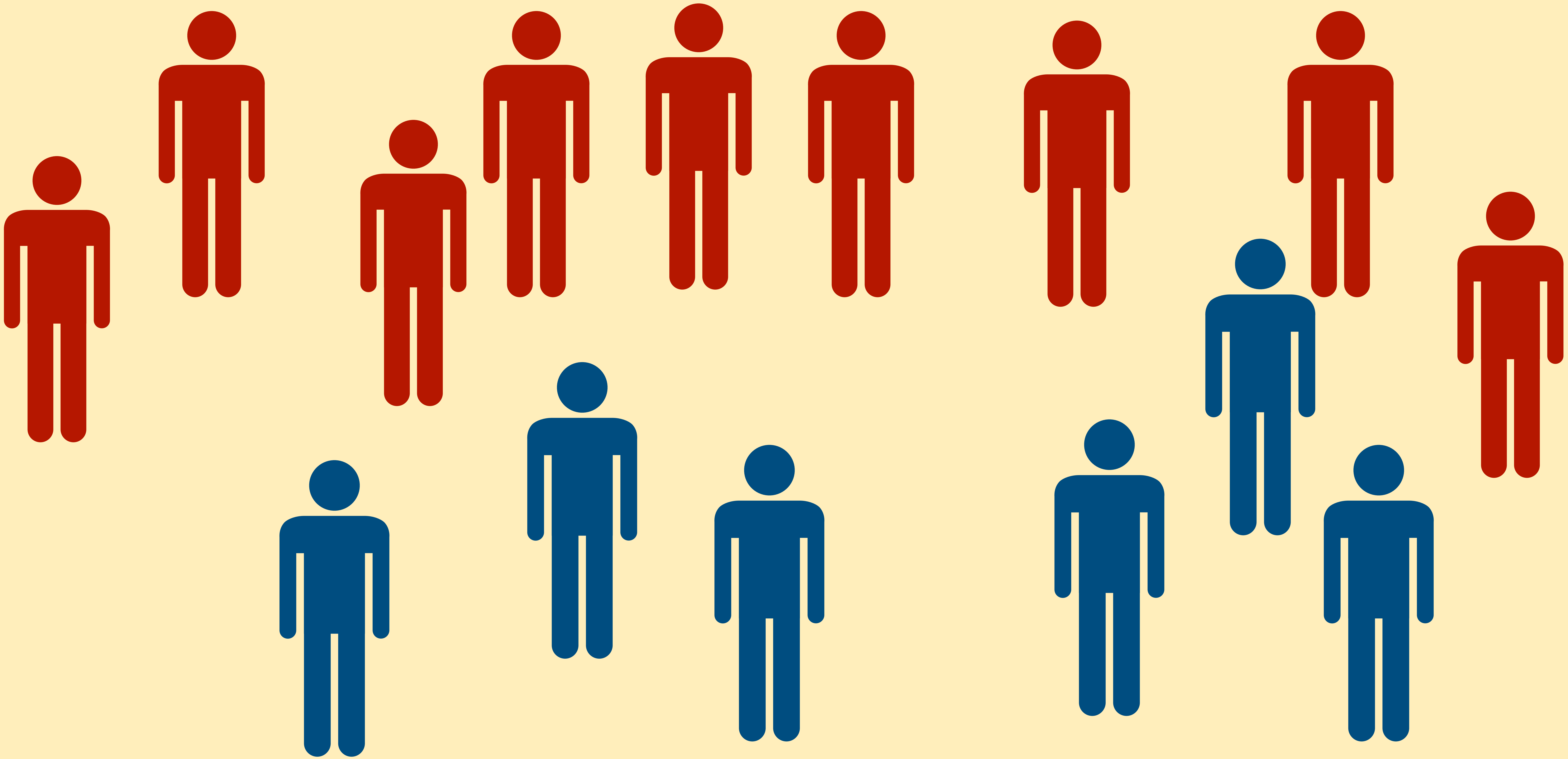
- Propensity scores - conditional probability of receiving treatment
- The probability is conditional on potential confounders.
- This means that the first step is...

Step 1 - Drawing the DAG



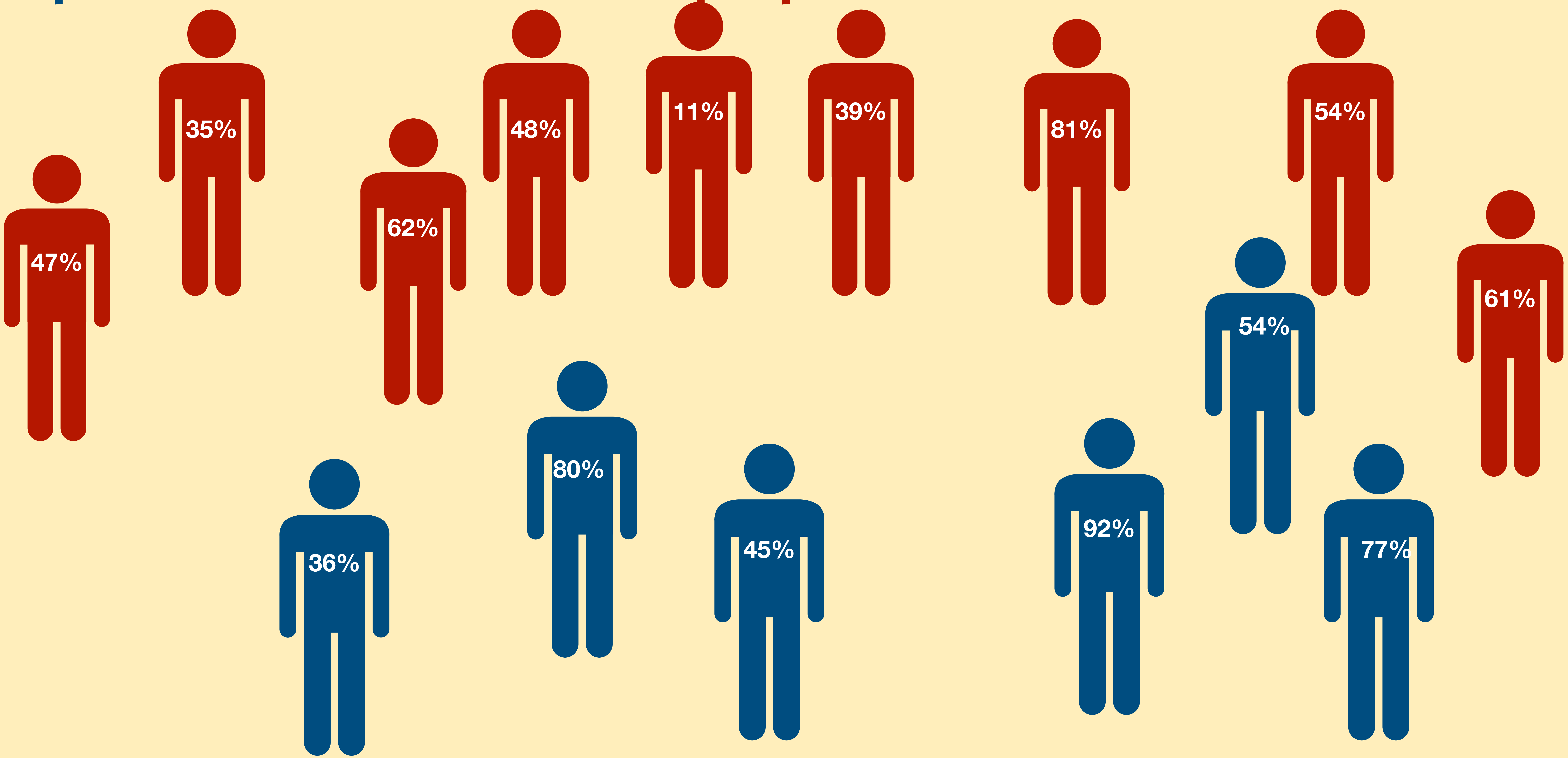
Step 2 - Estimating propensity scores

- **People who saw the debate** and **people who didn't see the debate**.



- Many models to do so, logistic regression most common (but newer methods more robust/convenient)

- **People who saw the debate** and **people who didn't see the debate**.



Questions?

Step 3 - Choosing Method

Propensity scores matching

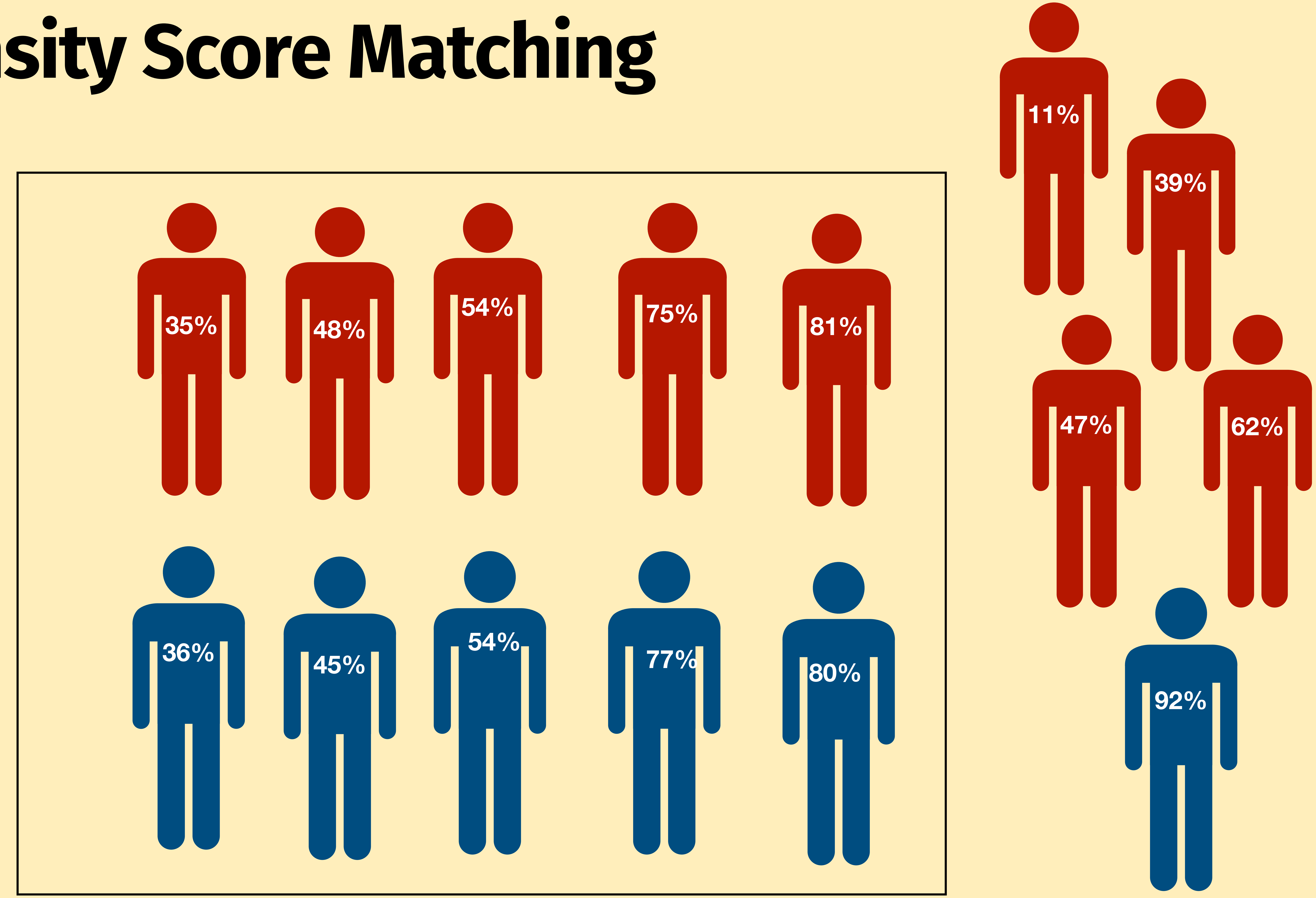
Propensity Scores

Propensity scores weighting

Step 4a - Propensity Score Matching

Match **respondents who got the treatment** and **respondents who didn't** with similar propensity scores.

Toss the rest.



Step 4a - Propensity Score Weighting

- Transform the probabilities of receiving treatment into weights.

- Give higher weight to respondents with:
  - Low probability of receiving treatment, but ultimately got it.
  - High probability of receiving treatment, but ultimately didn't got it.

  - In short, give higher weights to the less expected outcomes.
  - Many ways to do it.

Step 4a - Inverse probability treatment weights

- OG approach - Easy to compute, widely used

$$w_i = \frac{1}{p_i} \qquad if\ Treat = 1$$

$$w_i = \frac{1}{1 - p_i} \qquad if\ Treat = 0$$

Where p_i is the estimated probability of receiving treatment for every respondent i

Step 4a - Full Optimal Matching

- Newer approach
- More robust, but harder to compute - combines matching and weights

$$w_i = \frac{p \cdot (m + j)}{m} \qquad if\ Treat = 1$$

$$w_i = \frac{(1 - p) \cdot (m + j)}{j} \qquad if\ Treat = 0$$

Where p is the marginal (average) probability of receiving treatment, m is the number of respondents in matching set who received treatment and j is the number of respondents without treatment in the matching set.

Step 4 - IPTW vs Full Optimal Matching

Austin, P. C., & Stuart, E. A. (2017). The performance of inverse probability of treatment weighting and full matching on the propensity score in the presence of model misspecification when estimating the effect of treatment on survival outcomes. *Statistical Methods in Medical Research*, *26*(4), 1654–1670. https://doi.org/10.1177/0962280215584401

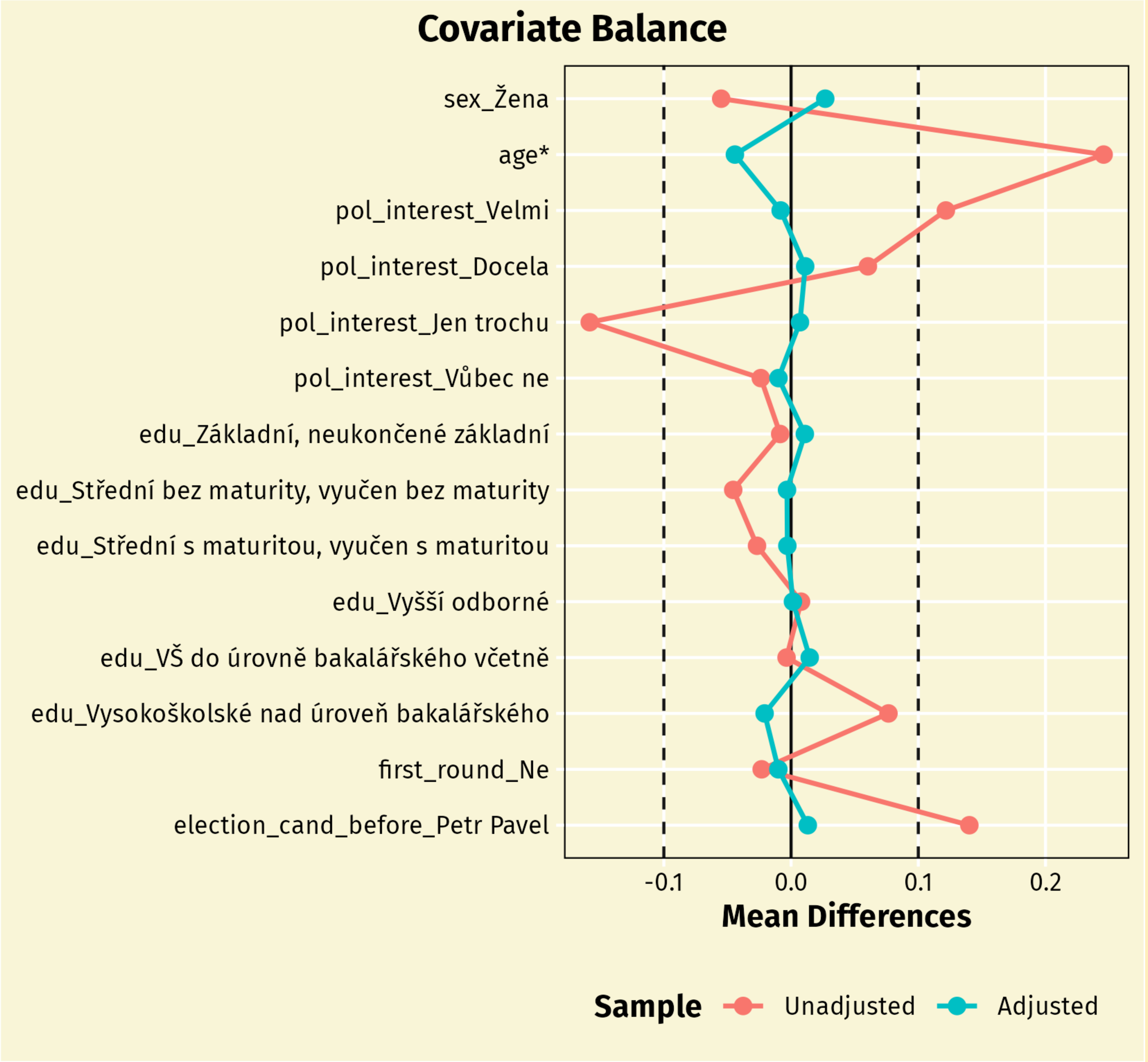
Questions?

Step 5 - Balance checking

- Once you have matched/weighted the data, you need to check whether the treatment and control groups are balanced.
- i.e. whether they no longer differ in observed confounders.

Step 5 - Balance checking

- Tables of visually.
- After matching/weighting, there should be no difference between treatment and control groups



Step 6 - Estimate The Effect

- If the matching/weighting were successful, you have achieved conditional ignorability/closed backdoor paths.
- The estimated difference between between treatment and control group represents the treatment causal effect.

- Congratulations, you have made it! (maybe, you can never be sure…)

Weighting Summary

- Advantages:
  - Doesn't throw away data.
  - Can estimate Average treatment effect on population.

- Disadvantages:
  - Can produce large weights, which makes results unstable.
  - Try explaining it to someone...

Matching Summary

- Advantages:
  - Easy to do (explain)
  - Robust to outliers.
- Disadvantages:
  - Throws aways data
  - Can only estimates **Average Treatment on Treated!!**
    - Because we threw away part of the data, we no longer have unbiased estimate for the population, only people in the sample

No Unobserved Confounders Assumptions

- Both approaches assume you have accounted for all confounders.
- At least the important ones.

- Good luck proving it...

Propensity Techniques vs Simple Conditioning

- Why use propensity scores, when we can control for variables directly?
- Propensity scores:
  - More efficient when number of predictors is large.
  - Can check balance

- But some people like to use treatment probabilities as a control variable.
- Some techniques use both (doubly robust estimators), worth checking out.

Questions?

InteRmezzo!