Epsilon

JULY 15, 2024

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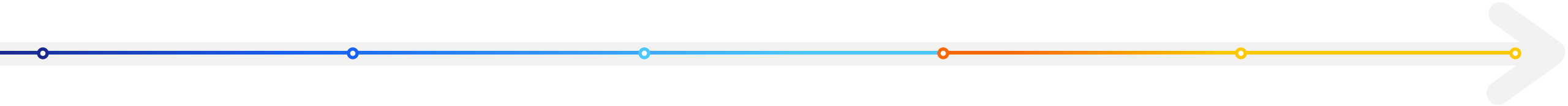
Analysis on Company XYZ Advertising

Roadmap



Data Cleaning **Data Analysis** **Establishing KPIs** **Data Analysis** **Interpret Results**

Step 1: Import Libraries to Load Data

- Use **pandas** to insert data

View of data when first loaded in

	Company Name (ID)	Campaign Name	Week Start Date	Advertising Spend	People Reached	Customers Acquired by Campaign	Campaign Conversions	Ads Delivered	Campaign Revenue
0	Brand XYZ	Campaign A	7/26/2020	$57	7,786	2	2	10,007	$203
1	Brand XYZ	Campaign A	8/2/2020	$1,140	124,987	28	29	199,975	$7,976
2	Brand XYZ	Campaign A	8/2/2020	$924	95,252	7	7	162,167	$1,130
3	Brand XYZ	Campaign A	8/9/2020	$853	87,318	56	58	149,655	$9,401
4	Brand XYZ	Campaign A	8/9/2020	$915	97,319	16	16	160,593	$2,276

Step 2: Data Cleaning (1/3)

Data types loaded in as strings…

```
Company Name (ID)                  object
Campaign Name                      object
Week Start Date                    object
Advertising Spend                  object
People Reached                     object
Customers Acquired by Campaign     object
Campaign Conversions               object
Ads Delivered                      object
Campaign Revenue                   object
dtype: object
```

…Data types converted to floats and date

```
Company Name (ID)                          object
Campaign Name                              object
Week Start Date                    datetime64[ns]
Advertising Spend                         float64
People Reached                            float64
Customers Acquired by Campaign            float64
Campaign Conversions                      float64
Ads Delivered                             float64
Campaign Revenue                          float64
dtype: object
```

- Commas and $ were removed from strings and converted into numeric floats

Step 2: Data Cleaning (2/3)

View of data after data type transformation

	Company Name (ID)	Campaign Name	Week Start Date	Advertising Spend	People Reached	Customers Acquired by Campaign	Campaign Conversions	Ads Delivered	Campaign Revenue
0	Brand XYZ	Campaign A	2020-07-26	57.0	7786.0	2.0	2.0	10007.0	203.0
1	Brand XYZ	Campaign A	2020-08-02	1140.0	124987.0	28.0	29.0	199975.0	7976.0
2	Brand XYZ	Campaign A	2020-08-02	924.0	95252.0	7.0	7.0	162167.0	1130.0
3	Brand XYZ	Campaign A	2020-08-09	853.0	87318.0	56.0	58.0	149655.0	9401.0
4	Brand XYZ	Campaign A	2020-08-09	915.0	97319.0	16.0	16.0	160593.0	2276.0

Step 2: Data Cleaning (3/3)

Searched for the following:

- Invalid Values
- Missing Values
- Outliers

Identified outliers as values greater than 10 standard deviations above the mean

Found outlier in Campaign Revenue

```
Outliers:
   Company Name (ID) Campaign Name Week Start Date  Advertising Spend  \
45         Brand XYZ    Campaign D      2020-04-05             1365.0

    People Reached  Customers Acquired by Campaign  Campaign Conversions  \
45         34890.0                            25.0                  26.0

    Ads Delivered  Campaign Revenue
45       227517.0      1.030402e+12
```

Step 3: KPI and Additional Metrics (1/2)

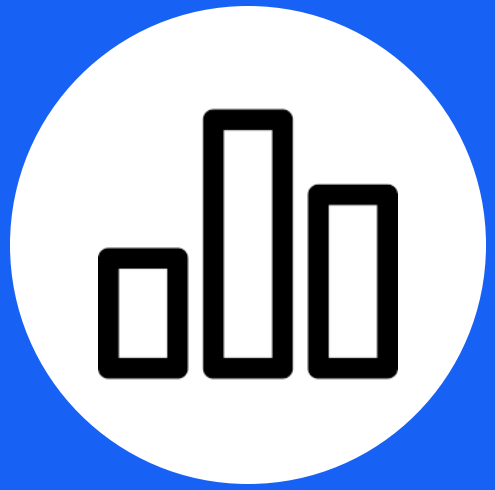
1. **CPA** → $\frac{\text{Advertising Spend}}{\text{Customers Acquired by Campaign}}$
2. **Profit** → Campaign Revenue x 0.05
3. **Conversion Rate** → $\frac{\text{Campaign Conversions}}{\text{People Reached}}$
4. **ROAS** → $\frac{\text{Campaign Revenue}}{\text{Advertising Spend}}$

Step 3: KPI and Additional Metrics (2/2)

View of data after additional metrics included

	Company Name (ID)	Campaign Name	Week Start Date	Advertising Spend	People Reached	Customers Acquired by Campaign	Campaign Conversions	Ads Delivered	Campaign Revenue	Profit	Conversion Rate	Cost per Acquisition	ROAS
0	Brand XYZ	Campaign A	2020-07-26	57.0	7786.0	2.0	2.0	10007.0	203.0	10.15	0.000257	28.500000	3.561404
1	Brand XYZ	Campaign A	2020-08-02	1140.0	124987.0	28.0	29.0	199975.0	7976.0	398.80	0.000232	40.714286	6.996491
2	Brand XYZ	Campaign A	2020-08-02	924.0	95252.0	7.0	7.0	162167.0	1130.0	56.50	0.000073	132.000000	1.222944
3	Brand XYZ	Campaign A	2020-08-09	853.0	87318.0	56.0	58.0	149655.0	9401.0	470.05	0.000664	15.232143	11.021102
4	Brand XYZ	Campaign A	2020-08-09	915.0	97319.0	16.0	16.0	160593.0	2276.0	113.80	0.000164	57.187500	2.487432

Step 4: Data Analysis



Summary Statistics

ANOVA Test

Tukey's HSD Test

Regression Analysis

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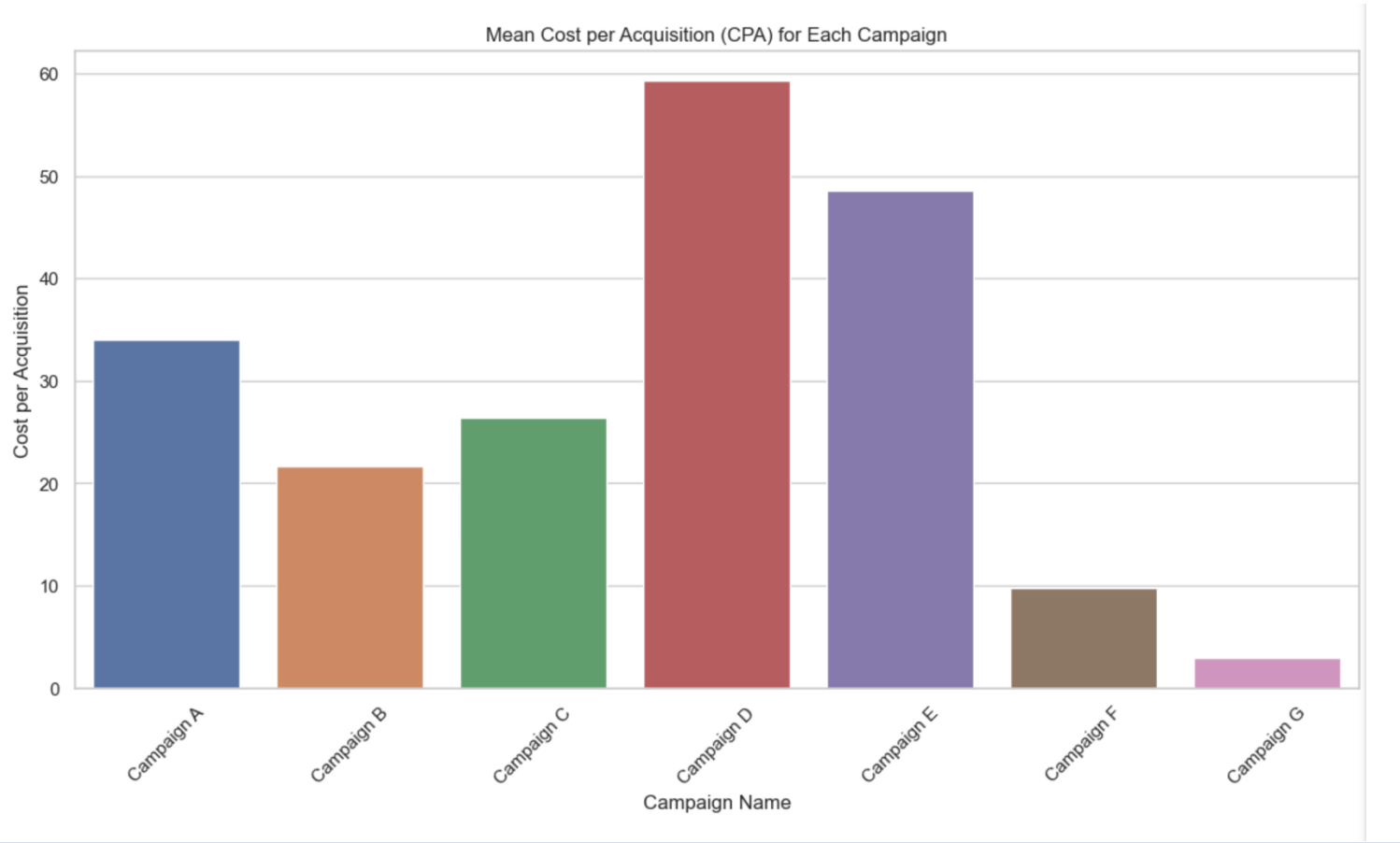
Step 4: Data Analysis: Summary Statistics

- **General comparison of means**
- Provides preliminary overview of campaign performance across metrics
- Calculate means of metrics across campaigns, visualized using bar plots

Step 5: Interpreting Results Summary Statistics (1/4)

Mean CPA across campaigns

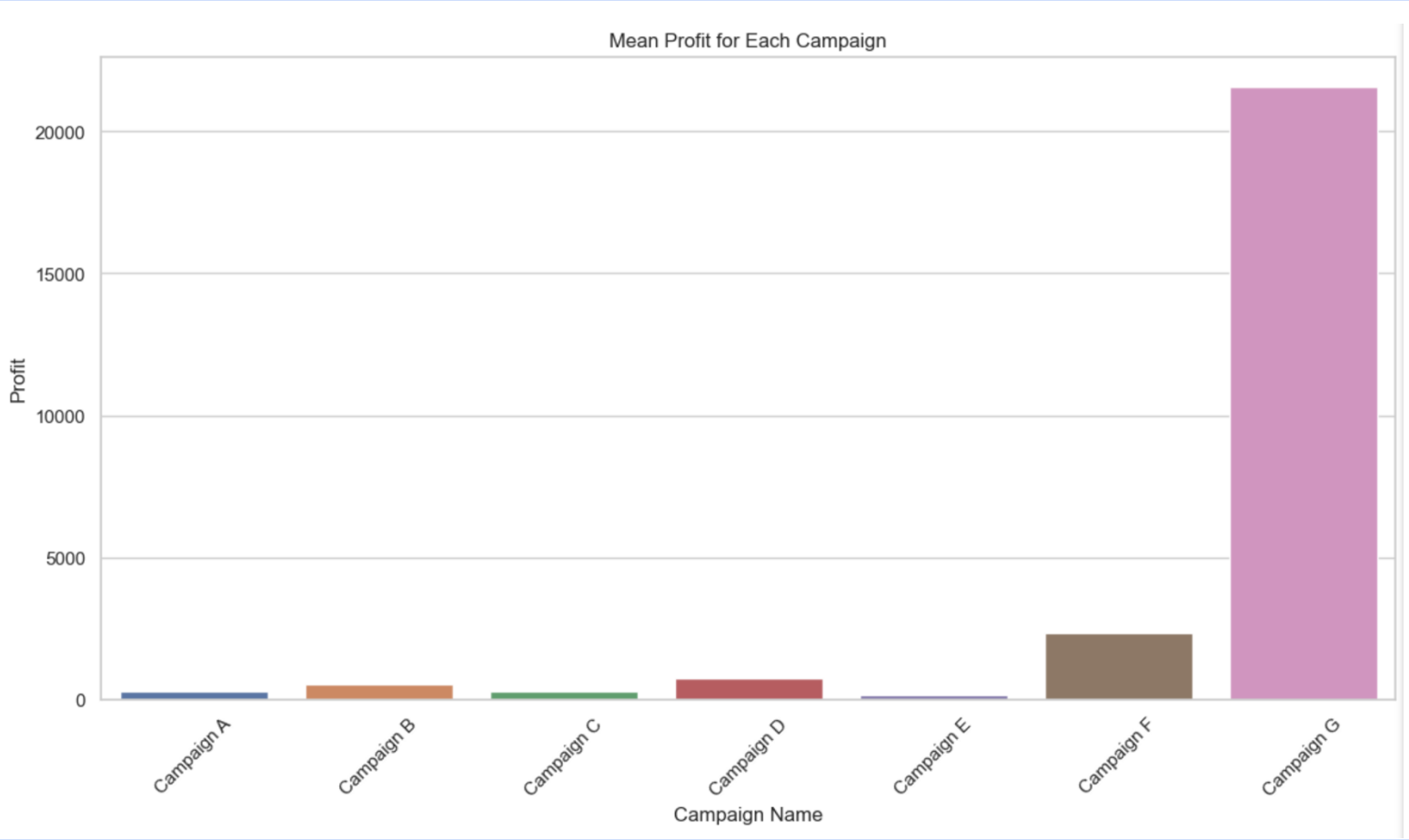


Key Takeaways

- Campaign G significantly outperforms all other campaigns
- Campaign F is a definitive second
- Campaign D and E have the highest CPA

Step 5: Interpreting Results Summary Statistics (2/4)

Mean Profit across campaigns

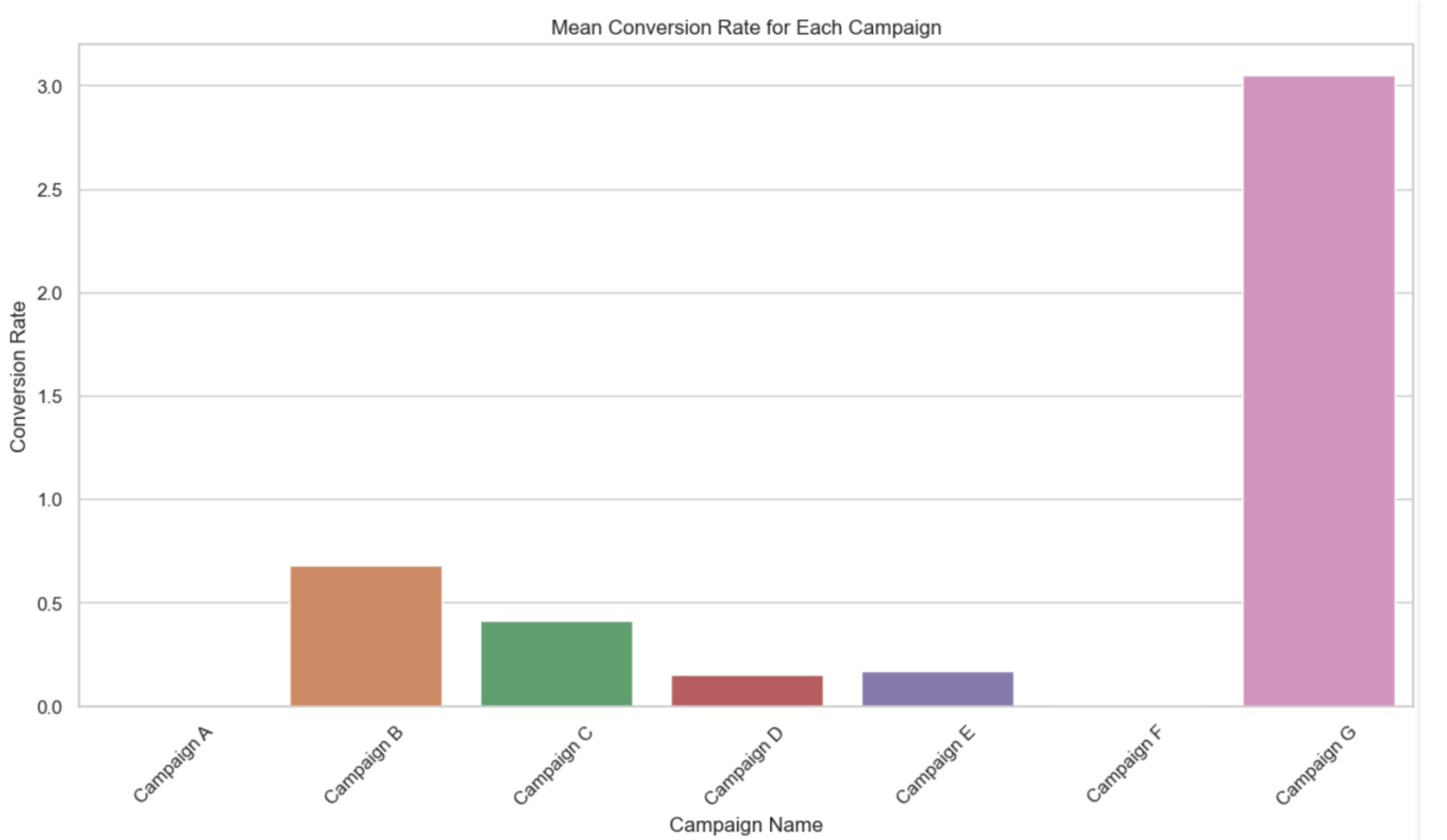


Key Takeaways

- Campaign G significantly outperforms all other campaigns
- Campaign F is a definitive second

Step 5: Interpreting Results Summary Statistics (3/4)

Mean Conversion Rate across Campaigns

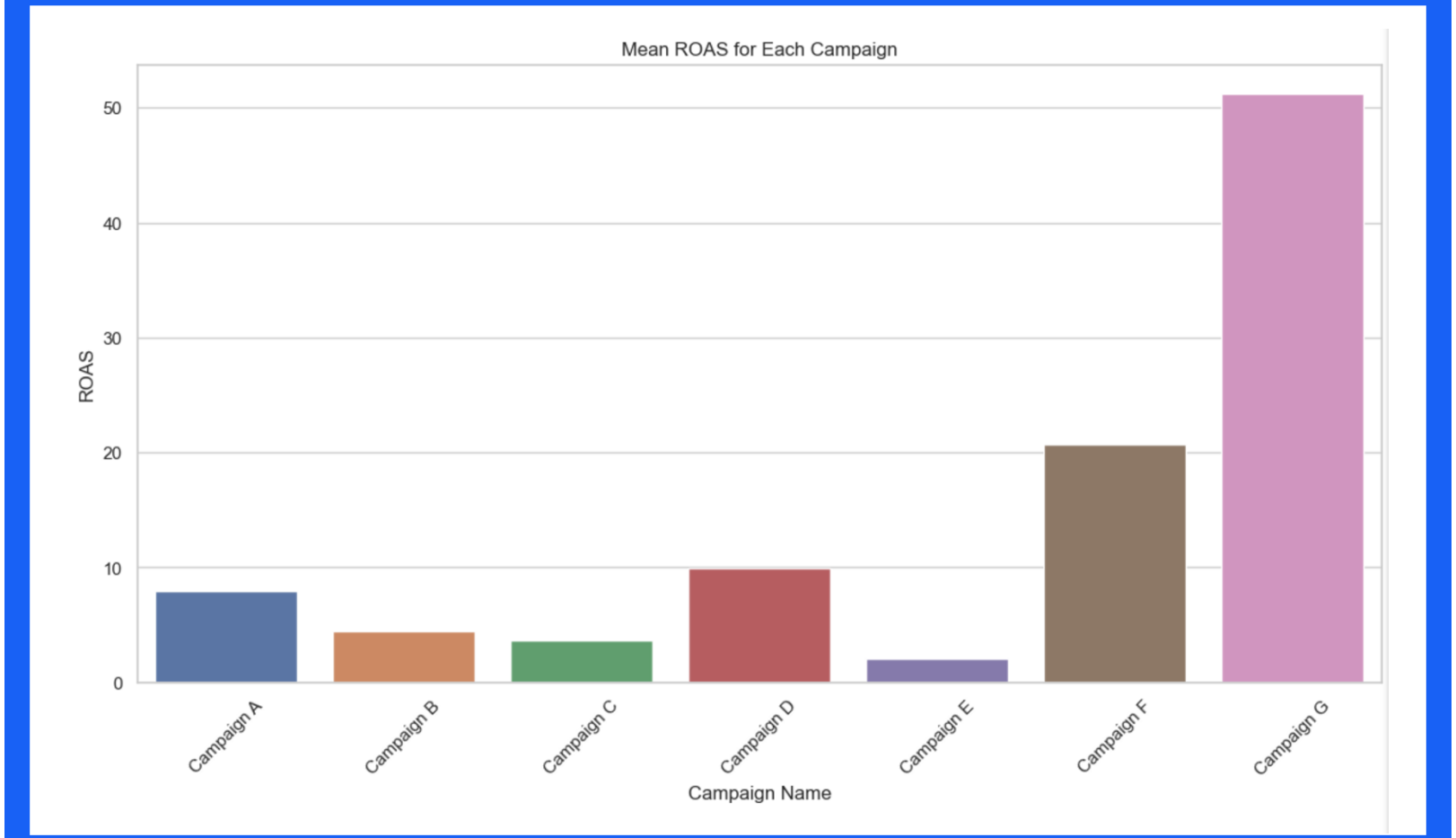


Key Takeaways

- Campaign G has the highest conversion rate
- Campaign B seems to be second
- Not many takeaways can be extracted from observing Conversion Rate

Step 5: Interpreting Results Summary Statistics (4/4)

Mean ROAS across campaigns



Key Takeaways

- Campaign G outperforms other campaigns in terms of ROAS
- Campaign F definitive second
- Seemingly negligible differences amongst others

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Step 4: Data Analysis
ANOVA Test Overview

Determines if there are statistically significant differences in performance across campaigns.

- F-statistic: Indicator of variability. Ratio of variance between groups to the variance within groups
- p-value: Probability of observing the data if null hypothesis is true. Low p-value (< 0.05) indicates strong evidence to reject the null hypothesis, which means a significant difference between group means
- Null Hypothesis: Assumption all group means are equal (no significant difference between group means)

Step 5: Interpret Results | ANOVA Test

CPA

F-statistic: 3.864

P-value: 0.00161

- p-value > 0.05 means that there is a statistically significant difference campaigns. Some campaigns are more cost-effective than others

Profit

F-statistic: 11.645

P-value: 6.058e-10

- F-statistic is high and p-value is much less than 0.05, which indicates variation in profits across campaigns.

Conversion Rate

F-statistic: 0.248

P-value: 0.959

- F-statistic is very low which indicates low variation in rates across campaigns. P-value is much greater than 0.05, which indicates there are no significant differences for conversion rates across campaigns

ROAS

F-statistic: 16.521

P-value: 2.701e-13

- F-statistic is very high and P-value is much less than 0.05, indicating significant variation across campaigns

Post-Hoc Analysis

Tukey's HSD Test

- The ANOVA test tells us if there is variance across campaigns for our chosen metrics
- Tukey's HSD test allows us to perform pairwise comparisons to identify which groups are significantly different
- P-values < 0.05 and Confidence Intervals that **do not** include 0 indicate significant difference
- Negative Mean Difference value indicates first group's mean is higher than second group's mean

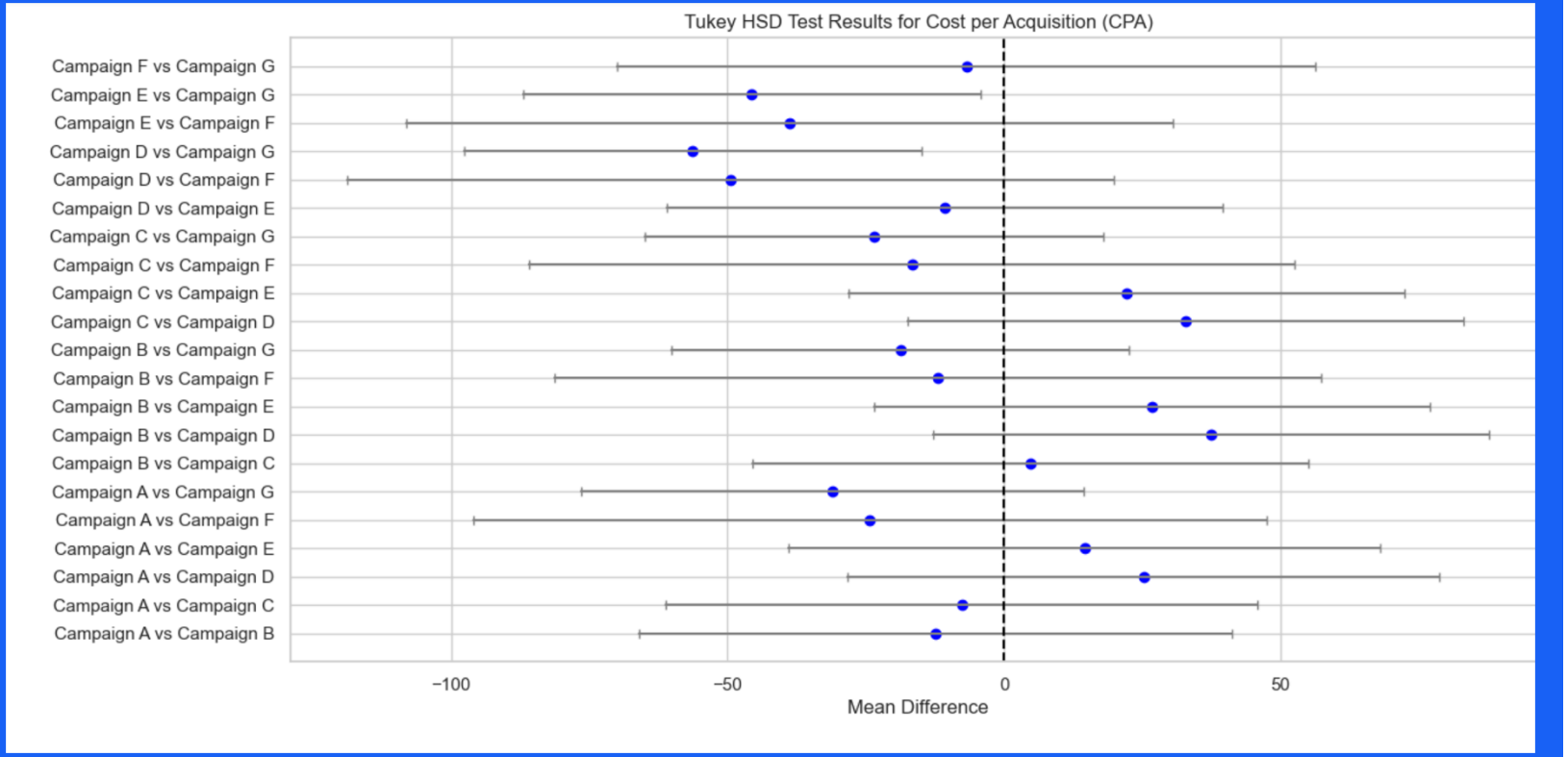
Tukey HSD results for CPA

Multiple Comparison of Means - Tukey HSD, FWER=0.05

group1	group2	meandiff	p-adj	lower	upper	reject
Campaign A	Campaign B	-12.3289	0.9928	-65.9193	41.2615	False
Campaign A	Campaign C	-7.6407	0.9995	-61.2311	45.9497	False
Campaign A	Campaign D	25.2206	0.7926	-28.3698	78.811	False
Campaign A	Campaign E	14.5283	0.9829	-39.0621	68.1187	False
Campaign A	Campaign F	-24.2911	0.9488	-96.0302	47.448	False
Campaign A	Campaign G	-31.0741	0.3856	-76.4822	14.3341	False
Campaign B	Campaign C	4.6882	1.0	-45.5841	54.9604	False
Campaign B	Campaign D	37.5495	0.2807	-12.7227	87.8218	False
Campaign B	Campaign E	26.8572	0.6786	-23.415	77.1294	False
Campaign B	Campaign F	-11.9622	0.9985	-81.2577	57.3333	False
Campaign B	Campaign G	-18.7452	0.8214	-60.1851	22.6947	False
Campaign C	Campaign D	32.8614	0.4427	-17.4109	83.1336	False
Campaign C	Campaign E	22.169	0.8383	-28.1032	72.4413	False
Campaign C	Campaign F	-16.6504	0.9909	-85.9459	52.6451	False
Campaign C	Campaign G	-23.4334	0.6174	-64.8733	18.0066	False
Campaign D	Campaign E	-10.6923	0.9953	-60.9646	39.5799	False
Campaign D	Campaign F	-49.5117	0.3328	-118.8072	19.7838	False
Campaign D	Campaign G	-56.2947	0.0016	-97.7346	-14.8548	True
Campaign E	Campaign F	-38.8194	0.6279	-108.1149	30.4761	False
Campaign E	Campaign G	-45.6024	0.0212	-87.0423	-4.1625	True
Campaign F	Campaign G	-6.783	0.9999	-69.964	56.398	False

Step 5: Interpreting Results Tukey HSD Test (1/2)

Tukey HSD Test results for CPA visualized



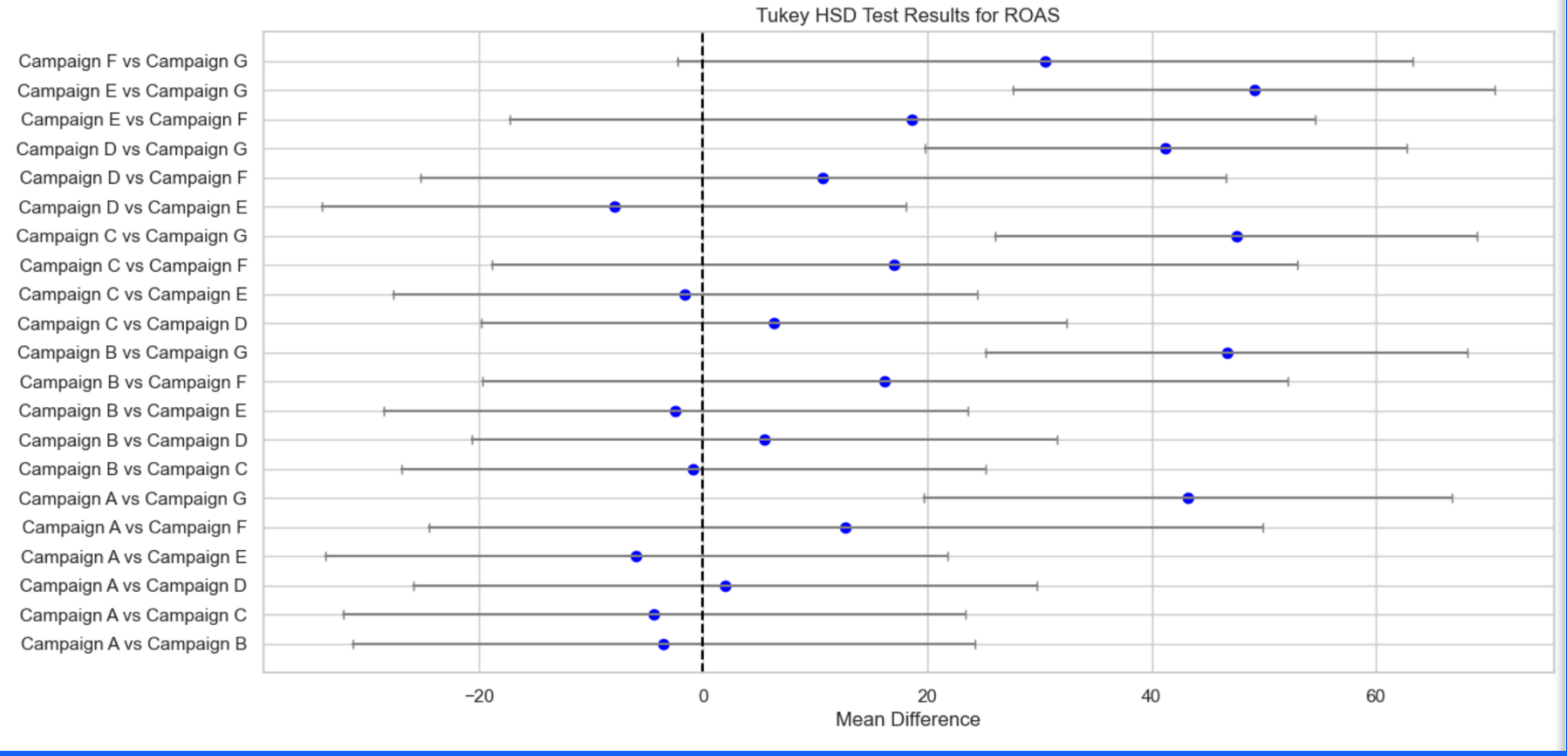
Key Takeaways

- Campaign E vs Campaign G
  - 0 not in Confidence Interval
  - Negative mean difference
- Campaign D vs Campaign G
  - 0 not in Confidence Interval
  - Negative mean difference

Campaign G significantly outperforms Campaigns D and E in CPA

Step 5: Interpreting Results Tukey HSD Test (2/2)

Tukey HSD Test results for ROAS visualized



Key Takeaways

- All Campaigns **except** Campaign F when compared to Campaign G:
  - 0 not in Confidence Interval
  - Positive mean difference

Campaign G significantly outperforms all other campaigns in ROAS apart from Campaign F

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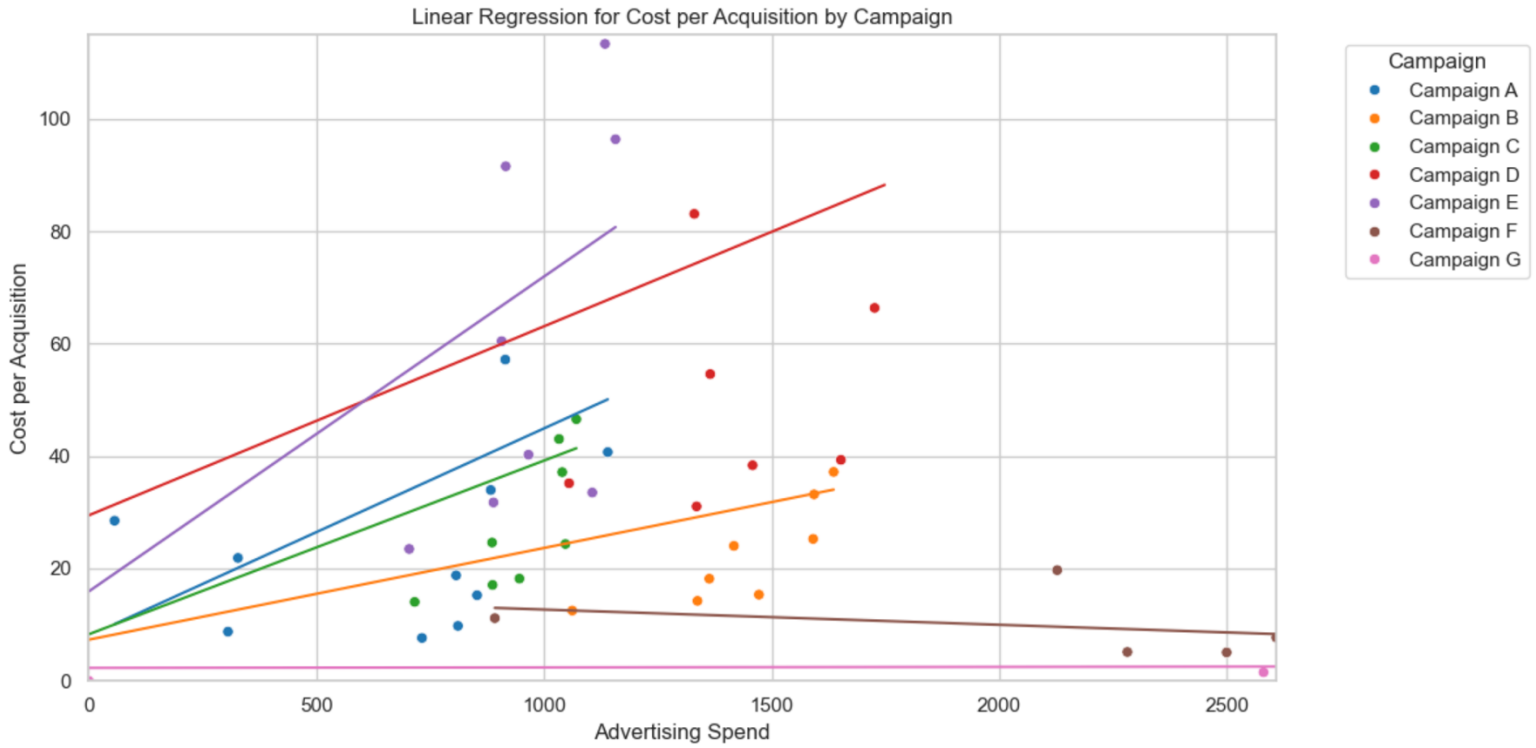
Step 4: Data Analysis
Linear Regression Analysis

- Analyze relationship between an independent variable and a dependent variable
- To predict performance of various campaigns across several metrics with increased advertising spend

Step 5: Interpreting Results Linear Regression Analysis (1/4)

CPA with increased Advertising Spend

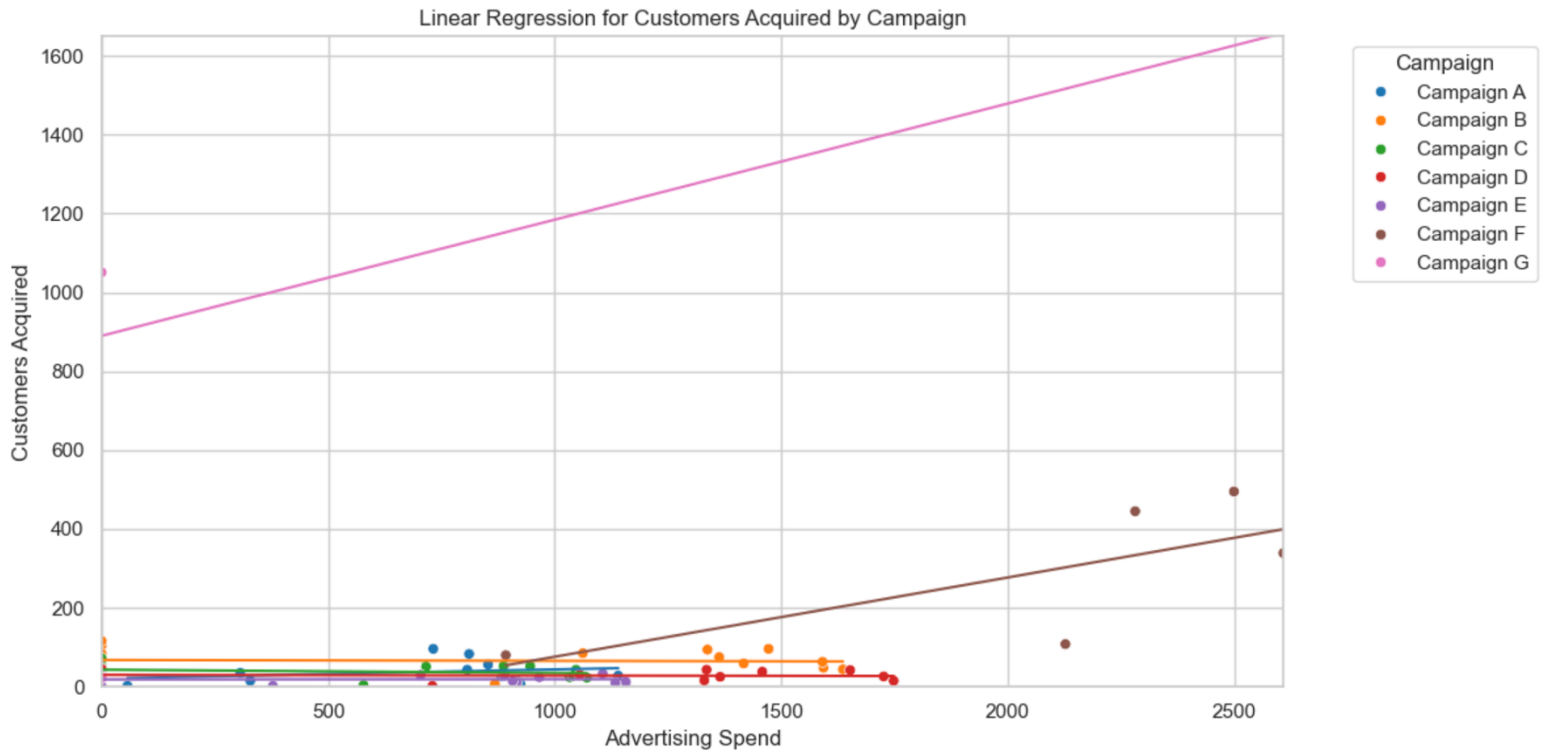


Key Takeaways

- Campaign G with least CPA
- Campaign F definitive second
- Campaigns D and E continue to show poor performance
- Campaigns A, B, C displaying similar performance

Step 5: Interpreting Results Linear Regression Analysis (2/4)

Customers Acquired with increased Advertising Spend

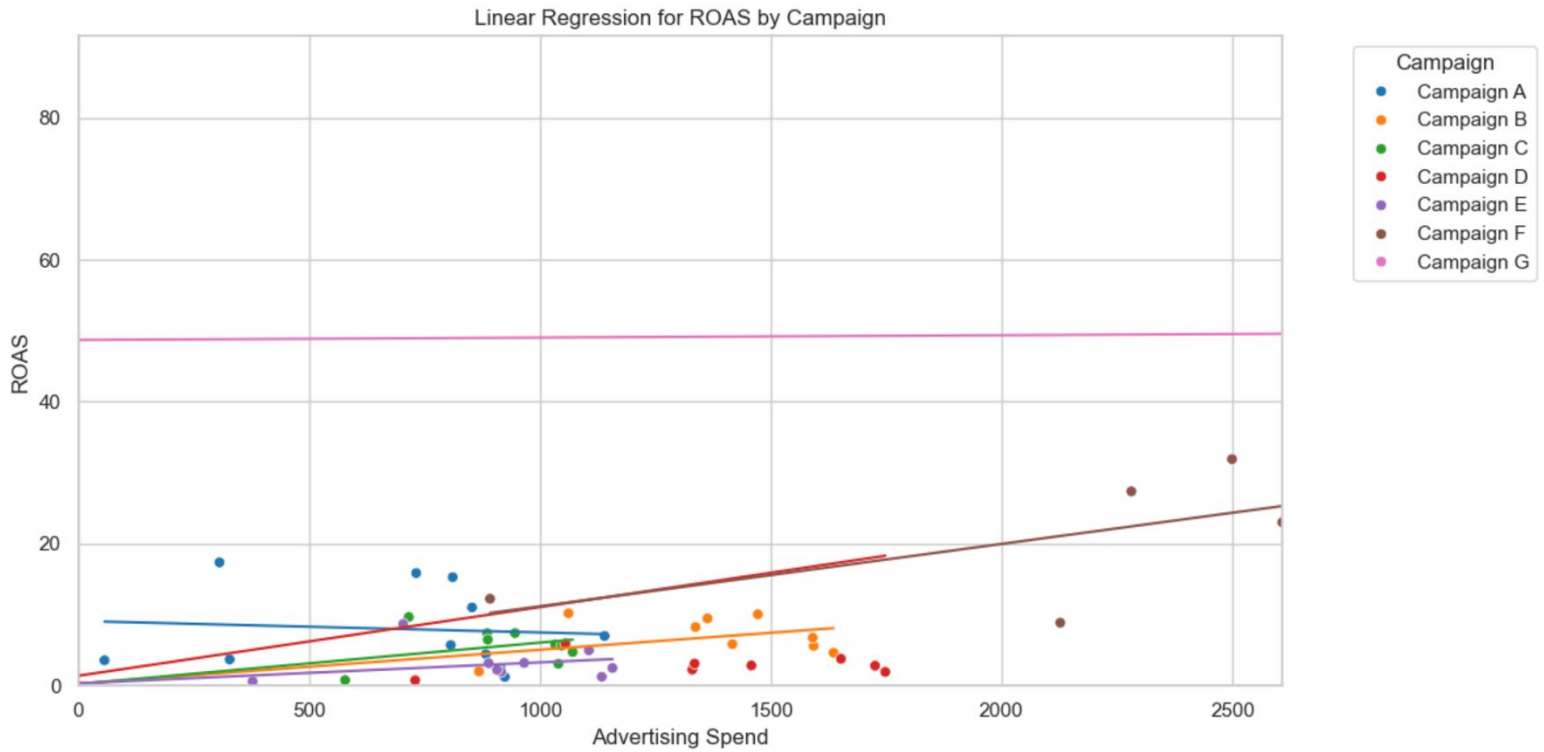


Key Takeaways

- Campaign G attracts most customers by far
- Campaign F a distant second
- Negligible difference amongst remaining campaigns

Step 5: Interpreting Results Linear Regression Analysis (3/4)

ROAS with increased Advertising Spend

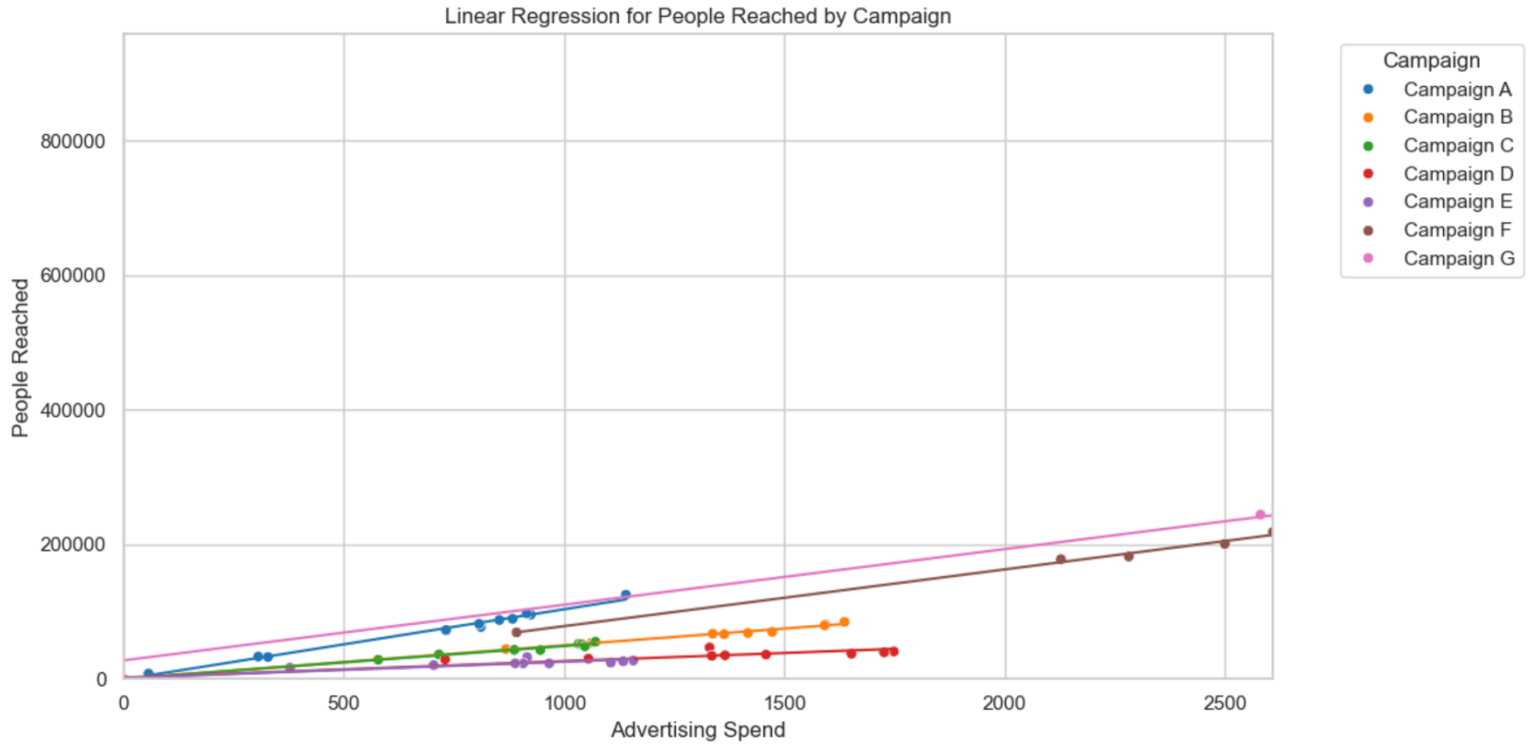


Key Takeaways

- Campaign G with greatest return
- Campaign F and D with similar projections
- Remaining campaigns with negligible differences

Step 5: Interpreting Results Linear Regression Analysis (4/4)

People Reached with increased Advertising Spend



Key Takeaways

- Campaigns G, F, and A with highest projections
- Remaining campaigns have negligible differences

Conclusion

Assessment of Campaigns and Recommendations

Conclusion | Top Performers

1

Campaign G

- Campaign G was the top performer across all tests
- Top performer in Summary Statistics, a definitive favorite across CPA, Profit, Conversion Rate, and ROAS
- Top Performer in Tukey's HSD Test, significantly outperforming campaigns D and E consistently
- Exhibited superior projections in Linear Regression across CPA, Customers Acquired, ROAS, and People Reached with increased Advertising Spend

2

Campaign F

- Consistently ranks second in majority of tests conducted
- Second best performer in Summary Statistics across CPA, Profit, and ROAS
- Second best performer in Tukey's HSD Test. Only campaign **not** showing significant differences in performance to Campaign G across CPA and ROAS
- Second Best performer in Linear Regression Analysis, displaying the second best projections across CPA and Customers Acquired with increased Advertising Spend

Conclusion | Mid Tier Performers

These 3 campaigns performed similarly, with negligible differences on most tests.

Campaign A

Campaign C

Campaign B

Conclusion | Worst Performers

Campaign D

Campaign E

These two campaigns were consistently the worst performers across all tests

- On the lower end of all metrics on the Summary Statistic Analysis
  - Notably highest CPA across all campaigns
- Only two campaigns that performed significantly worse than Campaign G according to Tukey's HSD Test across both CPA and ROAS
- Consistent poor performers across most metrics in Linear Regression Analysis
- Slight edge given to Campaign D for its performance on the ROAS metric

Appendix

XX (I/II)

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error, r2_score
from scipy import stats
from statsmodels.stats.multicomp import pairwise_tukeyhsd
from itertools import combinations
```

```
#loading data in
df = pd.read_csv('Sample_Data_Company_XYZ.csv')
```

```
#verifying data integrity
missing_val = df.isnull().sum()
print(missing_val)

duplicates = df.duplicated().sum()
print(f'Duplicates: {duplicates}')

df['Week Start Date'] = pd.to_datetime(df['Week Start Date'])
df['Advertising Spend'] = df['Advertising Spend'].str.replace(r'[$,]', '', regex=True).astype(float)
df['Campaign Revenue'] = df['Campaign Revenue'].str.replace(r'[$,]', '', regex=True).astype(float)
df['Customers Acquired by Campaign'] = df['Customers Acquired by Campaign'].str.replace(',', '', regex=True).astype(float)
df['People Reached'] = df['People Reached'].str.replace(',', '', regex=True).astype(float)
df['Campaign Conversions'] = df['Campaign Conversions'].str.replace(',', '', regex=True).astype(float)
df['Ads Delivered'] = df['Ads Delivered'].str.replace(',', '', regex=True).astype(float)
```

XX (II/III)

```
mean_revenue = df['Campaign Revenue'].mean()
std_revenue = df['Campaign Revenue'].std()

# Define a threshold for identifying outliers
threshold = mean_revenue + 10 * std_revenue

# Identify rows with outliers
outliers = df[df['Campaign Revenue'] > threshold]
print("Outliers:")
print(outliers)

#remove outliers
non_outliers_mean = df[df['Campaign Revenue'] <= threshold]['Campaign Revenue'].mean()
df.loc[df['Campaign Revenue'] > threshold, 'Campaign Revenue'] = non_outliers_mean
```

```
#establish KPIs
df['Profit'] = df['Campaign Revenue']*0.05
df['Conversion Rate'] = df['Campaign Conversions'] / df['People Reached']
df['Cost per Acquisition'] = df['Advertising Spend']/df['Customers Acquired by Campaign']
df['Profit Margin'] = (df['Campaign Revenue'] * 0.05) / df['Advertising Spend']
df['ROI'] = df['Campaign Revenue'] / df['Advertising Spend']

# Replace invalid values with 0
df.fillna(0, inplace=True)
df.replace([np.inf, -np.inf], 0, inplace=True)
```

Thank You

Thank you

Q&A