```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.stats import t



# Step 2: Load and prepare the data
qvi_data = pd.read_csv('/content/QVI_data.csv')
qvi_data['DATE'] = pd.to_datetime(qvi_data['DATE'])
qvi_data['YEARMONTH'] = qvi_data['DATE'].dt.to_period('M').astype(str).str.replace('-', '').astype(int)

print(qvi_data.info())
print(qvi_data.describe())
qvi_data.head()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 264834 entries, 0 to 264833
Data columns (total 13 columns):
 #   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
 12  YEARMONTH         264834 non-null  int64
dtypes: datetime64[ns](1), float64(1), int64(7), object(4)
memory usage: 26.3+ MB
None
       LYLTY_CARD_NBR                           DATE      STORE_NBR  \
count    2.648340e+05                         264834  264834.000000
mean     1.355488e+05  2018-12-30 00:52:10.292937984     135.079423
min      1.000000e+03            2018-07-01 00:00:00       1.000000
25%      7.002100e+04            2018-09-30 00:00:00      70.000000
50%      1.303570e+05            2018-12-30 00:00:00     130.000000
75%      2.030940e+05            2019-03-31 00:00:00     203.000000
max      2.373711e+06            2019-06-30 00:00:00     272.000000
std      8.057990e+04                            NaN      76.784063

              TXN_ID       PROD_NBR       PROD_QTY      TOT_SALES  \
count  2.648340e+05  264834.000000  264834.000000  264834.000000
mean   1.351576e+05      56.583554       1.905813       7.299346
min    1.000000e+00       1.000000       1.000000       1.500000
25%    6.760050e+04      28.000000       2.000000       5.400000
50%    1.351365e+05      56.000000       2.000000       7.400000
75%    2.026998e+05      85.000000       2.000000       9.200000
max    2.415841e+06     114.000000       5.000000      29.500000
std    7.813292e+04      32.826444       0.343436       2.527241

           PACK_SIZE      YEARMONTH
count  264834.000000  264834.000000
mean      182.425512  201856.055163
min        70.000000  201807.000000
25%       150.000000  201809.000000
50%       170.000000  201812.000000
75%       175.000000  201903.000000
max       380.000000  201906.000000
std        64.325148      47.035278
```

	LYLTY_CARD_NBR	DATE	STORE_NBR	TXN_ID	PROD_NBR	PROD_NAME	PROD_QTY	TOT_SALES	PACK_SIZE	BRAND	LIFESTAGE
0	1000	2018-10-17	1	1	5	Natural Chip Compny SeaSalt175g	2	6.0	175	NATURAL	YOUNG SINGLES/COUPLES
1	1002	2018-09-16	1	2	58	Red Rock Deli Chikn&Garlic Aioli 150g	1	2.7	150	RRD	YOUNG SINGLES/COUPLES
2	1003	2019-03-07	1	3	52	Grain Waves Sour Cream&Chives 210G	1	3.6	210	GRNWVES	YOUNG FAMILIES
3	1003	2019-03-08	1	4	106	Natural ChipCo Hony Soy Chckn175g	1	3.0	175	NATURAL	YOUNG FAMILIES
4	1004	2018-11-02	1	5	96	WW Original Stacked Chips 160g	1	1.9	160	WOOLWORTHS	OLDER SINGLES/COUPLES

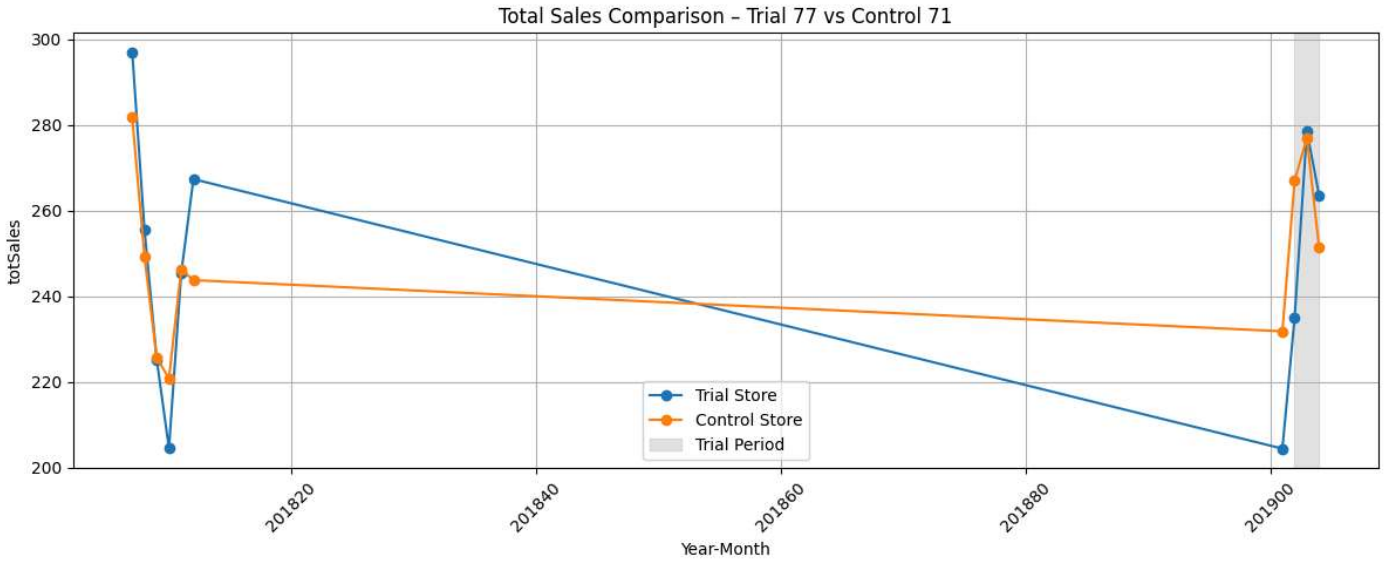
```
# Step 3: Create monthly metrics
monthly_metrics = qvi_data.groupby(['STORE_NBR', 'YEARMONTH']).agg(
    totSales=('TOT_SALES', 'sum'),
    nCustomers=('LYLTY_CARD_NBR', pd.Series.nunique),
    nTransactions=('TXN_ID', pd.Series.nunique),
```

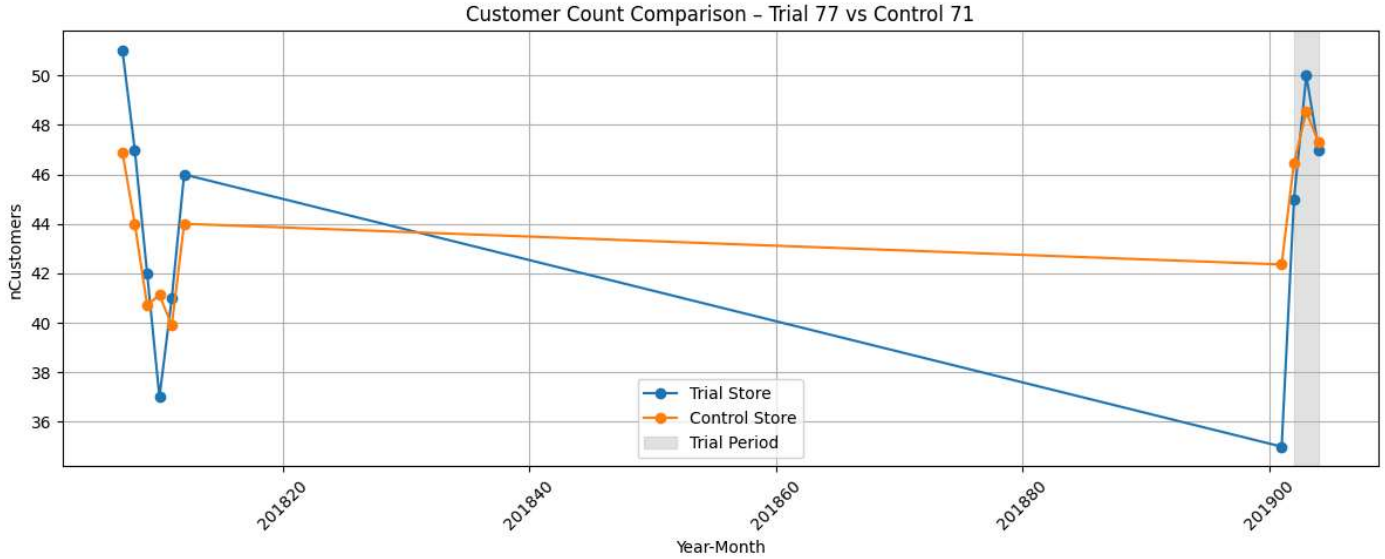
```
    nChips=('PROD_QTY', 'sum')
).reset_index()


# Step 4: Add derived metrics
monthly_metrics['nTxnPerCust'] = monthly_metrics['nTransactions'] / monthly_metrics['nCustomers']
monthly_metrics['nChipsPerTxn'] = monthly_metrics['nChips'] / monthly_metrics['nTransactions']
monthly_metrics['avgPricePerUnit'] = monthly_metrics['totSales'] / monthly_metrics['nChips']



# Step 5: Define correlation function
def calculate_correlation(metric_df, store_trial, metric='totSales'):
    trial = metric_df[metric_df['STORE_NBR'] == store_trial].sort_values('YEARMONTH')
    correlations = []
    for store in metric_df['STORE_NBR'].unique():
        if store == store_trial:
            continue
        control = metric_df[metric_df['STORE_NBR'] == store].sort_values('YEARMONTH')
        merged = pd.merge(trial, control, on='YEARMONTH', suffixes=('_trial', '_ctrl'))
        if merged.empty or len(merged) < 6:
            continue
        corr = merged[f'{metric}_trial'].corr(merged[f'{metric}_ctrl'])
        correlations.append((store_trial, store, corr))
    return pd.DataFrame(correlations, columns=['Store1', 'Store2', 'corr_measure'])



# Step 6: Define magnitude distance function
def calculate_magnitude(metric_df, store_trial, metric='totSales'):
    trial = metric_df[metric_df['STORE_NBR'] == store_trial]
    distances = []
    for store in metric_df['STORE_NBR'].unique():
        if store == store_trial:
            continue
        control = metric_df[metric_df['STORE_NBR'] == store]
        merged = pd.merge(trial, control, on='YEARMONTH', suffixes=('_trial', '_ctrl'))
        if merged.empty or len(merged) < 6:
            continue
        dist = abs(merged[f'{metric}_trial'] - merged[f'{metric}_ctrl'])
        norm_score = 1 - (dist - dist.min()) / (dist.max() - dist.min() + 1e-9)
        distances.append((store_trial, store, norm_score.mean()))
    return pd.DataFrame(distances, columns=['Store1', 'Store2', 'mag_measure'])


# Step 7: Define control store selector function
def find_best_control_store(trial_store, metric_df, metric='totSales'):
    pretrial_df = metric_df[metric_df['YEARMONTH'] < 201902]
    corr_df = calculate_correlation(pretrial_df, trial_store, metric=metric)
    mag_df = calculate_magnitude(pretrial_df, trial_store, metric=metric)
    if corr_df.empty or mag_df.empty:
        return None
    control_score = pd.merge(corr_df, mag_df, on=['Store1', 'Store2'])
    control_score['final_score'] = 0.5 * control_score['corr_measure'] + 0.5 * control_score['mag_measure']
    control_score = control_score.sort_values(by='final_score', ascending=False)
    return control_score.iloc[0]['Store2'], control_score



# Step 8: Apply function to all trial stores
trial_stores = [77, 86, 88]
control_store_results = {}
for trial in trial_stores:
    control_store, full_table = find_best_control_store(trial, monthly_metrics)
    control_store_results[trial] = {
        'control_store': control_store,
        'comparison_table': full_table
    }

for trial, result in control_store_results.items():
    print(f"Trial store {trial} → Best control store: {int(result['control_store'])}")
```

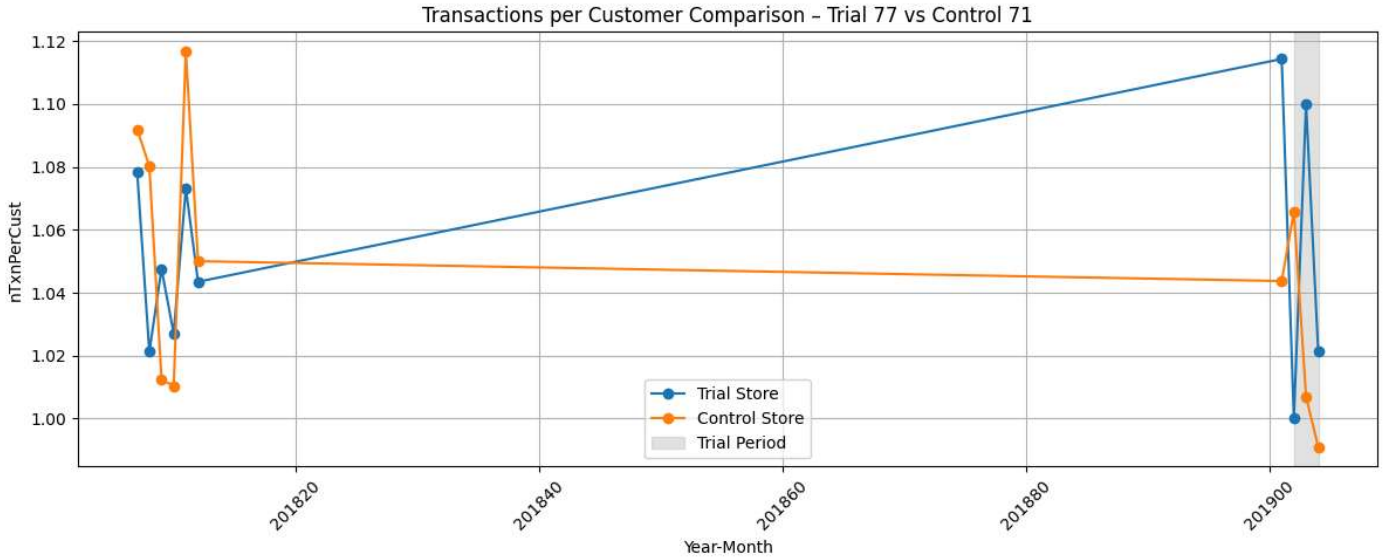
```
Trial store 77 → Best control store: 71
Trial store 86 → Best control store: 155
Trial store 88 → Best control store: 134
```

```
# Function to scale control and plot trial vs control store
def plot_metric_comparison(trial_store, control_store, metric, title=None):
```

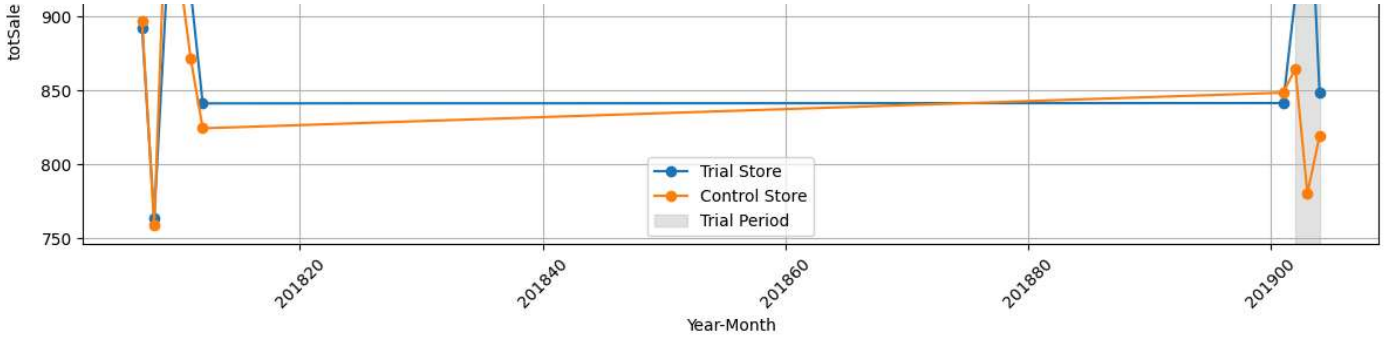
```
    subset = monthly_metrics[
        (monthly_metrics['STORE_NBR'].isin([trial_store, control_store])) &
        (monthly_metrics['YEARMONTH'] < 201905)
    ].copy()

    # Tag store type
    subset['Store_Type'] = subset['STORE_NBR'].apply(lambda x: 'Trial' if x == trial_store else 'Control')

    # Scale control store to match pre-trial levels
    pre_trial = subset['YEARMONTH'] < 201902
    pre_totals = subset[pre_trial].groupby('Store_Type')[metric].sum()
    scaling_factor = pre_totals['Trial'] / pre_totals['Control']
    subset['scaled_metric'] = subset.apply(
        lambda row: row[metric] * scaling_factor if row['Store_Type'] == 'Control' else row[metric],
        axis=1
    )

    # Plot
    plt.figure(figsize=(12, 5))
    for store_type in ['Trial', 'Control']:
        data = subset[subset['Store_Type'] == store_type]
        plt.plot(data['YEARMONTH'], data['scaled_metric'], marker='o', label=f"{store_type} Store")

    # Highlight trial period
    plt.axvspan(201902, 201904, color='gray', alpha=0.2, label='Trial Period')
    plt.title(title or f"{metric} Comparison – Trial {trial_store} vs Control {control_store}")
    plt.xlabel("Year-Month")
    plt.ylabel(metric)
    plt.xticks(rotation=45)
    plt.grid(True)
    plt.legend()
    plt.tight_layout()
    plt.show()



# Define the metrics you want to visualize
metrics_to_plot = ['totSales', 'nCustomers', 'nTxnPerCust']
metric_titles = {
    'totSales': 'Total Sales Comparison',
    'nCustomers': 'Customer Count Comparison',
    'nTxnPerCust': 'Transactions per Customer Comparison'
}

# Loop through all trial stores and their matched control stores
for trial in trial_stores:
    control = int(control_store_results[trial]['control_store'])
    for metric in metrics_to_plot:
        plot_metric_comparison(
            trial_store=trial,
            control_store=control,
            metric=metric,
            title=f'{metric_titles[metric]} – Trial {trial} vs Control {control}'
        )
```

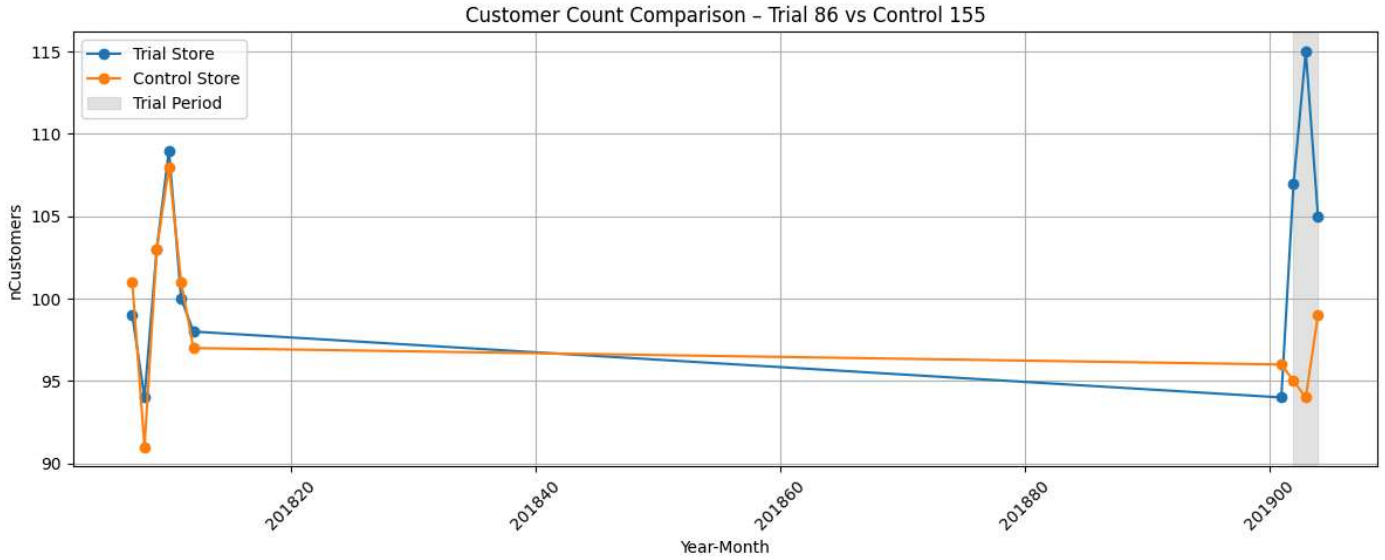

Total Sales Comparison – Trial 77 vs Control 71
totSales
Year-Month
Trial Store
Control Store
Trial Period

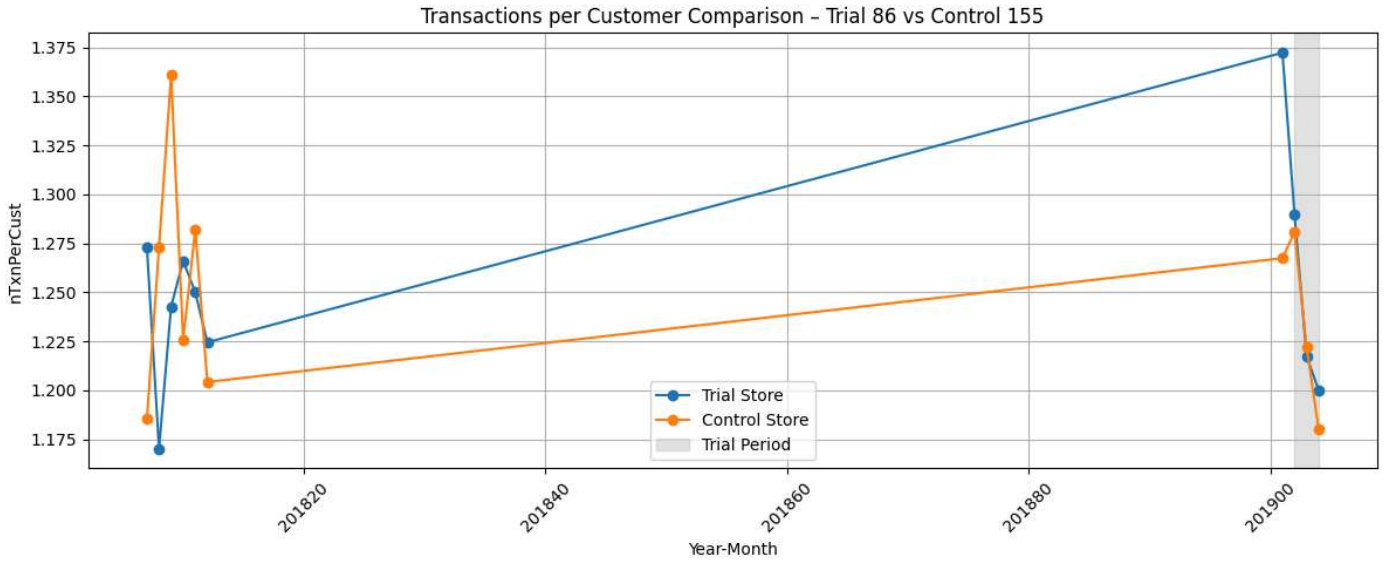

Customer Count Comparison – Trial 77 vs Control 71
nCustomers
Year-Month
Trial Store
Control Store
Trial Period


Transactions per Customer Comparison – Trial 77 vs Control 71
nTxnPerCust
Year-Month
Trial Store
Control Store
Trial Period


Total Sales Comparison – Trial 86 vs Control 155

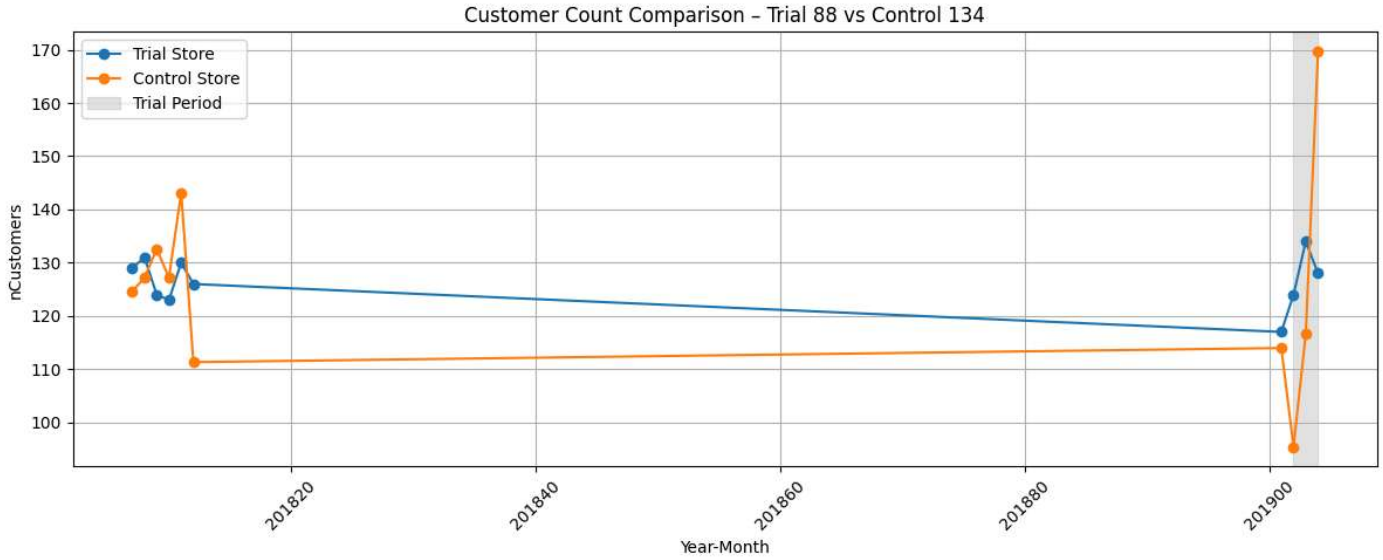

totSale
900
850
800
750
Trial Store
Control Store
Trial Period
201820
201840
201860
201880
201900
Year-Month

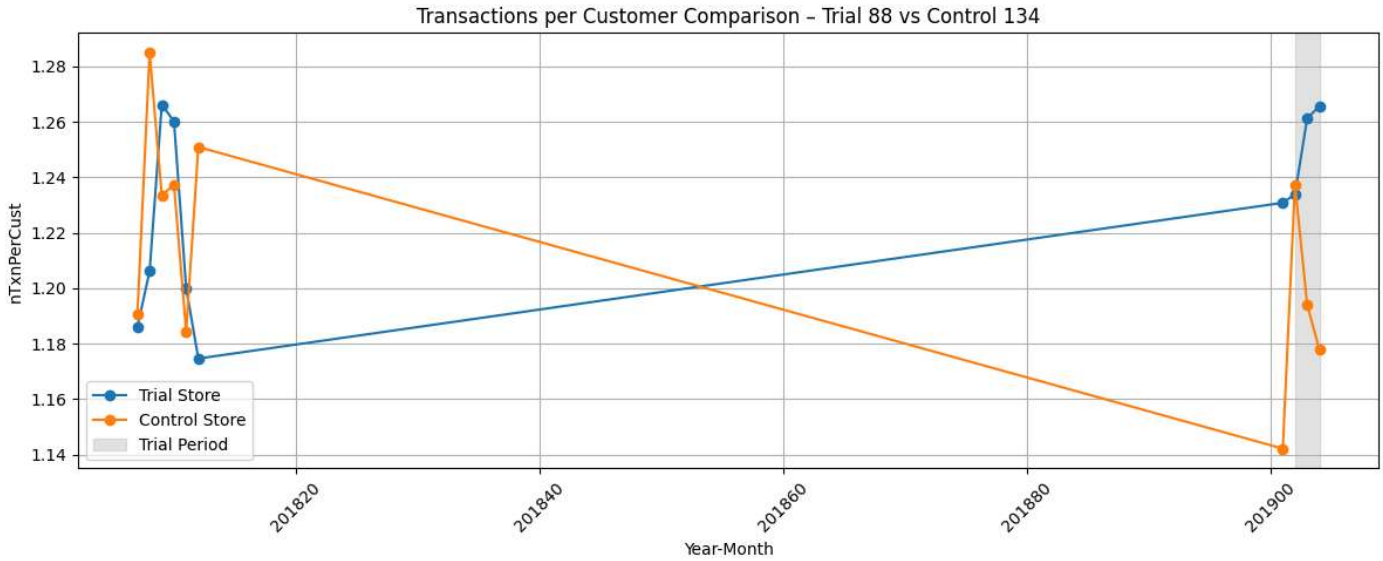

Customer Count Comparison – Trial 86 vs Control 155
nCustomers
115
110
105
100
95
90
Trial Store
Control Store
Trial Period
201820
201840
201860
201880
201900
Year-Month


Transactions per Customer Comparison – Trial 86 vs Control 155
nTxnPerCust
1.375
1.350
1.325
1.300
1.275
1.250
1.225
1.200
1.175
Trial Store
Control Store
Trial Period
201820
201840
201860
201880
201900
Year-Month


Total Sales Comparison – Trial 88 vs Control 134
totSales
1800
1700
1600
1500
1400
1300
1200
1100
Trial Store
Control Store
Trial Period


201820
201840
201860
201880
201900
Year-Month


Customer Count Comparison – Trial 88 vs Control 134
Trial Store
Control Store
Trial Period
nCustomers
170
160
150
140
130
120
110
100
201820
201840
201860
201880
201900
Year-Month


Transactions per Customer Comparison – Trial 88 vs Control 134
Trial Store
Control Store
Trial Period
nTxnPerCust
1.28
1.26
1.24
1.22
1.20
1.18
1.16
1.14
201820
201840
201860
201880
201900
Year-Month