# The Variables to Success

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*W200, Introduction to Data Science Programming*
*Thursday 630pm, Spring 2022*

# Research Questions

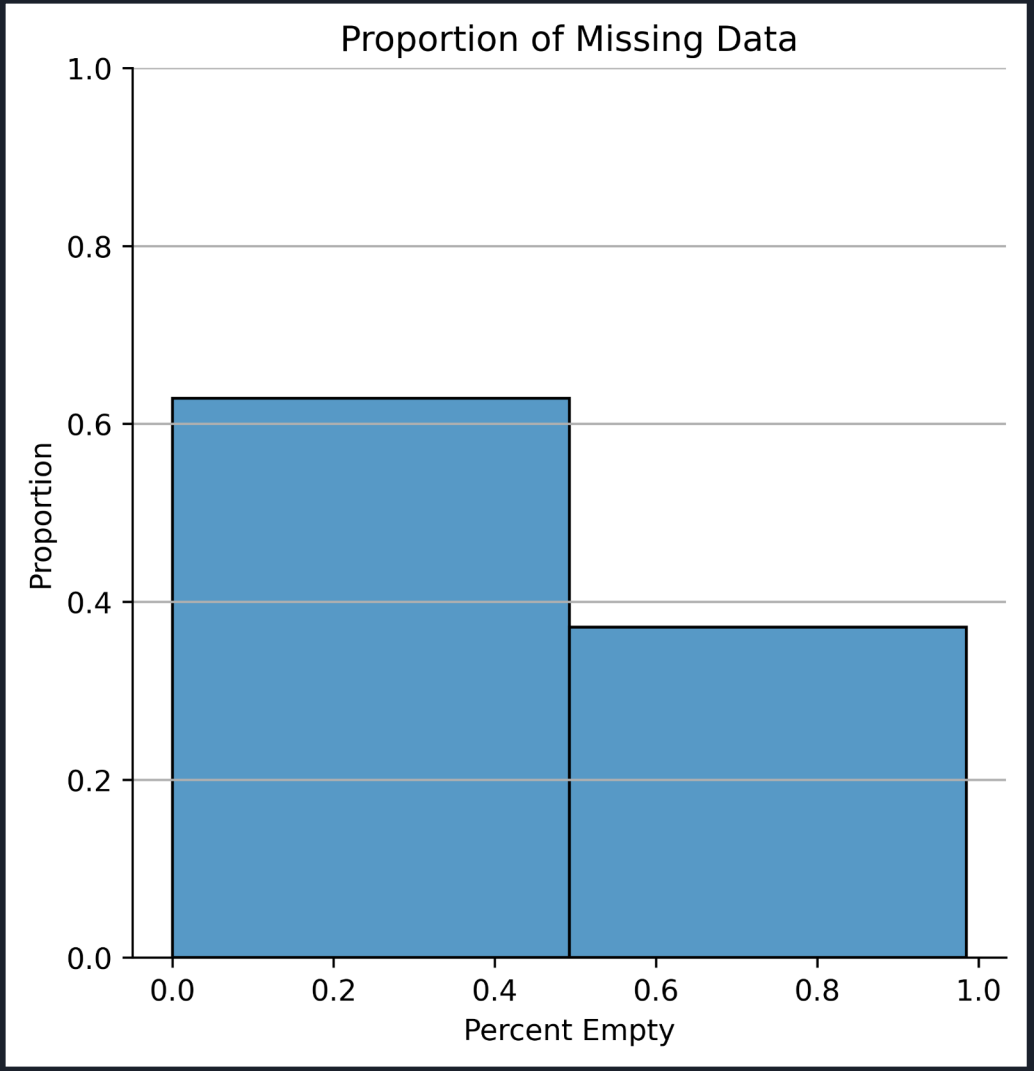
- Do students have higher earnings if their degree program was one of the top five degree programs for 2019?
- What top ten features are important in predicting higher earnings for students post graduation for 2019?

# Data Cleansing

- 24 CSV files from school years 1997 - 2020
- Transformation:
  - (170026, 2990) -> (48477, 175)
- From certificate to Graduate degrees

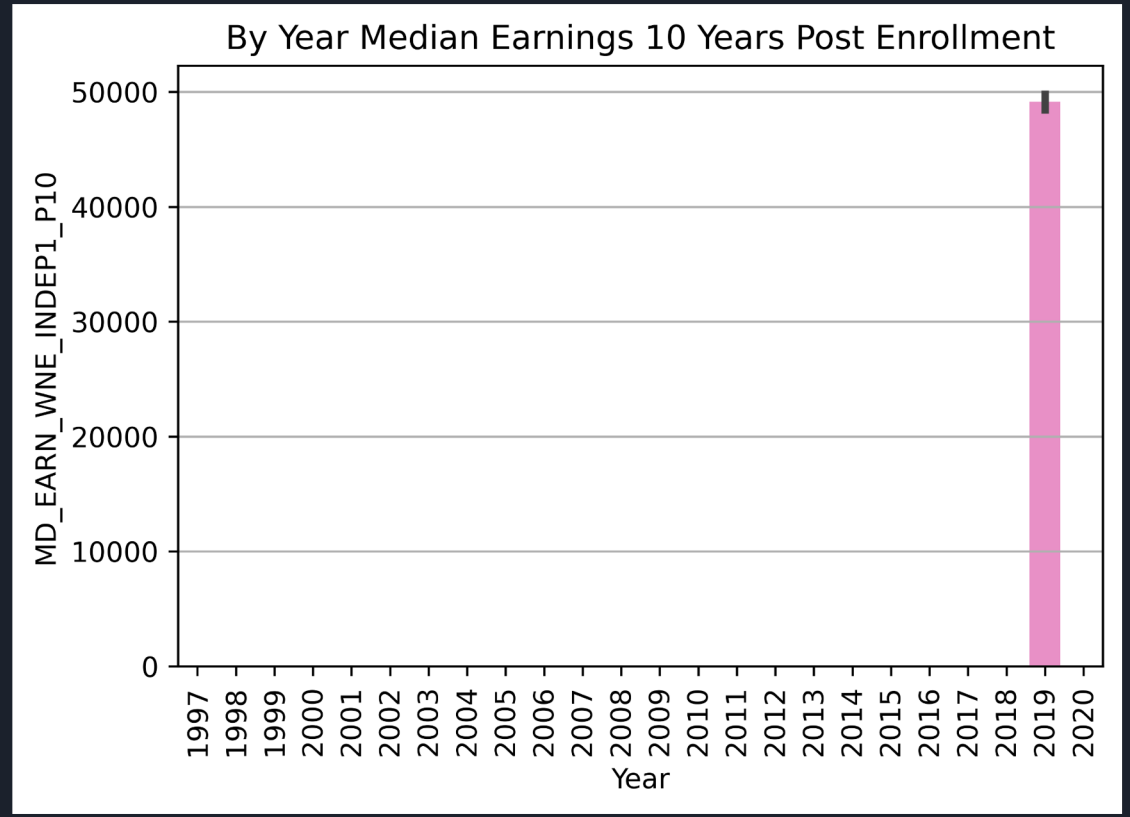
# Limitations

- ~40% of the columns have more than half of the data missing.
- Privacy Suppressed



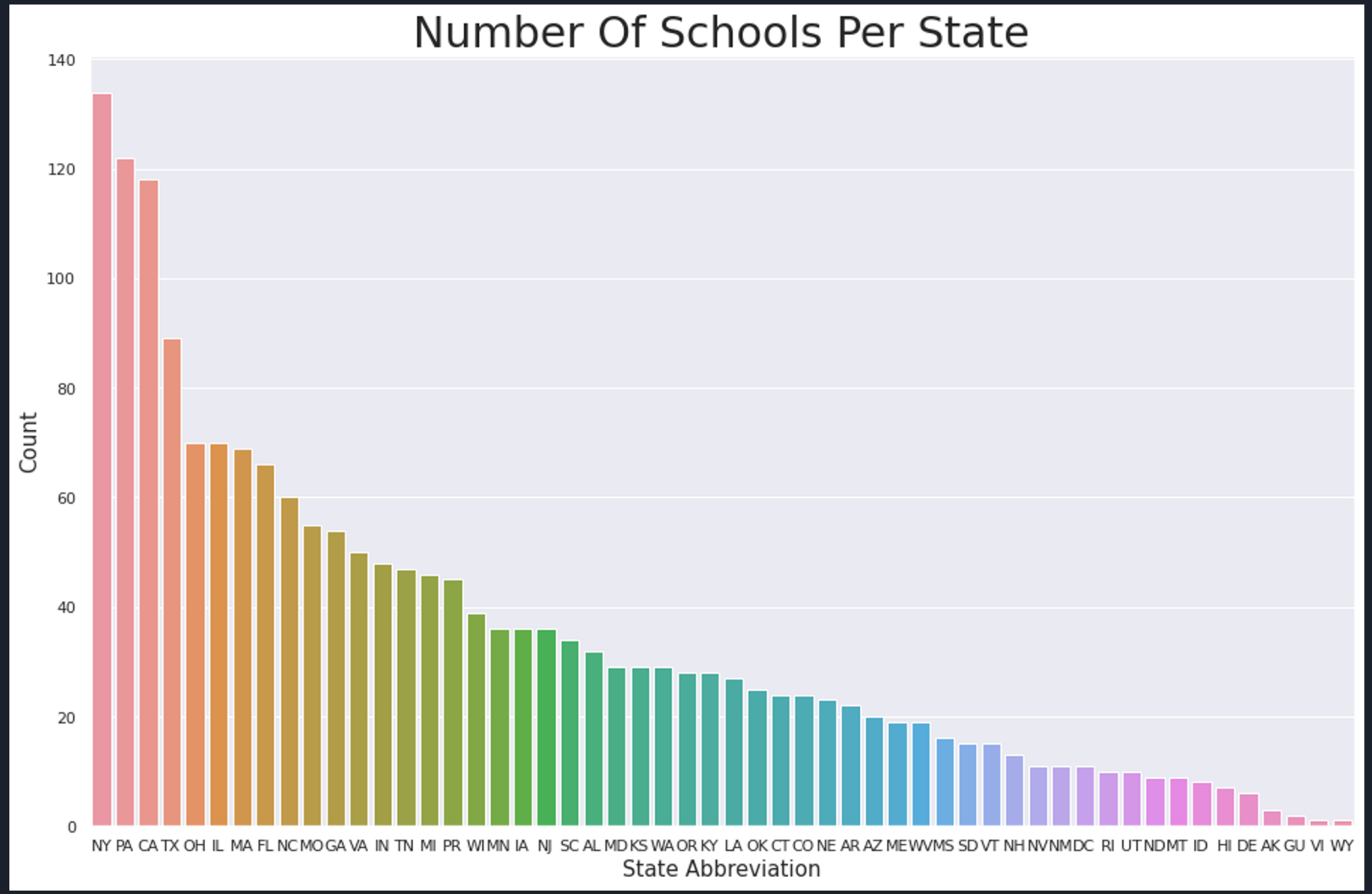
# Limitations

- Variables added as years passed
  - Median earnings of independent students working and not enrolled 10 years after entry (MD_EARN_WNE_INDEP1_P10)



# Exploratory Data Analysis

- Dataset consist of self reported information from 2,780 universities and colleges around the United States from 1997-2020
- The dataset does include US territories: Puerto Rico, Guam, and the Virgin islands which we left in the data set.
- The dataset itself has evolved over time but has never dropped any columns, so there were many columns that had Null values.
- Based on the question we are exploring, there were only 71 entries that had null values for the columns that we identified we needed to investigate our question.



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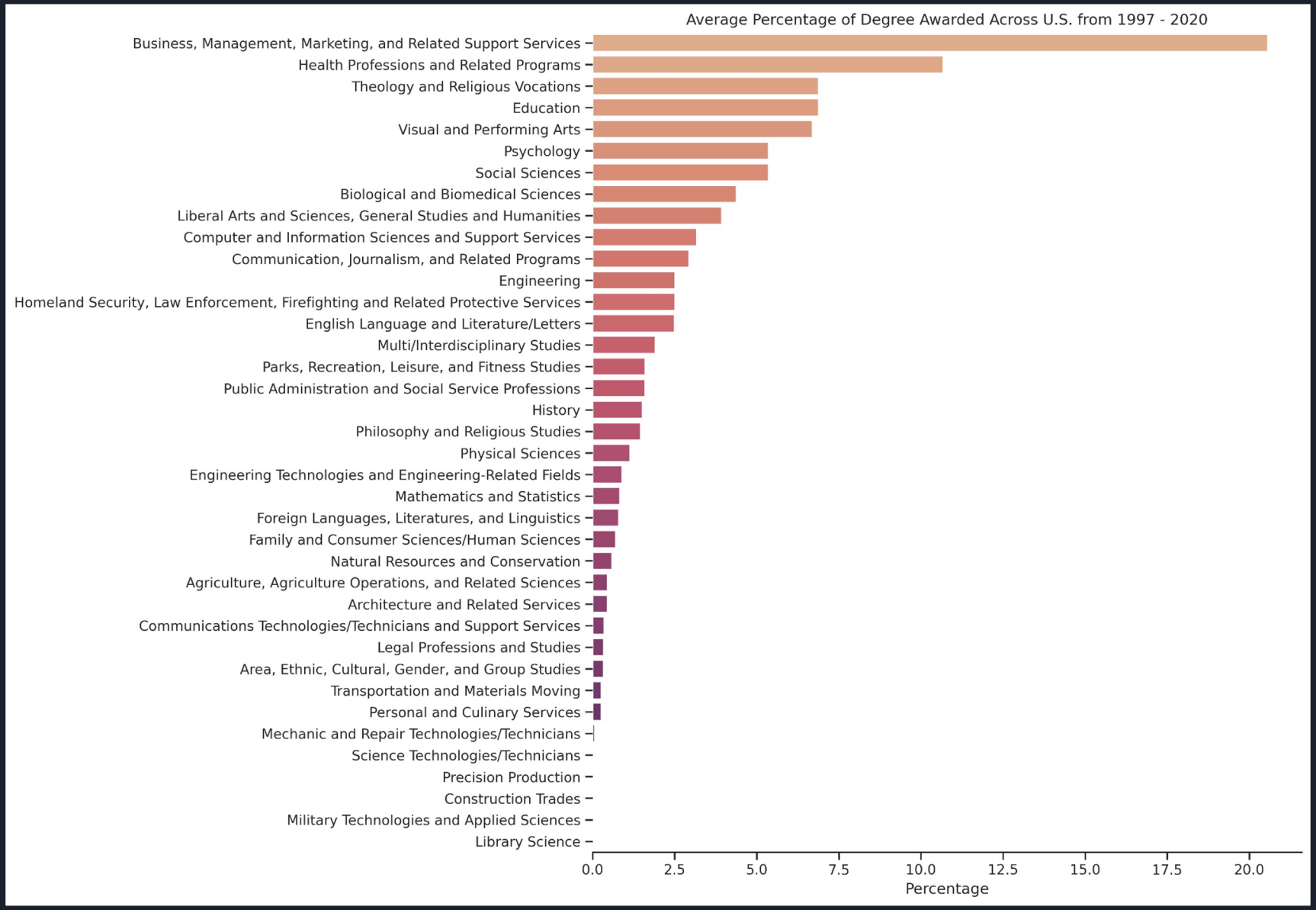

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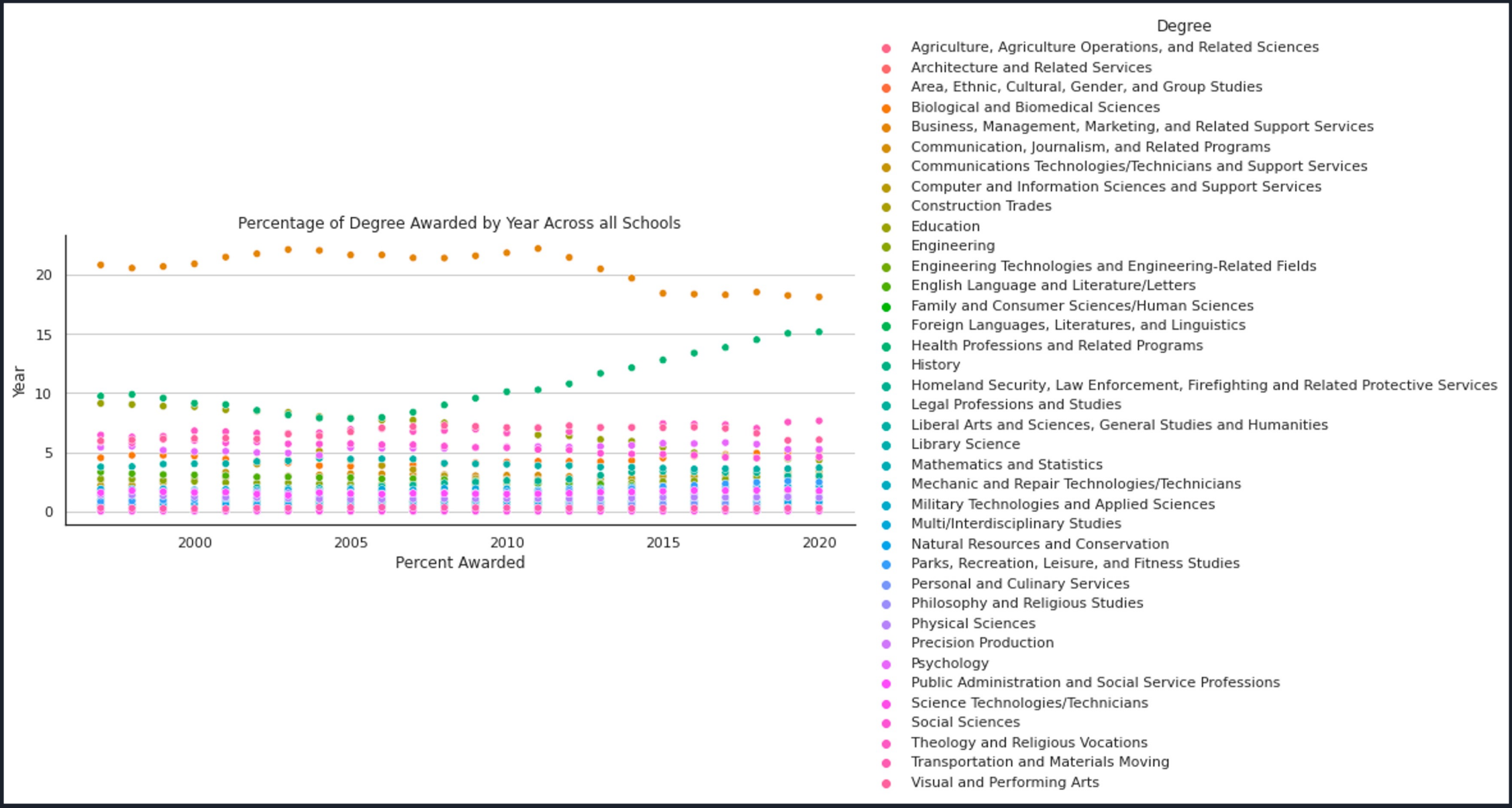

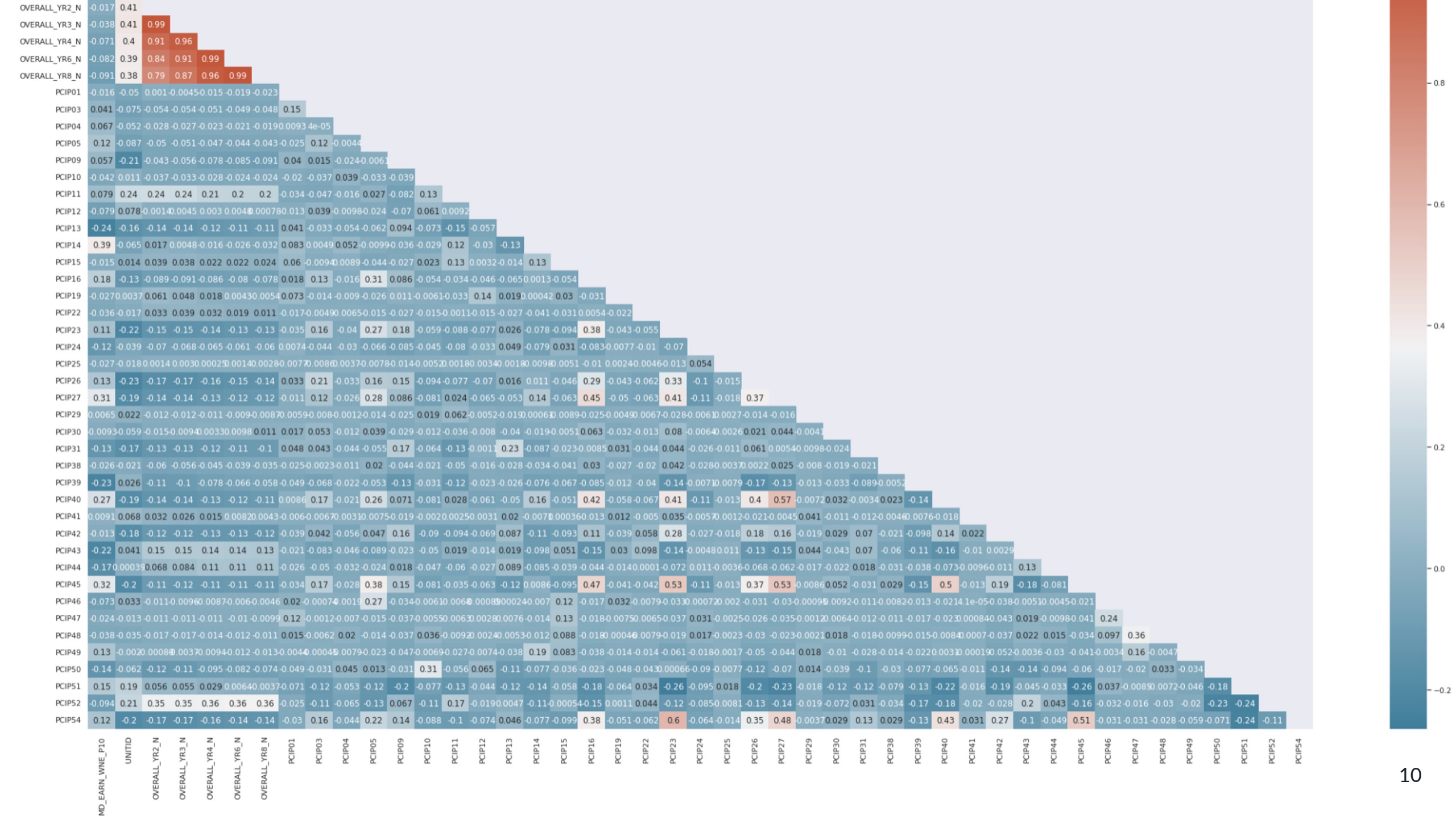
MD_EARN_WNE_P10
UNITID
OVERALL_YR2_N
OVERALL_YR3_N
OVERALL_YR4_N
OVERALL_YR6_N
OVERALL_YR8_N
PCIP01
PCIP03
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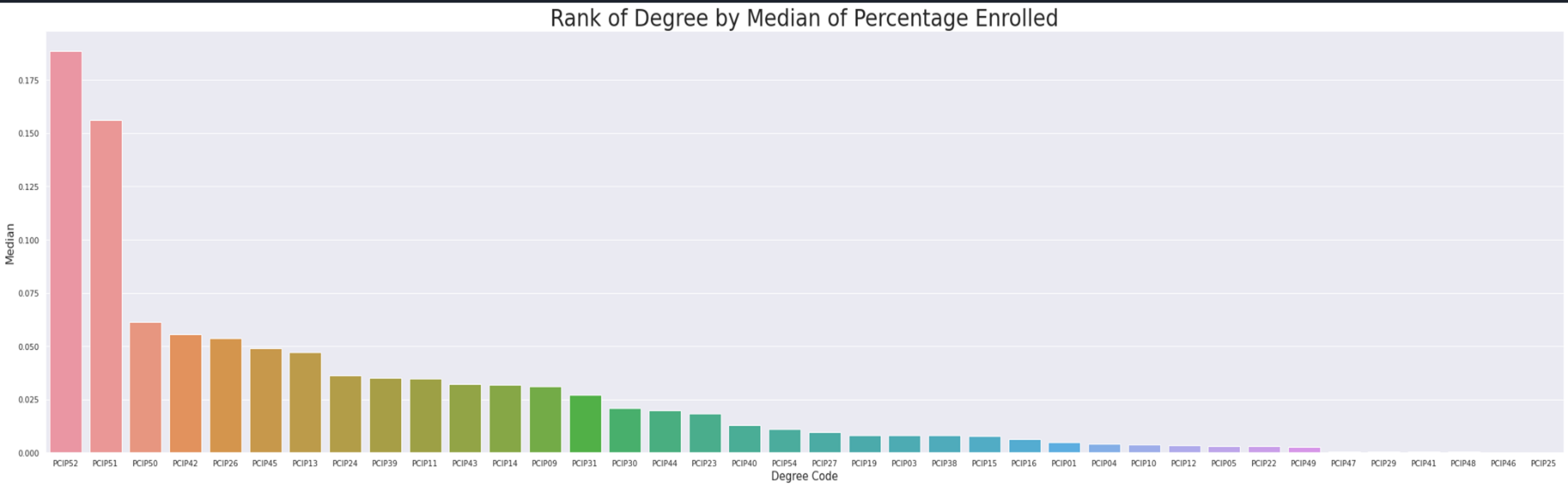
PCIP44
PCIP45
PCIP46
PCIP47
PCIP48
PCIP49
PCIP50
PCIP51
PCIP52
PCIP54
0.8
0.6
0.4
0.2
0.0
−0.2

# Exploratory Data Analysis

Top 5 degree programs by the median of students enrolled compared to total student body are:

1. PCIP52 - Percentage of degrees awarded in Business, Management, Marketing, And Related Support Services.
2. PCIP51 - Percentage of degrees awarded in Health Professions And Related Programs.
3. PCIP50 - Percentage of degrees awarded in Visual And Performing Arts.
4. PCIP42 - Percentage of degrees awarded in Psychology.
5. PCIP26 - Percentage of degrees awarded in Biological And Biomedical Sciences.



# Exploratory Data Analysis

## Correlation of top 5 Programs and Median Earning

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3. PCIP50 - Percentage of degrees awarded in Visual And Performing Arts.
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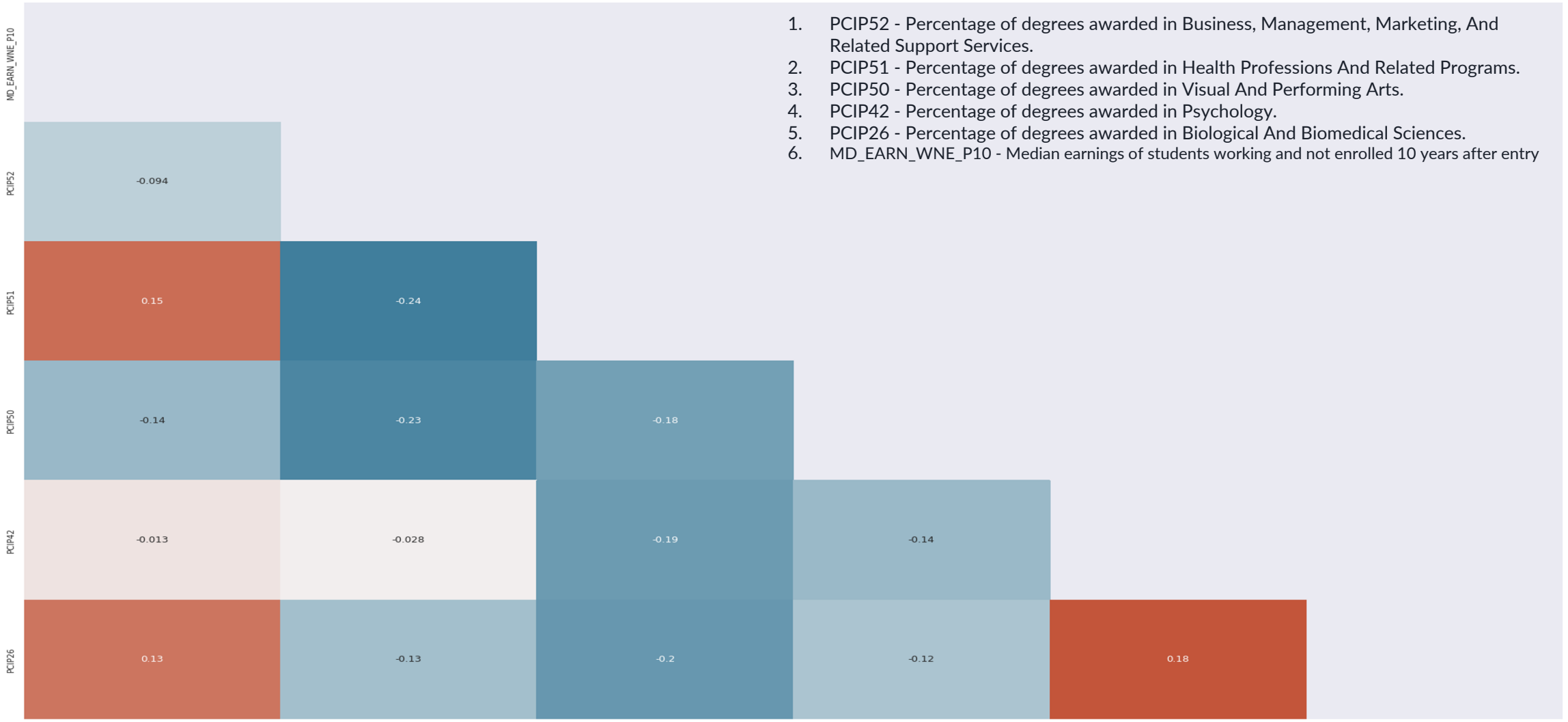
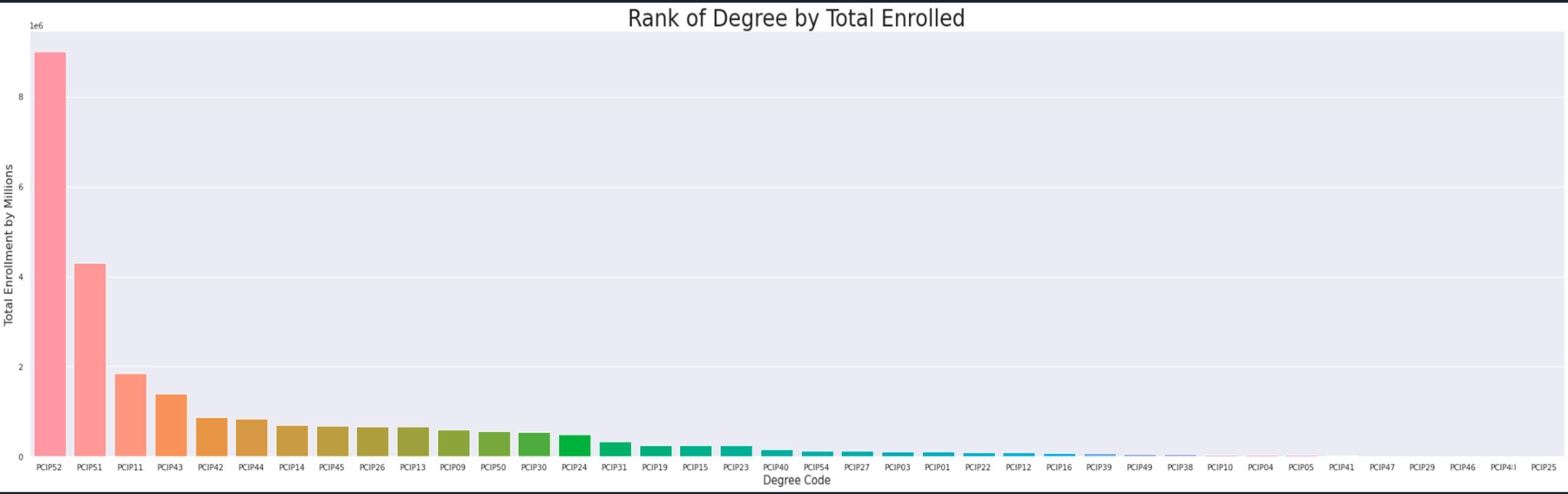
6. MD_EARN_WNE_P10 - Median earnings of students working and not enrolled 10 years after entry



# Exploratory Data Analysis

Top 5 degree programs by enrollment  are:

1. PCIP52 - Total Enrollment  for degrees awarded in Business, Management, Marketing, And Related Support Services.
2. PCIP51 - Total Enrollment  for degrees awarded in Health Professions And Related Programs.
3. PCIP11 - Total Enrollment  for degrees  awarded in Computer And Information Sciences And Support Services.
4. PCIP43 - Total Enrollment  for degrees  awarded in Homeland Security, Law Enforcement, Firefighting And Related Protective Services.
5. PCIP42 - Total Enrollment  for degrees  awarded in Psychology.



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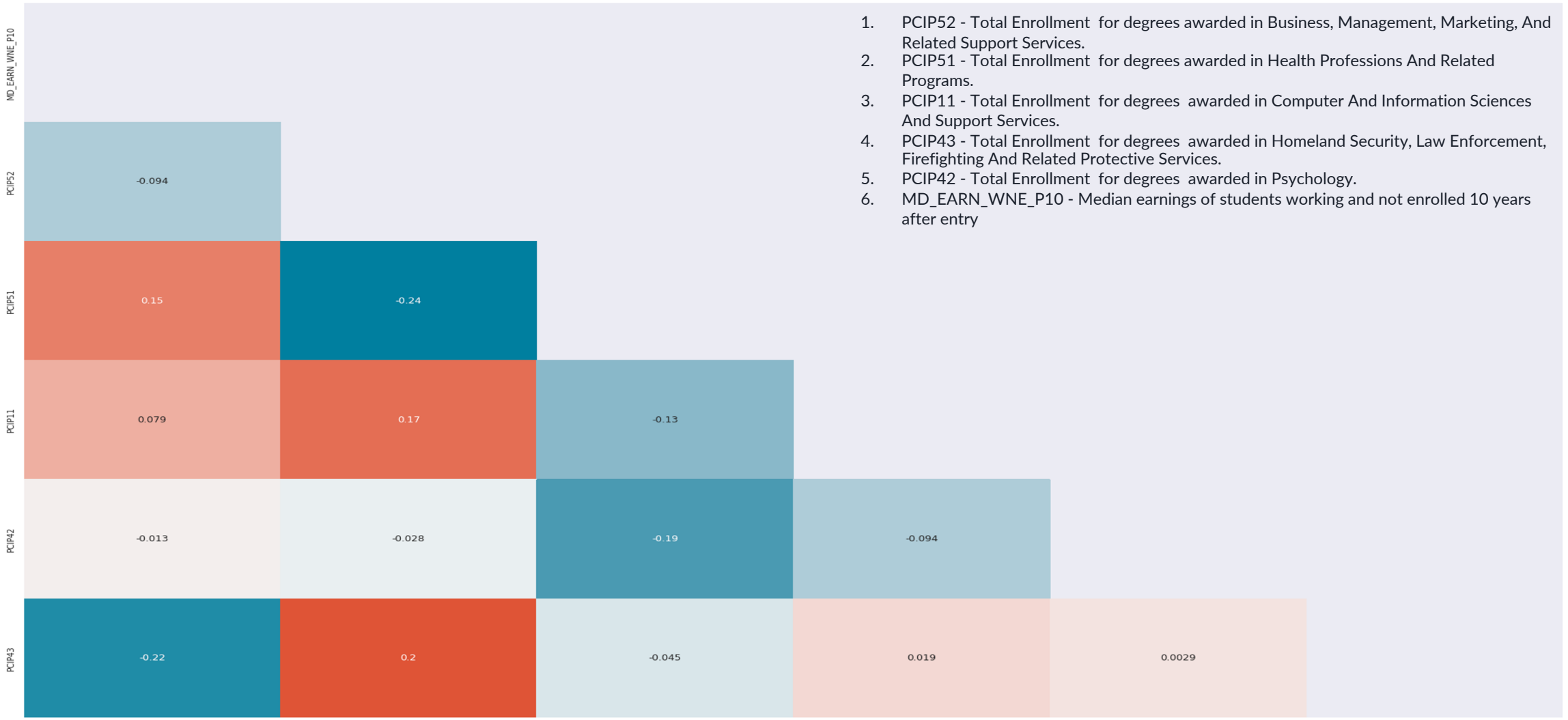

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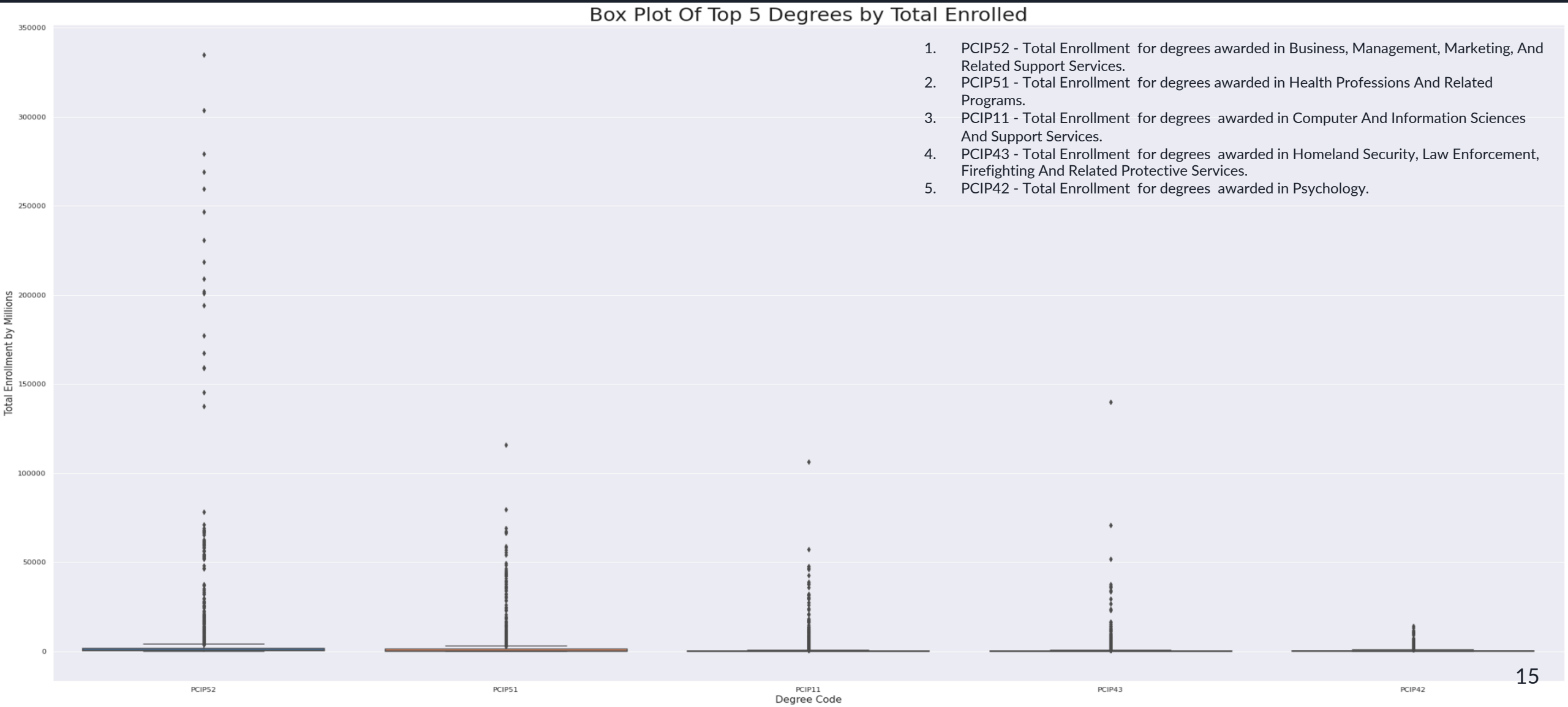


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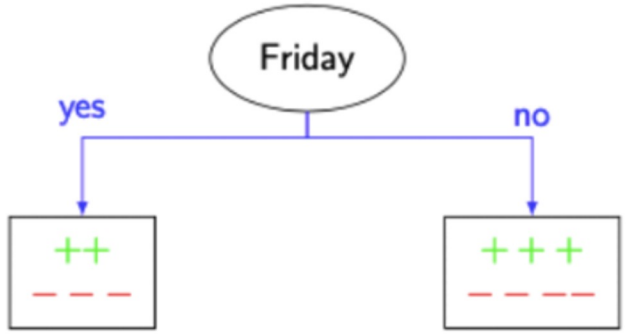
## Summary

- Create a tree with maximum depth
  - Either until every leaf is a single data point
  - Or use all features
- Pick a subtree (a node and all leaves)
- Aggregate that leaves all the way to the node
- Compute new error
  - Misclassification
  - Entropy
- Pruning is expensive
- Pruning is counter-intuitive
  - Fixing a bad model
- How about directly building a better model

## Decision Tree




Loss: 0.97928

- $H(S_1) = -\frac{2}{5}\log\frac{2}{5} - \frac{3}{5}\log\frac{3}{5} = .97$
- $H(S_2) = -\frac{3}{7}\log\frac{3}{7} - \frac{4}{7}\log\frac{4}{7} = .99$
- Entropy of Split: .

$$.97 * \frac{5}{12} + .99 * \frac{7}{12} = .979$$

- $IG = H(Y) - .979 = 1 - .929 = .021$
- *Not a great split.*

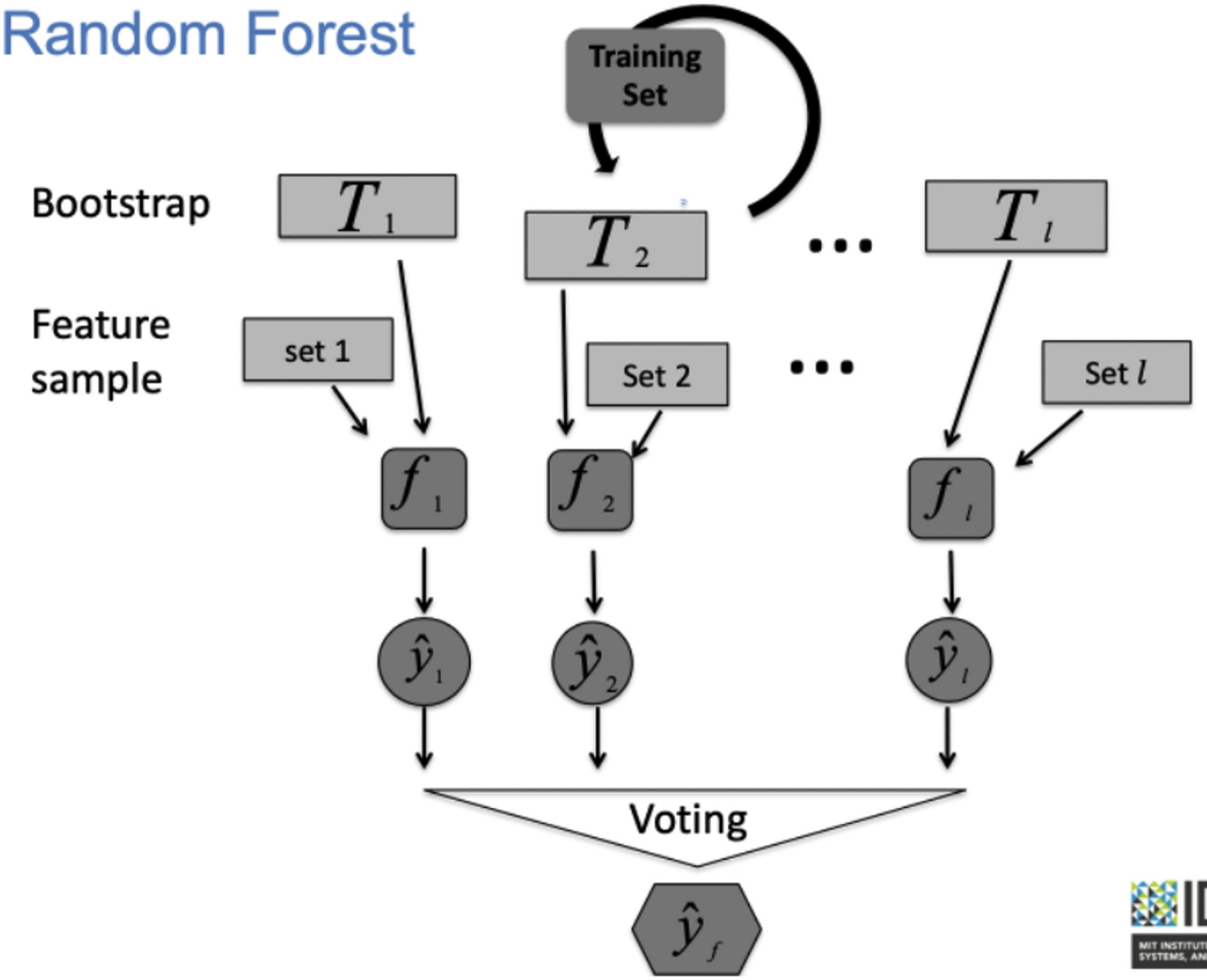
## Ensemble Learning/Random Forest

- Ensemble Methods are the key idea behind Random Forests
- Motivated by averaging techniques
- You can reduce the variance if you average a number of independent RVs

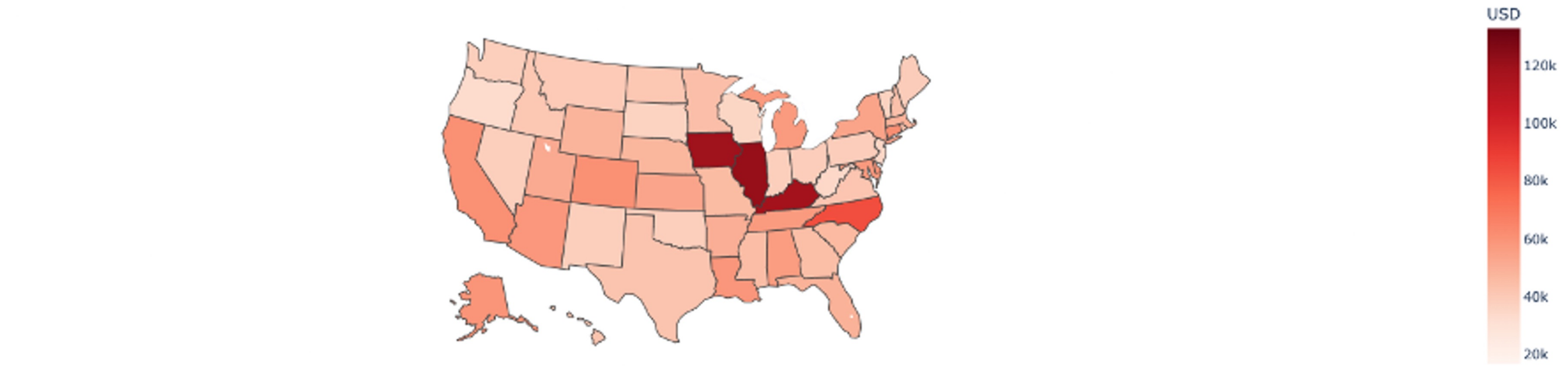
## Summary: Bagging

- Bagging= Bootstrap + Aggregation
- Bootstrap: sample with replacement
- Build a tree classifier with each sample
- Aggregate through majority voting

# Random Forest



# Students’ Median Earning by State



# Models and Performance

- Feature Engineering:
  - Categorical variables:
    - Group school level data by regions and impute missing values with the mode
    - Convert each categorical variable into dummy
  - Continuous variables:
    - Group data by school and year, and impute missing with the mean
    - Convert continuous variables into categorical ones by creating bins
- Target (Binary) - MD_EARN_WNE_P10 (Median earnings of students working and not enrolled 10 years after entry)
  - 1, if MD_EARN_WNE_P10> median
  - 0, else
- Random forest is more accurate than single decision trees, but it is not as comprehensible as decision trees.
- Important features from both models include:
  - Average cost of attendance
  - Enrollment of degree-seeking students and diversity of students
  - Average net price of family income
  - Degree programs
  - Type of school

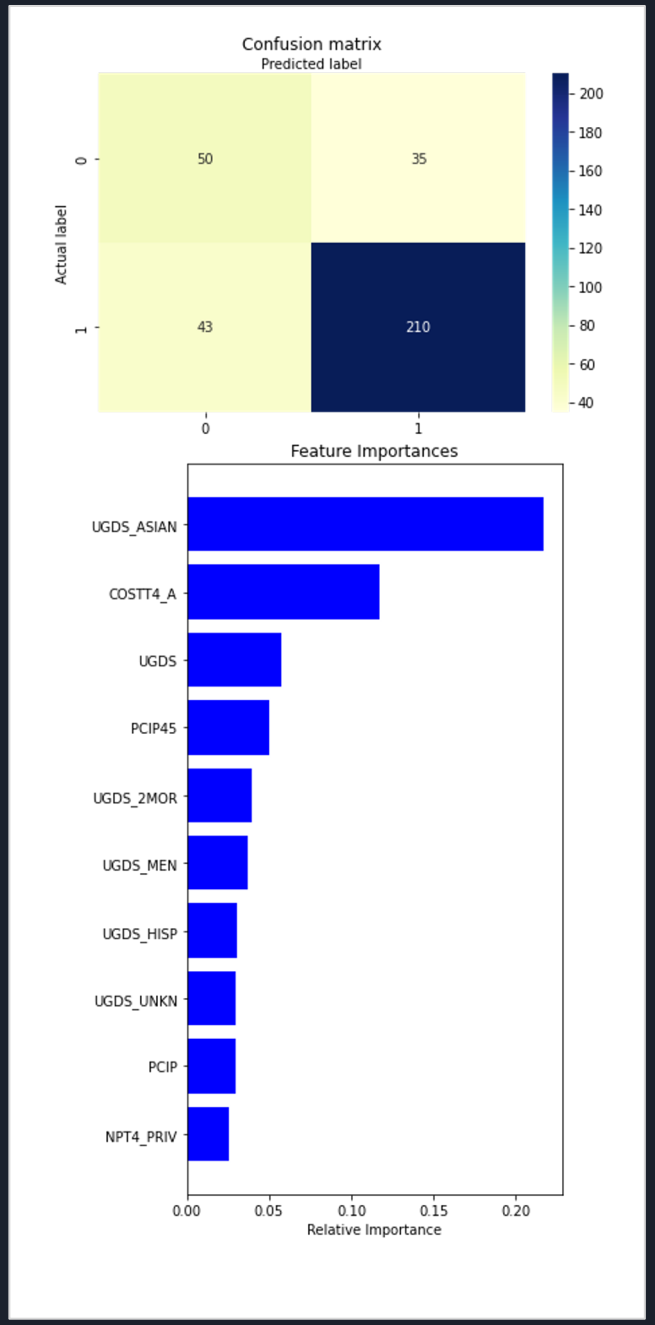
Classification Report for

| | precision | recall | f1-score | support |
|---|---|---|---|---|
| 0 | 0.86 | 0.50 | 0.64 | 113 |
| 1 | 0.85 | 0.97 | 0.91 | 338 |
| accuracy | | | 0.86 | 451 |
| macro avg | 0.86 | 0.74 | 0.77 | 451 |
| weighted avg | 0.86 | 0.86 | 0.84 | 451 |

Classification Report for RF

| | precision | recall | f1-score | support |
|---|---|---|---|---|
| 0 | 0.86 | 0.50 | 0.64 | 113 |
| 1 | 0.85 | 0.97 | 0.91 | 338 |
| accuracy | | | 0.86 | 451 |
| macro avg | 0.86 | 0.74 | 0.77 | 451 |
| weighted avg | 0.86 | 0.86 | 0.84 | 451 |

Confusion Matrix and Top 10 Features from DT

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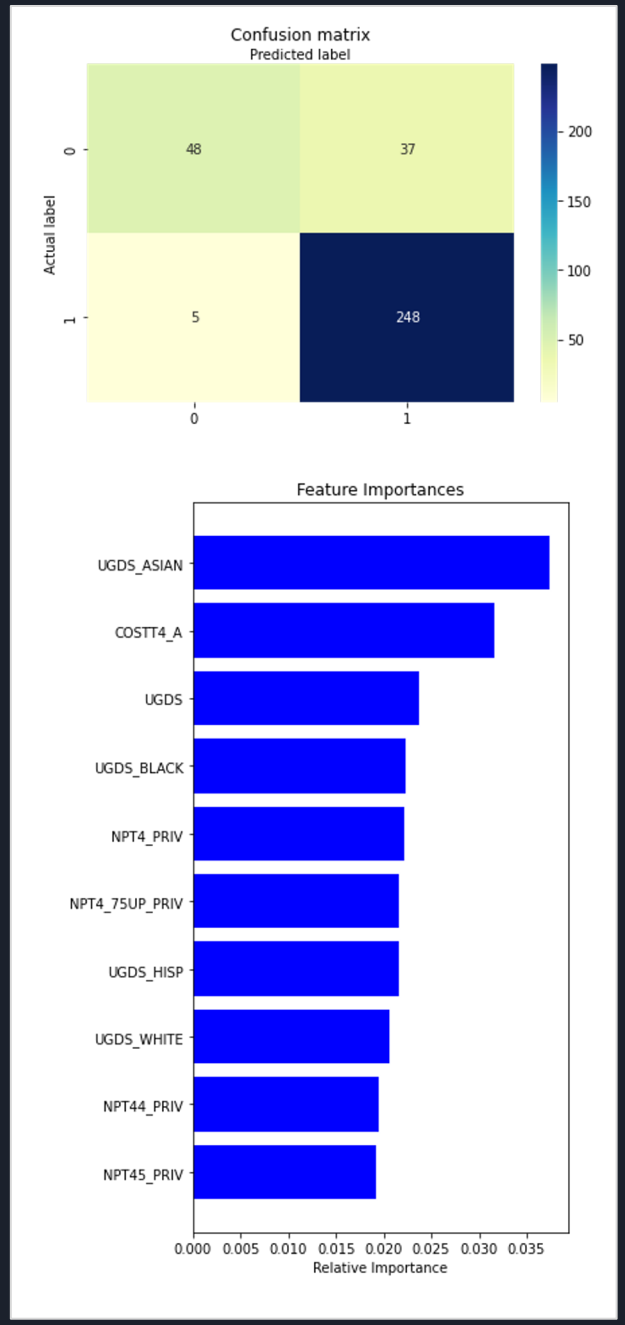

# References

U.S Department of Education (2020). *College Scorecard Institution-Level Data* [Data Files]. Available from College Scorecard https://collegescorecard.ed.gov/data/