GROWTH MINDSET INTERVENTION

Author : Darshit Shah
MS in Data Science, Department of Statistics, Rutgers University NB

Introduction

What is the Growth Mindset?
Belief that intelligence can develop with effort, versus being fixed at birth.
Why is it important?
A growth mindset intervention has been shown to improve academic performance among high school students.
Goal of this project:
Estimate the **causal effect** of a growth mindset intervention on achievement using synthetic student data. (This study uses synthetic data modeled after the NSLM study to explore causal inference techniques in educational interventions.)

Data Exploration

Data Overview
•10,000 students from synthetic dataset modeled after NSLM study.
•10 covariates: 4 student-level, 6 school-level.
•Treatment = Growth Mindset Program.
•Outcome = Achievement Score (continuous).

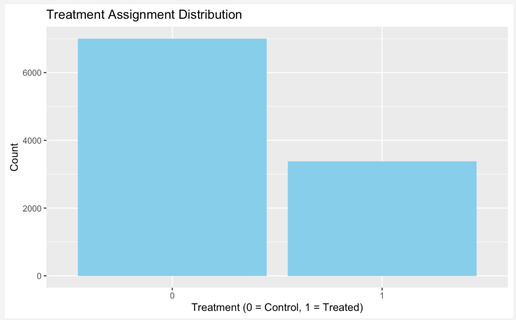

Fig 1: Distribution of Treatment groups

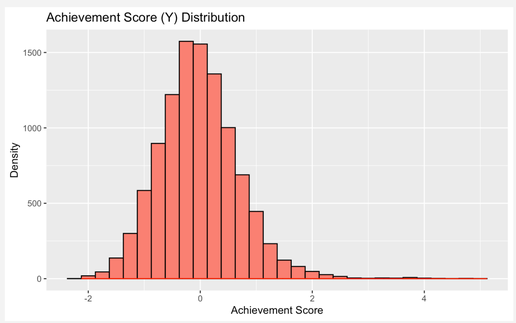

Fig 2: Distribution of Outcome (Achievement Score)

Exploratory Visuals

Group Size Check
Observed imbalance: Control group larger than treatment group (Fig 1). Important to adjust for this imbalance using causal methods.

Outcome Distribution:
Achievement score follows a near-normal distribution with slight skewness (Fig 2). Appropriate for linear modeling methods.

Propensity Score Distribution:
Substantial overlap in propensity scores (Fig 3), meeting the Common Support assumption required for causal inference

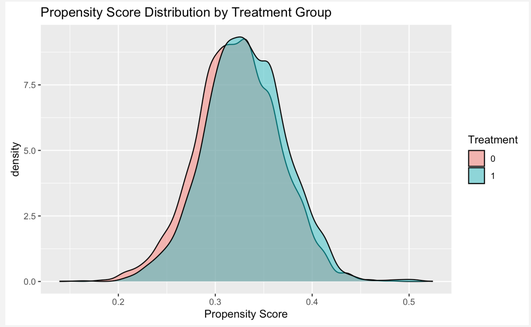

Fig 3: Common Support

Correlation with Achievement:
Self-reported expectations (selfrpt) and school racial composition (sch_race) are most correlated with achievement (Y)

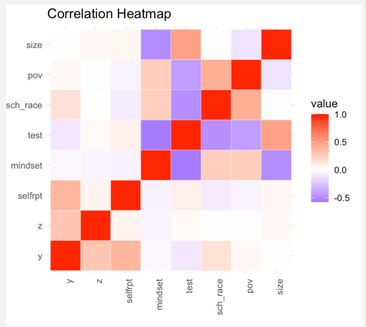

Fig 4: Heatmap of covariates vs Y

```
Top Covariates Correlated with Y:
 selfrpt     0.379128
sch_race     0.159631
Name: y, dtype: float64
```

Fig 5:Table of top covariates correlated with Y

Methods

Methods
•**IPW (Inverse Probability Weighting):** Reweights samples based on inverse of estimated propensity scores to simulate randomization.
•**PSM (Propensity Score Matching):** Matches treated and control units with similar propensity scores using Nearest Neighbor Matching.
•**GLM (Generalized Linear Model):** Linear regression adjusting for observed covariates to estimate treatment effect..
•**AIPW (Augmented IPW):** Doubly robust method combining IPW and outcome regression for unbiased estimates even if one model is misspecified.
Assumptions:
•**Ignorability (No Unmeasured Confounders):** All important confounders are included in the model.
•**Common Support:** Sufficient overlap in propensity scores between treated and control groups (verified visually).
•**SUTVA (Stable Unit Treatment Value Assumption):** No interference between students and only one version of treatment.
•**Estimation Strategy:** Selected for balance between **simplicity** (GLM, IPW) and **robustness** (PSM, AIPW).

Results

Average Treatment Effects (ATEs) Estimated:
- **AIPW** yielded the **highest** ATE estimate, indicating a strong positive effect of the intervention.
- All methods produced consistent ATEs, strengthening causal evidence.
- Confidence intervals reinforce reliability, with minor variation across methods.

The intervention increased achievement scores by approximately **0.42 to 0.46 points** across methods, demonstrating a substantial and consistent positive effect.

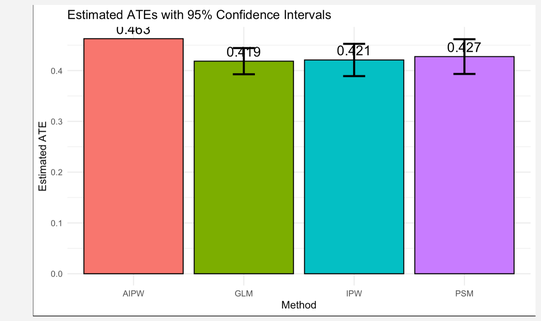

Fig 6: ATE Estimates with 95% CI

ATE VALUES:
• AIPW: 0.463
• GLM: 0.419
• IPW: 0.421
• PSM: 0.427

Discussion and Limitations

The Growth Mindset intervention shows a **positive and consistent impact** on achievement across all methods.
Robust estimates with overlapping confidence intervals strengthen causal claims.
Limitations
•Based on **synthetic data**; real-world effects may vary.
•Risk of **unmeasured confounding**.
•**IPW sensitive to extreme weights**.
•Assumes **SUTVA and no hidden bias**
Future Work
•**Validate with real-world data**.
•Perform **sensitivity analyses**.
•Explore **advanced propensity models** for better balance.

References

[1] D. S. Yeager, C. Romero, C. S. Paunesku, G. M. Walton, and D. K. Cohen, "A national experiment reveals where a growth mindset improves achievement," *Nature*, vol. 573, no. 7774, pp. 364–369, Sep. 2019. doi: 10.1038/s41586-019-1466-y
[2] E. A. Stuart, "Matching methods for causal inference: A review and a look forward," *Statistical Science*, 2010.
[3] Econometrics : Propensit Score in R (YouTube).