Unlocking Brighter Futures

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Evaluating Educational Programs Impact on Texas students

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Problem Statement

1 Problem

TEA is the state agency in charge of public education in Texas. TEA designs programs to boost student performance and aims to measure its impact. However, Texas is diverse and causal inference is a challenge.

2 Objective

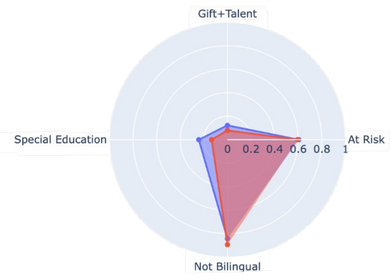
The objective of this project is to **measure the causal impact of TEA's initiatives on student success** by **optimally matching** classes that taught a new curriculum to control groups that didn't.

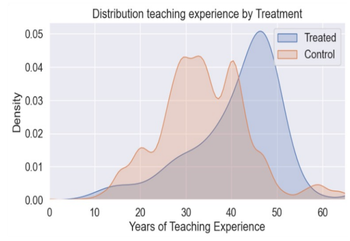
3 Data & EDA

We have 4 data sources

- Student demographics
- District data
- Teacher demographics
- Survey data

We compared treatment to control units





The units overlap, but there is selection bias

4 Timeline

Initial steps	Selection bias	Distance	Matching	Evaluation	Deliverables
• Receive data • Define scope • Literature • EDA	• Propensity scores • Dimension reduction	• Feature selection • Hard constraints	• Optimization model • KNN	• Metric definition • Model comparison	• Flexible Script • Report

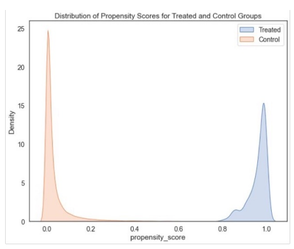
Feb | Mar | Apr | May | June | July | August

Methodology

5 Propensity Scores (PS)

Propensity scores (PS) account for selection bias in observational studies

Step 1: Compute PS

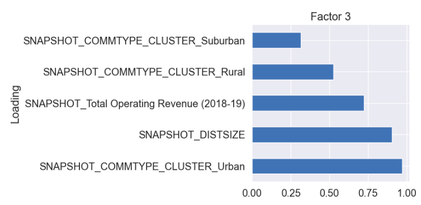


Logistic Regression
Model to predict likelihood of treatment for each unit

Overfitting *+70 features for 200 points*

Step 2: Dimension Reduction

Factor example: District type factor



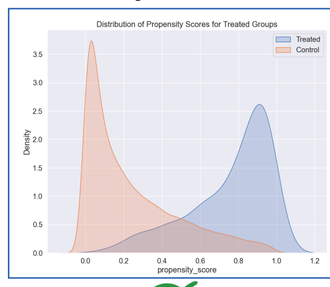
PCA and Factor Analysis
Compare techniques to reduce feature dimension and avoid overfitting

+70 features → *20 factors*

Choose Factor Analysis for higher interpretability

Class imbalance *200 treatment vs +35K control*

Step 3: PS on random subsets



Logistic Regression on random subsamples
Run PS for balanced random subsets and average PS for treated units

Balanced scores

6 Distance

Calculate distance for all combinations of treated and control

Original dataset

	X1	X2	X3	X4	T
T					1
C					0
C					0
T					1
C					0
C					0

1. Features to include — *All features or subset of relevant features*
2. Weighting features by importance — *High, Medium, or Low*
3. Adding penalties — *Ensures features are exact matches*

Distance matrix

	C1	C2	C3	C4	C5
T1	d_{11}				
T2					
T3					
T4					

Feature selection to get subset of most important features that explain the **outcome**

Ex: Matches need to be the same subject or grade

7 Matching

Wide range of matching options:

1:1 or 1:k | with or w/o replace | PS, Distance or PS Calipers | Optimal or greedy

Compare different algorithms, evaluate trade-offs, and recommend TEA which method to use while ensuring flexibility for future projects

Optimization model

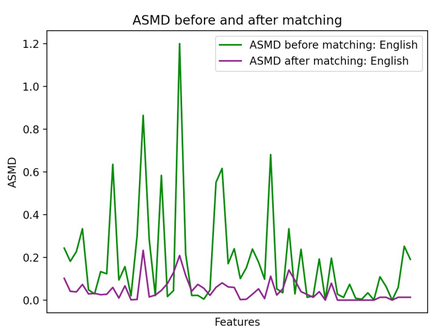
Objective function	Minimize total distance
Decision variable	Binary {1 if pair is selected, 0 otherwise}
Constraints	**C1**: Each treatment is matched with at least k control units **C2**: Each control is matched at most 1

Results and Impact

8 Results

Balance

Our matching results have proven to significantly reduce bias and increase balance across features, which allows TEA to confidently evaluate programs and communicate results to stakeholders.



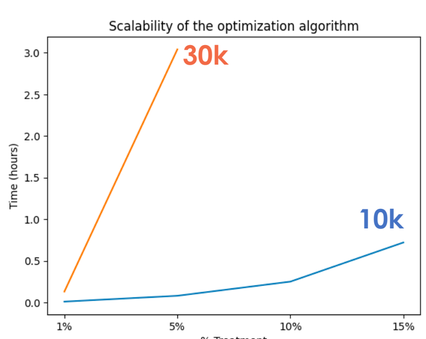
Treatment effect

Our tool performs a difference-in-difference analysis, where applicable, to measure the treatment effect. This automation will allow TEA to easily gauge the effect and significance of their initiatives.

"Continuous improvement is a core value at TEA. By rigorously evaluating our programs, we can encourage the field to adopt what works and improve what doesn't, to improve outcomes for all students in Texas."

Scalability

We have a scalable optimization model and a greedy model that can perform with varying data set sizes and different rations between control and treatment.



- **89% Bias Reduction** from unmatched data
- **80% Bias Reduction** from last year's baseline matching
- **100+** Different ways our script can be used to match

9 Deliverables

We presented these deliverables for TEA to summarize our project

Flexible Script
Flexible script to perform the matching and evaluation

Documentation
Explanation on code, installation, and optimization basics

Project overview
Project overview slides targeted to different TEA audiences

10 Next Steps

The next steps for our project are the following ones

Implementation
Implementation on other use cases

Selection
Choosing a matching method to evaluate 2023 CRIMSI results

Communication
Communicate project with stakeholders