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Task 2 :-

Experimentation and uplift testing

- Julia has asked us to evaluate the performance of a store trial which was performed in stores 77, 86 and 88.

```
• This can be broken down by:-
        ♦ Total sales revenue
        ♦ Total number of customers
        ♦ Average number of transactions per customer
```

- Create a measure to compare different control stores to each of the trial stores to do this write a function to reduce having to re-do the analysis for each trial store. Consider using Pearson correlations or a metric such as a magnitude distance e.g. 1- (Observed distance – minimum distance)/(Maximum distance – minimum distance) as a measure.

- Once you have selected your control stores, compare each trial and control pair during the trial period. You want to test if total sales are significantly different in the trial period and if so, check if the driver of change is more purchasing customers or more purchases per customers etc.

  - Main areas of Focus are :-
    - Select control stores – Explore data, define metrics, visualize graphs
    - Assessment of the trial – insights/trends by comparing trial stores with control stores
    - Collate findings – summarize and provide recommendations

Importing Necessary Libraries

In [1]:

```
import pandas as pd
import numpy as np

# for data visualization
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns

import warnings
warnings.filterwarnings('ignore')
```

Importing Dataset

In [3]:

```
qvi = pd.read_csv("Data/QVI_data.csv")
qvi.head()
```

Out[3]:

	LYLTY_CARD_NBR	DATE	STORE_NBR	TXN_ID	PROD_NBR	PROD_NAME	PROD_QTY	TOT_
0	1000	2018-10-17	1	1	5	Natural Chip Compny SeaSalt175g	2	
1	1002	2018-09-16	1	2	58	Red Rock Deli Chikn&Garlic Aioli 150g	1	
2	1003	2019-03-07	1	3	52	Grain Waves Sour Cream&Chives 210G	1	
3	1003	2019-03-08	1	4	106	Natural ChipCo Hony Soy Chckn175g	1	
4	1004	2018-11-02	1	5	96	WW Original Stacked Chips 160g	1	

Data Exploration

In [4]:

```
print("Number of Rows and Columns :- ", qvi.shape)
```

```
Number of Rows and Columns :-  (264834, 12)
```

In [5]:

```
# Basic Information of dataset
qvi.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 264834 entries, 0 to 264833
Data columns (total 12 columns):
 #   Column            Non-Null Count   Dtype  
---  ------            --------------   -----  
 0   LYLTY_CARD_NBR    264834 non-null  int64  
 1   DATE              264834 non-null  object 
 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: float64(1), int64(6), object(5)
memory usage: 24.2+ MB
```

In [6]:

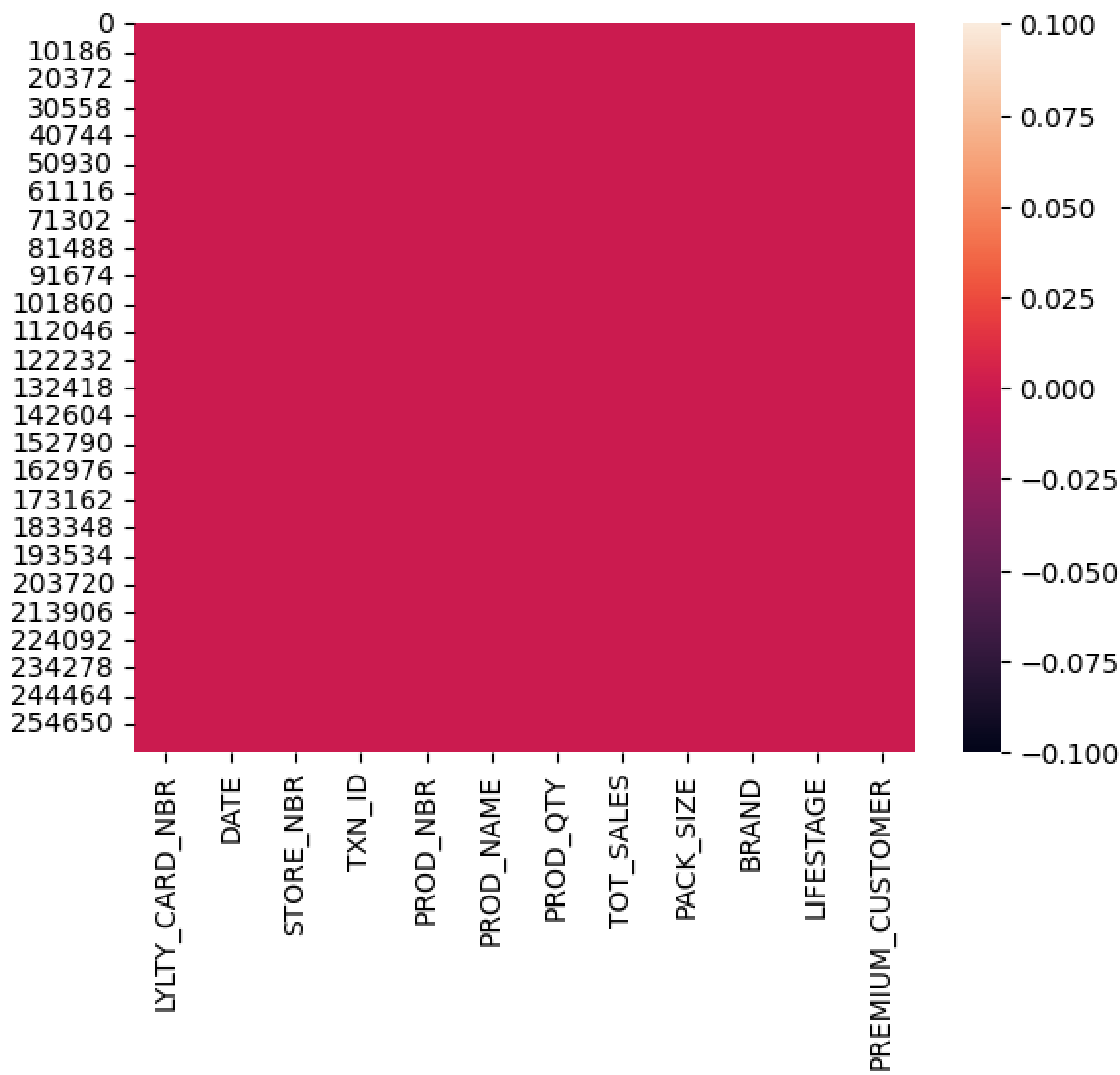
```
# Statistical Summary of QVI_data
qvi.describe().T
```

Out[6]:

	count	mean	std	min	25%	50%	75%
LYLTY_CARD_NBR	264834.0	135548.793331	80579.898912	1000.0	70021.0	130357.0	203094.0
STORE_NBR	264834.0	135.079423	76.784063	1.0	70.0	130.0	203.0
TXN_ID	264834.0	135157.623236	78132.920436	1.0	67600.5	135136.5	202699.7
PROD_NBR	264834.0	56.583554	32.826444	1.0	28.0	56.0	85.0
PROD_QTY	264834.0	1.905813	0.343436	1.0	2.0	2.0	2.0
TOT_SALES	264834.0	7.299346	2.527241	1.5	5.4	7.4	9.2
PACK_SIZE	264834.0	182.425512	64.325148	70.0	150.0	170.0	175.0

Checking missing values in Dataset

In [7]:
```
sns.heatmap(qvi.isnull())
plt.show()
```



In [8]:
```
qvi.isnull().sum()
```

Out[8]:
```
LYLTY_CARD_NBR      0
DATE                0
STORE_NBR           0
TXN_ID              0
PROD_NBR            0
PROD_NAME           0
PROD_QTY            0
TOT_SALES           0
PACK_SIZE           0
BRAND               0
LIFESTAGE           0
PREMIUM_CUSTOMER    0
dtype: int64
```

We can see there is no missing values the dataset.

In [9]:
```
### Handling "Date" column
qvi["DATE"] = pd.to_datetime(qvi["DATE"])
qvi["YEARMONTH"] = qvi["DATE"].dt.strftime("%Y%m").astype("int")
```

Compile each store's monthly:-

- Total sales
- Number of customers
- Average transactions per customer
- Average chips per customer
- Average price per unit

In [11]:
```
def monthly_store_metrics():
    store_yrmo_group = qvi.groupby(["STORE_NBR", "YEARMONTH"])
    total = store_yrmo_group["TOT_SALES"].sum()
    num_cust = store_yrmo_group["LYLTY_CARD_NBR"].nunique()
    trans_per_cust = store_yrmo_group.size() / num_cust
    avg_chips_per_cust = store_yrmo_group["PROD_QTY"].sum() / num_cust
    avg_chips_price = total / store_yrmo_group["PROD_QTY"].sum()
    aggregates = [total, num_cust, trans_per_cust, avg_chips_per_cust, avg_chip
    metrics = pd.concat(aggregates, axis=1)
    metrics.columns = ["TOT_SALES", "nCustomers", "nTxnPerCust", "nChipsPerTxn"
    return metrics
```

In [12]:
```
qvi_monthly_metrics = monthly_store_metrics().reset_index()
qvi_monthly_metrics.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3169 entries, 0 to 3168
Data columns (total 7 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   STORE_NBR       3169 non-null   int64  
 1   YEARMONTH       3169 non-null   int64  
 2   TOT_SALES       3169 non-null   float64
 3   nCustomers      3169 non-null   int64  
 4   nTxnPerCust     3169 non-null   float64
 5   nChipsPerTxn    3169 non-null   float64
 6   avgPricePerUnit 3169 non-null   float64
dtypes: float64(4), int64(3)
memory usage: 173.4 KB
```

Pre-Trial Observation as this filter only stores with full 12 months observation

In [14]:
```
observ_counts = qvi_monthly_metrics["STORE_NBR"].value_counts()
full_observ_index = observ_counts[observ_counts == 12].index
full_observ = qvi_monthly_metrics[qvi_monthly_metrics["STORE_NBR"].isin(full_ob
pretrial_full_observ = full_observ[full_observ["YEARMONTH"] < 201902]

pretrial_full_observ.head(8)
```

Out[14]:

	STORE_NBR	YEARMONTH	TOT_SALES	nCustomers	nTxnPerCust	nChipsPerTxn	avgPriceP
0	1	201807	206.9	49	1.061224	1.265306	3.:
1	1	201808	176.1	42	1.023810	1.285714	3
2	1	201809	278.8	59	1.050847	1.271186	3.
3	1	201810	188.1	44	1.022727	1.318182	3.:
4	1	201811	192.6	46	1.021739	1.239130	3.:
5	1	201812	189.6	42	1.119048	1.357143	3.:
6	1	201901	154.8	35	1.028571	1.200000	3.(
12	2	201807	150.8	39	1.051282	1.179487	3.

In [15]:
```
def calcCorrTable(metricCol, storeComparison, inputTable=pretrial_full_observ):
  control_store_nbrs = inputTable[~inputTable["STORE_NBR"].isin([77, 86, 88])][
  corrs = pd.DataFrame(columns = ["YEARMONTH", "Trial_Str", "Ctrl_Str", "Corr_S
  trial_store = inputTable[inputTable["STORE_NBR"] == storeComparison][metricCo
  for control in control_store_nbrs:
    concat_df = pd.DataFrame(columns = ["YEARMONTH", "Trial_Str", "Ctrl_Str", '
    control_store = inputTable[inputTable["STORE_NBR"] == control][metricCol].r
    concat_df["Corr_Score"] = trial_store.corrwith(control_store, axis=1)
    concat_df["Trial_Str"] = storeComparison
    concat_df["Ctrl_Str"] = control
    concat_df["YEARMONTH"] = list(inputTable[inputTable["STORE_NBR"] == storeCo
    corrs = pd.concat([corrs, concat_df])
  return corrs
```

In [16]:
```
corr_table = pd.DataFrame()
for trial_num in [77, 86, 88]:
    corr_table = pd.concat([corr_table, calcCorrTable(["TOT_SALES", "nCustomers

corr_table.head(8)
```

Out[16]:

	YEARMONTH	Trial_Str	Ctrl_Str	Corr_Score
0	201807	77	1	0.070414
1	201808	77	1	0.027276
2	201809	77	1	0.002389
3	201810	77	1	-0.020045
4	201811	77	1	0.030024
5	201812	77	1	0.063946
6	201901	77	1	0.001470
0	201807	77	2	0.142957

In [17]:
```
def calculateMagnitudeDistance(metricCol, storeComparison, inputTable=pretrial_
    control_store_nbrs = inputTable[~inputTable["STORE_NBR"].isin([77, 86, 88])
    dists = pd.DataFrame()
    trial_store = inputTable[inputTable["STORE_NBR"] == storeComparison][metric
    for control in control_store_nbrs:
        concat_df  = abs(inputTable[inputTable["STORE_NBR"] == storeComparison]
        concat_df["YEARMONTH"] = list(inputTable[inputTable["STORE_NBR"] == sto
        concat_df["Trial_Str"] = storeComparison
        concat_df["Ctrl_Str"] = control
        dists = pd.concat([dists, concat_df])
    for col in metricCol:
        dists[col] = 1 - ((dists[col] - dists[col].min()) / (dists[col].max() -
    dists["magnitude"] = dists[metricCol].mean(axis=1)
    return dists
```

In [18]:
```
dist_table = pd.DataFrame()
for trial_num in [77, 86, 88]:
    dist_table = pd.concat([dist_table, calculateMagnitudeDistance(["TOT_SALES'

dist_table.head(8)
dist_table
```

Out[18]:

	TOT_SALES	nCustomers	nTxnPerCust	nChipsPerTxn	avgPricePerUnit	YEARMONTH	Trial_
0	0.935431	0.980769	0.958035	0.739412	0.883569	201807	
1	0.942972	0.951923	0.993823	0.802894	0.886328	201808	
2	0.961503	0.836538	0.992126	0.730041	0.703027	201809	
3	0.988221	0.932692	0.989514	0.940460	0.590528	201810	
4	0.962149	0.951923	0.874566	0.730358	0.832481	201811	
...	...	...	...	...	...	...	
2	0.207554	0.286822	0.462846	0.779879	0.923887	201809	
3	0.346797	0.387597	0.571497	0.796875	0.971133	201810	
4	0.286706	0.310078	0.623883	0.813241	0.966999	201811	
5	0.347151	0.387597	0.376456	0.699748	0.962198	201812	
6	0.402353	0.449612	0.450378	0.739714	0.971335	201901	

5397 rows × 9 columns

We'll select control stores based on how similar monthly total sales in dollar amounts and monthly number of customers are to the trial stores by using correlation and magnitude distance.

In [23]:

```
def combine_corr_dist(metricCol, storeComparison, inputTable=pretrial_full_obse
    corrs = calcCorrTable(metricCol, storeComparison, inputTable)
    dists = calculateMagnitudeDistance(metricCol, storeComparison, inputTable)
    dists = dists.drop(metricCol, axis=1)
    combine = pd.merge(corrs, dists, on=["YEARMONTH", "Trial_Str", "Ctrl_Str"])
    return combine
```

In [24]:

```
compare_metrics_table1 = pd.DataFrame()
for trial_num in [77, 86, 88]:
    compare_metrics_table1 = pd.concat([compare_metrics_table1, combine_corr_di
```

In [25]:

```
corr_weight = 0.5
dist_weight = 1 - corr_weight
```

Determining the top five highest composite score for each trial based on Total sales

In [26]:

```
grouped_comparison_table1 = compare_metrics_table1.groupby(["Trial_Str", "Ctrl_
grouped_comparison_table1["CompScore"] = (corr_weight * grouped_comparison_tabl
for trial_num in compare_metrics_table1["Trial_Str"].unique():
    print(grouped_comparison_table1[grouped_comparison_table1["Trial_Str"] == t
```

```
     Trial_Str  Ctrl_Str  Corr_Score  magnitude  CompScore
218         77       233         1.0   0.986477   0.993238
239         77       255         1.0   0.979479   0.989739
177         77       188         1.0   0.977663   0.988831
49          77        53         1.0   0.976678   0.988339
120         77       131         1.0   0.976267   0.988134

     Trial_Str  Ctrl_Str  Corr_Score  magnitude  CompScore
356         86       109         1.0   0.966783   0.983391
401         86       155         1.0   0.965876   0.982938
464         86       222         1.0   0.962280   0.981140
467         86       225         1.0   0.960512   0.980256
471         86       229         1.0   0.951704   0.975852

     Trial_Str  Ctrl_Str  Corr_Score  magnitude  CompScore
551         88        40         1.0   0.941165   0.970582
538         88        26         1.0   0.904377   0.952189
582         88        72         1.0   0.903800   0.951900
517         88         4         1.0   0.903466   0.951733
568         88        58         1.0   0.891678   0.945839
```

In [27]:
```
compare_metrics_table2 = pd.DataFrame()
for trial_num in [77, 86, 88]:
    compare_metrics_table2 = pd.concat([compare_metrics_table2, combine_corr_di
```

Determining the top five highest composite score for each trial based on no. of customers

In [28]:
```
grouped_comparison_table2 = compare_metrics_table2.groupby(["Trial_Str", "Ctrl_
grouped_comparison_table2["CompScore"] = (corr_weight * grouped_comparison_tabl
for trial_num in compare_metrics_table2["Trial_Str"].unique():
    print(grouped_comparison_table2[grouped_comparison_table2["Trial_Str"] == t
```

```
     Trial_Str  Ctrl_Str  Corr_Score  magnitude  CompScore
218         77       233         1.0   0.993132   0.996566
38          77        41         1.0   0.976648   0.988324
101         77       111         1.0   0.968407   0.984203
105         77       115         1.0   0.967033   0.983516
15          77        17         1.0   0.965659   0.982830

     Trial_Str  Ctrl_Str  Corr_Score  magnitude  CompScore
401         86       155         1.0   0.986772   0.993386
467         86       225         1.0   0.969577   0.984788
356         86       109         1.0   0.969577   0.984788
471         86       229         1.0   0.964286   0.982143
293         86        39         1.0   0.961640   0.980820

     Trial_Str  Ctrl_Str  Corr_Score  magnitude  CompScore
736         88       237         1.0   0.987818   0.993909
705         88       203         1.0   0.944629   0.972315
551         88        40         1.0   0.942414   0.971207
668         88       165         1.0   0.935770   0.967885
701         88       199         1.0   0.932447   0.966224
```

In [29]:
```
for trial_num in compare_metrics_table2["Trial_Str"].unique():
    a = grouped_comparison_table1[grouped_comparison_table1["Trial_Str"] == tri
```

```
    b = grouped_comparison_table2[grouped_comparison_table2["Trial_Str"] == tri
    print((pd.concat([a,b], axis=1).sum(axis=1)/2).sort_values(ascending=False)
```

```
Trial_Str  Ctrl_Str
77         233         0.994902
           41          0.986020
           46          0.984762
dtype: float64

Trial_Str  Ctrl_Str
86         155         0.988162
           109         0.984090
           225         0.982522
dtype: float64

Trial_Str  Ctrl_Str
88         40          0.970895
           26          0.958929
           72          0.954079
dtype: float64
```

Observation

Similarities based on total sales:

1. Trial store 77: Store 233, 255, 188
2. Trial store 86: Store 109, 155, 222
3. Trial store 88: Store 40, 26, 72

Similarities based on No. of Customers:

1. Trial store 77: Store 233, 41, 111
2. Trial store 86: Store 155, 225, 109
3. Trial store 88: Store 237, 203, 40

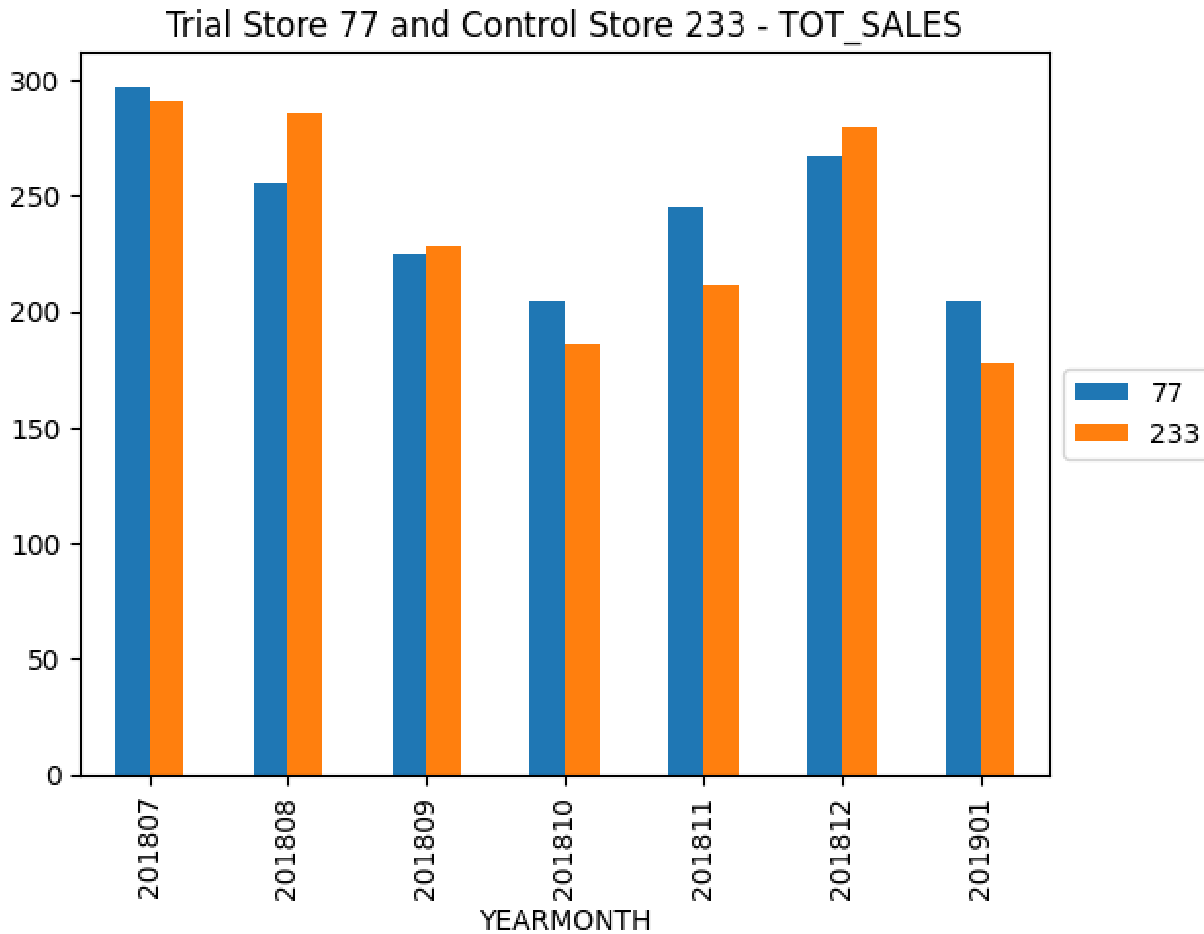
Final SImilarities based on Highest average of both features combined:

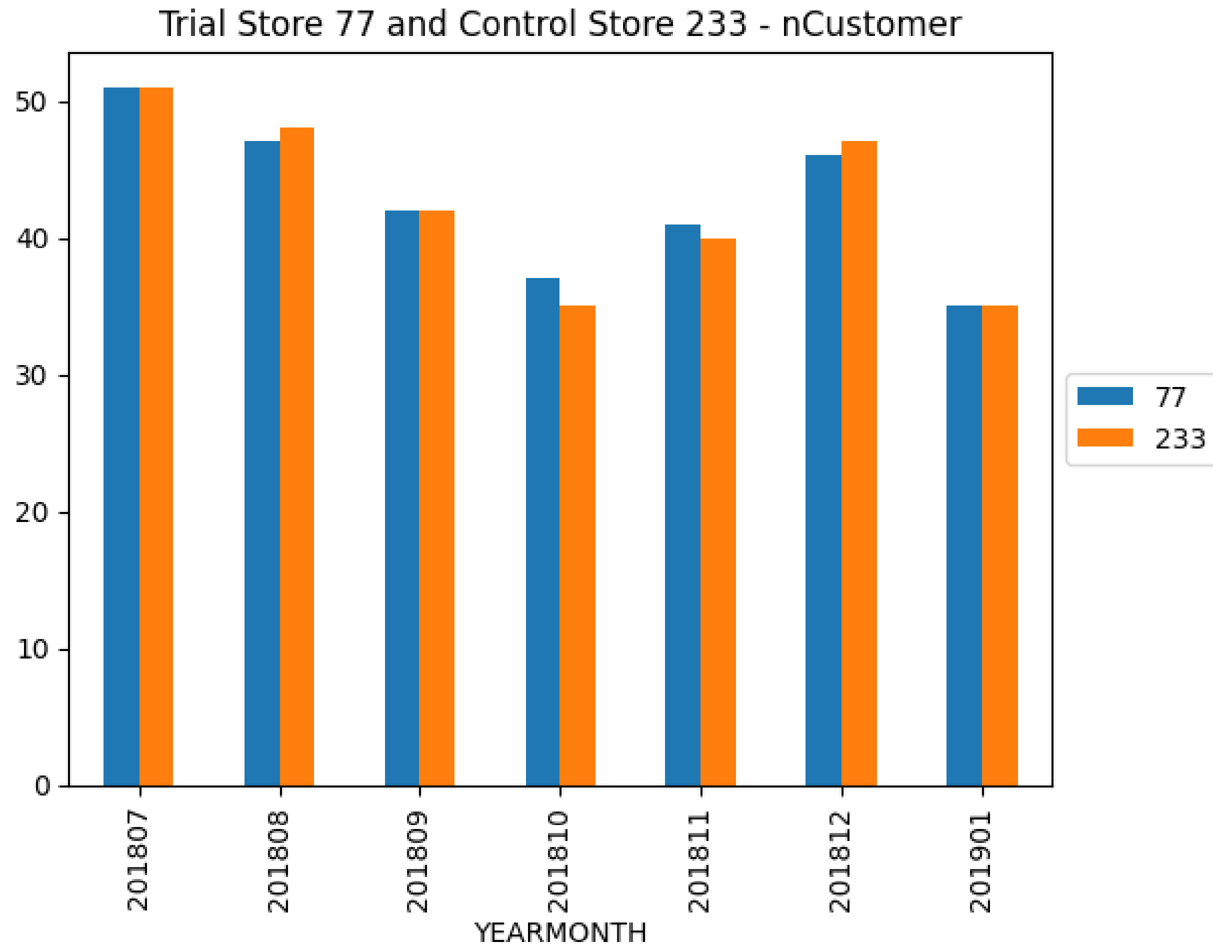
1. Trial store 77: Store 233
2. Trial store 86: Store 155
3. Trial store 88: Store 40

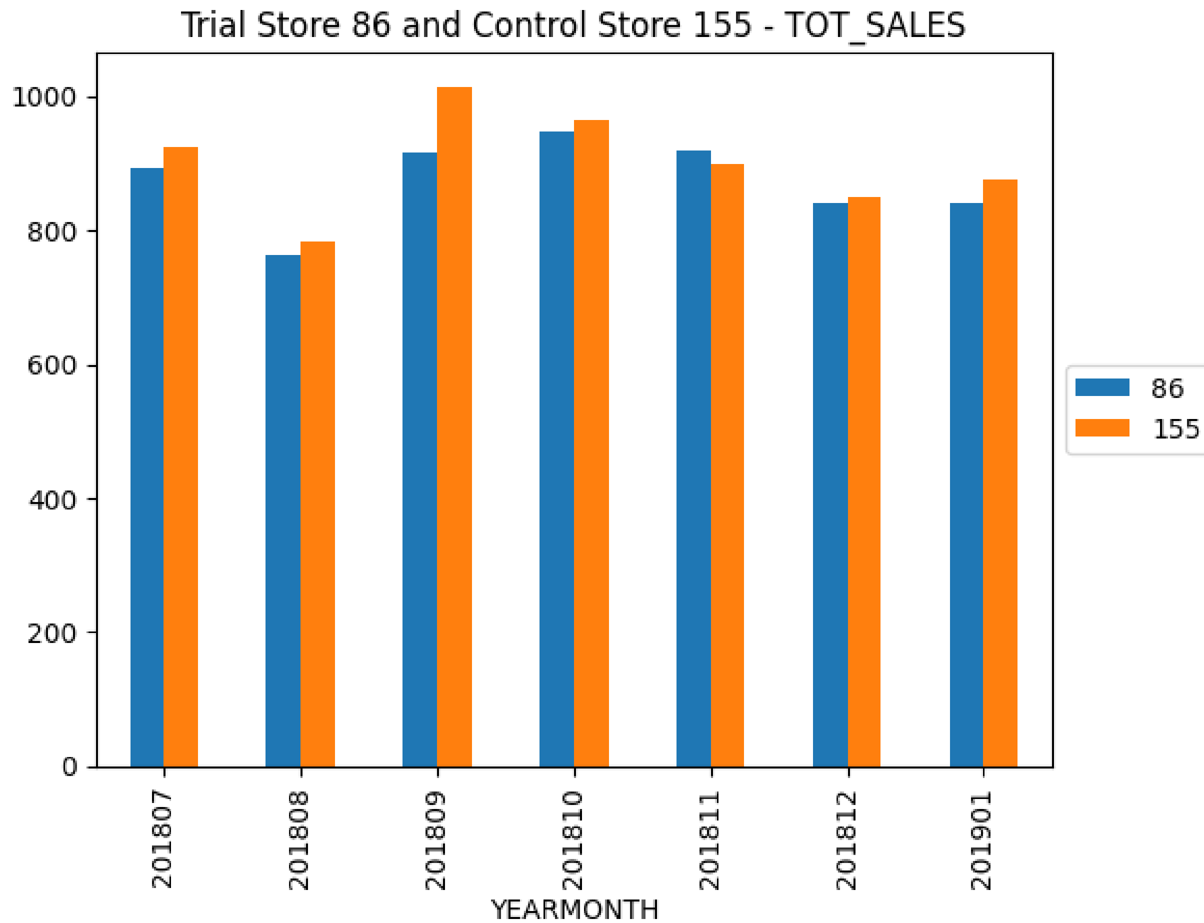
In [30]:

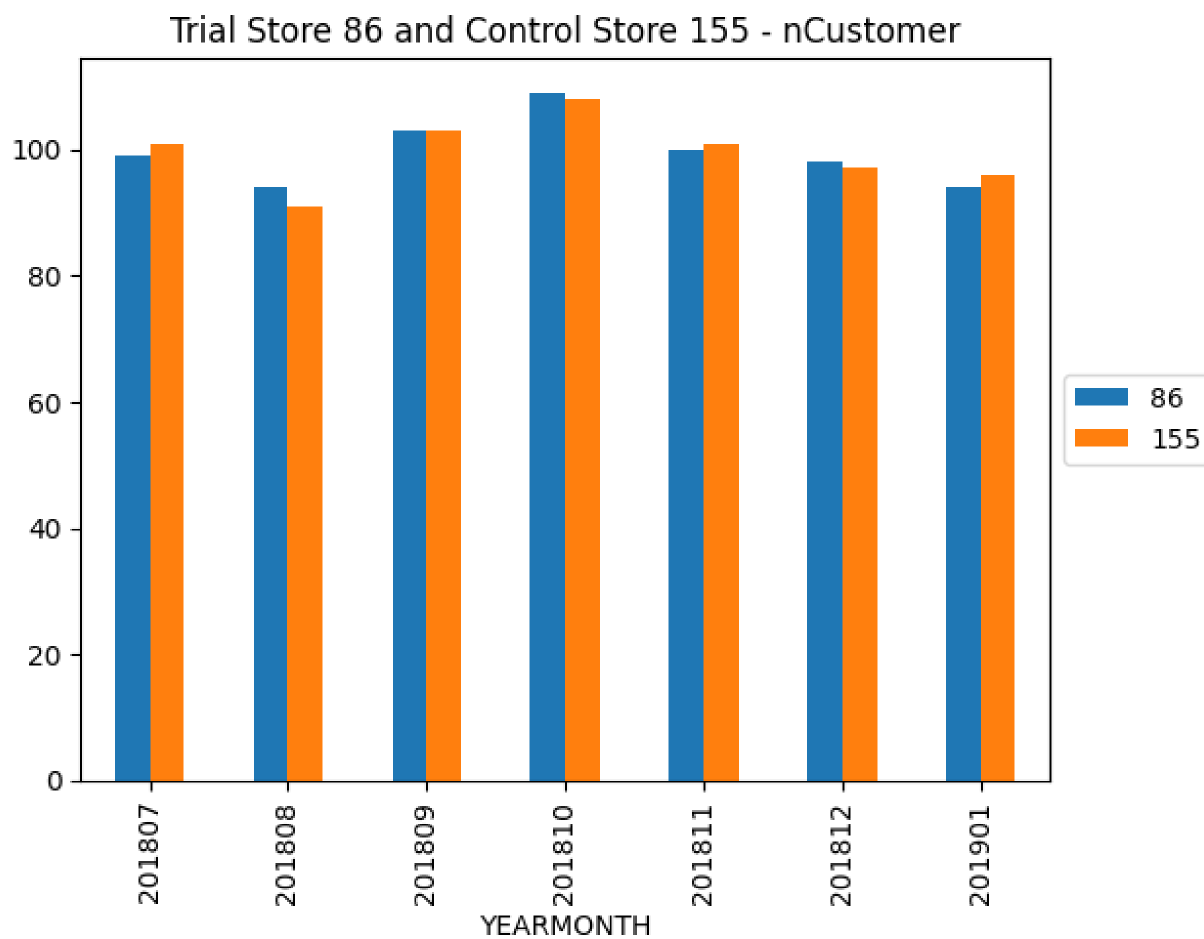
```
trial_control_dic = {77:233, 86:155, 88:40}

for key, val in trial_control_dic.items():
    pretrial_full_observ[pretrial_full_observ["STORE_NBR"].isin([key, val])].gr
        ["YEARMONTH", "STORE_NBR"]).sum()["TOT_SALES"].unstack().plot.bar()
    plt.legend(loc='center left', bbox_to_anchor=(1.0, 0.5))
    plt.title("Trial Store "+str(key)+" and Control Store "+str(val)+" - TOT_SA
    plt.show()

    pretrial_full_observ[pretrial_full_observ["STORE_NBR"].isin([key, val])].gr
    ["YEARMONTH", "STORE_NBR"]).sum()["nCustomers"].unstack().plot.bar()
    plt.legend(loc='center left', bbox_to_anchor=(1.0, 0.5))
    plt.title("Trial Store "+str(key)+" and Control Store "+str(val)+" - nCusto
```

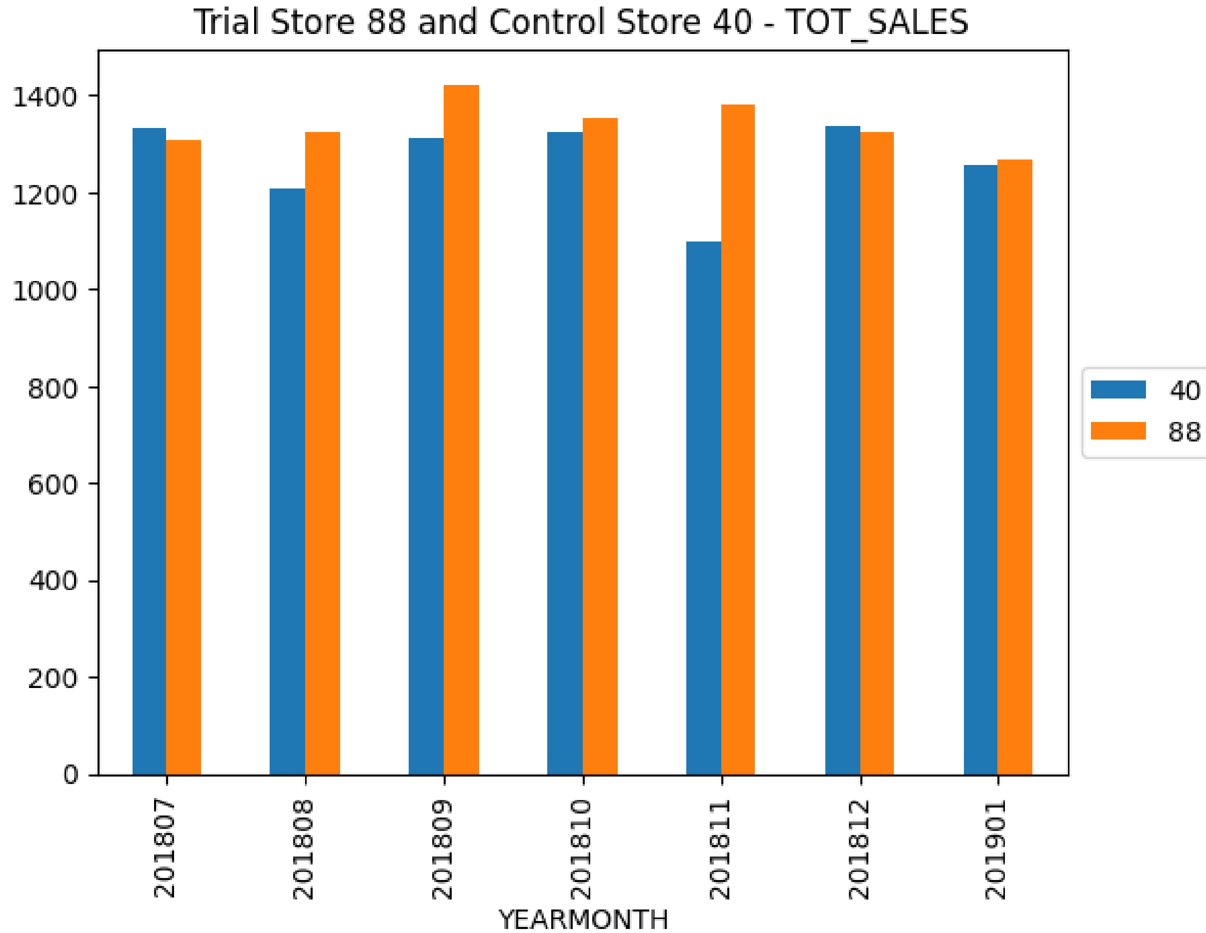
```
    plt.show()
    print('\n')
```

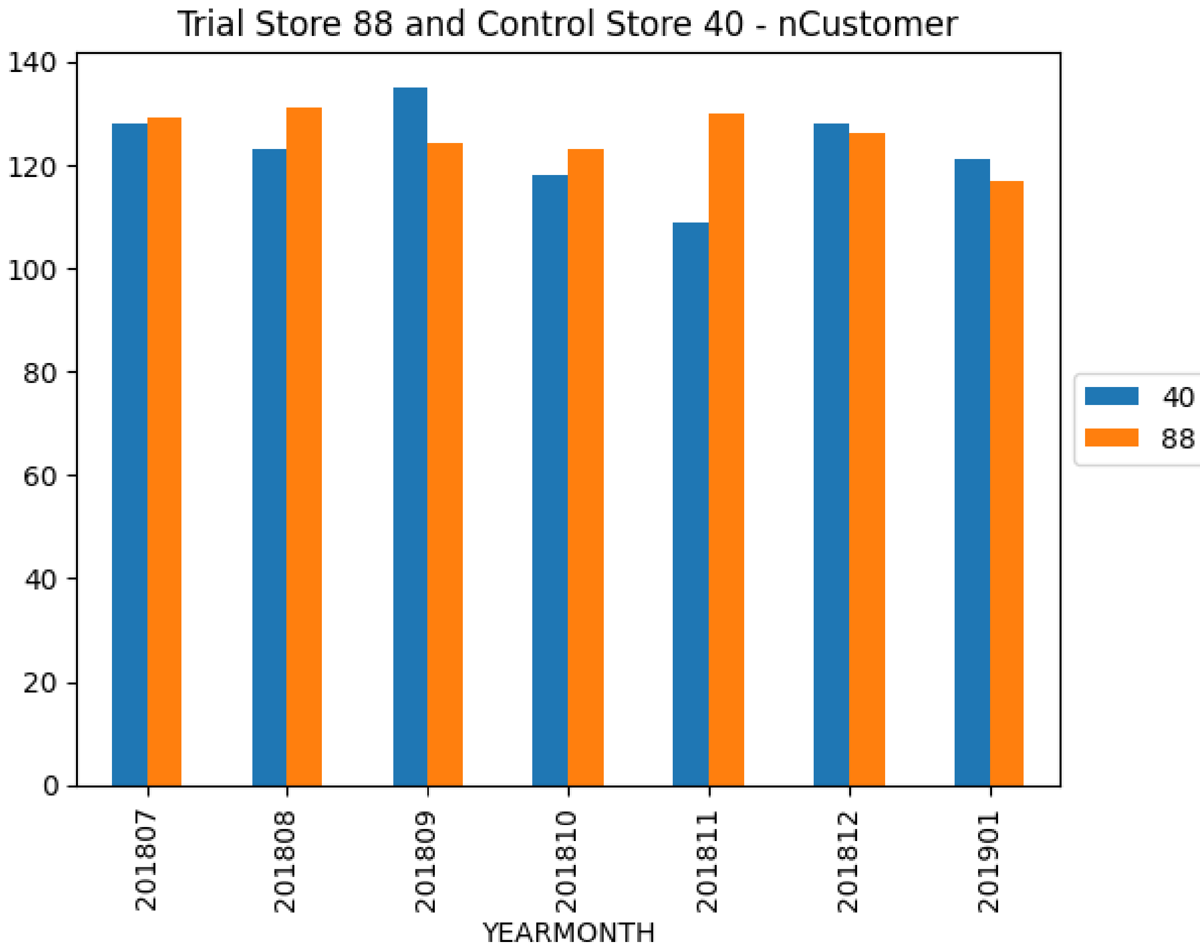



Trial Store 77 and Control Store 233 - nCustomer
50
40
30
20
10
0
201807
201808
201809
201810
201811
201812
201901
YEARMONTH
77
233


Trial Store 86 and Control Store 155 - TOT_SALES
1000
800
600
400
200
0
201807
201808
201809
201810
201811
201812
201901
YEARMONTH
86
155


Trial Store 86 and Control Store 155 - nCustomer
100
80
60
40
20
0
201807
201808
201809
201810
201811
201812
201901
YEARMONTH
86
155


Trial Store 88 and Control Store 40 - TOT_SALES
1400
1200
1000
800
600
400
200
0
201807
201808
201809
201810
201811
201812
201901
YEARMONTH
40
88



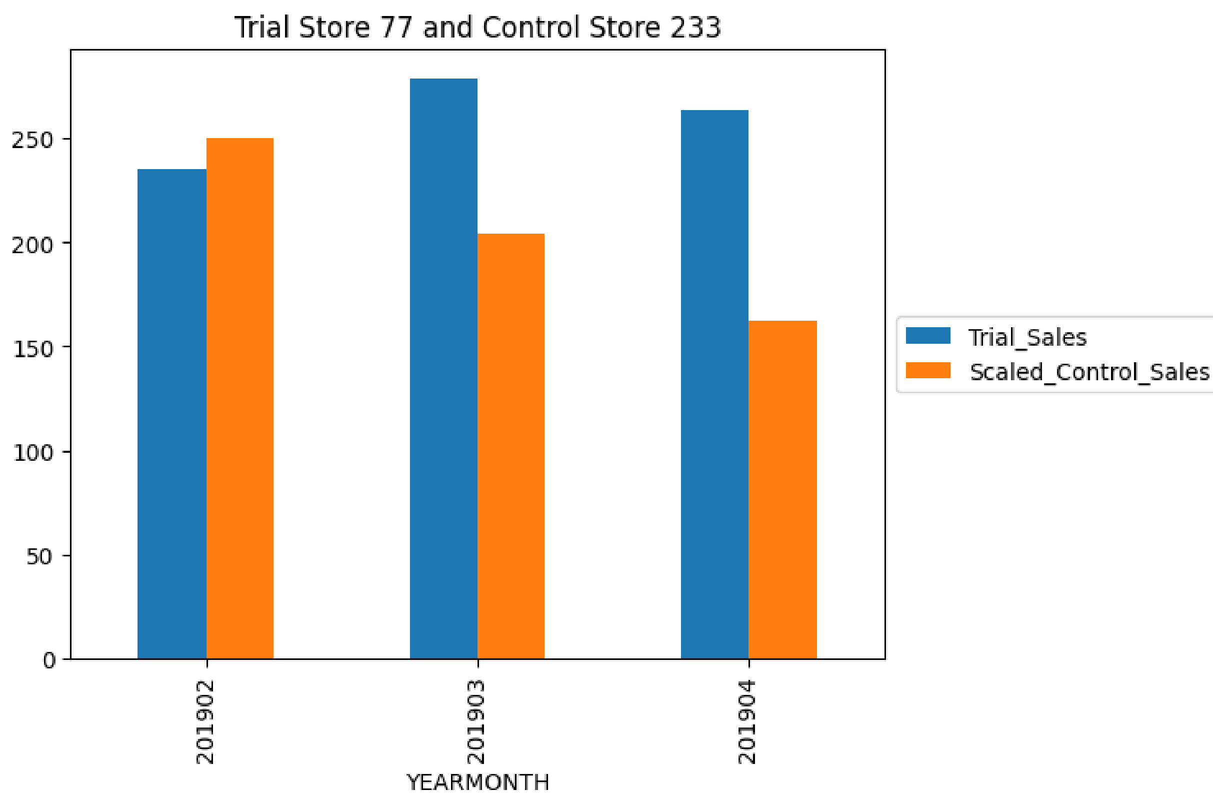
Performance of Trails Store to Control Store during trial period

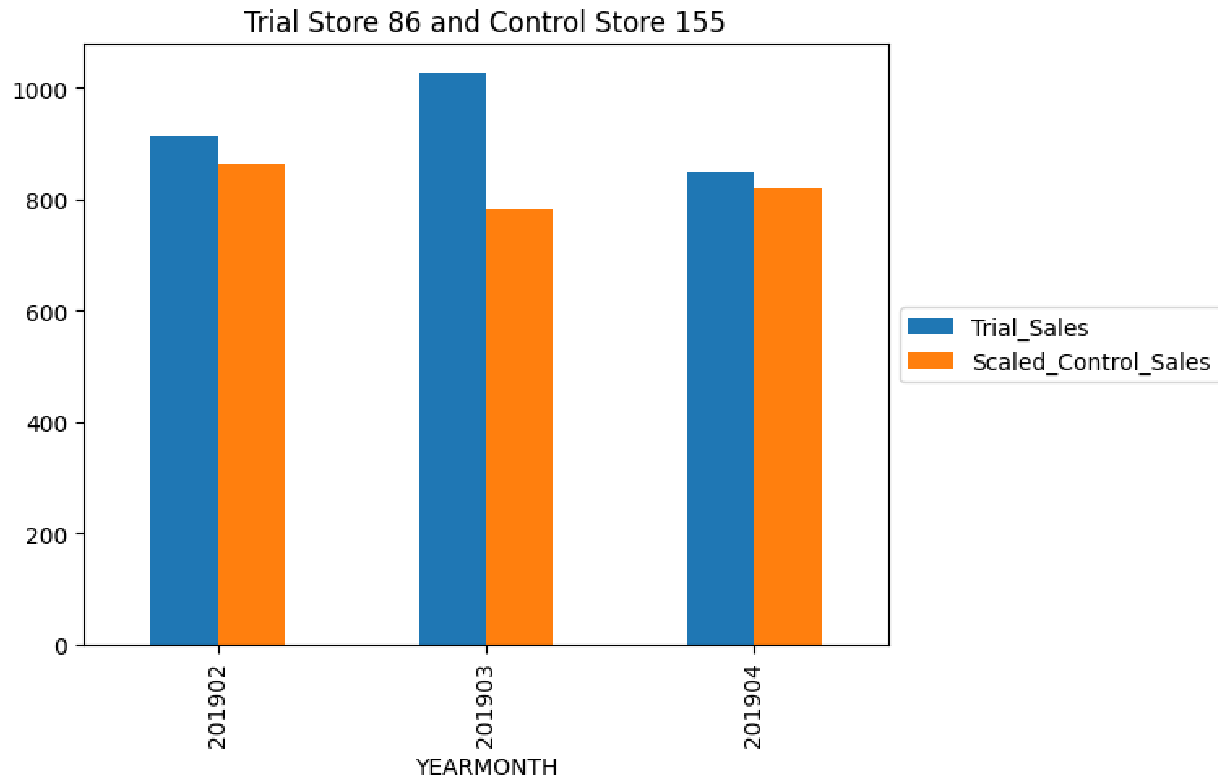
- Next we'll compare the performance of Trial stores to Control stores during the trial period.
- To ensure their performance is comparable during Trial period, we need to scale (multiply to ratio of trial / control) all of Control stores' performance to Trial store's performance during pre-trial.
- Starting with TOT_SALES.

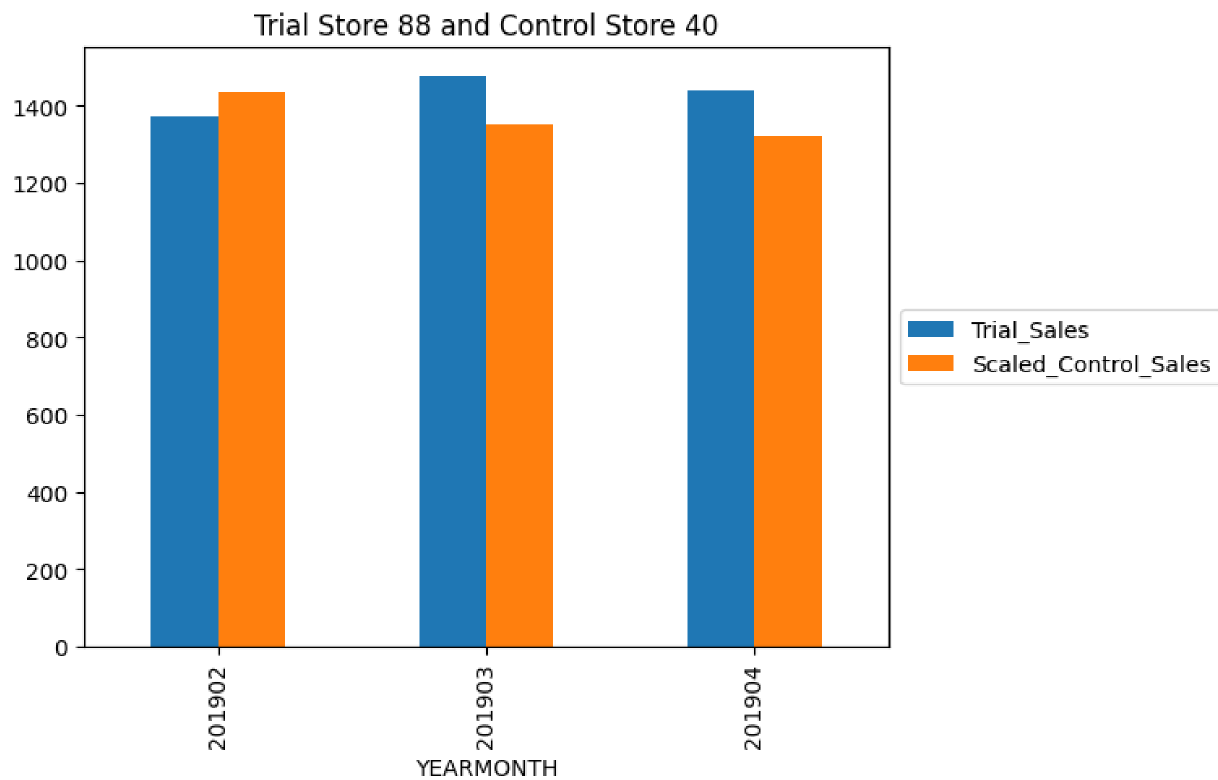
In [31]:
```
#Ratio of Store 77 and its Control store.
sales_ratio_77 = pretrial_full_observ[pretrial_full_observ["STORE_NBR"] == 77][

#Ratio of Store 86 and its Control store.
sales_ratio_86 = pretrial_full_observ[pretrial_full_observ["STORE_NBR"] == 86][

#Ratio of Store 77 and its Control store.
sales_ratio_88 = pretrial_full_observ[pretrial_full_observ["STORE_NBR"] == 88][
```

In [32]:
```
trial_full_observ = full_observ[(full_observ["YEARMONTH"] >= 201902) & (full_ob
scaled_sales_control_stores = full_observ[full_observ["STORE_NBR"].isin([233, 1

def scaler(row):
```

```
    if row["STORE_NBR"] == 233:
        return row["TOT_SALES"] * sales_ratio_77
    elif row["STORE_NBR"] == 155:
        return row["TOT_SALES"] * sales_ratio_86
    elif row["STORE_NBR"] == 40:
        return row["TOT_SALES"] * sales_ratio_88

scaled_sales_control_stores["ScaledSales"] = scaled_sales_control_stores.apply(

trial_scaled_sales_control_stores = scaled_sales_control_stores[(scaled_sales_c
pretrial_scaled_sales_control_stores = scaled_sales_control_stores[scaled_sales

percentage_diff = {}

for trial, control in trial_control_dic.items():
    a = trial_scaled_sales_control_stores[trial_scaled_sales_control_stores["ST
    b = trial_full_observ[trial_full_observ["STORE_NBR"] == trial][["STORE_NBR'
    percentage_diff[trial] = b["TOT_SALES"].sum() / a["ScaledSales"].sum()
    b[["YEARMONTH", "TOT_SALES"]].merge(a[["YEARMONTH", "ScaledSales"]],on="YEA
    plt.legend(loc='center left', bbox_to_anchor=(1.0, 0.5))
    plt.title("Trial Store "+str(trial)+" and Control Store "+str(control))
```







In [33]:
```
percentage_diff
```

Out[33]:
```
{77: 1.2615468650086281, 86: 1.1315014357363697, 88: 1.043458345854219}
```

In [34]:
```
temp1 = scaled_sales_control_stores.sort_values(by=["STORE_NBR", "YEARMONTH"],
temp2 = full_observ[full_observ["STORE_NBR"].isin([77,86,88])][["STORE_NBR", "Y
scaledsales_vs_trial = pd.concat([temp1, temp2], axis=1)
scaledsales_vs_trial.columns = ["c_STORE_NBR", "YEARMONTH", "c_ScaledSales", "t
scaledsales_vs_trial["Sales_Percentage_Diff"] = (scaledsales_vs_trial["t_TOT_SA
```

```
def label_period(cell):
    if cell < 201902:
        return "pre"
    elif cell > 201904:
        return "post"
    else:
        return "trial"
scaledsales_vs_trial["trial_period"] = scaledsales_vs_trial["YEARMONTH"].apply(
scaledsales_vs_trial[scaledsales_vs_trial["trial_period"] == "trial"]
```

Out[34]:

	c_STORE_NBR	YEARMONTH	c_ScaledSales	t_STORE_NBR	t_TOT_SALES	Sales_Percentag
7	233	201902	249.762622	77	235.0	-0.0
8	233	201903	203.802205	77	278.5	0.3
9	233	201904	162.345704	77	263.5	0.4
19	155	201902	864.522060	86	913.2	0.0
20	155	201903	780.320405	86	1026.8	0.2
21	155	201904	819.317024	86	848.2	0.0
31	40	201902	1434.399269	88	1370.2	-0.0
32	40	201903	1352.064709	88	1477.2	0.0
33	40	201904	1321.797762	88	1439.4	0.0

Check significance of Trial minus Control stores TOT_SALES Percentage Difference Pre-Trial vs Trial.

Step 1: Check null hypothesis of 0 difference between control store's Pre-Trial and Trial period performance.

Step 2: Proof control and trial stores are similar statistically

Check p-value of control store's Pre-Trial vs Trial store's Pre-Trial. If <5%, it is significantly different. If >5%, it is not significantly different (similar).

Step 3: After checking Null Hypothesis of first 2 step to be true, we can check Null Hypothesis of Percentage Difference between Trial and Control stores during pre-trial is the same as during trial.

Check T-Value of Percentage Difference of each Trial month (Feb, March, April 2019). Mean is mean of Percentage Difference during pre-trial. Standard deviation is stdev of Percentage Difference during pre-trial. Formula is Trial month's Percentage Difference minus Mean, divided by Standard deviation. Compare each T-Value with 95% percentage significance critical t-value of 6 degrees of freedom (7 months of sample - 1)

In [35]:

```
from scipy.stats import ttest_ind, t

# Step 1
for num in [40, 155, 233]:
    print("Store", num)
    print(ttest_ind(pretrial_scaled_sales_control_stores[pretrial_scaled_sales_
```

```
                    trial_scaled_sales_control_stores[trial_scaled_sales_control
                    equal_var=False), '\n')
    #print(len(pretrial_scaled_sales_control_stores[pretrial_scaled_sales_contr

alpha = 0.05
print("Critical t-value for 95% confidence interval:")
print(t.ppf((alpha/2, 1-alpha/2), df=min([len(pretrial_scaled_sales_control_sto
                        len(trial_scaled_sales_control_stores[trial_scaled_sales
```

```
Store 40
Ttest_indResult(statistic=-0.5958372343168558, pvalue=0.5722861621434027)

Store 155
Ttest_indResult(statistic=1.4291956879290917, pvalue=0.1972705865160342)

Store 233
Ttest_indResult(statistic=1.191102601097452, pvalue=0.2944500606486209)

Critical t-value for 95% confidence interval:
[-4.30265273  4.30265273]
```

In [36]:
```
a = pretrial_scaled_sales_control_stores[pretrial_scaled_sales_control_stores['
b = trial_scaled_sales_control_stores[trial_scaled_sales_control_stores["STORE_
```

Null hypothesis is true. There isn't any statistically significant difference between control store's scaled Pre-Trial and Trial period sales.

In [37]:
```
# Step 2
for trial, cont in trial_control_dic.items():
    print("Trial store:", trial, ", Control store:", cont)
    print(ttest_ind(pretrial_full_observ[pretrial_full_observ["STORE_NBR"] == t
                    pretrial_scaled_sales_control_stores[pretrial_scaled_sales_c
                    equal_var=True), '\n')
    #print(len(pretrial_full_observ[pretrial_full_observ["STORE_NBR"] == trial]

alpha = 0.05
print("Critical t-value for 95% confidence interval:")
print(t.ppf((alpha/2, 1-alpha/2), df=len(pretrial_full_observ[pretrial_full_obs
```

```
Trial store: 77 , Control store: 233
Ttest_indResult(statistic=-1.2533353315065932e-15, pvalue=0.999999999999999)

Trial store: 86 , Control store: 155
Ttest_indResult(statistic=3.1048311203382156e-15, pvalue=0.9999999999999976)

Trial store: 88 , Control store: 40
Ttest_indResult(statistic=-5.69358613974361e-15, pvalue=0.9999999999999956)

Critical t-value for 95% confidence interval:
[-2.44691185  2.44691185]
```

Null hypothesis is true. There isn't any statistically significant difference between Trial store's sales and Control store's scaled-sales performance during pre-trial.

In [38]:
```
# Step 3
for trial, cont in trial_control_dic.items():
    print("Trial store:", trial, ", Control store:", cont)
    temp_pre = scaledsales_vs_trial[(scaledsales_vs_trial["c_STORE_NBR"] == con
    std = temp_pre["Sales_Percentage_Diff"].std()
```

```
    mean = temp_pre["Sales_Percentage_Diff"].mean()
    #print(std, mean)
    for t_month in scaledsales_vs_trial[scaledsales_vs_trial["trial_period"] ==
        pdif = scaledsales_vs_trial[(scaledsales_vs_trial["YEARMONTH"] == t_mon
        print(t_month,":",(float(pdif)-mean)/std)
    print('\n')

print("Critical t-value for 95% confidence interval:")
conf_intv_95 = t.ppf(0.95, df=len(temp_pre)-1)
print(conf_intv_95)
```

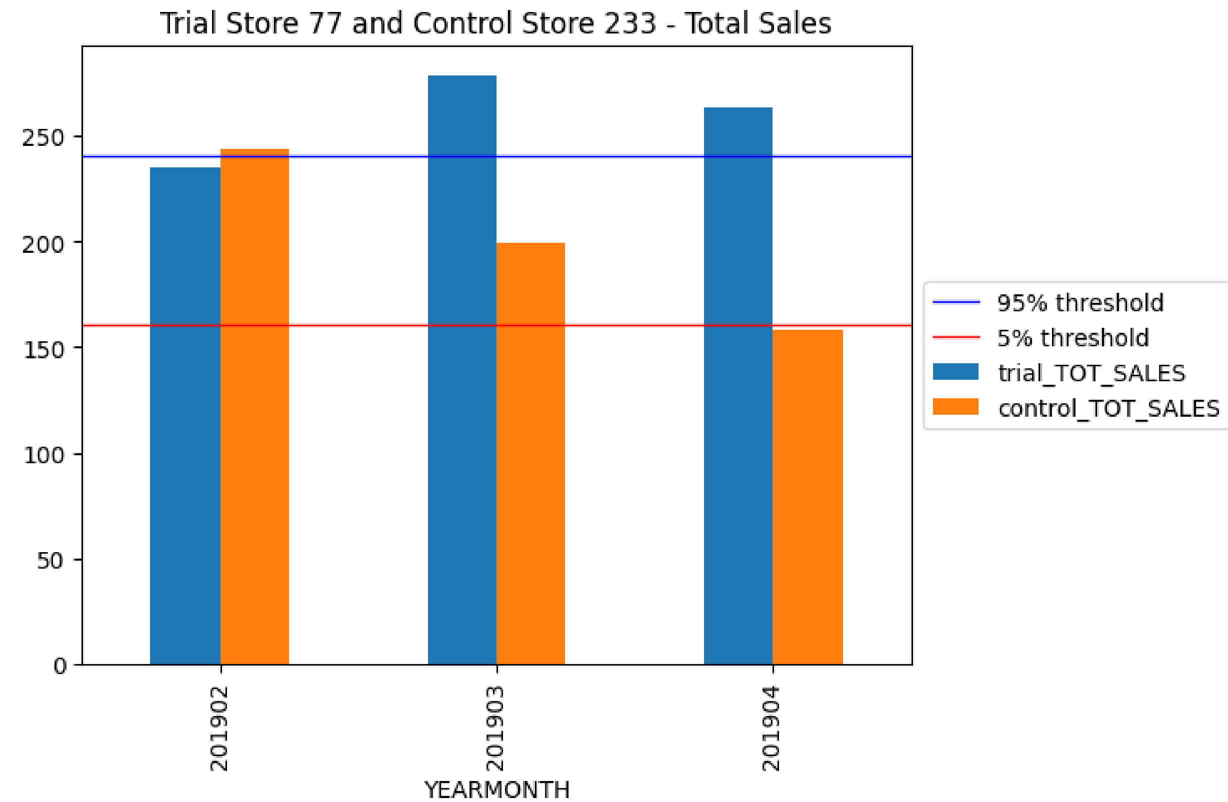
```
Trial store: 77 , Control store: 233
201902 : -0.7171038288055838
201903 : 3.035317928855674
201904 : 4.708944418758219


Trial store: 86 , Control store: 155
201902 : 1.4133618775921597
201903 : 7.123063846042147
201904 : 0.8863824572944234


Trial store: 88 , Control store: 40
201902 : -0.5481633746817577
201903 : 1.0089992743637823
201904 : 0.9710006270463672


Critical t-value for 95% confidence interval:
1.9431802803927816
```

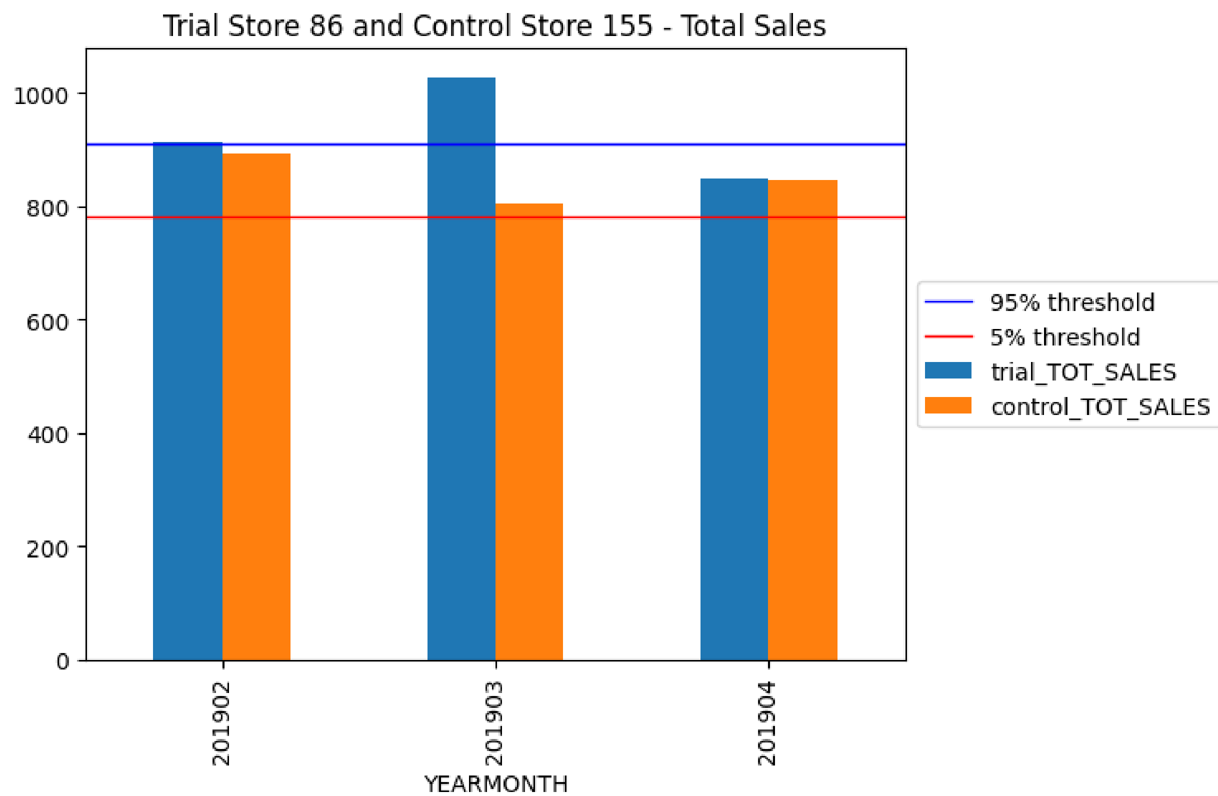
There are 3 months' increase in performance that are statistically significant (Above the 95% confidence interval t-score):

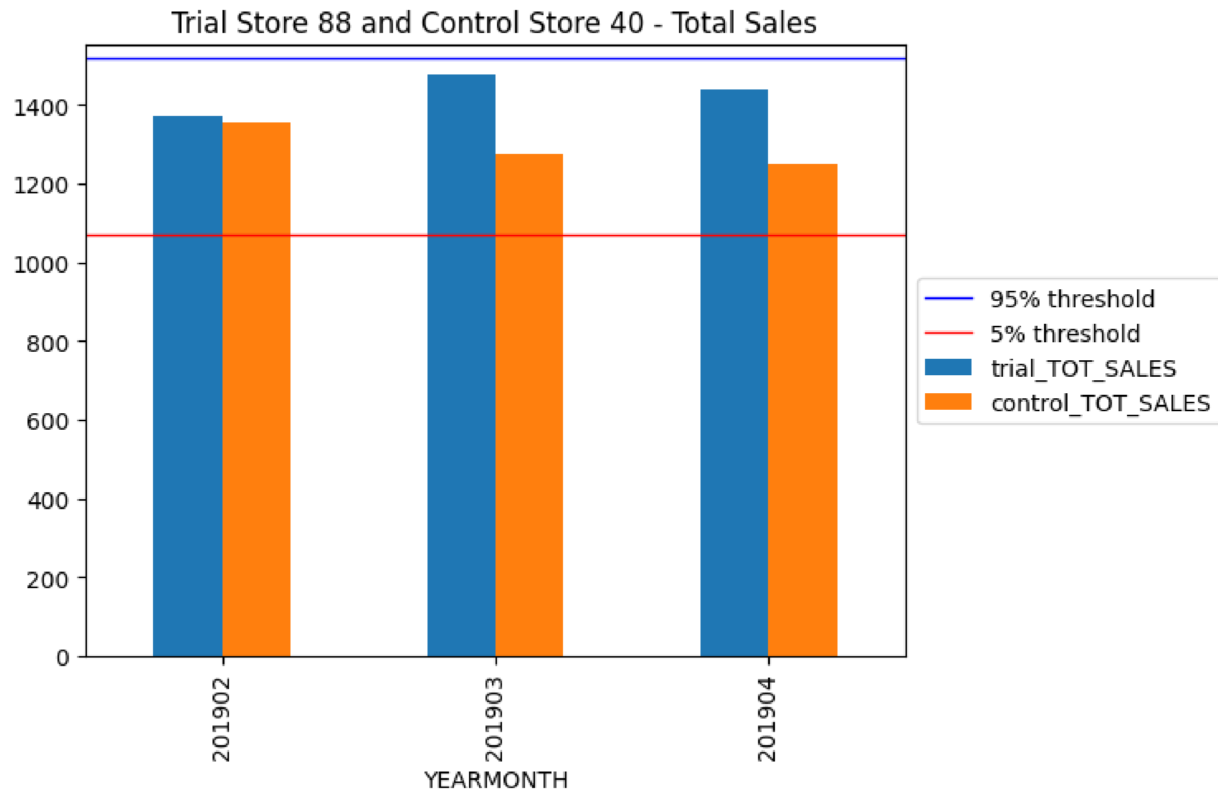
March and April trial months for trial store 77

March trial months for trial store 86

In [39]:
```
for trial, control in trial_control_dic.items():
    a = trial_scaled_sales_control_stores[trial_scaled_sales_control_stores["ST
    b = trial_full_observ[trial_full_observ["STORE_NBR"] == trial][["STORE_NBR'
    comb = b[["YEARMONTH", "trial_TOT_SALES"]].merge(a[["YEARMONTH", "control_T
    comb.plot.bar()
    cont_sc_sales = trial_scaled_sales_control_stores[trial_scaled_sales_contrc
    std = scaledsales_vs_trial[(scaledsales_vs_trial["c_STORE_NBR"] == control)
    thresh95 = cont_sc_sales.mean() + (cont_sc_sales.mean() * std * 2)
    thresh5 = cont_sc_sales.mean() - (cont_sc_sales.mean() * std * 2)
    plt.axhline(y=thresh95,linewidth=1, color='b', label="95% threshold")
    plt.axhline(y=thresh5,linewidth=1, color='r', label="5% threshold")
    plt.legend(loc='center left', bbox_to_anchor=(1.0, 0.5))
    plt.title("Trial Store "+str(trial)+" and Control Store "+str(control)+" -
    plt.savefig("TS {} and CS {} - TOT_SALES.png".format(trial,control), bbox_i
```


Trial Store 77 and Control Store 233 - Total Sales
250
200
150
100
50
0
201902
201903
201904
YEARMONTH
95% threshold
5% threshold
trial_TOT_SALES
control_TOT_SALES

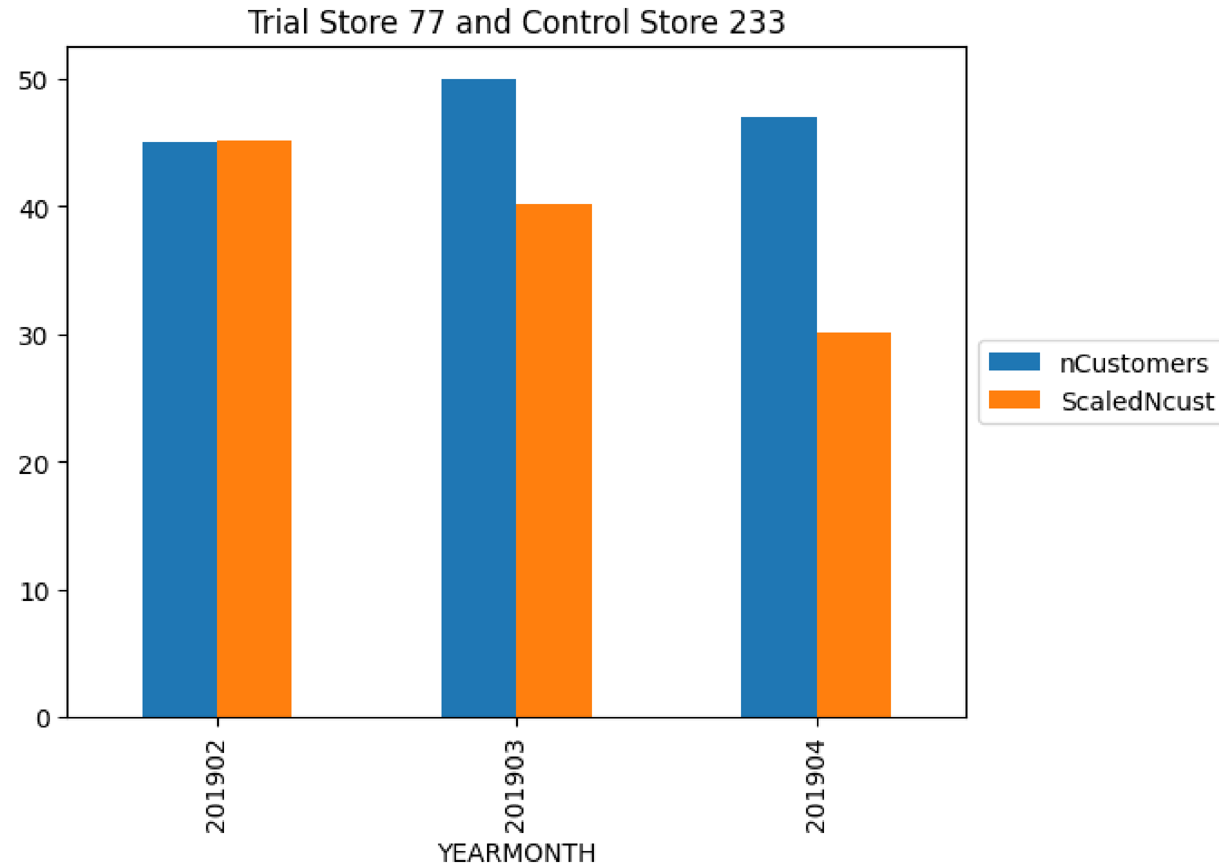

Trial Store 86 and Control Store 155 - Total Sales
1000
800
600
400
200
0
201902
201903
201904
YEARMONTH
95% threshold
5% threshold
trial_TOT_SALES
control_TOT_SALES

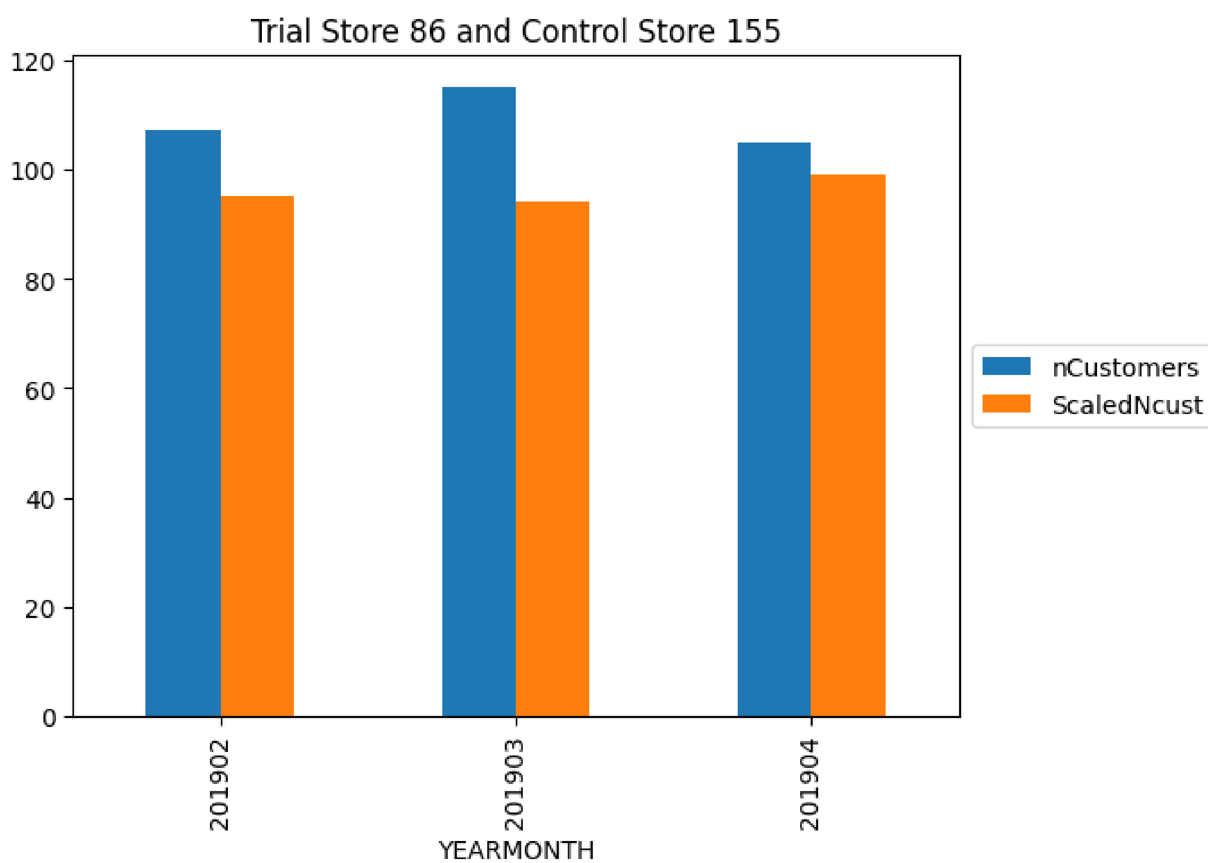


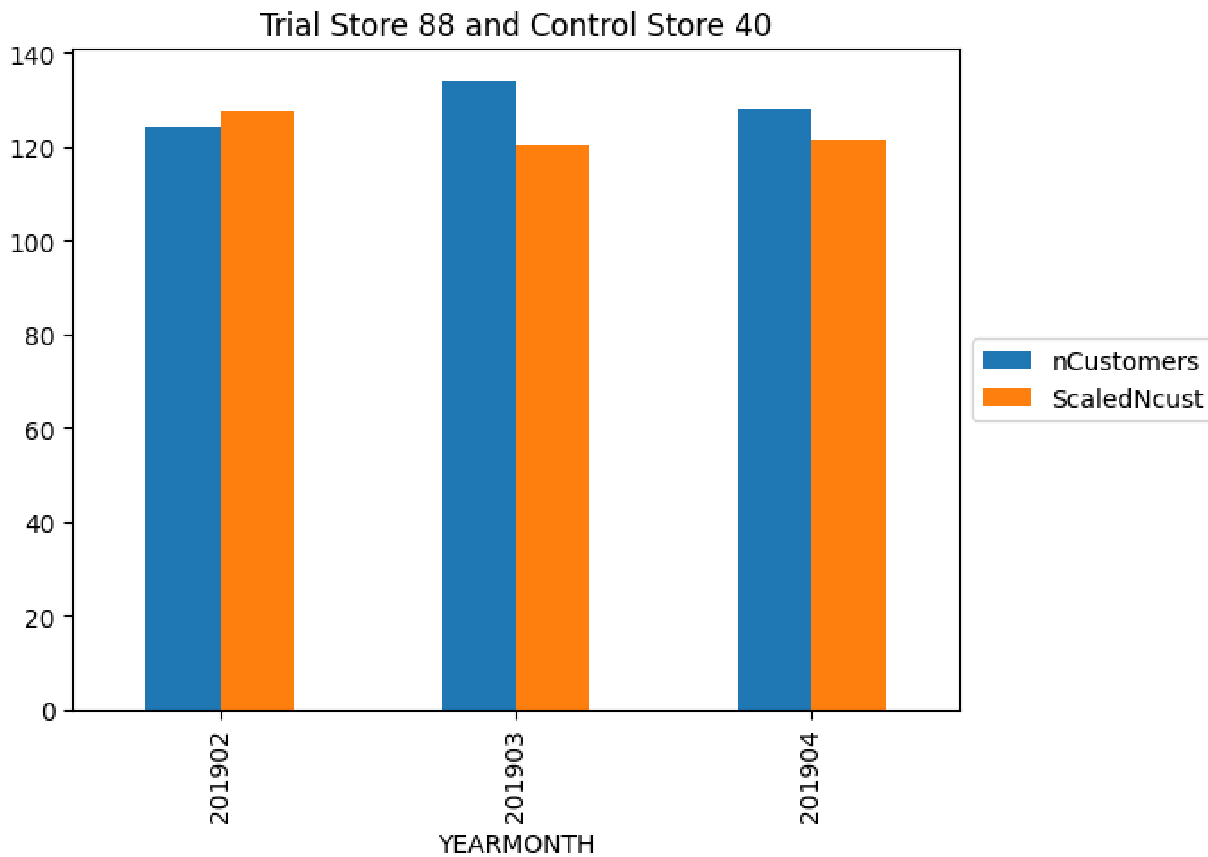
In [40]:
```
#Ratio of Store 77 and its Control store.
ncust_ratio_77 = pretrial_full_observ[pretrial_full_observ["STORE_NBR"] == 77][

#Ratio of Store 86 and its Control store.
ncust_ratio_86 = pretrial_full_observ[pretrial_full_observ["STORE_NBR"] == 86][

#Ratio of Store 77 and its Control store.
ncust_ratio_88 = pretrial_full_observ[pretrial_full_observ["STORE_NBR"] == 88][
```

In [41]:
```
#trial_full_observ = full_observ[(full_observ["YEARMONTH"] >= 201902) & (full_c
scaled_ncust_control_stores = full_observ[full_observ["STORE_NBR"].isin([233, 1

def scaler_c(row):
    if row["STORE_NBR"] == 233:
        return row["nCustomers"] * ncust_ratio_77
    elif row["STORE_NBR"] == 155:
        return row["nCustomers"] * ncust_ratio_86
    elif row["STORE_NBR"] == 40:
        return row["nCustomers"] * ncust_ratio_88

scaled_ncust_control_stores["ScaledNcust"] = scaled_ncust_control_stores.apply(

trial_scaled_ncust_control_stores = scaled_ncust_control_stores[(scaled_ncust_c
pretrial_scaled_ncust_control_stores = scaled_ncust_control_stores[scaled_ncust

ncust_percentage_diff = {}

for trial, control in trial_control_dic.items():
    a = trial_scaled_ncust_control_stores[trial_scaled_ncust_control_stores["ST
    b = trial_full_observ[trial_full_observ["STORE_NBR"] == trial][["STORE_NBR'
    ncust_percentage_diff[trial] = b["nCustomers"].sum() / a["ScaledNcust"].sum
    b[["YEARMONTH", "nCustomers"]].merge(a[["YEARMONTH", "ScaledNcust"]],on="YE
```

```
    plt.legend(loc='center left', bbox_to_anchor=(1.0, 0.5))
    plt.title("Trial Store "+str(trial)+" and Control Store "+str(control))
```







In [42]:
```
ncust_percentage_diff
```

Out[42]:
```
{77: 1.2306529009742622, 86: 1.1354166666666667, 88: 1.0444876946258161}
```

In [43]:
```
temp1 = scaled_ncust_control_stores.sort_values(by=["STORE_NBR", "YEARMONTH"],
temp2 = full_observ[full_observ["STORE_NBR"].isin([77,86,88])][["STORE_NBR", "Y
scaledncust_vs_trial = pd.concat([temp1, temp2], axis=1)
scaledncust_vs_trial.columns = ["c_STORE_NBR", "YEARMONTH", "c_ScaledNcust", "t
scaledncust_vs_trial["nCust_Percentage_Diff"] = (scaledncust_vs_trial["t_nCusto

scaledncust_vs_trial["trial_period"] = scaledncust_vs_trial["YEARMONTH"].apply(
scaledncust_vs_trial[scaledncust_vs_trial["trial_period"] == "trial"]
```

Out[43]:

	c_STORE_NBR	YEARMONTH	c_ScaledNcust	t_STORE_NBR	t_nCustomers	nCust_Percenta
7	233	201902	45.151007	77	45	-0
8	233	201903	40.134228	77	50	(
9	233	201904	30.100671	77	47	0
19	155	201902	95.000000	86	107	(
20	155	201903	94.000000	86	115	0
21	155	201904	99.000000	86	105	0
31	40	201902	127.610209	88	124	-0
32	40	201903	120.464037	88	134	(
33	40	201904	121.484919	88	128	0

Check significance of Trial minus Control stores nCustomers Percentage Difference Pre-Trial vs Trial.

Step 1: Check null hypothesis of 0 difference between control store's Pre-Trial and Trial period performance.

Step 2: Proof control and trial stores are similar statistically

Step 3: After checking Null Hypothesis of first 2 step to be true, we can check Null Hypothesis of Percentage Difference between Trial and Control stores during pre-trial is the same as during trial.

In [44]:
```
# Step 1
for num in [40, 155, 233]:
    print("Store", num)
    print(ttest_ind(pretrial_scaled_ncust_control_stores[pretrial_scaled_ncust_
                    trial_scaled_ncust_control_stores[trial_scaled_ncust_control
                    equal_var=False), '\n')

alpha = 0.05
print("Critical t-value for 95% confidence interval:")
print(t.ppf((alpha/2, 1-alpha/2), df=min([len(pretrial_scaled_ncust_control_stc
                        len(trial_scaled_ncust_control_stores[trial_scaled_ncust
```

```
Store 40
Ttest_indResult(statistic=0.644732693420032, pvalue=0.5376573016017127)

Store 155
Ttest_indResult(statistic=1.3888888888888882, pvalue=0.204345986327886)

Store 233
Ttest_indResult(statistic=0.8442563765225701, pvalue=0.4559280037660254)

Critical t-value for 95% confidence interval:
[-4.30265273  4.30265273]
```

In [45]:
```
# Step 2
for trial, cont in trial_control_dic.items():
    print("Trial store:", trial, ", Control store:", cont)
    print(ttest_ind(pretrial_full_observ[pretrial_full_observ["STORE_NBR"] == t
                    pretrial_scaled_ncust_control_stores[pretrial_scaled_ncust_c
                    equal_var=True), '\n')

alpha = 0.05
print("Critical t-value for 95% confidence interval:")
print(t.ppf((alpha/2, 1-alpha/2), df=len(pretrial_full_observ[pretrial_full_obs
```

```
Trial store: 77 , Control store: 233
Ttest_indResult(statistic=0.0, pvalue=1.0)

Trial store: 86 , Control store: 155
Ttest_indResult(statistic=0.0, pvalue=1.0)

Trial store: 88 , Control store: 40
Ttest_indResult(statistic=-7.648483953264653e-15, pvalue=0.999999999999994)

Critical t-value for 95% confidence interval:
[-2.44691185  2.44691185]
```

In [46]:

```
# Step 3
for trial, cont in trial_control_dic.items():
    print("Trial store:", trial, ", Control store:", cont)
    temp_pre = scaledncust_vs_trial[(scaledncust_vs_trial["c_STORE_NBR"] == cor
    std = temp_pre["nCust_Percentage_Diff"].std()
    mean = temp_pre["nCust_Percentage_Diff"].mean()
    #print(std, mean)
    for t_month in scaledncust_vs_trial[scaledncust_vs_trial["trial_period"] ==
        pdif = scaledncust_vs_trial[(scaledncust_vs_trial["YEARMONTH"] == t_mor
        print(t_month,":",(float(pdif)-mean)/std)
    print('\n')

print("Critical t-value for 95% confidence interval:")
conf_intv_95 = t.ppf(0.95, df=len(temp_pre)-1)
print(conf_intv_95)
```

```
Trial store: 77 , Control store: 233
201902 : -0.19886295797440687
201903 : 8.009609025380932
201904 : 16.114474772873923


Trial store: 86 , Control store: 155
201902 : 6.220524882227514
201903 : 10.52599074274189
201904 : 3.0763575852842706


Trial store: 88 , Control store: 40
201902 : -0.3592881735131531
201903 : 1.2575196020616801
201904 : 0.6092905590514273


Critical t-value for 95% confidence interval:
1.9431802803927816
```

There are 5 months' increase in performance that are statistically significant (Above the 95% confidence interval t-score):

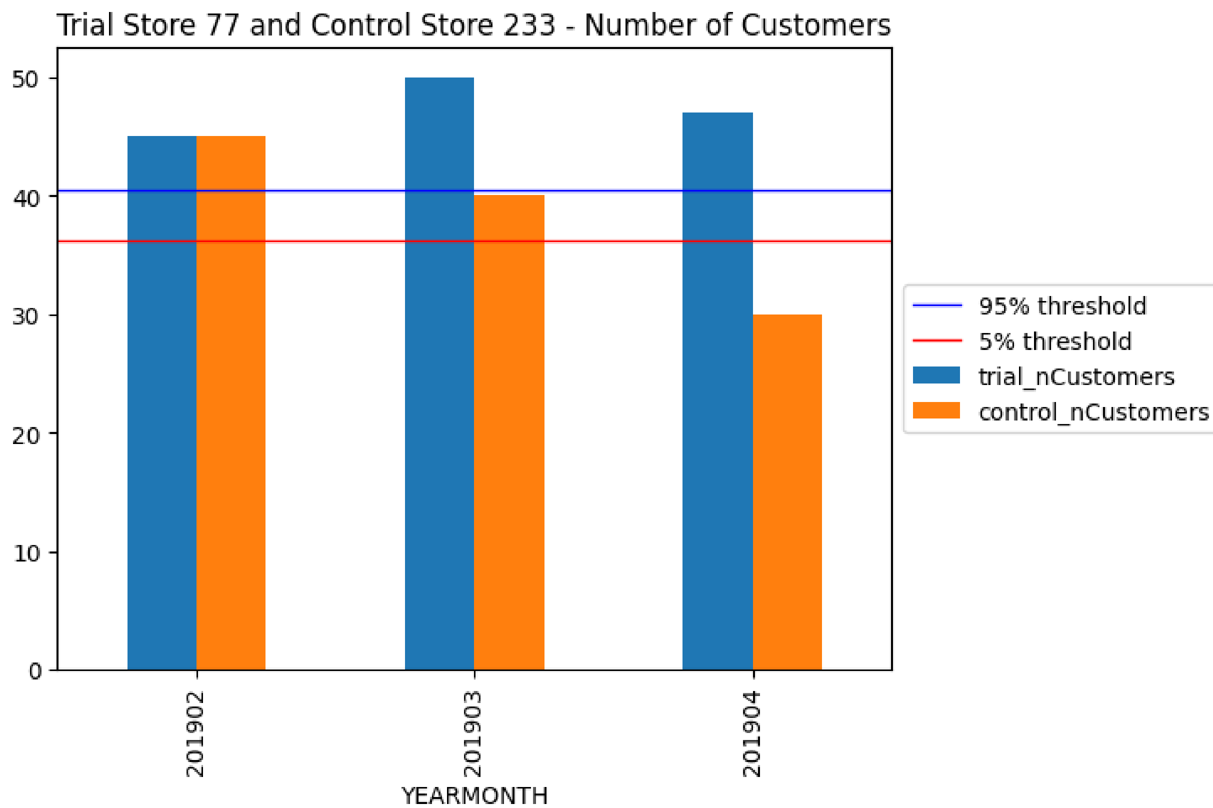
March and April trial months for trial store 77

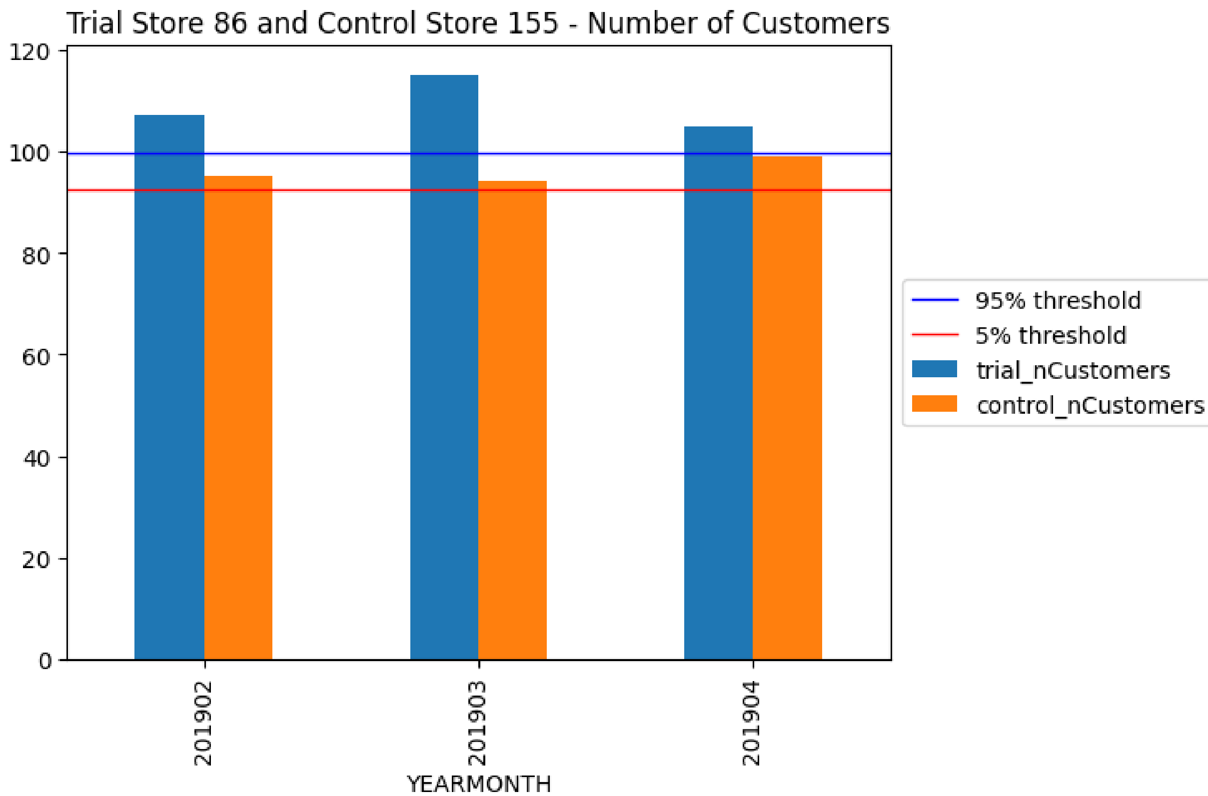
Feb, March and April trial months for trial store 86

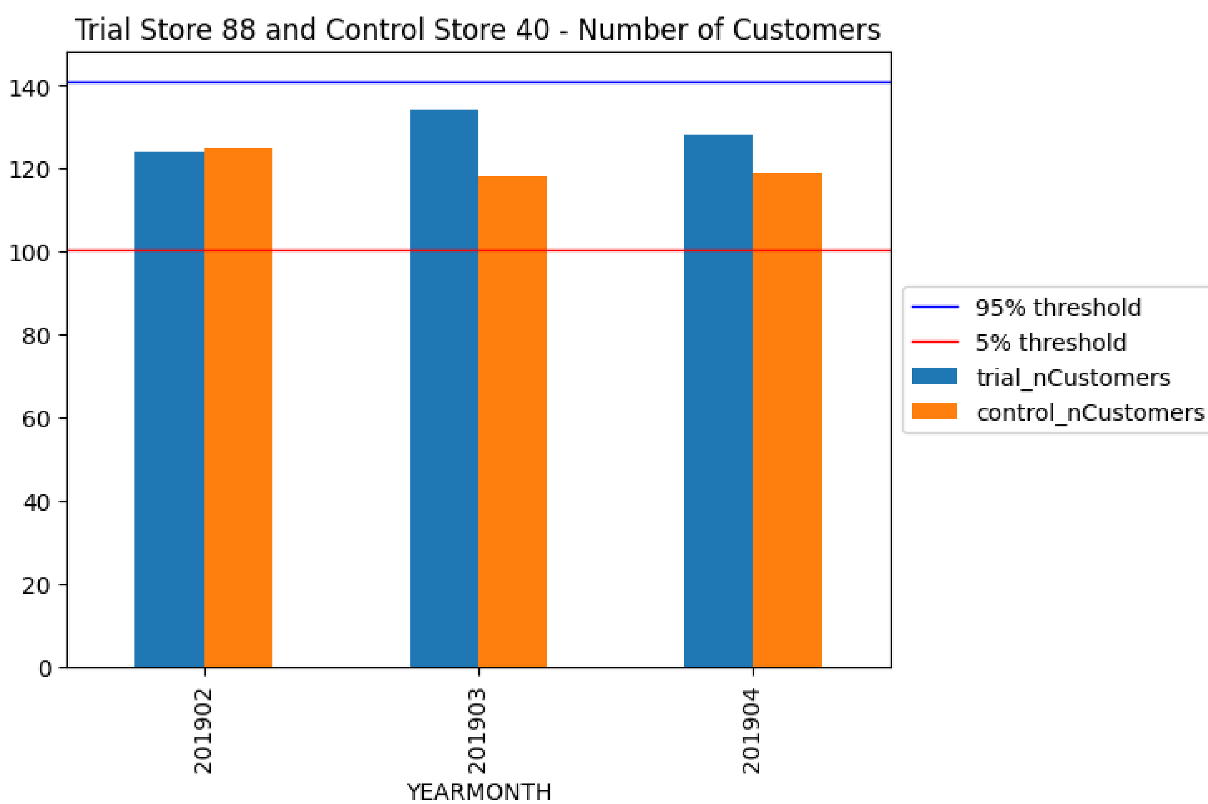
In [47]:

```
for trial, control in trial_control_dic.items():
    a = trial_scaled_ncust_control_stores[trial_scaled_ncust_control_stores["ST
    b = trial_full_observ[trial_full_observ["STORE_NBR"] == trial][["STORE_NBR'
```

```
    comb = b[["YEARMONTH", "trial_nCustomers"]].merge(a[["YEARMONTH", "control_
    comb.plot.bar()
    cont_sc_ncust = trial_scaled_ncust_control_stores[trial_scaled_ncust_contro
    std = scaledncust_vs_trial[(scaledncust_vs_trial["c_STORE_NBR"] == control)
    thresh95 = cont_sc_ncust.mean() + (cont_sc_ncust.mean() * std * 2)
    thresh5 = cont_sc_ncust.mean() - (cont_sc_ncust.mean() * std * 2)
    plt.axhline(y=thresh95,linewidth=1, color='b', label="95% threshold")
    plt.axhline(y=thresh5,linewidth=1, color='r', label="5% threshold")
    plt.legend(loc='center left', bbox_to_anchor=(1.0, 0.5))
    plt.title("Trial Store "+str(trial)+" and Control Store "+str(control)+" -
    plt.savefig("TS {} and CS {} - nCustomers.png".format(trial,control), bbox_
```







Insights :-

1. We can see that Trial store 77 sales for Feb, March, and April exceeds 95% threshold of control store. Same goes to store 86 sales for all 3 trial months.

2. Trial store 77: Control store 233

3. Trial store 86: Control store 155

4. Trial store 88: Control store 40

5. Both trial store 77 and 86 showed significant increase in Total Sales and Number of Customers during trial period. But not for trial store 88. Perhaps the client knows if there's anything about trial 88 that differs it from the other two trial.

6. Overall the trial showed positive significant result.

••♦••••♦••