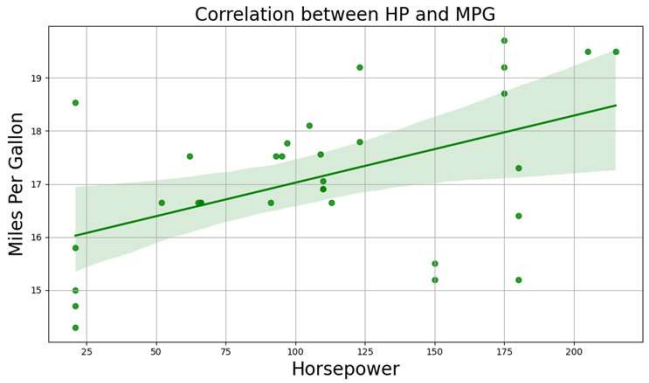
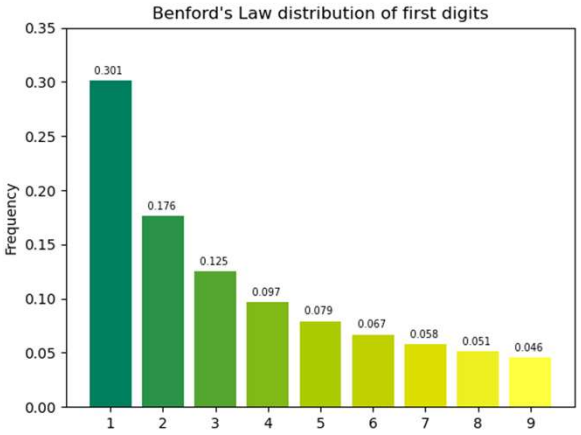
Correlation Reversal Manipulation Revealed By Benford's Law and Random Forest

Poj Netsiri, TU Wien Data Science

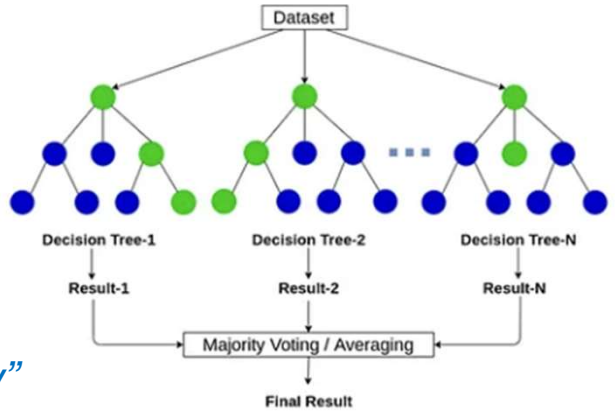
Q: Can we trust this data?



Benford's Law
(Statistical Analysis)



Random Forest
(Machine Learning)

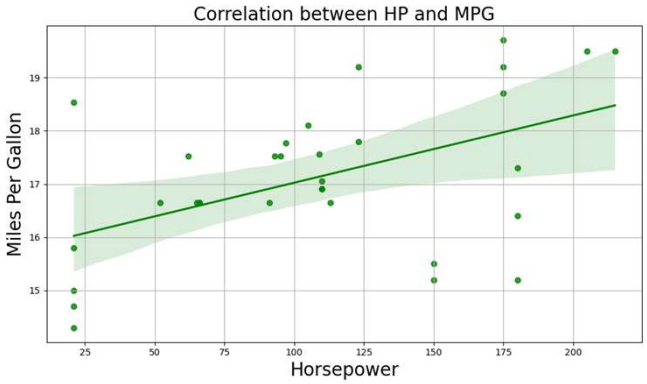


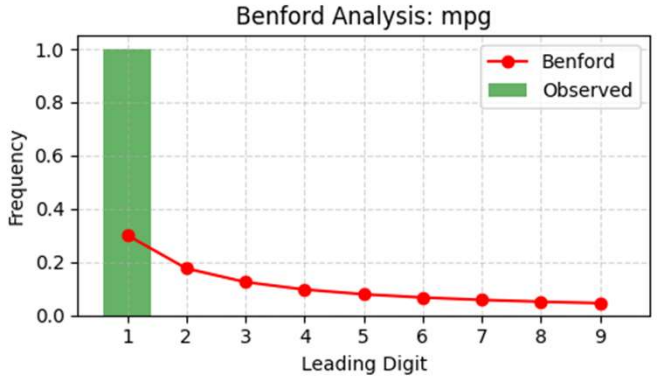
From the given data:

r = +0.5, p <0.001

"Cars with higher horsepower achieve better fuel efficiency"

Using Benford's Law to Detect Manipulation





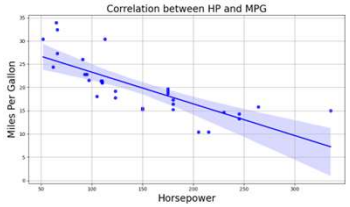
Chi-square = 74.3017, p-value = 0.0000000000006

Criteria: Chi-square > 30.58 and p < 0.0001

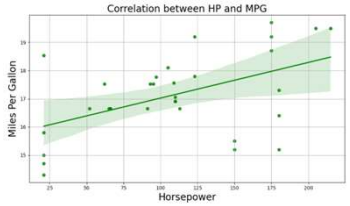
Classified as **manipulated** (anomaly and extreme)

Using Random Forest to Detect Manipulation

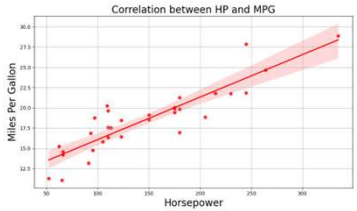
Original Data (Label=0)



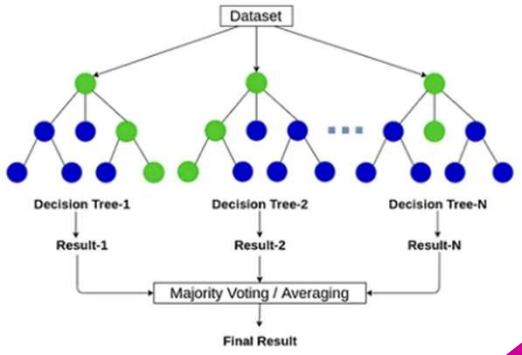
Manipulated Data (Label=1)



New Manipulated Data



Supervised Training



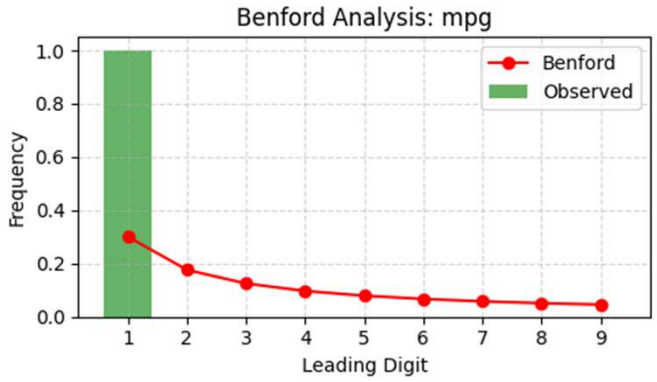
RF Model

Classifier

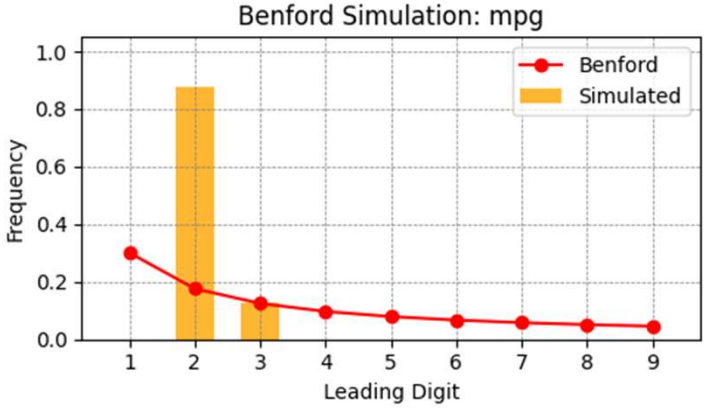
RF Model

Classified as **manipulated**

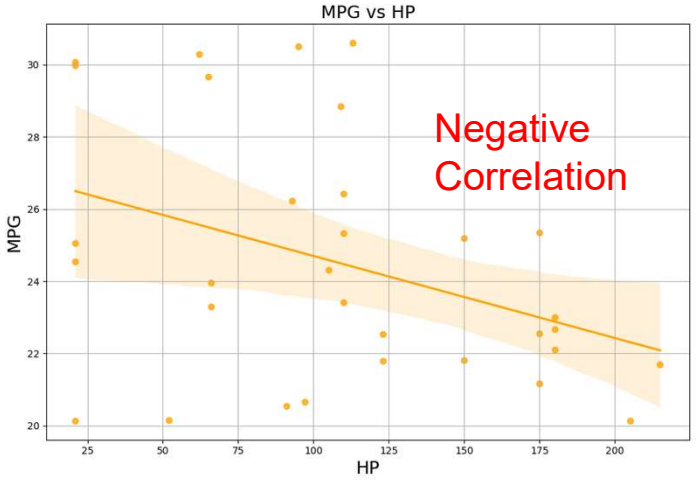
Using Benford's Law to Detect Correlation Reversal

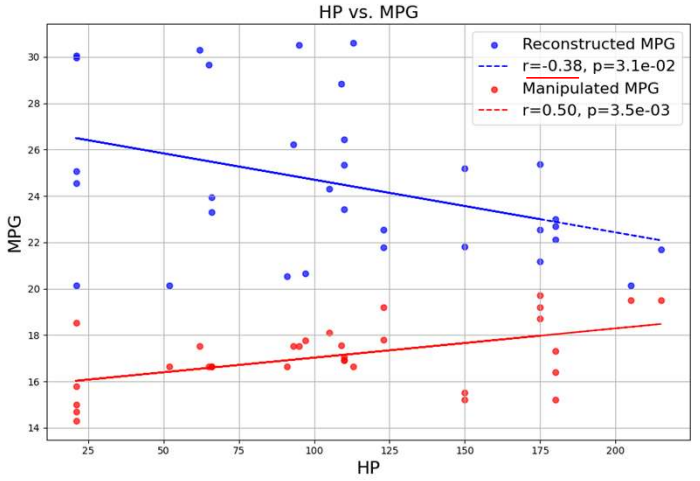


Stochastic Simulation



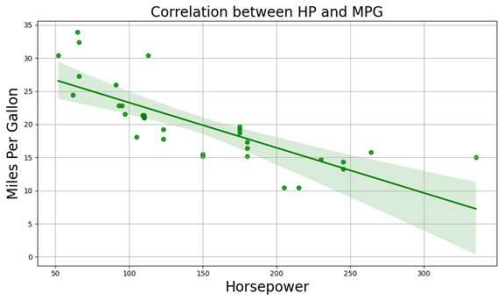
Reconstructed Data



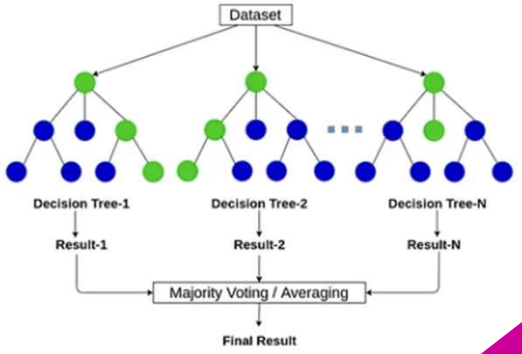


Using Random Forest to Detect Correlation Reversal

Original Data

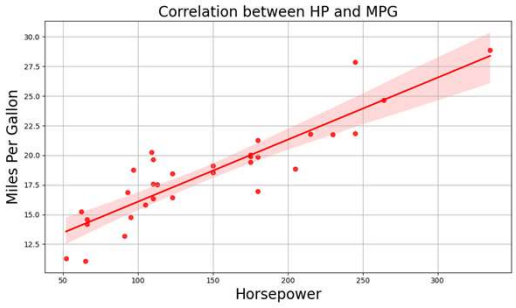


Training



RF Model

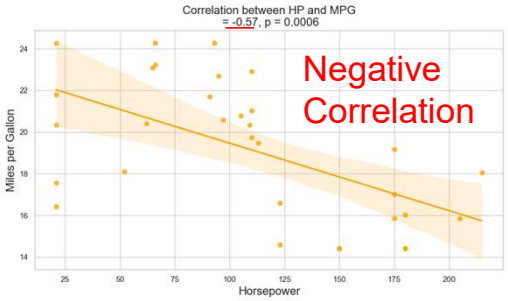
Manipulated Data

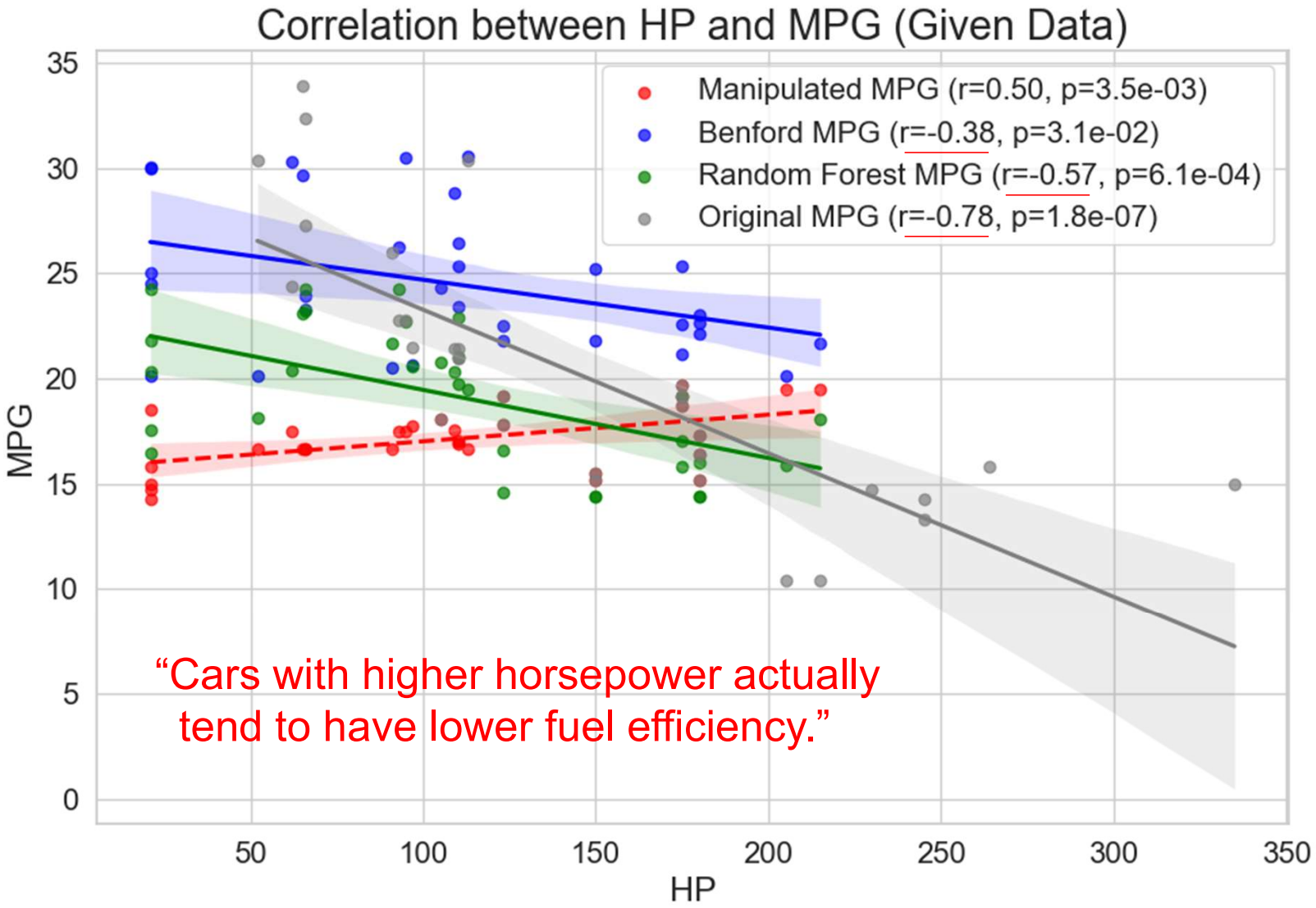


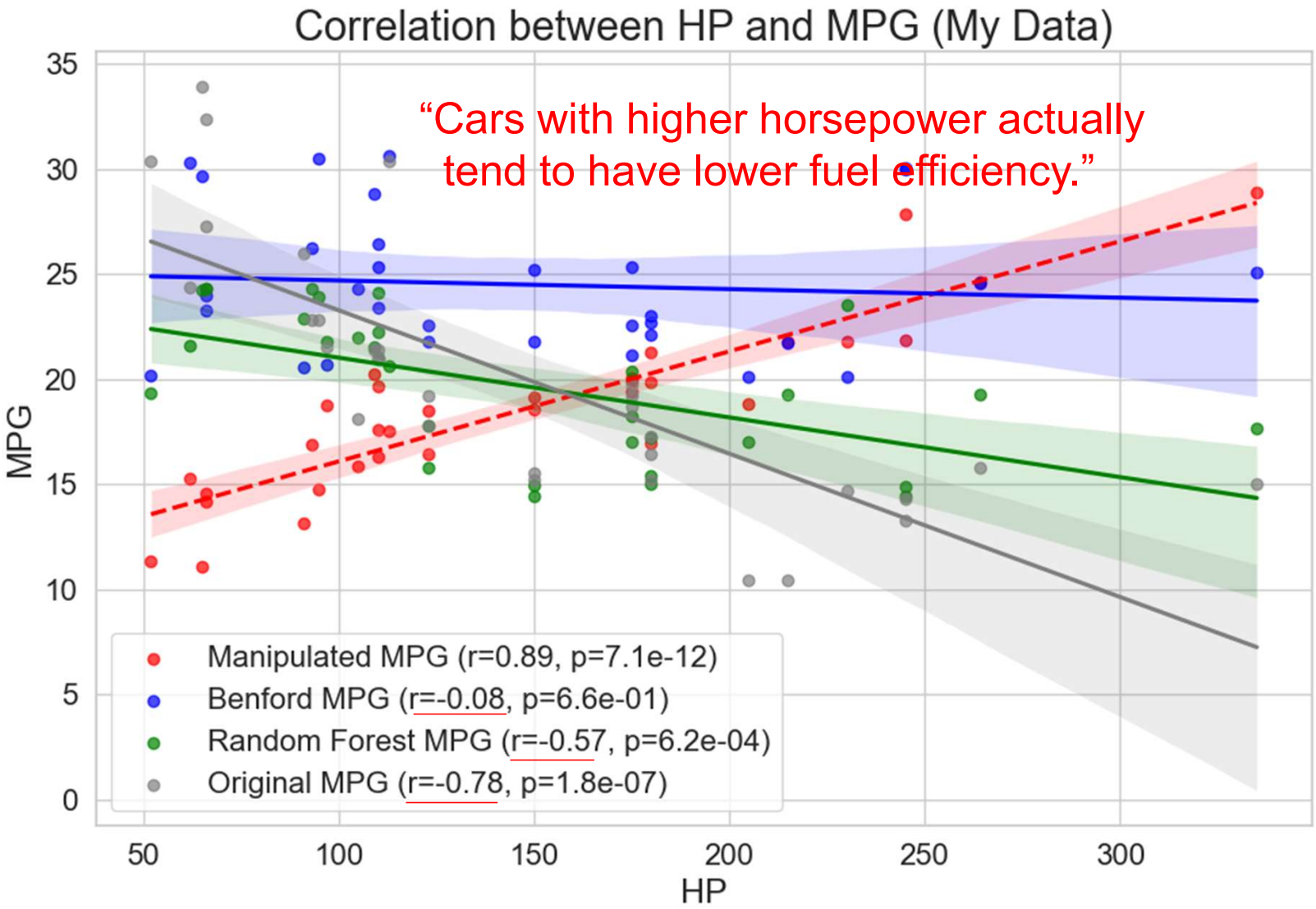
Regressor

RF Model

Reconstructed Data




Correlation between HP and MPG (Given Data)
Manipulated MPG (r=0.50, p=3.5e-03)
Benford MPG (r=-0.38, p=3.1e-02)
Random Forest MPG (r=-0.57, p=6.1e-04)
Original MPG (r=-0.78, p=1.8e-07)
MPG
HP
0
5
10
15
20
25
30
35
50
100
150
200
250
300
350
"Cars with higher horsepower actually tend to have lower fuel efficiency."


Correlation between HP and MPG (My Data)
"Cars with higher horsepower actually tend to have lower fuel efficiency."
MPG
HP
35
30
25
20
15
10
5
0
50
100
150
200
250
300
Manipulated MPG (r=0.89, p=7.1e-12)
Benford MPG (r=-0.08, p=6.6e-01)
Random Forest MPG (r=-0.57, p=6.2e-04)
Original MPG (r=-0.78, p=1.8e-07)

Evaluation of Random Forest Classifier and Regressor

```
=== Random Forest Classification Evaluation ===
              precision    recall  f1-score   support

           0       0.83      1.00      0.91         5
           1       1.00      0.88      0.93         8


=== Random Forest Regression Evaluation  ===
R² Score              : 0.6643
Mean Squared Error : 4.1079
Mean Absolute Error: 1.7576
```

Conclusion

1. Benford's law can detect data manipulation and correlation reversal.
2. Random Forest Algorithm can also detect data manipulation and correlation reversal.
3. Random Forest could approximate original data better than Benford's law (84% vs. 45%).
4. The original data was manipulated to show positive correlation between HP and MPG while still $p < 5\%$.