QUANTIUM TASK 2

import pandas as pd

data_df= pd.read_csv('QVI_data.csv')

data_df['DATE']= pd.to_datetime(data_df['DATE'], format= '%Y-%m-%d', errors='coerce')

data_df.info()

```
 #   Column            Non-Null Count   Dtype
---  ------            --------------   -----
 0   LYLTY_CARD_NBR    264834 non-null  int64
 1   DATE              264834 non-null  datetime64[ns]
 2   STORE_NBR         264834 non-null  int64
 3   TXN_ID            264834 non-null  int64
 4   PROD_NBR          264834 non-null  int64
 5   PROD_NAME         264834 non-null  object
 6   PROD_QTY          264834 non-null  int64
 7   TOT_SALES         264834 non-null  float64
 8   PACK_SIZE         264834 non-null  int64
 9   BRAND             264834 non-null  object
 10  LIFESTAGE         264834 non-null  object
 11  PREMIUM_CUSTOMER  264834 non-null  object
dtypes: datetime64[ns](1), float64(1), int64(6), object(4)
memory usage: 24.2+ MB
```

data_df['MONTH']= data_df['DATE'].dt.to_period('M')

pre_trial_months= pd.period_range(start='2018-07', end='2019-01', freq= 'M') # Define pre-trial period

pre_trial_df = data_df[data_df['MONTH'].isin(pre_trial_months)]

tot_sales= pre_trial_df.groupby(['STORE_NBR', 'MONTH'])['TOT_SALES'].sum()

tot_customers= pre_trial_df.groupby(['STORE_NBR', 'MONTH'])['LYLTY_CARD_NBR'].nunique()

tot_transactions= pre_trial_df.groupby(['STORE_NBR', 'MONTH'])['TXN_ID'].nunique()

trans_per_customer= tot_transactions/tot_customers

print(trans_per_customer)

```
STORE_NBR  MONTH
1          2018-07    1.061224
           2018-08    1.023810
           2018-09    1.050847
           2018-10    1.022727
           2018-11    1.021739
                         ...
272        2018-09    1.125000
           2018-10    1.136364
           2018-11    1.097561
           2018-12    1.000000
           2019-01    1.086957
Length: 1848, dtype: float64
```

metrics_df = pd.DataFrame({ #Combining all metrics in one DataFrame

'total_sales': tot_sales,

'total_customers': tot_customers,

'total_transactions': tot_transactions,

'transactions_per_customer': trans_per_customer

}).reset_index()

metrics_df.head()

Filter to stores present in all pre-trial months:

store_counts= metrics_df['STORE_NBR'].value_counts()

valid_stores= store_counts[store_counts==7].index

```
## filtered_df= metrics_df[metrics_df['STORE_NBR'].isin(valid_stores)]
## print(filtered_df['STORE_NBR'].nunique())
260          # These are the number of unique stores
```

Calculating Avg price per unit & Chips per customer:

```
avg_price_per_unit= filtered_df['total_sales']/filtered_df['total_transactions']
filtered_df['avg_price_per_unit']= avg_price_per_unit

chips_per_customer= filtered_df['total_transactions']/filtered_df['total_customers']
filtered_df['chips_per_customer']= chips_per_customer

filtered_df.head()
```

Creating a Function to get Correlation Scores:

```
## def get_correlation_scores(filtered_df, trial_store, metric_col='total_sales'):

    trial_sales= filtered_df[filtered_df['STORE_NBR']==trial_store][['MONTH', metric_col]]
    correlations=[]

    other_stores = filtered_df['STORE_NBR'].unique()
    other_stores= other_stores[other_stores != trial_store]
```

```
 for store in other_stores:
      store_sales = filtered_df[filtered_df['STORE_NBR'] == store][['MONTH', metric_col]]
      merged = trial_sales.merge(store_sales, on='MONTH', suffixes=('_trial', '_store'))
      corr = merged[f'{metric_col}_trial'].corr(merged[f'{metric_col}_store'])
      correlations.append((store, corr))
   correlation_df = pd.DataFrame(correlations, columns=['STORE_NBR', 'correlation'])
   correlation_df = correlation_df.sort_values(by='correlation', ascending=False)
   return correlation_df
```

For Trial store 77:

```
trial_store = 77
# Get correlation scores
correlation_df = get_correlation_scores(filtered_df, trial_store)
print(correlation_df.head())
```

```
     STORE_NBR  correlation
67          71     0.914106
220        233     0.903774
110        119     0.867664
15          17     0.842668
2            3     0.806644
```

Creating a Function to get Magnitude Distance Scores:

```
## def get_mag_distance_scores (filtered_df, trial_store, metric_col='total_sales'):

   trial_sales= filtered_df[filtered_df['STORE_NBR']==trial_store][['MONTH', metric_col]]
   distances=[]
```

```
    other_stores = filtered_df['STORE_NBR'].unique()
    other_stores= other_stores[other_stores != trial_store]

    for store in other_stores:
        store_sales= filtered_df[filtered_df['STORE_NBR']==store][['MONTH', metric_col]]
        merged= trial_sales.merge(store_sales, on= 'MONTH', suffixes=('_trial', '_store'))

        abs_diff= abs(merged[f'{metric_col}_trial']- merged[f'{metric_col}_store'])

        # Sum total distance over the months
        distance = abs_diff.sum()

        distances.append((store, distance))

    distance_df= pd.DataFrame(distances, columns=['STORE_NBR', 'total_distance'])

    # Standardize the distance using min-max scaling to convert it into a similarity score
    min_dist = distance_df['total_distance'].min()
    max_dist = distance_df['total_distance'].max()

    distance_df['magnitude_score']= 1- (distance_df['total_distance']-min_dist)/(max_dist-
min_dist)

    distance_df= distance_df.sort_values(by='magnitude_score', ascending=False)
    return distance_df
```

For Trial Store 77:

```
trial_store=77

mag_score_df= get_mag_distance_scores(filtered_df, trial_store)

print(mag_score_df.head())
```

	STORE_NBR	total_distance	magnitude_score
220	233	131.8	1.000000
241	255	200.0	0.991889
179	188	217.7	0.989784
49	53	227.3	0.988642
122	131	231.3	0.988167

Calculating Correlation & Magnitude scores on total sales and total customers:

```
corr_sales_77= get_correlation_scores(filtered_df, 77, metric_col='total_sales')

corr_customers_77= get_correlation_scores(filtered_df, 77, metric_col='total_customers')

mag_sales_77= get_mag_distance_scores(filtered_df, 77, metric_col='total_sales')

mag_customers_77= get_mag_distance_scores(filtered_df, 77,
metric_col='total_customers')

sales_scores= corr_sales_77.merge(mag_sales_77, on='STORE_NBR')

sales_scores['sales_score']= sales_scores['correlation'] + sales_scores['magnitude_score']
/ 2

customer_scores= corr_customers_77.merge(mag_customers_77, on='STORE_NBR')

customer_scores['customer_score']= customer_scores['correlation'] +
customer_scores['magnitude_score'] / 2
```

```
final_scores= sales_scores[['STORE_NBR',
'sales_score']].merge(customer_scores[['STORE_NBR','customer_score']],
on='STORE_NBR')

final_scores['final_score']= final_scores['sales_score'] + final_scores['customer_score'] / 2

final_scores.sort_values(by='final_score', ascending=False)
```

	STORE_NBR	sales_score	customer_score	final_score
1	233	1.403774	1.490358	2.148953
5	41	1.272195	1.334960	1.939675
3	17	1.285731	1.231876	1.901669
6	50	1.257253	1.071125	1.792816
11	115	1.160509	1.204221	1.762619
...	...	...	...	...
245	102	-0.315761	-0.465027	-0.548274
250	55	-0.442680	-0.216461	-0.550910
251	19	-0.392823	-0.375737	-0.580691
248	247	-0.377662	-0.418102	-0.586713
257	75	-0.671431	-0.435643	-0.889252

259 rows × 4 columns

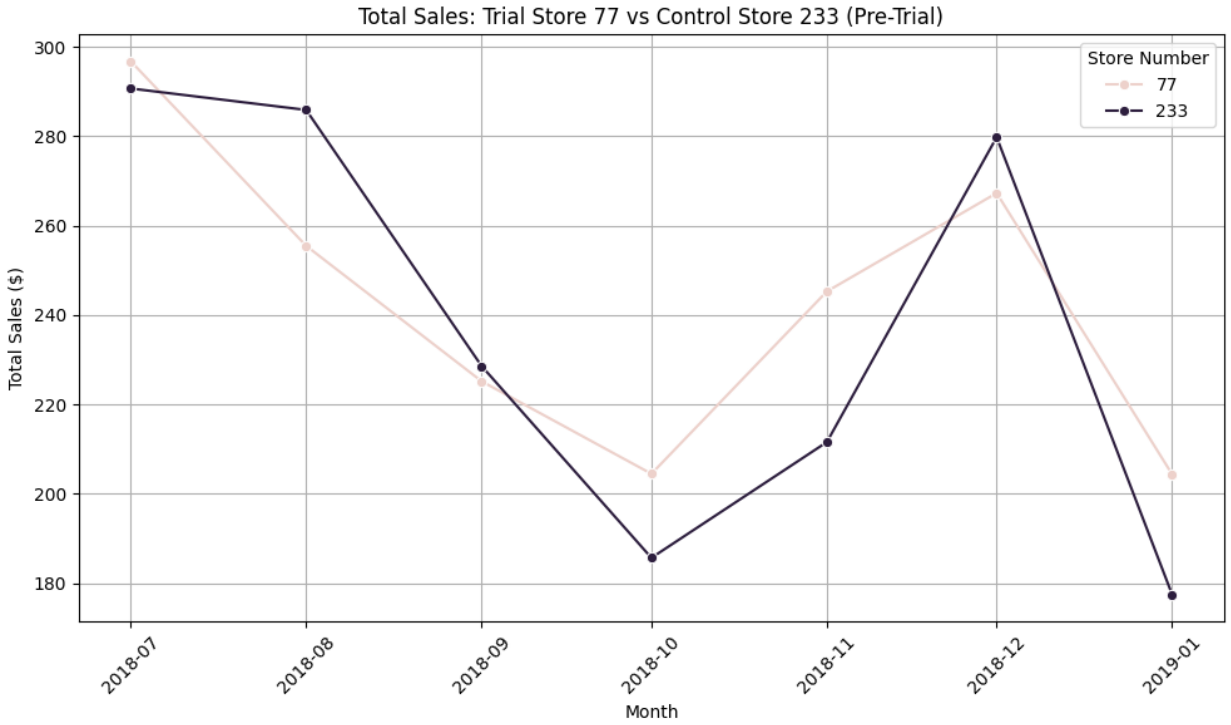
Conclusion:

#The store with the highest final score is 233. So 233 is a control store for trial store 77.

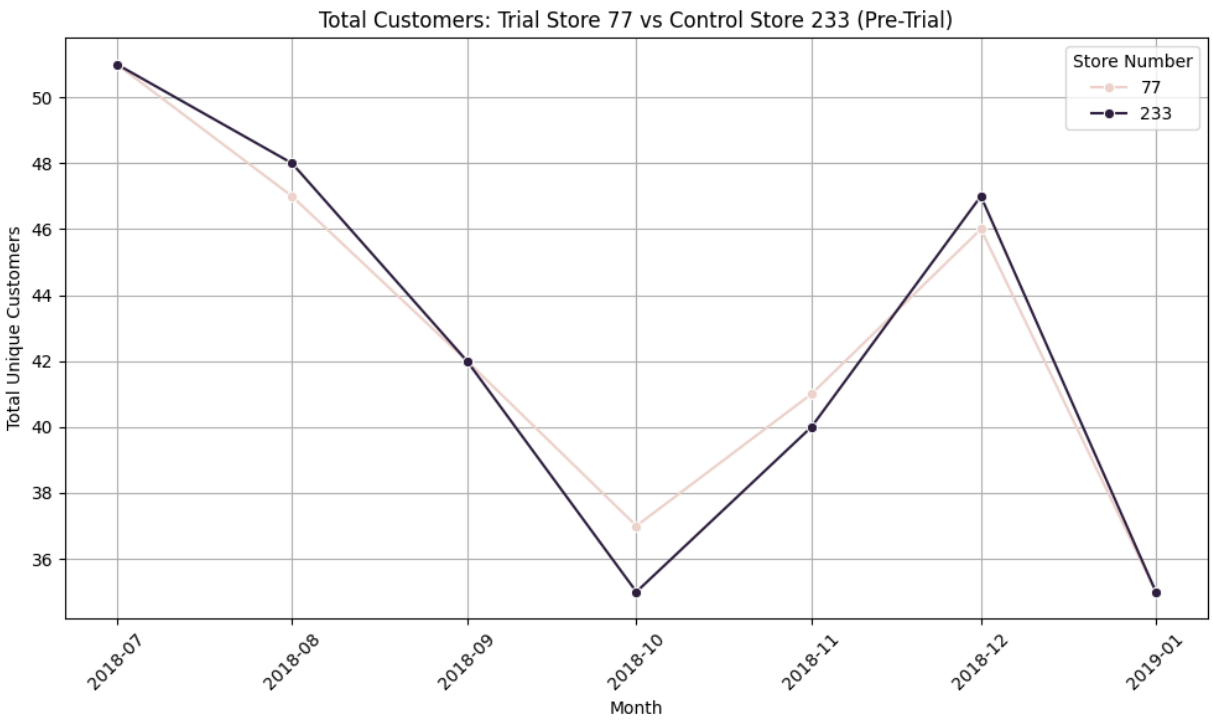
Visualizing the Trial & Control Store with respect to Total Sales and Total Customers:

```
control_store= 233

trial_store=77


plot_df = filtered_df[filtered_df['STORE_NBR'].isin([trial_store, control_store])]

plot_df['MONTH'] = plot_df['MONTH'].dt.to_timestamp()
```

```
import matplotlib.pyplot as plt
import seaborn as sns

plt.figure(figsize=(10,6))
sns.lineplot(data=plot_df, x='MONTH', y='total_sales', hue='STORE_NBR', marker='o')

plt.title(f'Total Sales: Trial Store {trial_store} vs Control Store {control_store} (Pre-Trial)')
plt.xlabel('Month')
plt.ylabel('Total Sales ($)')
plt.xticks(rotation=45)
plt.grid(True)
plt.legend(title='Store Number')
plt.tight_layout()
plt.show()
```



```
control_store= 233

trial_store=77


plot_df = filtered_df[filtered_df['STORE_NBR'].isin([trial_store, control_store])]

plot_df['MONTH'] = plot_df['MONTH'].dt.to_timestamp()


import matplotlib.pyplot as plt

import seaborn as sns


plt.figure(figsize=(10,6))

sns.lineplot(data=plot_df, x='MONTH', y='total_customers', hue='STORE_NBR', marker='o')


plt.title(f'Total Customers: Trial Store {trial_store} vs Control Store {control_store} (Pre-Trial)')

plt.xlabel('Month')

plt.ylabel('Total Unique Customers')

plt.xticks(rotation=45)

plt.grid(True)

plt.legend(title='Store Number')

plt.tight_layout()

plt.show()
```



UPLIFT TESTING:

```
trial_months= pd.period_range(start='2019-02', end='2019-04', freq= 'M')


trial_sales_pre = filtered_df[filtered_df['STORE_NBR'] == trial_store]['total_sales'].sum()

control_sales_pre = filtered_df[filtered_df['STORE_NBR'] ==
control_store]['total_sales'].sum()


scaling_factor = trial_sales_pre / control_sales_pre   #Scaling the sales
```

Recalculating metrics for trial period only:

```
control_store= 233

trial_store= 77


trial_period_df= data_df[data_df['MONTH'].isin(trial_months)]


tot_sales_trial= trial_period_df.groupby(['STORE_NBR', 'MONTH'])['TOT_SALES'].sum()

tot_customers_trial= trial_period_df.groupby(['STORE_NBR',
'MONTH'])['LYLTY_CARD_NBR'].nunique()

tot_transactions_trial= trial_period_df.groupby(['STORE_NBR',
'MONTH'])['TXN_ID'].nunique()


metrics_df_trial = pd.DataFrame({                    #Combining all metrics in one
DataFrame

   'total_sales': tot_sales_trial,

   'total_customers': tot_customers_trial,

   'total_transactions': tot_transactions_trial,

}).reset_index()


metrics_df_trial['scaled_sales'] = metrics_df_trial.apply(lambda row: row['total_sales'] *
scaling_factor if row['STORE_NBR']==control_store else row['total_sales'], axis=1)

metrics_df_trial = metrics_df_trial[

   metrics_df_trial['STORE_NBR'].isin([trial_store, control_store])

]
```

comparison_df = metrics_df_trial.pivot(index='MONTH', columns='STORE_NBR', values=['total_sales', 'scaled_sales'])

comparison_df['percentage_difference']= ((comparison_df[('total_sales', trial_store)] - comparison_df[('scaled_sales', control_store)]) / comparison_df[('scaled_sales', control_store)]) * 100

comparison_df

	total_sales		scaled_sales		percentage_difference
STORE_NBR	77	233	77	233	
MONTH					
2019-02	235.0	244.0	235.0	249.762622	-5.910661
2019-03	278.5	199.1	278.5	203.802205	36.652103
2019-04	263.5	158.6	263.5	162.345704	62.307960

Percentage difference for pre-trial months to calculate Standard Deviation:

trial_store=77

control_store= 233

filtered_df['scaled_sales'] = filtered_df.apply(lambda row: row['total_sales'] * scaling_factor if row['STORE_NBR']==control_store else row['total_sales'], axis=1)

filtered_df= filtered_df[

  filtered_df['STORE_NBR'].isin([trial_store, control_store])

]

comparison_df_pre = filtered_df.pivot(index='MONTH', columns='STORE_NBR', values=['total_sales', 'scaled_sales'])

```
pct_diff_pre = (
   (comparison_df_pre[('total_sales', trial_store)] - comparison_df_pre[('scaled_sales', control_store)]) /
   comparison_df_pre[('scaled_sales', control_store)]) *100
```

```
print(pct_diff_pre)
```

```
MONTH
2018-07    -0.257271
2018-08   -12.694997
2018-09    -3.760238
2018-10     7.583035
2018-11    13.251579
2018-12    -6.671641
2019-01    12.498029
Freq: M, dtype: float64
```

```
std_dev = pct_diff_pre.std()
```

```
print(std_dev)
```

9.958646884078389 **#This is the standard deviation of percentage difference of pre-trial month**

```
t_values= comparison_df['percentage_difference']/std_dev
```

```
print(t_values)
```

```
MONTH
2019-02   -0.593520
2019-03    3.680430
2019-04    6.256669
Freq: M, Name: percentage_difference, dtype: float64
```

Calculating t-critical value:

```
from scipy.stats import t
```

```
t_critical= t.ppf(0.95, df=7)

print('t-values for trial period',t_values,

    '\n','t-critical', t_critical)
```

```
t-values for trial period MONTH
2019-02   -0.593520
2019-03    3.680430
2019-04    6.256669
Freq: M, Name: percentage_difference, dtype: float64
 t-critical 1.894578605061305
```

Conclusion:

t_feb < t_critical

t_mar > t_critical

t_apr > t_critical.

Thus, we reject the null hypothesis for March & April.

We found that there was an uplift in total sales during the trial period, the uplift was statistically significant at the 95% confidence level in March and April and not in Feb, when compared to the control store's scaled performance.

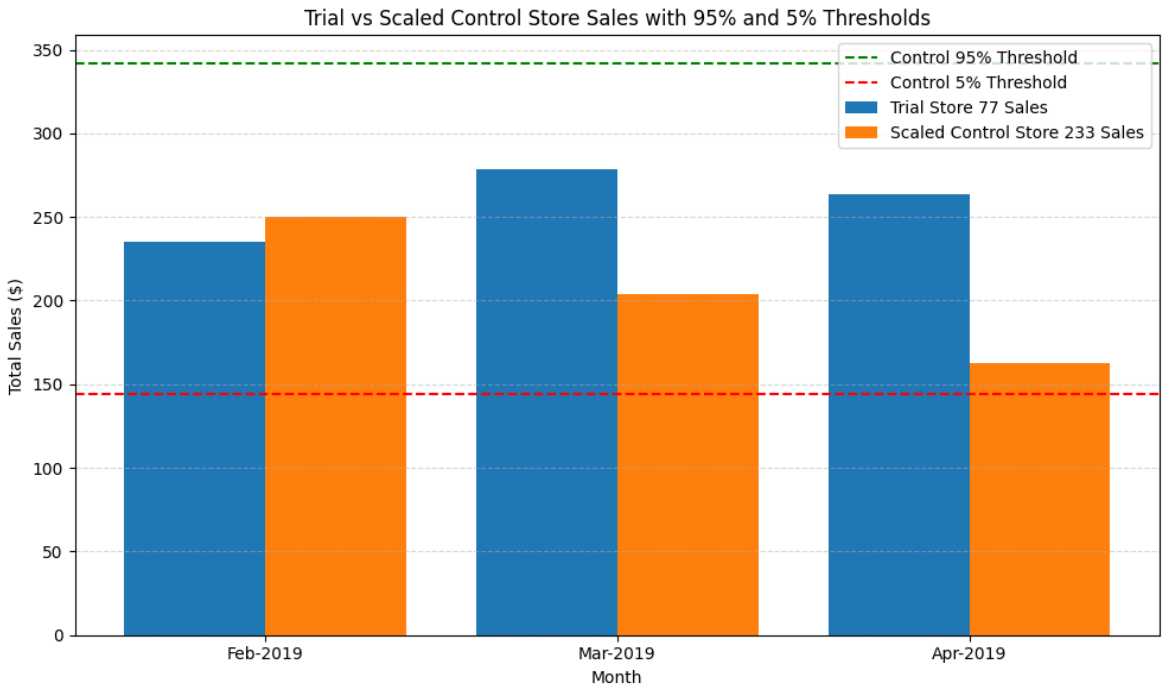
So, this suggests that the trial was effective in driving a meaningful uplift in sales during these months. The company can consider rolling out the trial strategy to other stores, as the results show a statistically significant uplift during the trial period.

Plotting the combined visual:

```
import numpy as np

pre_control = filtered_df[

  (filtered_df['STORE_NBR']==233)&
```

```
   (filtered_df['MONTH'].isin(pd.period_range('2018-07','2019-01',freq='M')))
]['total_sales'] * scaling_factor
std_dev = pre_control.std()
mean_sales = pre_control.mean()
std_dev_ratio = std_dev / mean_sales

upper_threshold = mean_sales + 2 * std_dev
lower_threshold = mean_sales - 2 * std_dev

import matplotlib.pyplot as plt

# Data for trial period
trial_months = pd.period_range(start='2019-02', end='2019-04', freq='M')

comparison_plot_df = comparison_df.reset_index()
months = comparison_plot_df['MONTH'].dt.to_timestamp()

trial_sales = comparison_plot_df[('total_sales', 77)]
control_sales = comparison_plot_df[('scaled_sales', 233)]

x = range(len(months))

plt.figure(figsize=(10,6))

# Bar chart
plt.bar(x, trial_sales, width=0.4, label='Trial Store 77 Sales', align='center')
```

```
plt.bar([i + 0.4 for i in x], control_sales, width=0.4, label='Scaled Control Store 233 Sales', align='center')

# Threshold lines
plt.axhline(y=upper_threshold, color='green', linestyle='--', label='Control 95% Threshold')
plt.axhline(y=lower_threshold, color='red', linestyle='--', label='Control 5% Threshold')

# Labels and formatting
plt.xticks([i + 0.2 for i in x], [m.strftime('%b-%Y') for m in months])
plt.title('Trial vs Scaled Control Store Sales with 95% and 5% Thresholds')

plt.xlabel('Month')
plt.ylabel('Total Sales ($)')
plt.legend()
plt.grid(axis='y', linestyle='--', alpha=0.5)
plt.tight_layout()
plt.show()
```



```
print("Trial Pre-Trial Sales:", trial_sales_pre)
print("Control Pre-Trial Sales:", control_sales_pre)
print("Scaling Factor:", scaling_factor)
```

```
Trial Pre-Trial Sales: 1699.0
Control Pre-Trial Sales: 1659.7999999999997
Scaling Factor: 1.023617303289553
```

```
print("Upper Threshold (95%):", upper_threshold)
print("Lower Threshold (5%):", lower_threshold)
```

```
Upper Threshold (95%): 341.58500916939136
Lower Threshold (5%): 143.84356225918012
```

```
print("Trial Sales During Trial Period:\n", trial_sales.values)
print("Scaled Control Sales During Trial Period:\n", control_sales.values)
```

```
Trial Sales During Trial Period:
 [235.  278.5 263.5]
Scaled Control Sales During Trial Period:
 [249.762622   203.80220508 162.3457043 ]
```

FINAL VISUSALIZATION FOR TRIAL AND SCALED CONTROL SALES:

```
import pandas as pd
import matplotlib.pyplot as plt

# Ensure 'MONTH' is timestamp for consistent plotting
filtered_df['MONTH'] = filtered_df['MONTH'].dt.to_timestamp()
metrics_df_trial['MONTH'] = metrics_df_trial['MONTH'].dt.to_timestamp()
```

```
# Combine pre-trial and trial data
plot_pre = filtered_df[['MONTH', 'STORE_NBR', 'scaled_sales', 'total_sales']]
plot_trial = metrics_df_trial[['MONTH', 'STORE_NBR', 'scaled_sales', 'total_sales']]
plot_df = pd.concat([plot_pre, plot_trial], ignore_index=True)

# Create control and trial DataFrames
trial_store = 77
control_store = 233

trial_df = plot_df[plot_df['STORE_NBR'] == trial_store].sort_values('MONTH')
control_df = plot_df[plot_df['STORE_NBR'] == control_store].sort_values('MONTH')

# Plot
plt.figure(figsize=(12, 6))

plt.plot(control_df['MONTH'], control_df['scaled_sales'],
      label='Control Store (Scaled)', color='blue', marker='o')
plt.plot(trial_df['MONTH'], trial_df['total_sales'],
      label='Trial Store', color='orange', marker='o')

# Highlight the trial period
plt.axvspan(pd.Timestamp('2019-02-01'), pd.Timestamp('2019-04-30'),
        color='green', alpha=0.2, label='Trial Period')

# Labels and formatting
plt.title('Trial vs Scaled Control Store Sales with Trial Period Highlighted')
```

```
plt.xlabel('Month')
plt.ylabel('Total Sales ($)')
plt.legend()
plt.grid(True)
plt.xticks(rotation=45)
plt.tight_layout()

plt.show()
```