Part 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:

1. total sales revenue
2. total number of customers
3. 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.

1. period before trial : 07/2018 to 02/2019 (8 months)
2. trial period : 03/2019 to 06/2019 (4 months)

This task can be finished in 2 steps:

1. Based on the first 8 months' data, find the control store of each trial store(the control store is actually the store that displays very similar trend and pattern to the trial store)
2. Compare the last 4 months' data to identify the impact of the new trial layouts

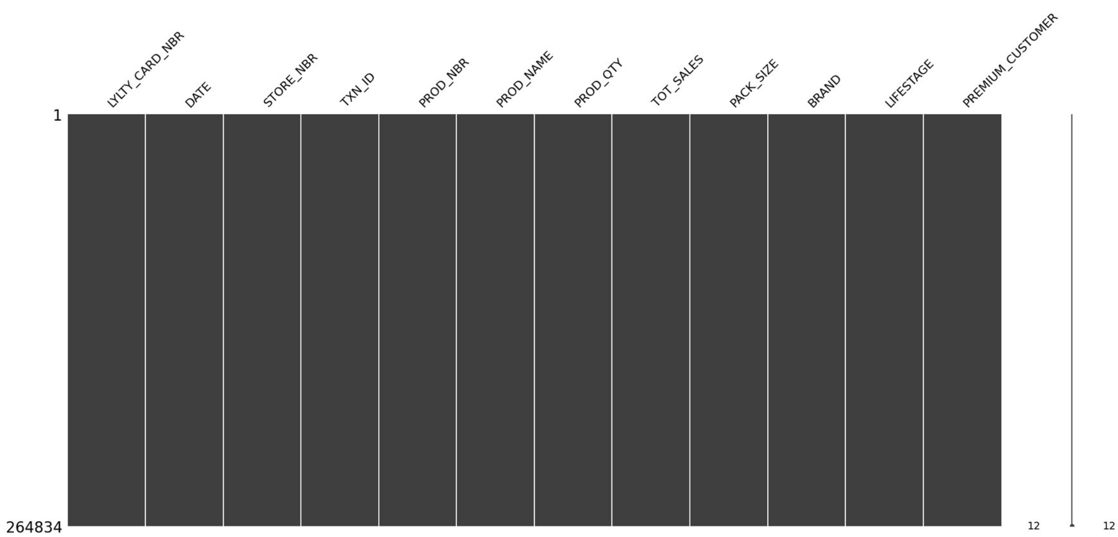
```
# Import Libraries
# Data analysis and wragling
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import missingno
from statistics import stdev
from scipy.stats import t
import matplotlib.dates as mdates
import warnings
warnings.filterwarnings('ignore')

# Import data

data = pd.read_csv('QVI_data.csv')
data.head()
```

```
   LYLTY_CARD_NBR        DATE  STORE_NBR  TXN_ID  PROD_NBR  \
0            1000  2018-10-17          1       1         5
1            1002  2018-09-16          1       2        58
```

```
2            1003  2019-03-07          1       3        52
3            1003  2019-03-08          1       4       106
4            1004  2018-11-02          1       5        96

                                PROD_NAME  PROD_QTY  TOT_SALES
PACK_SIZE  \
0  Natural Chip        Compny SeaSalt175g         2        6.0
175
1   Red Rock Deli Chikn&Garlic Aioli 150g         1        2.7
150
2   Grain Waves Sour    Cream&Chives 210G         1        3.6
210
3  Natural ChipCo      Hony Soy Chckn175g         1        3.0
175
4          WW Original Stacked Chips 160g         1        1.9
160

        BRAND              LIFESTAGE PREMIUM_CUSTOMER
0     NATURAL  YOUNG SINGLES/COUPLES          Premium
1         RRD  YOUNG SINGLES/COUPLES       Mainstream
2     GRNWVES         YOUNG FAMILIES           Budget
3     NATURAL         YOUNG FAMILIES           Budget
4  WOOLWORTHS  OLDER SINGLES/COUPLES       Mainstream
```

```
# Check for null

missingno.matrix(data)
```

```
<AxesSubplot: >
```



In order to find the control store, we need to calculate the similarity between each store and a trial store first. The store with the highest similarity is chosen as the control store. I pick monthly sales revenue and monthly customers count as the key metrics to measure the overall similarity. Let's first create the metrics of interest and filter out stores that are present throughout the pre-trial period. This is done in Part 1.

```
# Create 'YEARMONTH' feature
data['YEARMONTH'] = [''.join(x.split('-')[0:2]) for x in data.DATE]
data['YEARMONTH'] = pd.to_numeric(data['YEARMONTH'])
data['YEARMONTH'].head()
```

```
0    201810
1    201809
2    201903
3    201903
4    201811
Name: YEARMONTH, dtype: int64
```

For each month and store, calculate:

- Total sales
- Number of customers
- Transaction per customer
- Chips per transaction
- Average price per unit

Create individual dataframe and then concatenate all of them together at the end.

```
# Monthly store total sales
# Sum up total sales
totSales = data.groupby(['STORE_NBR', 'YEARMONTH']).TOT_SALES.sum()
totSales
```

```
STORE_NBR  YEARMONTH
1          201807       206.9
           201808       176.1
           201809       278.8
           201810       188.1
           201811       192.6
                        ...
272        201902       395.5
           201903       442.3
           201904       445.1
           201905       314.6
           201906       312.1
Name: TOT_SALES, Length: 3169, dtype: float64
```

```
# Monthly store number of customers
# Count the unique loyalty card number for each store in each month
nCustomers = data.groupby(['STORE_NBR',
'YEARMONTH']).LYLTY_CARD_NBR.nunique()
nCustomers
```

```
STORE_NBR  YEARMONTH
1          201807       49
           201808       42
           201809       59
           201810       44
           201811       46
                        ..
272        201902       45
           201903       50
           201904       54
           201905       34
           201906       34
Name: LYLTY_CARD_NBR, Length: 3169, dtype: int64
```

```
# Monthly store number of transactions per customer
# Divided unique transaction ID by unique loyalty card number
nTxnPerCust = data.groupby(['STORE_NBR',
'YEARMONTH']).TXN_ID.nunique() / data.groupby(['STORE_NBR',
'YEARMONTH']).LYLTY_CARD_NBR.nunique()
nTxnPerCust
```

```
STORE_NBR  YEARMONTH
1          201807       1.061224
           201808       1.023810
           201809       1.050847
           201810       1.022727
           201811       1.021739
                          ...
272        201902       1.066667
           201903       1.060000
           201904       1.018519
           201905       1.176471
           201906       1.088235
Length: 3169, dtype: float64
```

```
# Monthly store number of chips per transaction
# Sum up product quantity and divided that by number of unique
transactions
nChipsPerTxn = data.groupby(['STORE_NBR', 'YEARMONTH']).PROD_QTY.sum()
/ data.groupby(['STORE_NBR', 'YEARMONTH']).TXN_ID.nunique()
nChipsPerTxn
```

```
STORE_NBR  YEARMONTH
1          201807       1.192308
           201808       1.255814
           201809       1.209677
           201810       1.288889
           201811       1.212766
                          ...
272        201902       1.895833
           201903       1.905660
```

```
           201904       1.909091
           201905       1.775000
           201906       1.891892
Length: 3169, dtype: float64
```

```
# Monthly store average price per unit
# Sum up total sales and divide that by sum of product quantity
avgPricePerUnit = data.groupby(['STORE_NBR',
'YEARMONTH']).TOT_SALES.sum() / data.groupby(['STORE_NBR',
'YEARMONTH']).PROD_QTY.sum()
avgPricePerUnit
```

```
STORE_NBR  YEARMONTH
1          201807       3.337097
           201808       3.261111
           201809       3.717333
           201810       3.243103
           201811       3.378947
                          ...
272        201902       4.346154
           201903       4.379208
           201904       4.239048
           201905       4.430986
           201906       4.458571
Length: 3169, dtype: float64
```

```
# Concatenate into a new dataframe called 'measureOverTime'
df = [totSales, nCustomers, nTxnPerCust, nChipsPerTxn,
avgPricePerUnit]
measureOverTime = pd.concat(df, join = 'outer', axis = 1)
measureOverTime
```

```
                     TOT_SALES  LYLTY_CARD_NBR         0         1
2
STORE_NBR YEARMONTH

1         201807         206.9              49  1.061224  1.192308
3.337097
          201808         176.1              42  1.023810  1.255814
3.261111
          201809         278.8              59  1.050847  1.209677
3.717333
          201810         188.1              44  1.022727  1.288889
3.243103
          201811         192.6              46  1.021739  1.212766
3.378947
...                        ...             ...       ...       ...
...
272       201902         395.5              45  1.066667  1.895833
4.346154
          201903         442.3              50  1.060000  1.905660
```

```
4.379208
          201904         445.1              54  1.018519  1.909091
4.239048
          201905         314.6              34  1.176471  1.775000
4.430986
          201906         312.1              34  1.088235  1.891892
4.458571

[3169 rows x 5 columns]
```

```python
# Rename the columns
measureOverTime.rename(columns = {'TOT_SALES': 'totSales',
'LYLTY_CARD_NBR': 'nCustomers', 0: 'nChipsPerCust', 1: 'nChipsPerTxn',
2: 'avgPricePerUnit'}, inplace = True)
measureOverTime.head()
```

```
                     totSales  nCustomers  nChipsPerCust  nChipsPerTxn
\
STORE_NBR YEARMONTH

1         201807        206.9          49       1.061224      1.192308

          201808        176.1          42       1.023810      1.255814

          201809        278.8          59       1.050847      1.209677

          201810        188.1          44       1.022727      1.288889

          201811        192.6          46       1.021739      1.212766


                     avgPricePerUnit
STORE_NBR YEARMONTH
1         201807            3.337097
          201808            3.261111
          201809            3.717333
          201810            3.243103
          201811            3.378947
```

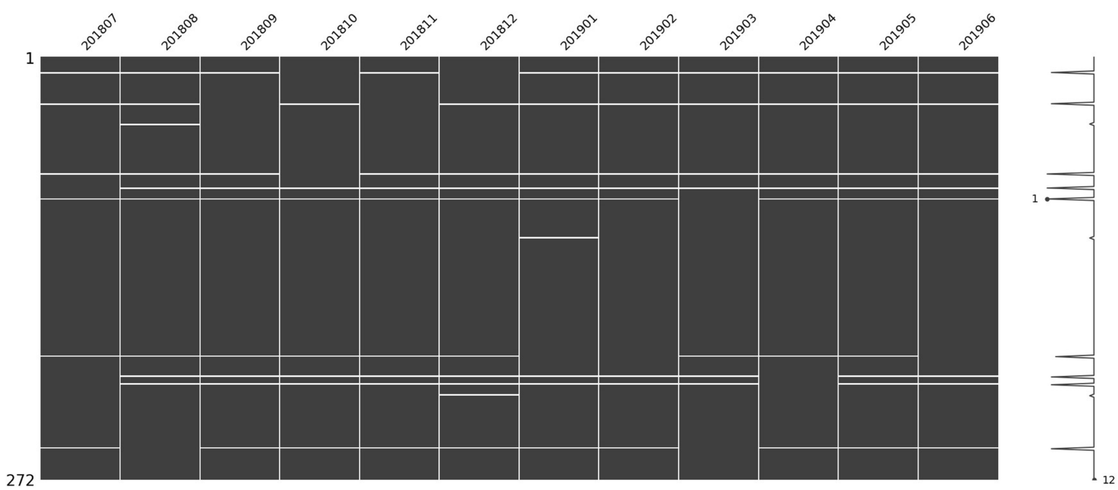
```python
# Which stores do not have full observation i.e. have months where
there is no transaction for chips
a = pd.pivot_table(data, index = 'STORE_NBR', columns = 'YEARMONTH',
values = 'TXN_ID', aggfunc = 'count')
a.isnull().sum()
```

```
YEARMONTH
201807    6
201808    9
201809    8
201810    7
```

```
201811    8
201812    9
201901    9
201902    8
201903    7
201904    7
201905    9
201906    8
dtype: int64
```

```
# Let's visualise the null values
missingno.matrix(a)
```

```
&lt;AxesSubplot: &gt;
```




```
# Store numbers that do not have full observation periods
null_store = a[a.isnull().any(axis=1)].index.tolist()
null_store
```

```
[11, 31, 44, 76, 85, 92, 117, 193, 206, 211, 218, 252]
```

```
len(null_store)
```

```
12
```

There are 12 stores with incomplete observation period

```
# Let's drop these stores from 'measureOverTime'
measureOverTime.head()
```

```
                     totSales  nCustomers  nChipsPerCust  nChipsPerTxn
\
STORE_NBR YEARMONTH

1         201807        206.9          49       1.061224      1.192308

          201808        176.1          42       1.023810      1.255814
```

```
          201809       278.8          59       1.050847      1.209677

          201810       188.1          44       1.022727      1.288889

          201811       192.6          46       1.021739      1.212766


                     avgPricePerUnit
STORE_NBR YEARMONTH
1         201807            3.337097
          201808            3.261111
          201809            3.717333
          201810            3.243103
          201811            3.378947
```

```
len(measureOverTime)
```

```
3169
```

```
measureOverTime.reset_index(inplace = True)
measureOverTime.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit
0         3.337097
1         3.261111
2         3.717333
3         3.243103
4         3.378947
```

```
# Drop 'null_store' from 'measureOverTime' dataframe
measureOverTime =
measureOverTime[~measureOverTime['STORE_NBR'].isin(null_store)]
len(measureOverTime)
```

```
3120
```

```
# Create new dataframe 'preTrialMeasures'
# Filter to pre-trial period i.e. before 201902
preTrialMeasures = measureOverTime.loc[measureOverTime['YEARMONTH'] <
201902, :]
len(preTrialMeasures)

1820

preTrialMeasures.head()

   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit
0         3.337097
1         3.261111
2         3.717333
3         3.243103
4         3.378947

# Create a function which calculates the correlation between trial
store and other stores based on a single metric

def calculateCorrelation(inputTable, metric, trial_store):
    output = pd.DataFrame({'Store1': [], 'Store2': [], 'Correlation':
[]})
    a = inputTable.loc[inputTable['STORE_NBR'] == trial_store, metric]
    a.reset_index(drop = True, inplace = True)
    storeNumbers = inputTable['STORE_NBR'].unique()
    for i in storeNumbers:
        b = inputTable.loc[inputTable['STORE_NBR'] == i, metric]
        b.reset_index(drop = True, inplace = True)
        output = output.append({'Store1': trial_store, 'Store2': i,
'Correlation': b.corr(a)}, ignore_index = True)
    return output

# Create another function which calculates a standardised magnitude
difference

def calculateMagnitudeDistance(inputTable, metric, trial_store):
    output = pd.DataFrame({'Store1': [], 'Store2': [], 'Magnitude' :
```

```
[]})
    a = inputTable.loc[inputTable['STORE_NBR'] == trial_store, metric]
    a.reset_index(drop = True, inplace = True)
    storeNumbers = inputTable['STORE_NBR'].unique()
    for i in storeNumbers:
        b = inputTable.loc[inputTable['STORE_NBR'] == i, metric]
        b.reset_index(drop = True, inplace = True)
        c = abs(a-b)
        d = np.mean(1-(c-min(c))/(max(c)-min(c)))
        output = output.append({'Store1': trial_store, 'Store2': i,
'Magnitude': d}, ignore_index = True)
    return output
```

Selecting control store for trial store 77

```
# Now let's use those two functions to find the control store

# Compute correlation with trial store 77
trial_store = 77
corr_nSales = calculateCorrelation(preTrialMeasures, 'totSales',
trial_store)
corr_nCustomers = calculateCorrelation(preTrialMeasures, 'nCustomers',
trial_store)

# Compute magnitude with trial store 77
magnitude_nSales = calculateMagnitudeDistance(preTrialMeasures,
'totSales', trial_store)
magnitude_nCustomers = calculateMagnitudeDistance(preTrialMeasures,
'nCustomers', trial_store)

# Let's see what they look like
corr_nSales.head()
```

	Store1	Store2	Correlation
0	77.0	1.0	0.075218
1	77.0	2.0	-0.263079
2	77.0	3.0	0.806644
3	77.0	4.0	-0.263300
4	77.0	5.0	-0.110652

```
magnitude_nSales.head()
```

	Store1	Store2	Magnitude
0	77.0	1.0	0.408163
1	77.0	2.0	0.590119
2	77.0	3.0	0.522914
3	77.0	4.0	0.644934
4	77.0	5.0	0.516320

```
# Concatenate the scores together for 'nSales'
```

```
score_nSales = pd.concat([corr_nSales, magnitude_nSales['Magnitude']],
axis = 1)

# Add an additional column which calculates the weighted average
corr_weight = 0.5
score_nSales['scoreNSales'] = corr_weight *
score_nSales['Correlation'] + (1 - corr_weight) *
score_nSales['Magnitude']
score_nSales.head()
```

```
   Store1  Store2  Correlation  Magnitude  scoreNSales
0    77.0     1.0     0.075218   0.408163     0.241691
1    77.0     2.0    -0.263079   0.590119     0.163520
2    77.0     3.0     0.806644   0.522914     0.664779
3    77.0     4.0    -0.263300   0.644934     0.190817
4    77.0     5.0    -0.110652   0.516320     0.202834
```

```
# Now do the same for 'nCustomers'
score_nCustomers = pd.concat([corr_nCustomers,
magnitude_nCustomers['Magnitude']], axis = 1)
score_nCustomers.head()
```

```
   Store1  Store2  Correlation  Magnitude
0    77.0     1.0     0.322168   0.663866
1    77.0     2.0    -0.572051   0.471429
2    77.0     3.0     0.834207   0.489796
3    77.0     4.0    -0.295639   0.498258
4    77.0     5.0     0.370659   0.512605
```

```
# Again add a new column for weighted average
score_nCustomers['scoreNCust'] = corr_weight *
score_nCustomers['Correlation'] + (1 - corr_weight) *
score_nCustomers['Magnitude']
score_nCustomers.head()
```

```
   Store1  Store2  Correlation  Magnitude  scoreNCust
0    77.0     1.0     0.322168   0.663866    0.493017
1    77.0     2.0    -0.572051   0.471429   -0.050311
2    77.0     3.0     0.834207   0.489796    0.662002
3    77.0     4.0    -0.295639   0.498258    0.101310
4    77.0     5.0     0.370659   0.512605    0.441632
```

```
# Index both 'score_nSales' and 'score_nCustomers' dataframe
score_nSales.set_index(['Store1', 'Store2'], inplace = True)
score_nCustomers.set_index(['Store1', 'Store2'], inplace = True)

# Create a new dataframe 'score_Control' which takes the average of
'scoreNSales' and 'scoreNCust'
score_Control = pd.concat([score_nSales['scoreNSales'],
score_nCustomers['scoreNCust']], axis = 1)
score_Control
```

```
               scoreNSales  scoreNCust
Store1 Store2                         
77.0   1.0        0.241691    0.493017
       2.0        0.163520   -0.050311
       3.0        0.664779    0.662002
       4.0        0.190817    0.101310
       5.0        0.202834    0.441632
...                    ...         ...
       268.0      0.387272    0.470473
       269.0      0.121684    0.005090
       270.0      0.453489    0.202710
       271.0      0.348289    0.174100
       272.0      0.320626    0.384336

[260 rows x 2 columns]
```

```
# Add a new column to 'score_Control' which computes the average of
'scoreNSales' and 'scoreNCust'
score_Control['finalControlScore'] = 0.5 *
(score_Control['scoreNSales'] + score_Control['scoreNCust'])
score_Control.head()
```

```
               scoreNSales  scoreNCust  finalControlScore
Store1 Store2                                            
77.0   1.0        0.241691    0.493017           0.367354
       2.0        0.163520   -0.050311           0.056604
       3.0        0.664779    0.662002           0.663390
       4.0        0.190817    0.101310           0.146064
       5.0        0.202834    0.441632           0.322233
```

```
# Let's see the top 5 stores with highest 'finalControlScore'
score_Control.sort_values(by = 'finalControlScore', ascending =
False).head()
```

```
               scoreNSales  scoreNCust  finalControlScore
Store1 Store2                                            
77.0   233.0      0.697290    0.816607           0.756949
       71.0       0.789497    0.663123           0.726310
       84.0       0.656972    0.715000           0.685986
       119.0      0.636046    0.729729           0.682887
       115.0      0.708347    0.645155           0.676751
```

Store 233 matches trial store 77 the most

```
# Now that we have found a control store, let's check visually if the
drivers are indeed similar to store 77 before the trial period
# Set store 233 as 'control_store'
control_store = 233
```

```
# Create a new dataframe 'pastSales'
pastSales = preTrialMeasures
```

```
# Create a new column within 'pastSales' which categorises store type
store_type = []

for i in pastSales['STORE_NBR']:
    if i == trial_store:
        store_type.append('Trial Store')
    elif i == control_store:
        store_type.append('Control Store')
    else:
        store_type.append('Other Stores')

pastSales['store_type'] = store_type
pastSales.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit    store_type
0         3.337097  Other Stores
1         3.261111  Other Stores
2         3.717333  Other Stores
3         3.243103  Other Stores
4         3.378947  Other Stores
```

```
# Check the unique values under 'store_type' column
pastSales['store_type'].unique()
pastSales.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1820 entries, 0 to 3163
Data columns (total 8 columns):
 #   Column           Non-Null Count  Dtype
---  ------           --------------  -----
 0   STORE_NBR        1820 non-null   int64
 1   YEARMONTH        1820 non-null   int64
 2   totSales         1820 non-null   float64
 3   nCustomers       1820 non-null   int64
 4   nChipsPerCust    1820 non-null   float64
 5   nChipsPerTxn     1820 non-null   float64
```

```
 6   avgPricePerUnit  1820 non-null   float64
 7   store_type       1820 non-null   object
dtypes: float64(4), int64(3), object(1)
memory usage: 128.0+ KB
```

```
# Currently 'YEARMONTH' is an int64 so we need to turn it into a
datetime variable to able to plot
# Create a new column 'TransactionMonth'
pastSales['TransactionMonth'] =
pd.to_datetime(pastSales['YEARMONTH'].astype(str), format = '%Y%m')
pastSales.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit    store_type TransactionMonth
0         3.337097  Other Stores       2018-07-01
1         3.261111  Other Stores       2018-08-01
2         3.717333  Other Stores       2018-09-01
3         3.243103  Other Stores       2018-10-01
4         3.378947  Other Stores       2018-11-01
```

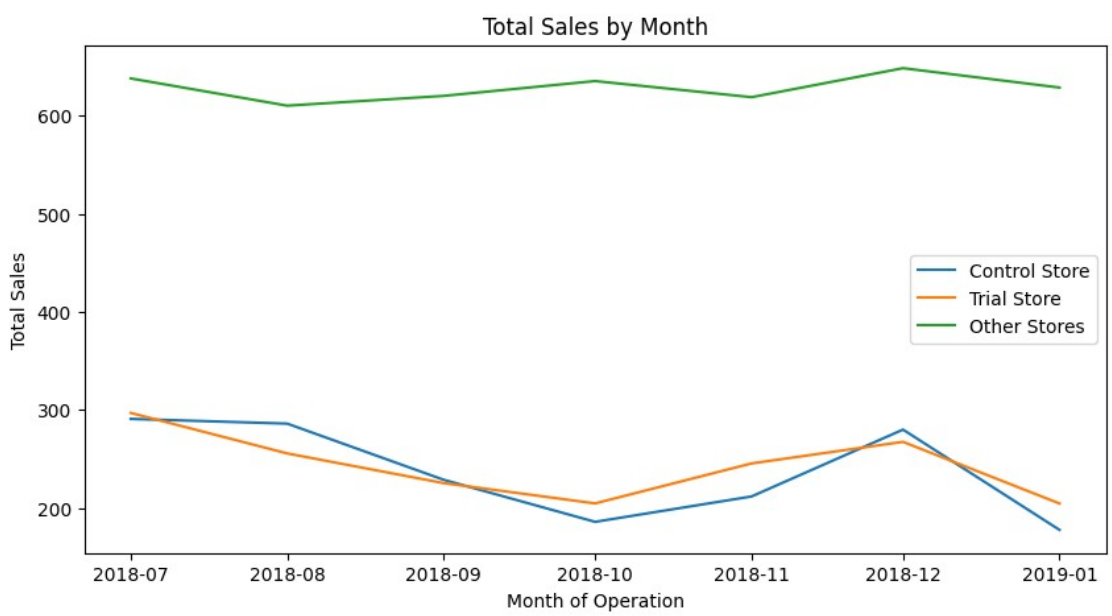
```
# Now create 'totSales' visualisation for control store, trial store
and other stores
# First create relevant dataframes
controlSalesPlot = pastSales.loc[pastSales['store_type'] == 'Control
Store', ['TransactionMonth', 'totSales']]
controlSalesPlot.set_index('TransactionMonth', inplace = True)
controlSalesPlot.rename(columns = {'totSales': 'Control Store'},
inplace = True)
trialSalesPlot = pastSales.loc[pastSales['store_type'] == 'Trial
Store', ['TransactionMonth', 'totSales']]
trialSalesPlot.set_index('TransactionMonth', inplace = True)
trialSalesPlot.rename(columns = {'totSales': 'Trial Store'}, inplace =
True)
otherSalesPlot = pastSales.loc[pastSales['store_type'] == 'Other
Stores', ['TransactionMonth', 'totSales']]
otherSalesPlot =
pd.DataFrame(otherSalesPlot.groupby('TransactionMonth').totSales.mean(
))
otherSalesPlot.rename(columns = {'totSales': 'Other Stores'}, inplace
```

```
= True)

# Concatenate
combineSalesPlot = pd.concat([controlSalesPlot, trialSalesPlot,
otherSalesPlot], axis = 1)
combineSalesPlot
```

```
                  Control Store  Trial Store  Other Stores
TransactionMonth
2018-07-01                290.7        296.8    638.004651
2018-08-01                285.9        255.5    610.223450
2018-09-01                228.6        225.2    620.198450
2018-10-01                185.7        204.5    635.314729
2018-11-01                211.6        245.3    618.864341
2018-12-01                279.8        267.3    648.453876
2019-01-01                177.5        204.4    628.684496
```

```
# Plot total sales by month for all 3 types of stores
plt.figure(figsize = (10, 5))
plt.plot(combineSalesPlot)
plt.title('Total Sales by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Total Sales')
plt.legend(['Control Store', 'Trial Store', 'Other Stores'], loc = 5)
```

```
<matplotlib.legend.Legend at 0x13659f0a0>
```



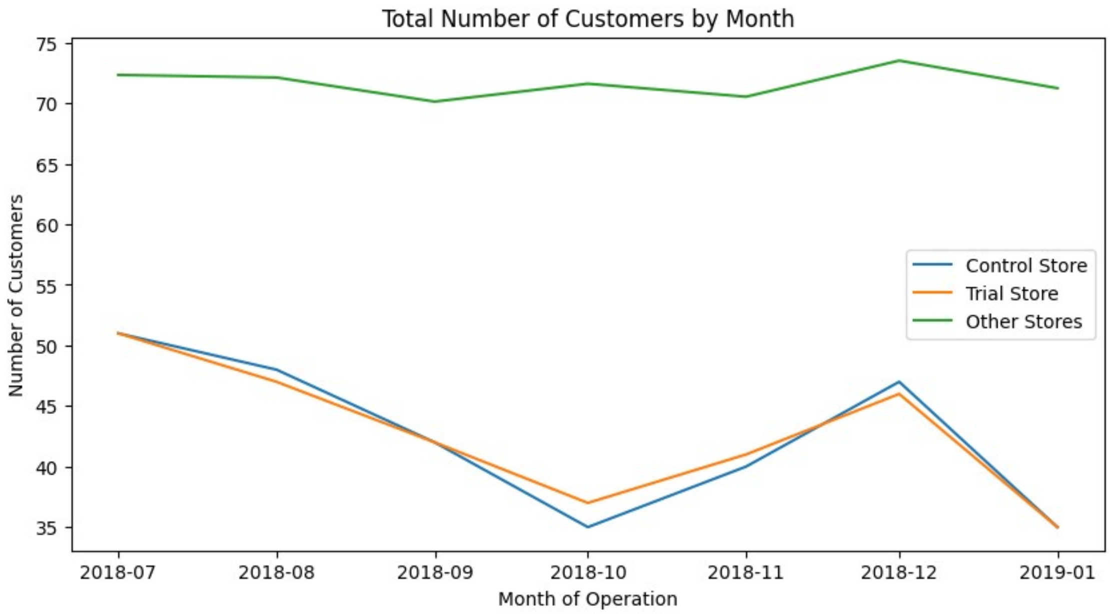

```
# Do the same for 'nCustomers'
# First create relevant dataframes
controlCustomersPlot = pastSales.loc[pastSales['store_type'] ==
'Control Store', ['TransactionMonth', 'nCustomers']]
controlCustomersPlot.set_index('TransactionMonth', inplace = True)
```

```
controlCustomersPlot.rename(columns = {'nCustomers': 'Control Store'},
inplace = True)
trialCustomersPlot = pastSales.loc[pastSales['store_type'] == 'Trial
Store', ['TransactionMonth', 'nCustomers']]
trialCustomersPlot.set_index('TransactionMonth', inplace = True)
trialCustomersPlot.rename(columns = {'nCustomers': 'Trial Store'},
inplace = True)
otherCustomersPlot = pastSales.loc[pastSales['store_type'] == 'Other
Stores', ['TransactionMonth', 'nCustomers']]
otherCustomersPlot =
pd.DataFrame(otherCustomersPlot.groupby('TransactionMonth').nCustomers
.mean())
otherCustomersPlot.rename(columns = {'nCustomers': 'Other Stores'},
inplace = True)

# Concatenate
combineCustomersPlot = pd.concat([controlCustomersPlot,
trialCustomersPlot, otherCustomersPlot], axis = 1)
combineCustomersPlot
```

```
                  Control Store  Trial Store  Other Stores
TransactionMonth
2018-07-01                   51           51     72.333333
2018-08-01                   48           47     72.120155
2018-09-01                   42           42     70.131783
2018-10-01                   35           37     71.608527
2018-11-01                   40           41     70.534884
2018-12-01                   47           46     73.515504
2019-01-01                   35           35     71.240310
```

```
# Plot total number of customers for all 3 types of stores

plt.figure(figsize = (10, 5))
plt.plot(combineCustomersPlot)
plt.title('Total Number of Customers by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Number of Customers')
plt.legend(['Control Store', 'Trial Store', 'Other Stores'], loc = 5)
```

```
<matplotlib.legend.Legend at 0x13596a1d0>
```



Assessment of trial for trial strore 77

```
preTrialMeasures.head()

   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit    store_type TransactionMonth
0         3.337097  Other Stores       2018-07-01
1         3.261111  Other Stores       2018-08-01
2         3.717333  Other Stores       2018-09-01
3         3.243103  Other Stores       2018-10-01
4         3.378947  Other Stores       2018-11-01

# First we need to work out a scaling factor to applied to the control
store
# We compute this by dividing sum of 'totSales' for trial store by sum
of 'totSales' for control store
# Let's call this variable 'scalingFactorSales'

trial_sum = preTrialMeasures.loc[preTrialMeasures['store_type'] ==
'Trial Store' , 'totSales'].sum()
```

```
control_sum = preTrialMeasures.loc[preTrialMeasures['store_type'] ==
'Control Store', 'totSales'].sum()
scalingFactorSales = trial_sum / control_sum
scalingFactorSales
```

```
1.023617303289553
```

```
# Create a new dataframe 'scaledControlSales'
# Recall our dataframe before filtering out the trial period is called
'measureOverTime'

measureOverTime.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit
0         3.337097
1         3.261111
2         3.717333
3         3.243103
4         3.378947
```

```
# Create dataframe and reset index

scaledControlSales = measureOverTime
scaledControlSales.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766
```

```
   avgPricePerUnit
0         3.337097
1         3.261111
2         3.717333
3         3.243103
4         3.378947
```

```
# We only want control store i.e. store 233

scaledControlSales =
scaledControlSales.loc[scaledControlSales['STORE_NBR'] ==
control_store]
scaledControlSales
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2699        233     201807     290.7          51       1.058824
1.629630
2700        233     201808     285.9          48       1.041667
1.600000
2701        233     201809     228.6          42       1.071429
1.555556
2702        233     201810     185.7          35       1.028571
1.555556
2703        233     201811     211.6          40       1.025000
1.512195
2704        233     201812     279.8          47       1.063830
1.500000
2705        233     201901     177.5          35       1.000000
1.342857
2706        233     201902     244.0          45       1.044444
1.489362
2707        233     201903     199.1          40       1.025000
1.439024
2708        233     201904     158.6          30       1.066667
1.437500
2709        233     201905     344.4          57       1.087719
1.483871
2710        233     201906     221.0          41       1.000000
1.487805

      avgPricePerUnit
2699         3.303409
2700         3.573750
2701         3.265714
2702         3.316071
2703         3.412903
2704         3.730667
2705         3.776596
2706         3.485714
```

```
2707         3.374576
2708         3.447826
2709         3.743478
2710         3.622951
```

```
# Create 'controlSales' which applies 'scalingFactorSales' to
'totSales' column

scaledControlSales['controlSales'] = scaledControlSales['totSales'] *
scalingFactorSales
scaledControlSales.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2699        233     201807     290.7          51       1.058824
1.629630
2700        233     201808     285.9          48       1.041667
1.600000
2701        233     201809     228.6          42       1.071429
1.555556
2702        233     201810     185.7          35       1.028571
1.555556
2703        233     201811     211.6          40       1.025000
1.512195

      avgPricePerUnit  controlSales
2699         3.303409    297.565550
2700         3.573750    292.652187
2701         3.265714    233.998916
2702         3.316071    190.085733
2703         3.412903    216.597421
```

```
# Create 'percentageDiff' dataframe
percentageDiff = scaledControlSales[['YEARMONTH', 'controlSales']]
percentageDiff.reset_index(drop = True, inplace = True)

# Concatenate with trial store 'totSales'
trialSales = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, 'totSales']
trialSales.reset_index(drop = True, inplace = True)
percentageDiff = pd.concat([percentageDiff, trialSales], axis = 1)
percentageDiff.rename(columns = {'totSales': 'trialSales'}, inplace =
True)

percentageDiff
```

```
    YEARMONTH  controlSales  trialSales
0      201807    297.565550       296.8
1      201808    292.652187       255.5
2      201809    233.998916       225.2
3      201810    190.085733       204.5
```

```
4      201811    216.597421       245.3
5      201812    286.408121       267.3
6      201901    181.692071       204.4
7      201902    249.762622       235.0
8      201903    203.802205       278.5
9      201904    162.345704       263.5
10     201905    352.533799       299.3
11     201906    226.219424       264.7
```

```
# Calculate percentage difference and put it in a new column

percentageDiff['percentageDiff'] = abs(percentageDiff.controlSales -
percentageDiff.trialSales) / percentageDiff.controlSales
percentageDiff
```

```
    YEARMONTH  controlSales  trialSales  percentageDiff
0      201807    297.565550       296.8        0.002573
1      201808    292.652187       255.5        0.126950
2      201809    233.998916       225.2        0.037602
3      201810    190.085733       204.5        0.075830
4      201811    216.597421       245.3        0.132516
5      201812    286.408121       267.3        0.066716
6      201901    181.692071       204.4        0.124980
7      201902    249.762622       235.0        0.059107
8      201903    203.802205       278.5        0.366521
9      201904    162.345704       263.5        0.623080
10     201905    352.533799       299.3        0.151003
11     201906    226.219424       264.7        0.170103
```

```
# Our null hypothesis is such that the trial period is the same as the
pre-trial period
# Let's take the standard deviation based on the scaled percentage
difference in the pre-trial period

stdDev = stdev(percentageDiff.loc[percentageDiff['YEARMONTH'] <
201902, 'percentageDiff'])
stdDev
```

```
0.049940762641425364
```

```
# Define the degrees of freedom
# Since we have 8 pre-trial months, dof = 8 - 1 = 7

dof = 7

# We will test with a null hypothesis of there being 0 difference
between trial and control stores
# Create a new column for 'tValue'

percentageDiff['tValue'] = (percentageDiff['percentageDiff'] - 0) /
stdDev
```

```
percentageDiff.loc[(percentageDiff['YEARMONTH'] > 201901) &
(percentageDiff['YEARMONTH'] < 201905), 'tValue']
```

```
7     1.183534
8     7.339116
9    12.476373
Name: tValue, dtype: float64
```

```
# Find the 95th percentile of the t distribution with dof = 7

t.isf(0.05, dof)
```

```
1.8945786050613054
```

```
# Recall our 'scaledControlSales' dataframe

scaledControlSales.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2699        233     201807     290.7          51       1.058824
1.629630
2700        233     201808     285.9          48       1.041667
1.600000
2701        233     201809     228.6          42       1.071429
1.555556
2702        233     201810     185.7          35       1.028571
1.555556
2703        233     201811     211.6          40       1.025000
1.512195

      avgPricePerUnit  controlSales
2699         3.303409    297.565550
2700         3.573750    292.652187
2701         3.265714    233.998916
2702         3.316071    190.085733
2703         3.412903    216.597421
```

```
# Add a new column 'TransactionMonth' to 'scaledControlSales'

scaledControlSales['TransactionMonth'] =
pd.to_datetime(scaledControlSales['YEARMONTH'].astype(str), format =
'%Y%m')
scaledControlSales
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2699        233     201807     290.7          51       1.058824
1.629630
2700        233     201808     285.9          48       1.041667
1.600000
```

```
2701        233     201809     228.6           42       1.071429
1.555556
2702        233     201810     185.7           35       1.028571
1.555556
2703        233     201811     211.6           40       1.025000
1.512195
2704        233     201812     279.8           47       1.063830
1.500000
2705        233     201901     177.5           35       1.000000
1.342857
2706        233     201902     244.0           45       1.044444
1.489362
2707        233     201903     199.1           40       1.025000
1.439024
2708        233     201904     158.6           30       1.066667
1.437500
2709        233     201905     344.4           57       1.087719
1.483871
2710        233     201906     221.0           41       1.000000
1.487805

      avgPricePerUnit  controlSales TransactionMonth
2699         3.303409    297.565550       2018-07-01
2700         3.573750    292.652187       2018-08-01
2701         3.265714    233.998916       2018-09-01
2702         3.316071    190.085733       2018-10-01
2703         3.412903    216.597421       2018-11-01
2704         3.730667    286.408121       2018-12-01
2705         3.776596    181.692071       2019-01-01
2706         3.485714    249.762622       2019-02-01
2707         3.374576    203.802205       2019-03-01
2708         3.447826    162.345704       2019-04-01
2709         3.743478    352.533799       2019-05-01
2710         3.622951    226.219424       2019-06-01
```

```python
# Time for some visualisation
# First we need to create the appropriate dataframe
# Extract 'controlSales' from 'scaledControlSales' dataframe for
control store

controlSales = scaledControlSales.loc[:, ['TransactionMonth',
'controlSales']]
controlSales.set_index('TransactionMonth', inplace = True)
controlSales.rename(columns = {'controlSales': 'Control Sales'},
inplace = True)
controlSales
```

```
                  Control Sales
TransactionMonth
2018-07-01           297.565550
```

```
2018-08-01          292.652187
2018-09-01          233.998916
2018-10-01          190.085733
2018-11-01          216.597421
2018-12-01          286.408121
2019-01-01          181.692071
2019-02-01          249.762622
2019-03-01          203.802205
2019-04-01          162.345704
2019-05-01          352.533799
2019-06-01          226.219424
```

```
# Recall 'measureOverTime' dataframe

measureOverTime.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit
0         3.337097
1         3.261111
2         3.717333
3         3.243103
4         3.378947
```

```
# Create a new column 'TransationMonth' under 'measureOverTime'
dataframe

measureOverTime['TransactionMonth'] =
pd.to_datetime(measureOverTime['YEARMONTH'].astype(str), format = '%Y
%m')
measureOverTime.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
```

```
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01
```

```
# Extract 'totSales' for trial store from 'measureOverTime'

trialSales = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, ['TransactionMonth', 'totSales']]
trialSales.set_index('TransactionMonth', inplace = True)
trialSales.rename(columns = {'totSales': 'Trial Sales'}, inplace =
True)
trialSales
```

```
                  Trial Sales
TransactionMonth
2018-07-01              296.8
2018-08-01              255.5
2018-09-01              225.2
2018-10-01              204.5
2018-11-01              245.3
2018-12-01              267.3
2019-01-01              204.4
2019-02-01              235.0
2019-03-01              278.5
2019-04-01              263.5
2019-05-01              299.3
2019-06-01              264.7
```

```
# Create two new columns under 'controlSales' which calculates the 5%
and 95% confidence interval

controlSales['Control 5% Confidence Interval'] = controlSales['Control
Sales'] * (1 - stdDev*2)
controlSales['Control 95% Confidence Interval'] =
controlSales['Control Sales'] * (1 + stdDev*2)
controlSales
```

```
                  Control Sales  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01           297.565550                      267.844249
2018-08-01           292.652187                      263.421640
2018-09-01           233.998916                      210.626747
```

```
2018-10-01          190.085733                            171.099680
2018-11-01          216.597421                            194.963341
2018-12-01          286.408121                            257.801241
2019-01-01          181.692071                            163.544390
2019-02-01          249.762622                            224.815950
2019-03-01          203.802205                            183.446130
2019-04-01          162.345704                            146.130368
2019-05-01          352.533799                            317.322186
2019-06-01          226.219424                            203.624283

                  Control 95% Confidence Interval
TransactionMonth
2018-07-01                             327.286851
2018-08-01                             321.882734
2018-09-01                             257.371084
2018-10-01                             209.071786
2018-11-01                             238.231502
2018-12-01                             315.015001
2019-01-01                             199.839753
2019-02-01                             274.709294
2019-03-01                             224.158280
2019-04-01                             178.561041
2019-05-01                             387.745413
2019-06-01                             248.814565
```

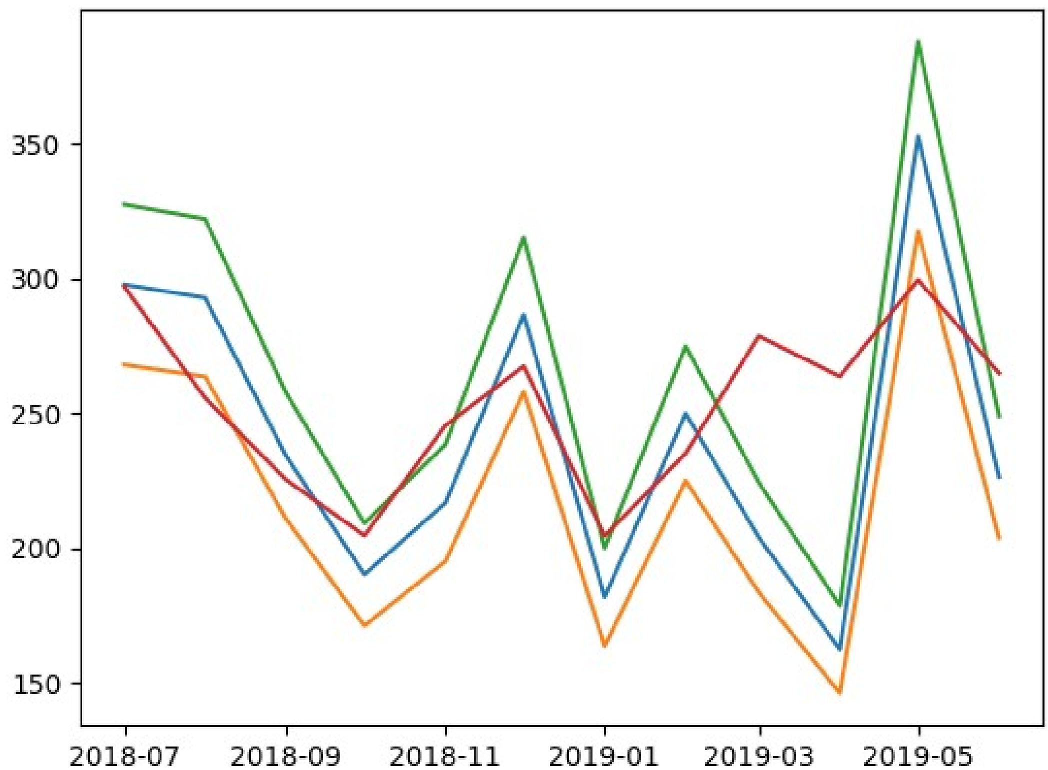
```
# Merge the two dataframes together 'controlSales' and 'trialSales'

combineSales = pd.merge(controlSales, trialSales, left_index = True,
right_index = True)
combineSales
```

```
                  Control Sales  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01          297.565550                            267.844249
2018-08-01          292.652187                            263.421640
2018-09-01          233.998916                            210.626747
2018-10-01          190.085733                            171.099680
2018-11-01          216.597421                            194.963341
2018-12-01          286.408121                            257.801241
2019-01-01          181.692071                            163.544390
2019-02-01          249.762622                            224.815950
2019-03-01          203.802205                            183.446130
2019-04-01          162.345704                            146.130368
2019-05-01          352.533799                            317.322186
2019-06-01          226.219424                            203.624283

                  Control 95% Confidence Interval  Trial Sales
TransactionMonth
2018-07-01                             327.286851        296.8
2018-08-01                             321.882734        255.5
```

```
2018-09-01                                       257.371084        225.2
2018-10-01                                       209.071786        204.5
2018-11-01                                       238.231502        245.3
2018-12-01                                       315.015001        267.3
2019-01-01                                       199.839753        204.4
2019-02-01                                       274.709294        235.0
2019-03-01                                       224.158280        278.5
2019-04-01                                       178.561041        263.5
2019-05-01                                       387.745413        299.3
2019-06-01                                       248.814565        264.7
```

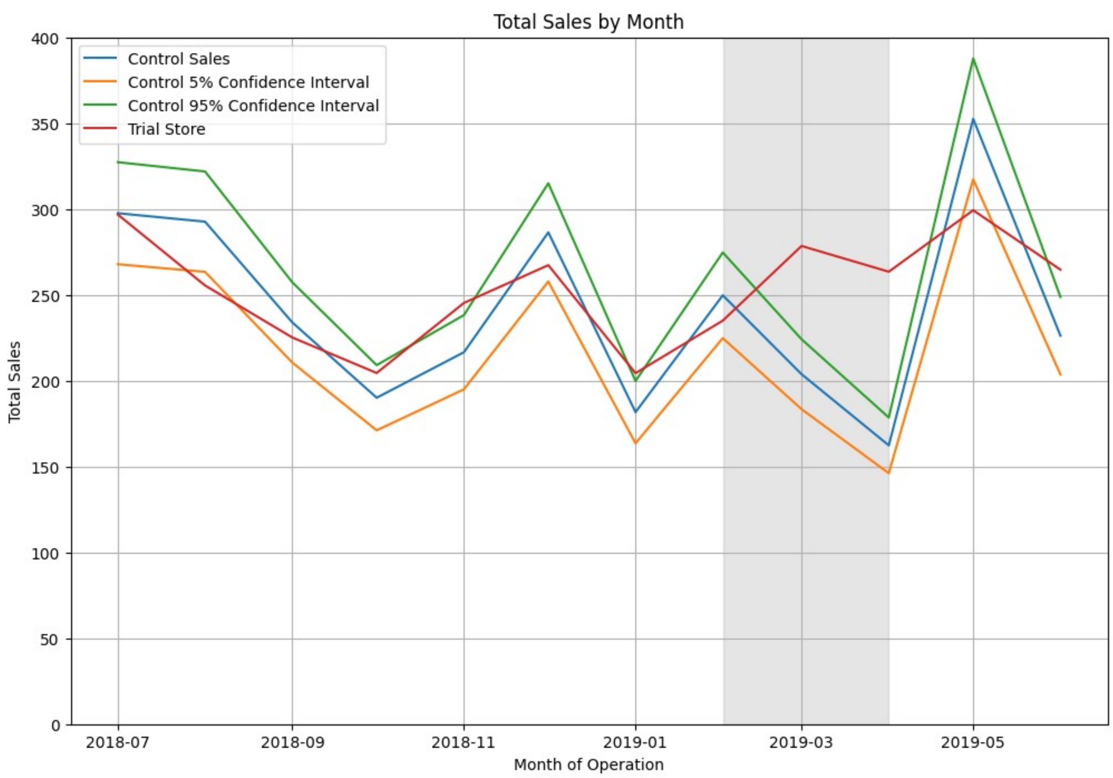
```
plt.plot(combineSales)
```

```
[<matplotlib.lines.Line2D at 0x135ade7d0>,
 <matplotlib.lines.Line2D at 0x135b2fe20>,
 <matplotlib.lines.Line2D at 0x135b2fd90>,
 <matplotlib.lines.Line2D at 0x135b2fd00>]
```




```
# Let's embellish the plot

# Make it bigger
plt.figure(figsize = (12, 8))
plt.plot(combineSales)

# Set graph title and axis title
plt.title('Total Sales by Month')
```

```
plt.xlabel('Month of Operation')
plt.ylabel('Total Sales')

# Set legend
plt.legend(['Control Sales', 'Control 5% Confidence Interval',
'Control 95% Confidence Interval', 'Trial Store'], loc = 2)

# Set new y-axis limit
plt.ylim((0, 400))

# Highlight trial period
plt.axvspan(*mdates.datestr2num(['2019-02-01', '2019-04-01']), color =
'grey', alpha = 0.2)

# Set grid
plt.grid()
plt.show()
```



The results show that the trial in store 77 is significantly different to its control store in the trial period. The trial store performance lies outside the 5% and 95% confidence intervals in the two of the 3 trial months.

```
# Now let's move on to 'nCustomers'
# First, compute scaling factor
# Let's call this variable 'scalingFactorCustomers'
```

```
trial_customers = preTrialMeasures.loc[preTrialMeasures['store_type']
== 'Trial Store' , 'nCustomers'].sum()
control_customers =
preTrialMeasures.loc[preTrialMeasures['store_type'] == 'Control
Store', 'nCustomers'].sum()
scalingFactorCustomers = trial_customers / control_customers
scalingFactorCustomers
```

```
1.0033557046979866
```

```
scaledControlCustomers = measureOverTime
scaledControlCustomers.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01
```

```
scaledControlCustomers =
scaledControlCustomers.loc[scaledControlCustomers['STORE_NBR'] ==
control_store]
scaledControlCustomers.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2699        233     201807     290.7          51       1.058824
1.629630
2700        233     201808     285.9          48       1.041667
1.600000
2701        233     201809     228.6          42       1.071429
1.555556
2702        233     201810     185.7          35       1.028571
1.555556
2703        233     201811     211.6          40       1.025000
1.512195
```

```
      avgPricePerUnit TransactionMonth
2699         3.303409       2018-07-01
2700         3.573750       2018-08-01
2701         3.265714       2018-09-01
2702         3.316071       2018-10-01
2703         3.412903       2018-11-01
```

```
scaledControlCustomers['controlCustomers'] =
scaledControlCustomers['nCustomers'] * scalingFactorCustomers
scaledControlCustomers.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2699        233     201807     290.7          51       1.058824
1.629630
2700        233     201808     285.9          48       1.041667
1.600000
2701        233     201809     228.6          42       1.071429
1.555556
2702        233     201810     185.7          35       1.028571
1.555556
2703        233     201811     211.6          40       1.025000
1.512195

      avgPricePerUnit TransactionMonth  controlCustomers
2699         3.303409       2018-07-01         51.171141
2700         3.573750       2018-08-01         48.161074
2701         3.265714       2018-09-01         42.140940
2702         3.316071       2018-10-01         35.117450
2703         3.412903       2018-11-01         40.134228
```

```
# Create 'percentageDiff' dataframe
percentageDiff = scaledControlCustomers[['YEARMONTH',
'controlCustomers']]
percentageDiff.reset_index(drop = True, inplace = True)

# Concatenate with trial store 'nCustomers'
trialCustomers = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, 'nCustomers']
trialCustomers.reset_index(drop = True, inplace = True)
percentageDiff = pd.concat([percentageDiff, trialCustomers], axis = 1)
percentageDiff.rename(columns = {'nCustomers': 'trialCustomers'},
inplace = True)

percentageDiff
```

```
    YEARMONTH  controlCustomers  trialCustomers
0      201807         51.171141              51
1      201808         48.161074              47
2      201809         42.140940              42
3      201810         35.117450              37
```

```
4      201811        40.134228             41
5      201812        47.157718             46
6      201901        35.117450             35
7      201902        45.151007             45
8      201903        40.134228             50
9      201904        30.100671             47
10     201905        57.191275             55
11     201906        41.137584             41
```

```python
# Calculate percentage difference and put it in a new column

percentageDiff['percentageDiff'] = abs(percentageDiff.controlCustomers
- percentageDiff.trialCustomers) / percentageDiff.controlCustomers
percentageDiff
```

	YEARMONTH	controlCustomers	trialCustomers	percentageDiff
0	201807	51.171141	51	0.003344
1	201808	48.161074	47	0.024108
2	201809	42.140940	42	0.003344
3	201810	35.117450	37	0.053607
4	201811	40.134228	41	0.021572
5	201812	47.157718	46	0.024550
6	201901	35.117450	35	0.003344
7	201902	45.151007	45	0.003344
8	201903	40.134228	50	0.245819
9	201904	30.100671	47	0.561427
10	201905	57.191275	55	0.038315
11	201906	41.137584	41	0.003344

```python
# Our null hypothesis is such that the trial period is the same as the
pre-trial period
# Let's take the standard deviation based on the scaled percentage
difference in the pre-trial period

stdDev = stdev(percentageDiff.loc[percentageDiff['YEARMONTH'] <
201902, 'percentageDiff'])
stdDev
```

```
0.018240748558243945
```

```python
# Define the degrees of freedom
# Since we have 8 pre-trial months, dof = 8 - 1 = 7

dof = 7

# We will test with a null hypothesis of there being 0 difference
between trial and control stores
# Create a new column for 'tValue'

percentageDiff['tValue'] = (percentageDiff['percentageDiff'] - 0) /
stdDev
```

```
percentageDiff.loc[(percentageDiff['YEARMONTH'] > 201901) &
(percentageDiff['YEARMONTH'] < 201905), 'tValue']
```

```
7     0.183352
8    13.476388
9    30.778725
Name: tValue, dtype: float64
```

```
# Find the 95th percentile of the t distribution with dof = 7

t.isf(0.05, dof)
```

```
1.8945786050613054
```

```
# Time for some visualisation
# First we need to create the appropriate dataframe
# Extract 'controlCustomers' from 'scaledControlCustomers' dataframe
for control store

controlCustomers = scaledControlCustomers.loc[:, ['TransactionMonth',
'controlCustomers']]
controlCustomers.set_index('TransactionMonth', inplace = True)
controlCustomers.rename(columns = {'controlCustomers': 'Control
Customers'}, inplace = True)
controlCustomers
```

```
                  Control Customers
TransactionMonth
2018-07-01                51.171141
2018-08-01                48.161074
2018-09-01                42.140940
2018-10-01                35.117450
2018-11-01                40.134228
2018-12-01                47.157718
2019-01-01                35.117450
2019-02-01                45.151007
2019-03-01                40.134228
2019-04-01                30.100671
2019-05-01                57.191275
2019-06-01                41.137584
```

```
# Extract 'nCustomers' for trial store from 'measureOverTime'

trialCustomers = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, ['TransactionMonth', 'nCustomers']]
trialCustomers.set_index('TransactionMonth', inplace = True)
trialCustomers.rename(columns = {'nCustomers': 'Trial Customers'},
inplace = True)
trialCustomers
```

```
                  Trial Customers
TransactionMonth
2018-07-01                     51
2018-08-01                     47
2018-09-01                     42
2018-10-01                     37
2018-11-01                     41
2018-12-01                     46
2019-01-01                     35
2019-02-01                     45
2019-03-01                     50
2019-04-01                     47
2019-05-01                     55
2019-06-01                     41
```

```python
# Create two new columns under 'controlCustomers' which calculates the
5% and 95% confidence interval

controlCustomers['Control 5% Confidence Interval'] =
controlCustomers['Control Customers'] * (1 - stdDev*2)
controlCustomers['Control 95% Confidence Interval'] =
controlCustomers['Control Customers'] * (1 + stdDev*2)
controlCustomers
```

```
                  Control Customers  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01                51.171141                       49.304341
2018-08-01                48.161074                       46.404086
2018-09-01                42.140940                       40.603575
2018-10-01                35.117450                       33.836313
2018-11-01                40.134228                       38.670071
2018-12-01                47.157718                       45.437334
2019-01-01                35.117450                       33.836313
2019-02-01                45.151007                       43.503830
2019-03-01                40.134228                       38.670071
2019-04-01                30.100671                       29.002554
2019-05-01                57.191275                       55.104852
2019-06-01                41.137584                       39.636823

                  Control 95% Confidence Interval
TransactionMonth
2018-07-01                              53.037941
2018-08-01                              49.918062
2018-09-01                              43.678304
2018-10-01                              36.398587
2018-11-01                              41.598385
2018-12-01                              48.878102
2019-01-01                              36.398587
2019-02-01                              46.798183
2019-03-01                              41.598385
```

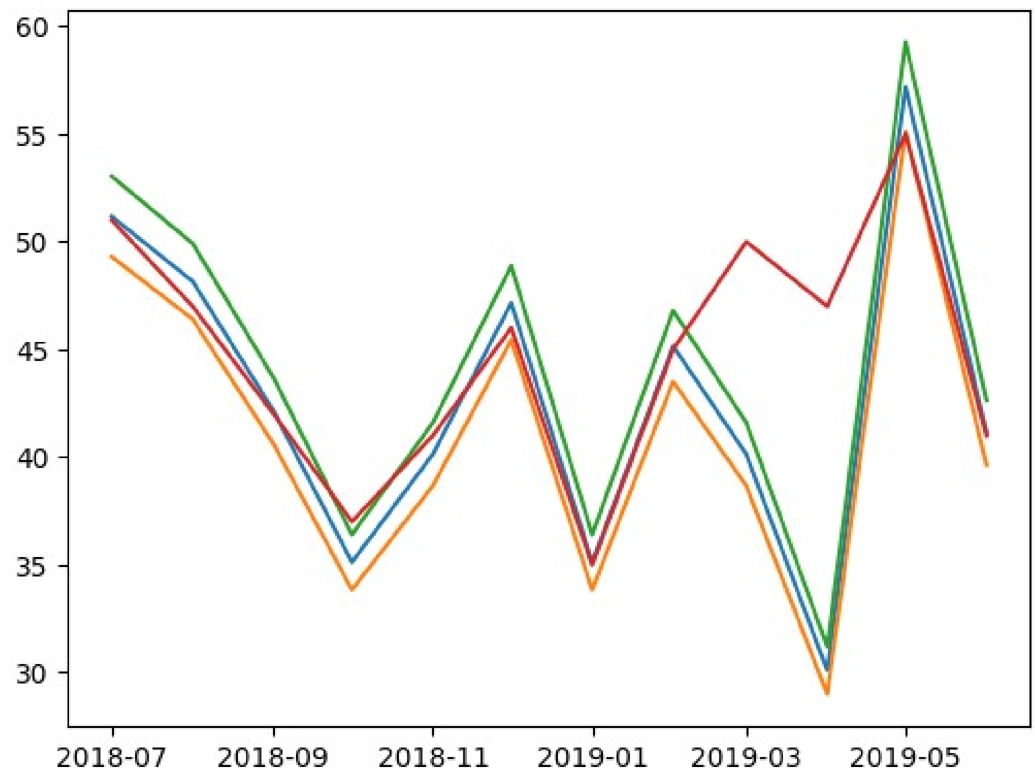
```
2019-04-01                              31.198789
2019-05-01                              59.277699
2019-06-01                              42.638345
```

```python
# Merge the two dataframes together 'controlSales' and 'trialSales'

combineCustomers = pd.merge(controlCustomers, trialCustomers,
left_index = True, right_index = True)
combineCustomers
```

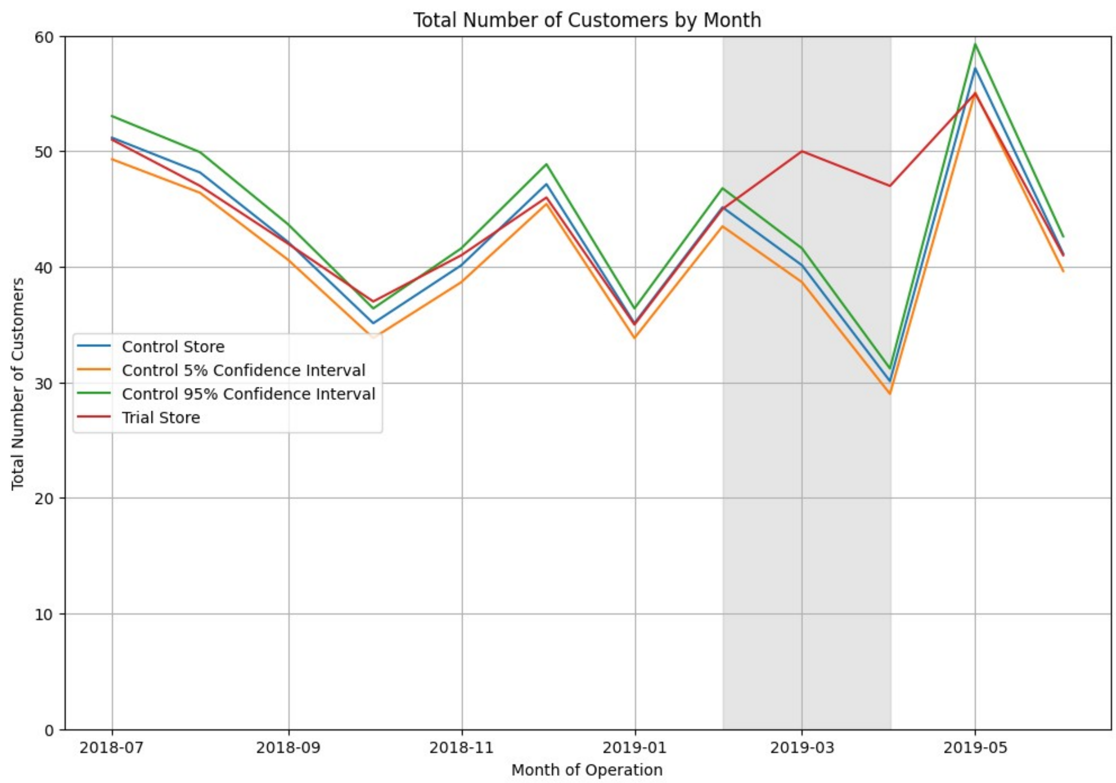
```
                  Control Customers  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01                51.171141                       49.304341
2018-08-01                48.161074                       46.404086
2018-09-01                42.140940                       40.603575
2018-10-01                35.117450                       33.836313
2018-11-01                40.134228                       38.670071
2018-12-01                47.157718                       45.437334
2019-01-01                35.117450                       33.836313
2019-02-01                45.151007                       43.503830
2019-03-01                40.134228                       38.670071
2019-04-01                30.100671                       29.002554
2019-05-01                57.191275                       55.104852
2019-06-01                41.137584                       39.636823

                  Control 95% Confidence Interval  Trial Customers
TransactionMonth
2018-07-01                              53.037941               51
2018-08-01                              49.918062               47
2018-09-01                              43.678304               42
2018-10-01                              36.398587               37
2018-11-01                              41.598385               41
2018-12-01                              48.878102               46
2019-01-01                              36.398587               35
2019-02-01                              46.798183               45
2019-03-01                              41.598385               50
2019-04-01                              31.198789               47
2019-05-01                              59.277699               55
2019-06-01                              42.638345               41
```

```python
plt.plot(combineCustomers)
```

```
[<matplotlib.lines.Line2D at 0x135c1d900>,
 <matplotlib.lines.Line2D at 0x135c1e440>,
 <matplotlib.lines.Line2D at 0x135cbe4a0>,
 <matplotlib.lines.Line2D at 0x135cbe4d0>]
```




```
# Let's embellish the plot

# Make it bigger
plt.figure(figsize = (12, 8))
plt.plot(combineCustomers)

# Set graph title and axis title
plt.title('Total Number of Customers by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Total Number of Customers')

# Set legend
plt.legend(['Control Store', 'Control 5% Confidence Interval',
'Control 95% Confidence Interval', 'Trial Store'], loc = 6)

# Set new y-axis limit
plt.ylim((0, 60))

# Highlight trial period
plt.axvspan(*mdates.datestr2num(['2019-02-01', '2019-04-01']), color =
'grey', alpha = 0.2)

# Set grid
plt.grid()
plt.show()
```



Now we need to repeat the process of finding the control store and assessing the impact of the trial for the two remaining trial stores, 86 and 88.

Selecting control store for trial 86

```
# Compute correlation with trial store 86
trial_store = 86
corr_nSales = calculateCorrelation(preTrialMeasures, 'totSales',
trial_store)
corr_nCustomers = calculateCorrelation(preTrialMeasures, 'nCustomers',
trial_store)

# Compute magnitude with trial store 86
magnitude_nSales = calculateMagnitudeDistance(preTrialMeasures,
'totSales', trial_store)
magnitude_nCustomers = calculateMagnitudeDistance(preTrialMeasures,
'nCustomers', trial_store)

# Concatenate the scores together for 'nSales'
score_nSales = pd.concat([corr_nSales, magnitude_nSales['Magnitude']],
axis = 1)

# Add an additional column which calculates the weighted average
corr_weight = 0.5
score_nSales['scoreNSales'] = corr_weight *
score_nSales['Correlation'] + (1 - corr_weight) *
score_nSales['Magnitude']
score_nSales.head()
```

```
   Store1  Store2  Correlation  Magnitude  scoreNSales
0    86.0     1.0     0.445632   0.488334     0.466983
1    86.0     2.0    -0.403835   0.321131    -0.041352
2    86.0     3.0    -0.261284   0.507515     0.123116
3    86.0     4.0    -0.039035   0.635654     0.298309
4    86.0     5.0     0.235159   0.579835     0.407497
```

```
# Now do the same for 'nCustomers'
score_nCustomers = pd.concat([corr_nCustomers,
magnitude_nCustomers['Magnitude']], axis = 1)
score_nCustomers.head()
```

```
   Store1  Store2  Correlation  Magnitude
0    86.0     1.0     0.485831   0.510204
1    86.0     2.0    -0.086161   0.428571
2    86.0     3.0    -0.353786   0.563025
3    86.0     4.0    -0.169608   0.537815
4    86.0     5.0    -0.253229   0.714286
```

```
# Again add a new column for weighted average
score_nCustomers['scoreNCust'] = corr_weight *
score_nCustomers['Correlation'] + (1 - corr_weight) *
score_nCustomers['Magnitude']
score_nCustomers.head()
```

```
   Store1  Store2  Correlation  Magnitude  scoreNCust
0    86.0     1.0     0.485831   0.510204    0.498018
1    86.0     2.0    -0.086161   0.428571    0.171205
2    86.0     3.0    -0.353786   0.563025    0.104620
3    86.0     4.0    -0.169608   0.537815    0.184103
4    86.0     5.0    -0.253229   0.714286    0.230528
```

```
# Index both 'score_nSales' and 'score_nCustomers' dataframe
score_nSales.set_index(['Store1', 'Store2'], inplace = True)
score_nCustomers.set_index(['Store1', 'Store2'], inplace = True)

# Create a new dataframe 'score_Control' which takes the average of
'scoreNSales' and 'scoreNCust'
score_Control = pd.concat([score_nSales['scoreNSales'],
score_nCustomers['scoreNCust']], axis = 1)
score_Control
```

```
               scoreNSales  scoreNCust
Store1 Store2
86.0   1.0        0.466983    0.498018
       2.0       -0.041352    0.171205
       3.0        0.123116    0.104620
       4.0        0.298309    0.184103
       5.0        0.407497    0.230528
...                    ...         ...
       268.0     -0.080126    0.266027
```

```
        269.0      0.588661    0.241523
        270.0     -0.106832   -0.058237
        271.0      0.546651    0.432804
        272.0      0.294383    0.139863

[260 rows x 2 columns]
```

```
# Add a new column to 'score_Control' which computes the average of
'scoreNSales' and 'scoreNCust'
score_Control['finalControlScore'] = 0.5 *
(score_Control['scoreNSales'] + score_Control['scoreNCust'])
score_Control.head()
```

```
               scoreNSales  scoreNCust  finalControlScore
Store1 Store2
86.0   1.0        0.466983    0.498018           0.482500
       2.0       -0.041352    0.171205           0.064927
       3.0        0.123116    0.104620           0.113868
       4.0        0.298309    0.184103           0.241206
       5.0        0.407497    0.230528           0.319013
```

```
# Let's see the top 5 stores with highest 'finalControlScore'
score_Control.sort_values(by = 'finalControlScore', ascending =
False).head()
```

```
               scoreNSales  scoreNCust  finalControlScore
Store1 Store2
86.0   155.0      0.808106    0.733343           0.770724
       109.0      0.697120    0.742532           0.719826
       114.0      0.631393    0.663384           0.647389
       225.0      0.601841    0.684356           0.643099
       138.0      0.593296    0.660565           0.626930
```

Store 155 matches trial store 86 the most

```
# Set control store 135 as 'control_store'
control_store = 155

# Create a new dataframe 'pastSales'
pastSales = preTrialMeasures

# Create a new column within 'pastSales' which categorises store type
store_type = []

for i in pastSales['STORE_NBR']:
    if i == trial_store:
        store_type.append('Trial Store')
    elif i == control_store:
        store_type.append('Control Store')
    else:
        store_type.append('Other Stores')
```

```
pastSales['store_type'] = store_type
pastSales.head()

   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit    store_type TransactionMonth
0         3.337097  Other Stores       2018-07-01
1         3.261111  Other Stores       2018-08-01
2         3.717333  Other Stores       2018-09-01
3         3.243103  Other Stores       2018-10-01
4         3.378947  Other Stores       2018-11-01

# Currently 'YEARMONTH' is an int64 so we need to turn it into a
datetime variable to able to plot
# Create a new column 'TransactionMonth'

pastSales['TransactionMonth'] =
pd.to_datetime(pastSales['YEARMONTH'].astype(str), format = '%Y%m')
pastSales.head()

   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit    store_type TransactionMonth
0         3.337097  Other Stores       2018-07-01
1         3.261111  Other Stores       2018-08-01
2         3.717333  Other Stores       2018-09-01
```

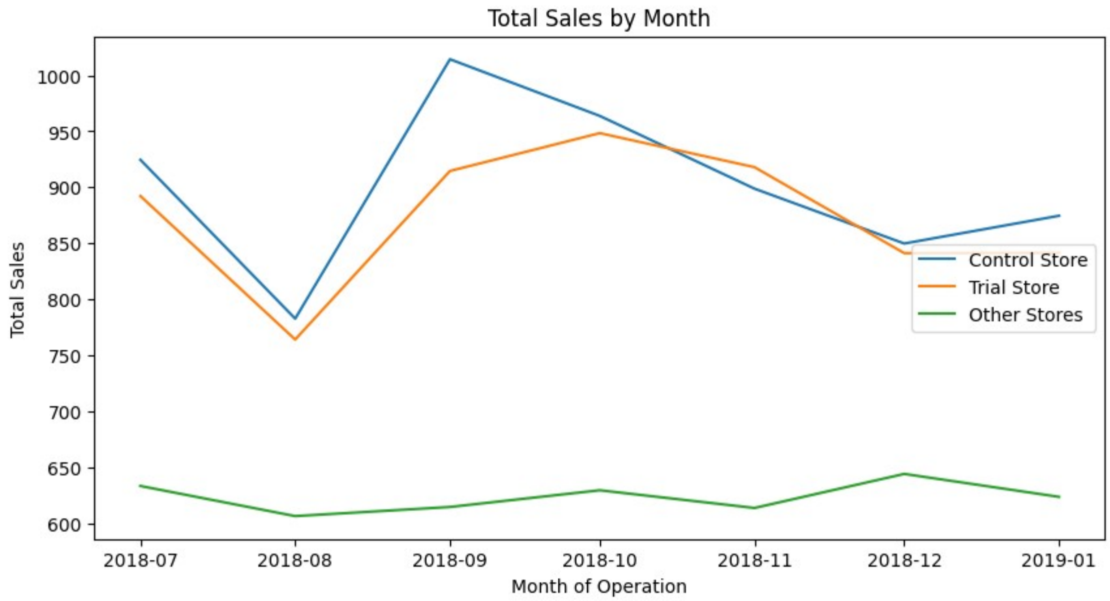
```
3         3.243103  Other Stores       2018-10-01
4         3.378947  Other Stores       2018-11-01
```

```
# Now create 'totSales' visualisation for control store, trial store
and other stores

# First create relevant dataframes
controlSalesPlot = pastSales.loc[pastSales['store_type'] == 'Control
Store', ['TransactionMonth', 'totSales']]
controlSalesPlot.set_index('TransactionMonth', inplace = True)
controlSalesPlot.rename(columns = {'totSales': 'Control Store'},
inplace = True)
trialSalesPlot = pastSales.loc[pastSales['store_type'] == 'Trial
Store', ['TransactionMonth', 'totSales']]
trialSalesPlot.set_index('TransactionMonth', inplace = True)
trialSalesPlot.rename(columns = {'totSales': 'Trial Store'}, inplace =
True)
otherSalesPlot = pastSales.loc[pastSales['store_type'] == 'Other
Stores', ['TransactionMonth', 'totSales']]
otherSalesPlot =
pd.DataFrame(otherSalesPlot.groupby('TransactionMonth').totSales.mean(
))
otherSalesPlot.rename(columns = {'totSales': 'Other Stores'}, inplace
= True)

# Concatenate
combineSalesPlot = pd.concat([controlSalesPlot, trialSalesPlot,
otherSalesPlot], axis = 1)
combineSalesPlot
```

```
                  Control Store  Trial Store  Other Stores
TransactionMonth
2018-07-01                924.6       892.20    633.239922
2018-08-01                782.7       764.05    606.326744
2018-09-01               1014.4       914.60    614.480620
2018-10-01                963.8       948.40    629.415504
2018-11-01                898.8       918.00    613.593411
2018-12-01                849.8       841.20    644.020155
2019-01-01                874.6       841.40    623.513566
```

```
# Plot total sales by month for all 3 types of stores

plt.figure(figsize = (10, 5))
plt.plot(combineSalesPlot)
plt.title('Total Sales by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Total Sales')
plt.legend(['Control Store', 'Trial Store', 'Other Stores'], loc = 5)
```

```
<matplotlib.legend.Legend at 0x13606b310>
```



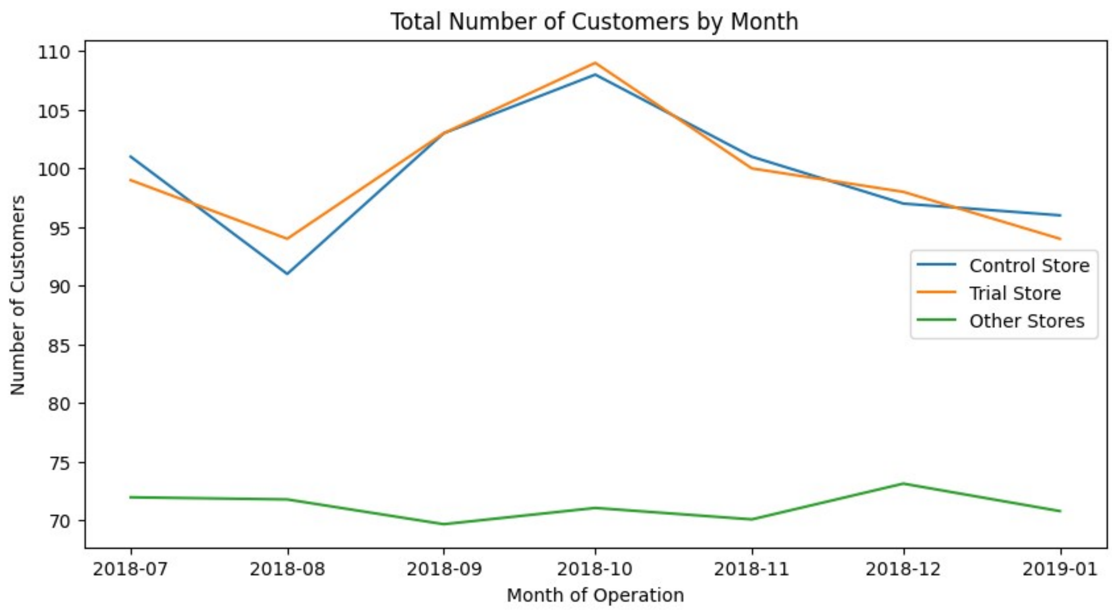

```
# Do the same for 'nCustomers'

# First create relevant dataframes
controlCustomersPlot = pastSales.loc[pastSales['store_type'] ==
'Control Store', ['TransactionMonth', 'nCustomers']]
controlCustomersPlot.set_index('TransactionMonth', inplace = True)
controlCustomersPlot.rename(columns = {'nCustomers': 'Control Store'},
inplace = True)
trialCustomersPlot = pastSales.loc[pastSales['store_type'] == 'Trial
Store', ['TransactionMonth', 'nCustomers']]
trialCustomersPlot.set_index('TransactionMonth', inplace = True)
trialCustomersPlot.rename(columns = {'nCustomers': 'Trial Store'},
inplace = True)
otherCustomersPlot = pastSales.loc[pastSales['store_type'] == 'Other
Stores', ['TransactionMonth', 'nCustomers']]
otherCustomersPlot =
pd.DataFrame(otherCustomersPlot.groupby('TransactionMonth').nCustomers
.mean())
otherCustomersPlot.rename(columns = {'nCustomers': 'Other Stores'},
inplace = True)

# Concatenate
combineCustomersPlot = pd.concat([controlCustomersPlot,
trialCustomersPlot, otherCustomersPlot], axis = 1)
combineCustomersPlot
```

```
                  Control Store  Trial Store  Other Stores
TransactionMonth
2018-07-01                  101           99     71.953488
2018-08-01                   91           94     71.771318
2018-09-01                  103          103     69.658915
```

```
2018-10-01                    108          109     71.046512
2018-11-01                    101          100     70.069767
2018-12-01                     97           98     73.120155
2019-01-01                     96           94     70.775194
```

```
# Plot total number of customers for all 3 types of stores

plt.figure(figsize = (10, 5))
plt.plot(combineCustomersPlot)
plt.title('Total Number of Customers by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Number of Customers')
plt.legend(['Control Store', 'Trial Store', 'Other Stores'], loc = 5)
```

```
<matplotlib.legend.Legend at 0x135be0dc0>
```



Assessment for trial for trial store 86

```
# First we need to work out a scaling factor to applied to the control
store
# We compute this by dividing sum of 'totSales' for trial store by sum
of 'totSales' for control store
# Let's call this variable 'scalingFactorSales'

trial_sum = preTrialMeasures.loc[preTrialMeasures['store_type'] ==
'Trial Store' , 'totSales'].sum()
control_sum = preTrialMeasures.loc[preTrialMeasures['store_type'] ==
'Control Store', 'totSales'].sum()
scalingFactorSales = trial_sum / control_sum
scalingFactorSales
```

```
0.9700651481287743
```

```
# Create a new dataframe 'scaledControlSales'
# Recall our dataframe before filtering out the trial period is called
'measureOverTime'

measureOverTime.head()

   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01

# Create dataframe and reset index

scaledControlSales = measureOverTime
scaledControlSales.head()

   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01
```

```
# We only want control store i.e. store 155

scaledControlSales =
scaledControlSales.loc[scaledControlSales['STORE_NBR'] ==
control_store]
scaledControlSales
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
1793        155     201807    924.60         101       1.217822
2.032520
1794        155     201808    782.70          91       1.307692
1.924370
1795        155     201809   1014.40         103       1.398058
2.013889
1796        155     201810    963.80         108       1.259259
2.000000
1797        155     201811    898.80         101       1.316832
2.030075
1798        155     201812    849.80          97       1.237113
2.016667
1799        155     201901    874.60          96       1.302083
2.016000
1800        155     201902    891.20          95       1.315789
2.032000
1801        155     201903    804.40          94       1.255319
2.033898
1802        155     201904    844.60          99       1.212121
2.016667
1803        155     201905    922.85         106       1.283019
1.948529
1804        155     201906    857.20          95       1.273684
2.016529

      avgPricePerUnit TransactionMonth
1793         3.698400       2018-07-01
1794         3.417904       2018-08-01
1795         3.497931       2018-09-01
1796         3.543382       2018-10-01
1797         3.328889       2018-11-01
1798         3.511570       2018-12-01
1799         3.470635       2019-01-01
1800         3.508661       2019-02-01
1801         3.351667       2019-03-01
1802         3.490083       2019-04-01
1803         3.482453       2019-05-01
1804         3.513115       2019-06-01
```

```
# Create 'controlSales' which applies 'scalingFactorSales' to
'totSales' column
```

```
scaledControlSales['controlSales'] = scaledControlSales['totSales'] *
scalingFactorSales
scaledControlSales.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
1793        155     201807     924.6         101       1.217822
2.032520
1794        155     201808     782.7          91       1.307692
1.924370
1795        155     201809    1014.4         103       1.398058
2.013889
1796        155     201810     963.8         108       1.259259
2.000000
1797        155     201811     898.8         101       1.316832
2.030075

      avgPricePerUnit TransactionMonth  controlSales
1793         3.698400       2018-07-01    896.922236
1794         3.417904       2018-08-01    759.269991
1795         3.497931       2018-09-01    984.034086
1796         3.543382       2018-10-01    934.948790
1797         3.328889       2018-11-01    871.894555
```

```
# Create 'percentageDiff' dataframe
percentageDiff = scaledControlSales[['YEARMONTH', 'controlSales']]
percentageDiff.reset_index(drop = True, inplace = True)

# Concatenate with trial store 'totSales'
trialSales = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, 'totSales']
trialSales.reset_index(drop = True, inplace = True)
percentageDiff = pd.concat([percentageDiff, trialSales], axis = 1)
percentageDiff.rename(columns = {'totSales': 'trialSales'}, inplace =
True)

# Calculate percentage difference and put it in a new column

percentageDiff['percentageDiff'] = abs(percentageDiff.controlSales -
percentageDiff.trialSales) / percentageDiff.controlSales
percentageDiff
```

```
    YEARMONTH  controlSales  trialSales  percentageDiff
0      201807    896.922236      892.20        0.005265
1      201808    759.269991      764.05        0.006296
2      201809    984.034086      914.60        0.070561
3      201810    934.948790      948.40        0.014387
4      201811    871.894555      918.00        0.052880
5      201812    824.361363      841.20        0.020426
6      201901    848.418979      841.40        0.008273
```

```
7      201902    864.522060      913.20        0.056306
8      201903    780.320405     1026.80        0.315870
9      201904    819.317024      848.20        0.035253
10     201905    895.224622      889.30        0.006618
11     201906    831.539845      838.00        0.007769
```

```
# Our null hypothesis is such that the trial period is the same as the
pre-trial period
# Let's take the standard deviation based on the scaled percentage
difference in the pre-trial period

stdDev = stdev(percentageDiff.loc[percentageDiff['YEARMONTH'] <
201902, 'percentageDiff'])
stdDev

0.02583395285477237

# Recall our 'scaledControlSales' dataframe

scaledControlSales.head()

      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
1793        155     201807     924.6         101       1.217822
2.032520
1794        155     201808     782.7          91       1.307692
1.924370
1795        155     201809    1014.4         103       1.398058
2.013889
1796        155     201810     963.8         108       1.259259
2.000000
1797        155     201811     898.8         101       1.316832
2.030075

      avgPricePerUnit TransactionMonth  controlSales
1793         3.698400       2018-07-01    896.922236
1794         3.417904       2018-08-01    759.269991
1795         3.497931       2018-09-01    984.034086
1796         3.543382       2018-10-01    934.948790
1797         3.328889       2018-11-01    871.894555

# Add a new column 'TransactionMonth' to 'scaledControlSales'

scaledControlSales['TransactionMonth'] =
pd.to_datetime(scaledControlSales['YEARMONTH'].astype(str), format =
'%Y%m')
scaledControlSales

      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
1793        155     201807    924.60         101       1.217822
```

```
2.032520
1794         155     201808    782.70          91       1.307692
1.924370
1795         155     201809   1014.40         103       1.398058
2.013889
1796         155     201810    963.80         108       1.259259
2.000000
1797         155     201811    898.80         101       1.316832
2.030075
1798         155     201812    849.80          97       1.237113
2.016667
1799         155     201901    874.60          96       1.302083
2.016000
1800         155     201902    891.20          95       1.315789
2.032000
1801         155     201903    804.40          94       1.255319
2.033898
1802         155     201904    844.60          99       1.212121
2.016667
1803         155     201905    922.85         106       1.283019
1.948529
1804         155     201906    857.20          95       1.273684
2.016529

      avgPricePerUnit TransactionMonth  controlSales
1793         3.698400       2018-07-01    896.922236
1794         3.417904       2018-08-01    759.269991
1795         3.497931       2018-09-01    984.034086
1796         3.543382       2018-10-01    934.948790
1797         3.328889       2018-11-01    871.894555
1798         3.511570       2018-12-01    824.361363
1799         3.470635       2019-01-01    848.418979
1800         3.508661       2019-02-01    864.522060
1801         3.351667       2019-03-01    780.320405
1802         3.490083       2019-04-01    819.317024
1803         3.482453       2019-05-01    895.224622
1804         3.513115       2019-06-01    831.539845
```

```
# Time for some visualisation
# First we need to create the appropriate dataframe
# Extract 'controlSales' from 'scaledControlSales' dataframe for
control store

controlSales = scaledControlSales.loc[:, ['TransactionMonth',
'controlSales']]
controlSales.set_index('TransactionMonth', inplace = True)
controlSales.rename(columns = {'controlSales': 'Control Sales'},
inplace = True)
```

```
# Create a new column 'TransationMonth' under 'measureOverTime'
dataframe

measureOverTime['TransactionMonth'] =
pd.to_datetime(measureOverTime['YEARMONTH'].astype(str), format = '%Y
%m')
measureOverTime.head()

   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01

# Extract 'totSales' for trial store from 'measureOverTime'

trialSales = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, ['TransactionMonth', 'totSales']]
trialSales.set_index('TransactionMonth', inplace = True)
trialSales.rename(columns = {'totSales': 'Trial Sales'}, inplace =
True)
trialSales

                  Trial Sales
TransactionMonth
2018-07-01             892.20
2018-08-01             764.05
2018-09-01             914.60
2018-10-01             948.40
2018-11-01             918.00
2018-12-01             841.20
2019-01-01             841.40
2019-02-01             913.20
2019-03-01            1026.80
2019-04-01             848.20
```

```
2019-05-01            889.30
2019-06-01            838.00
```

```python
# Create two new columns under 'controlSales' which calculates the 5%
and 95% confidence interval

controlSales['Control 5% Confidence Interval'] = controlSales['Control
Sales'] * (1 - stdDev*2)
controlSales['Control 95% Confidence Interval'] =
controlSales['Control Sales'] * (1 + stdDev*2)
controlSales
```

```
                  Control Sales  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01           896.922236                      850.580142
2018-08-01           759.269991                      720.040101
2018-09-01           984.034086                      933.191106
2018-10-01           934.948790                      886.641944
2018-11-01           871.894555                      826.845589
2018-12-01           824.361363                      781.768338
2019-01-01           848.418979                      804.582947
2019-02-01           864.522060                      819.854016
2019-03-01           780.320405                      740.002884
2019-04-01           819.317024                      776.984629
2019-05-01           895.224622                      848.970241
2019-06-01           831.539845                      788.575923

                  Control 95% Confidence Interval
TransactionMonth
2018-07-01                             943.264329
2018-08-01                             798.499882
2018-09-01                            1034.877067
2018-10-01                             983.255636
2018-11-01                             916.943521
2018-12-01                             866.954388
2019-01-01                             892.255010
2019-02-01                             909.190104
2019-03-01                             820.637926
2019-04-01                             861.649419
2019-05-01                             941.479003
2019-06-01                             874.503767
```

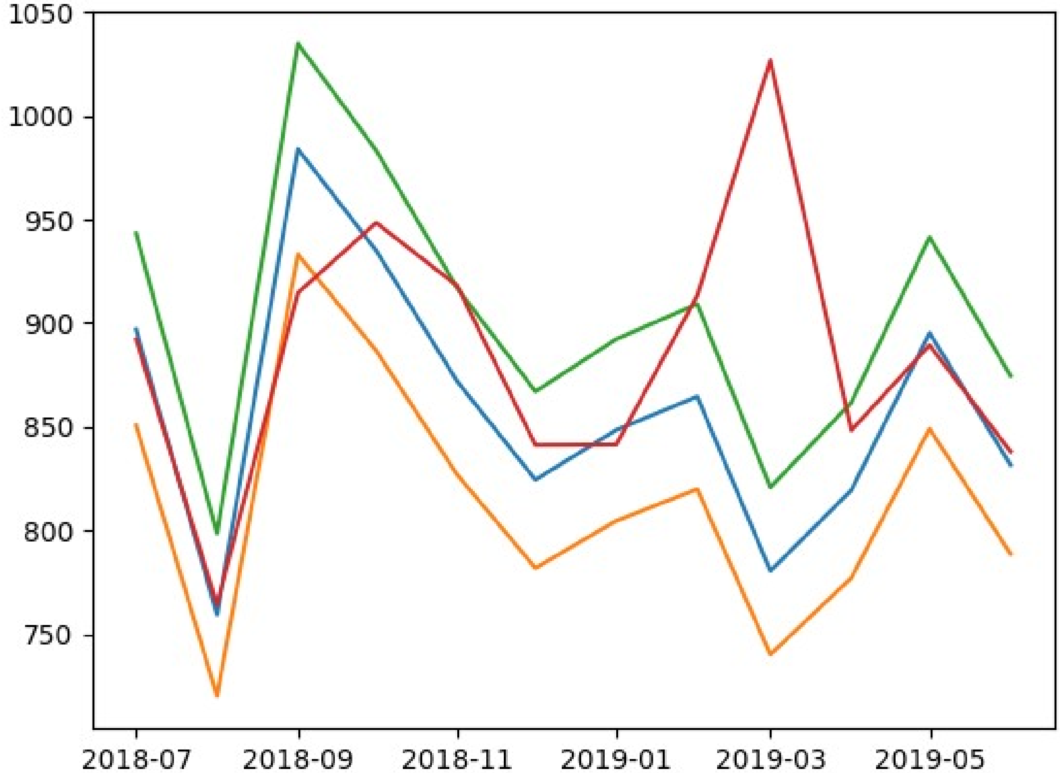
```python
# Merge the two dataframes together 'controlSales' and 'trialSales'

combineSales = pd.merge(controlSales, trialSales, left_index = True,
right_index = True)
combineSales
```

```
                  Control Sales  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01           896.922236                      850.580142
```

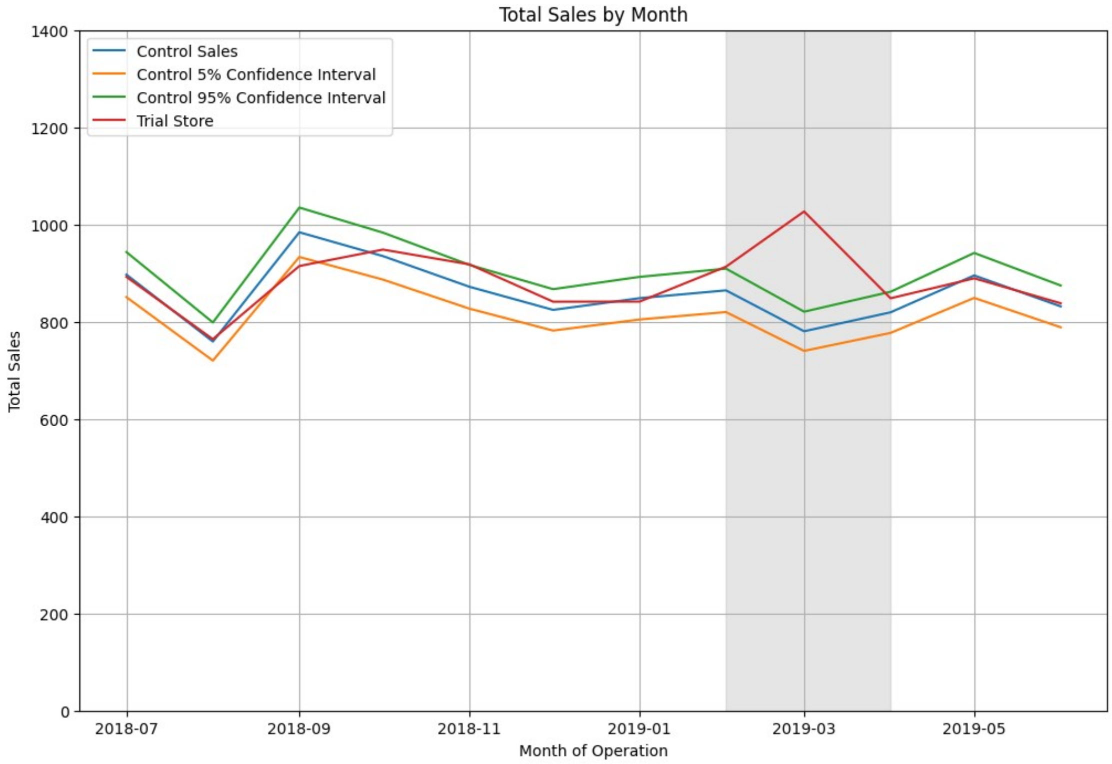
```
2018-08-01          759.269991                              720.040101
2018-09-01          984.034086                              933.191106
2018-10-01          934.948790                              886.641944
2018-11-01          871.894555                              826.845589
2018-12-01          824.361363                              781.768338
2019-01-01          848.418979                              804.582947
2019-02-01          864.522060                              819.854016
2019-03-01          780.320405                              740.002884
2019-04-01          819.317024                              776.984629
2019-05-01          895.224622                              848.970241
2019-06-01          831.539845                              788.575923

                  Control 95% Confidence Interval  Trial Sales
TransactionMonth
2018-07-01                             943.264329       892.20
2018-08-01                             798.499882       764.05
2018-09-01                            1034.877067       914.60
2018-10-01                             983.255636       948.40
2018-11-01                             916.943521       918.00
2018-12-01                             866.954388       841.20
2019-01-01                             892.255010       841.40
2019-02-01                             909.190104       913.20
2019-03-01                             820.637926      1026.80
2019-04-01                             861.649419       848.20
2019-05-01                             941.479003       889.30
2019-06-01                             874.503767       838.00
```

```
plt.plot(combineSales)
```

```
[<matplotlib.lines.Line2D at 0x1362e8610>,
 <matplotlib.lines.Line2D at 0x1362e95a0>,
 <matplotlib.lines.Line2D at 0x1363594e0>,
 <matplotlib.lines.Line2D at 0x136359510>]
```




```
# Let's embellish the plot

# Make it bigger
plt.figure(figsize = (12, 8))
plt.plot(combineSales)

# Set graph title and axis title
plt.title('Total Sales by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Total Sales')

# Set legend
plt.legend(['Control Sales', 'Control 5% Confidence Interval',
'Control 95% Confidence Interval', 'Trial Store'], loc = 2)

# Set new y-axis limit
plt.ylim((0, 1400))

# Highlight trial period
plt.axvspan(*mdates.datestr2num(['2019-02-01', '2019-04-01']), color =
'grey', alpha = 0.2)

# Set grid
plt.grid()
plt.show()
```



The results show that the trial in store 86 is not significantly different to its control store in the trial period. The trial store performance lies inside the 5% to 95% confidence interval of the control store in two of the three trial months.

```
# Now let's move on to 'nCustomers'
# First, compute scaling factor
# Let's call this variable 'scalingFactorCustomers'

trial_customers = preTrialMeasures.loc[preTrialMeasures['store_type']
== 'Trial Store' , 'nCustomers'].sum()
control_customers =
preTrialMeasures.loc[preTrialMeasures['store_type'] == 'Control
Store', 'nCustomers'].sum()
scalingFactorCustomers = trial_customers / control_customers
scalingFactorCustomers

1.0

scaledControlCustomers = measureOverTime
scaledControlCustomers.head()

   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
```

```
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01
```

```
scaledControlCustomers =
scaledControlCustomers.loc[scaledControlCustomers['STORE_NBR'] ==
control_store]
scaledControlCustomers.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
1793        155     201807     924.6         101       1.217822
2.032520
1794        155     201808     782.7          91       1.307692
1.924370
1795        155     201809    1014.4         103       1.398058
2.013889
1796        155     201810     963.8         108       1.259259
2.000000
1797        155     201811     898.8         101       1.316832
2.030075

      avgPricePerUnit TransactionMonth
1793         3.698400       2018-07-01
1794         3.417904       2018-08-01
1795         3.497931       2018-09-01
1796         3.543382       2018-10-01
1797         3.328889       2018-11-01
```

```
scaledControlCustomers['controlCustomers'] =
scaledControlCustomers['nCustomers'] * scalingFactorCustomers
scaledControlCustomers.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
1793        155     201807     924.6         101       1.217822
2.032520
1794        155     201808     782.7          91       1.307692
1.924370
1795        155     201809    1014.4         103       1.398058
```

```
2.013889
1796        155     201810     963.8         108       1.259259
2.000000
1797        155     201811     898.8         101       1.316832
2.030075

      avgPricePerUnit TransactionMonth  controlCustomers
1793         3.698400       2018-07-01             101.0
1794         3.417904       2018-08-01              91.0
1795         3.497931       2018-09-01             103.0
1796         3.543382       2018-10-01             108.0
1797         3.328889       2018-11-01             101.0
```

```
# Create 'percentageDiff' dataframe
percentageDiff = scaledControlCustomers[['YEARMONTH',
'controlCustomers']]
percentageDiff.reset_index(drop = True, inplace = True)

# Concatenate with trial store 'nCustomers'
trialCustomers = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, 'nCustomers']
trialCustomers.reset_index(drop = True, inplace = True)
percentageDiff = pd.concat([percentageDiff, trialCustomers], axis = 1)
percentageDiff.rename(columns = {'nCustomers': 'trialCustomers'},
inplace = True)

percentageDiff
```

```
    YEARMONTH  controlCustomers  trialCustomers
0      201807             101.0              99
1      201808              91.0              94
2      201809             103.0             103
3      201810             108.0             109
4      201811             101.0             100
5      201812              97.0              98
6      201901              96.0              94
7      201902              95.0             107
8      201903              94.0             115
9      201904              99.0             105
10     201905             106.0             104
11     201906              95.0              98
```

```
# Calculate percentage difference and put it in a new column

percentageDiff['percentageDiff'] = abs(percentageDiff.controlCustomers
- percentageDiff.trialCustomers) / percentageDiff.controlCustomers
percentageDiff
```

```
    YEARMONTH  controlCustomers  trialCustomers  percentageDiff
0      201807             101.0              99        0.019802
1      201808              91.0              94        0.032967
```

```
2      201809             103.0              103        0.000000
3      201810             108.0              109        0.009259
4      201811             101.0              100        0.009901
5      201812              97.0               98        0.010309
6      201901              96.0               94        0.020833
7      201902              95.0              107        0.126316
8      201903              94.0              115        0.223404
9      201904              99.0              105        0.060606
10     201905             106.0              104        0.018868
11     201906              95.0               98        0.031579
```

```
# Our null hypothesis is such that the trial period is the same as the
pre-trial period
# Let's take the standard deviation based on the scaled percentage
difference in the pre-trial period

stdDev = stdev(percentageDiff.loc[percentageDiff['YEARMONTH'] <
201902, 'percentageDiff'])
stdDev
```

```
0.010687444701395238
```

```
# Define the degrees of freedom
# Since we have 8 pre-trial months, dof = 8 - 1 = 7

dof = 7

# We will test with a null hypothesis of there being 0 difference
between trial and control stores
# Create a new column for 'tValue'

percentageDiff['tValue'] = (percentageDiff['percentageDiff'] - 0) /
stdDev
percentageDiff.loc[(percentageDiff['YEARMONTH'] > 201901) &
(percentageDiff['YEARMONTH'] < 201905), 'tValue']
```

```
7    11.819082
8    20.903430
9     5.670772
Name: tValue, dtype: float64
```

```
# Find the 95th percentile of the t distribution with dof = 7

t.isf(0.05, dof)
```

```
1.8945786050613054
```

```
# Time for some visualisation
# First we need to create the appropriate dataframe
# Extract 'controlCustomers' from 'scaledControlCustomers' dataframe
for control store
```

```
controlCustomers = scaledControlCustomers.loc[:, ['TransactionMonth',
'controlCustomers']]
controlCustomers.set_index('TransactionMonth', inplace = True)
controlCustomers.rename(columns = {'controlCustomers': 'Control
Customers'}, inplace = True)
controlCustomers
```

```
                  Control Customers
TransactionMonth
2018-07-01                    101.0
2018-08-01                     91.0
2018-09-01                    103.0
2018-10-01                    108.0
2018-11-01                    101.0
2018-12-01                     97.0
2019-01-01                     96.0
2019-02-01                     95.0
2019-03-01                     94.0
2019-04-01                     99.0
2019-05-01                    106.0
2019-06-01                     95.0
```

```
# Extract 'nCustomers' for trial store from 'measureOverTime'

trialCustomers = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, ['TransactionMonth', 'nCustomers']]
trialCustomers.set_index('TransactionMonth', inplace = True)
trialCustomers.rename(columns = {'nCustomers': 'Trial Customers'},
inplace = True)
trialCustomers
```

```
                  Trial Customers
TransactionMonth
2018-07-01                     99
2018-08-01                     94
2018-09-01                    103
2018-10-01                    109
2018-11-01                    100
2018-12-01                     98
2019-01-01                     94
2019-02-01                    107
2019-03-01                    115
2019-04-01                    105
2019-05-01                    104
2019-06-01                     98
```

```
# Create two new columns under 'controlCustomers' which calculates the
5% and 95% confidence interval

controlCustomers['Control 5% Confidence Interval'] =
```

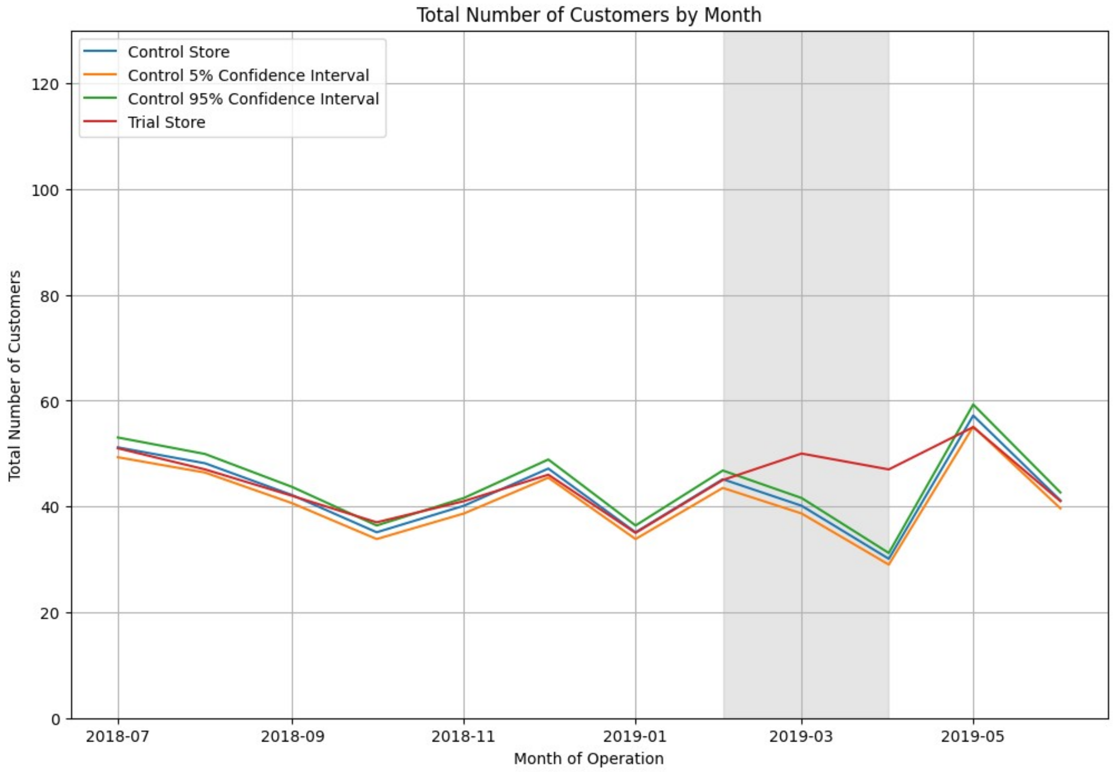
```
controlCustomers['Control Customers'] * (1 - stdDev*2)
controlCustomers['Control 95% Confidence Interval'] =
controlCustomers['Control Customers'] * (1 + stdDev*2)
controlCustomers
```

```
                  Control Customers  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01                    101.0                       98.841136
2018-08-01                     91.0                       89.054885
2018-09-01                    103.0                      100.798386
2018-10-01                    108.0                      105.691512
2018-11-01                    101.0                       98.841136
2018-12-01                     97.0                       94.926636
2019-01-01                     96.0                       93.948011
2019-02-01                     95.0                       92.969386
2019-03-01                     94.0                       91.990760
2019-04-01                     99.0                       96.883886
2019-05-01                    106.0                      103.734262
2019-06-01                     95.0                       92.969386

                  Control 95% Confidence Interval
TransactionMonth
2018-07-01                             103.158864
2018-08-01                              92.945115
2018-09-01                             105.201614
2018-10-01                             110.308488
2018-11-01                             103.158864
2018-12-01                              99.073364
2019-01-01                              98.051989
2019-02-01                              97.030614
2019-03-01                              96.009240
2019-04-01                             101.116114
2019-05-01                             108.265738
2019-06-01                              97.030614
```

```
plt.plot(combineCustomers)
```

```
[<matplotlib.lines.Line2D at 0x13676ffd0>,
 <matplotlib.lines.Line2D at 0x13676ff70>,
 <matplotlib.lines.Line2D at 0x13676ffa0>,
 <matplotlib.lines.Line2D at 0x13676fee0>]
```


```
# Let's embellish the plot

# Make it bigger
plt.figure(figsize = (12, 8))
plt.plot(combineCustomers)

# Set graph title and axis title
plt.title('Total Number of Customers by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Total Number of Customers')

# Set legend
plt.legend(['Control Store', 'Control 5% Confidence Interval',
'Control 95% Confidence Interval', 'Trial Store'], loc = 2)

# Set new y-axis limit
plt.ylim((0, 130))

# Highlight trial period
plt.axvspan(*mdates.datestr2num(['2019-02-01', '2019-04-01']), color =
'grey', alpha = 0.2)

# Set grid
plt.grid()
plt.show()
```



It looks like the number of customers is significantly higher in all of the three months. This seems to suggest that the trial had a significant impact on increasing the number of customers in trial store 86 but as we saw, sales were not significantly higher. We should check with the Category Manager if there were special deals in the trial store that were may have resulted in lower prices, impacting the results.

Selecting control store for trial store 88

```
# Now let's use those two functions to find the control store

# Compute correlation with trial store 88
trial_store = 88
corr_nSales = calculateCorrelation(preTrialMeasures, 'totSales', trial_store)
corr_nCustomers = calculateCorrelation(preTrialMeasures, 'nCustomers', trial_store)

# Compute magnitude with trial store 88
magnitude_nSales = calculateMagnitudeDistance(preTrialMeasures, 'totSales', trial_store)
magnitude_nCustomers = calculateMagnitudeDistance(preTrialMeasures, 'nCustomers', trial_store)

# Concatenate the scores together for 'nSales'

score_nSales = pd.concat([corr_nSales, magnitude_nSales['Magnitude']], axis = 1)
```

```
# Add an additional column which calculates the weighted average

corr_weight = 0.5
score_nSales['scoreNSales'] = corr_weight *
score_nSales['Correlation'] + (1 - corr_weight) *
score_nSales['Magnitude']
score_nSales.head()
```

```
   Store1  Store2  Correlation  Magnitude  scoreNSales
0    88.0     1.0     0.813636   0.548959     0.681297
1    88.0     2.0    -0.067927   0.541212     0.236643
2    88.0     3.0    -0.507847   0.458109    -0.024869
3    88.0     4.0    -0.745566   0.484447    -0.130559
4    88.0     5.0     0.190330   0.496409     0.343370
```

```
# Now do the same for 'nCustomers'

score_nCustomers = pd.concat([corr_nCustomers,
magnitude_nCustomers['Magnitude']], axis = 1)
score_nCustomers.head()
```

```
   Store1  Store2  Correlation  Magnitude
0    88.0     1.0     0.305334   0.357143
1    88.0     2.0    -0.452379   0.285714
2    88.0     3.0     0.522884   0.683673
3    88.0     4.0    -0.361503   0.577922
4    88.0     5.0    -0.025320   0.558442
```

```
# Again add a new column for weighted average

score_nCustomers['scoreNCust'] = corr_weight *
score_nCustomers['Correlation'] + (1 - corr_weight) *
score_nCustomers['Magnitude']
score_nCustomers.head()
```

```
   Store1  Store2  Correlation  Magnitude  scoreNCust
0    88.0     1.0     0.305334   0.357143    0.331238
1    88.0     2.0    -0.452379   0.285714   -0.083332
2    88.0     3.0     0.522884   0.683673    0.603279
3    88.0     4.0    -0.361503   0.577922    0.108210
4    88.0     5.0    -0.025320   0.558442    0.266561
```

```
# Index both 'score_nSales' and 'score_nCustomers' dataframe

score_nSales.set_index(['Store1', 'Store2'], inplace = True)
score_nCustomers.set_index(['Store1', 'Store2'], inplace = True)

# Create a new dataframe 'score_Control' which takes the average of
'scoreNSales' and 'scoreNCust'

score_Control = pd.concat([score_nSales['scoreNSales'],
```

```
score_nCustomers['scoreNCust']], axis = 1)
score_Control

               scoreNSales  scoreNCust
Store1 Store2
88.0   1.0        0.681297    0.331238
       2.0        0.236643   -0.083332
       3.0       -0.024869    0.603279
       4.0       -0.130559    0.108210
       5.0        0.343370    0.266561
...                    ...         ...
       268.0      0.250709    0.651462
       269.0      0.196139    0.043061
       270.0     -0.104971    0.132467
       271.0      0.163091    0.318507
       272.0     -0.077482    0.237944

[260 rows x 2 columns]

# Add a new column to 'score_Control' which computes the average of
'scoreNSales' and 'scoreNCust'

score_Control['finalControlScore'] = 0.5 *
(score_Control['scoreNSales'] + score_Control['scoreNCust'])
score_Control.head()

               scoreNSales  scoreNCust  finalControlScore
Store1 Store2
88.0   1.0        0.681297    0.331238           0.506268
       2.0        0.236643   -0.083332           0.076655
       3.0       -0.024869    0.603279           0.289205
       4.0       -0.130559    0.108210          -0.011175
       5.0        0.343370    0.266561           0.304965

# Let's see the top 5 stores with highest 'finalControlScore'

score_Control.sort_values(by = 'finalControlScore', ascending =
False).head()

               scoreNSales  scoreNCust  finalControlScore
Store1 Store2
88.0   178.0      0.650803    0.707828           0.679316
       14.0       0.646064    0.685774           0.665919
       134.0      0.775084    0.540154           0.657619
       237.0      0.451974    0.777235           0.614604
       187.0      0.616752    0.594560           0.605656

# After doing some visualisations, found that stores 178, 14 and 134
do not match trial store so set store 237 as control store

control_store = 237
```

```
# Create a new dataframe 'pastSales'
pastSales = preTrialMeasures

# Create a new column within 'pastSales' which categorises store type
store_type = []

for i in pastSales['STORE_NBR']:
    if i == trial_store:
        store_type.append('Trial Store')
    elif i == control_store:
        store_type.append('Control Store')
    else:
        store_type.append('Other Stores')

pastSales['store_type'] = store_type
pastSales.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit    store_type TransactionMonth
0         3.337097  Other Stores       2018-07-01
1         3.261111  Other Stores       2018-08-01
2         3.717333  Other Stores       2018-09-01
3         3.243103  Other Stores       2018-10-01
4         3.378947  Other Stores       2018-11-01
```

```
# Currently 'YEARMONTH' is an int64 so we need to turn it into a
datetime variable to able to plot
# Create a new column 'TransactionMonth'

pastSales['TransactionMonth'] =
pd.to_datetime(pastSales['YEARMONTH'].astype(str), format = '%Y%m')
pastSales.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
```

```
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit    store_type TransactionMonth
0         3.337097  Other Stores       2018-07-01
1         3.261111  Other Stores       2018-08-01
2         3.717333  Other Stores       2018-09-01
3         3.243103  Other Stores       2018-10-01
4         3.378947  Other Stores       2018-11-01
```

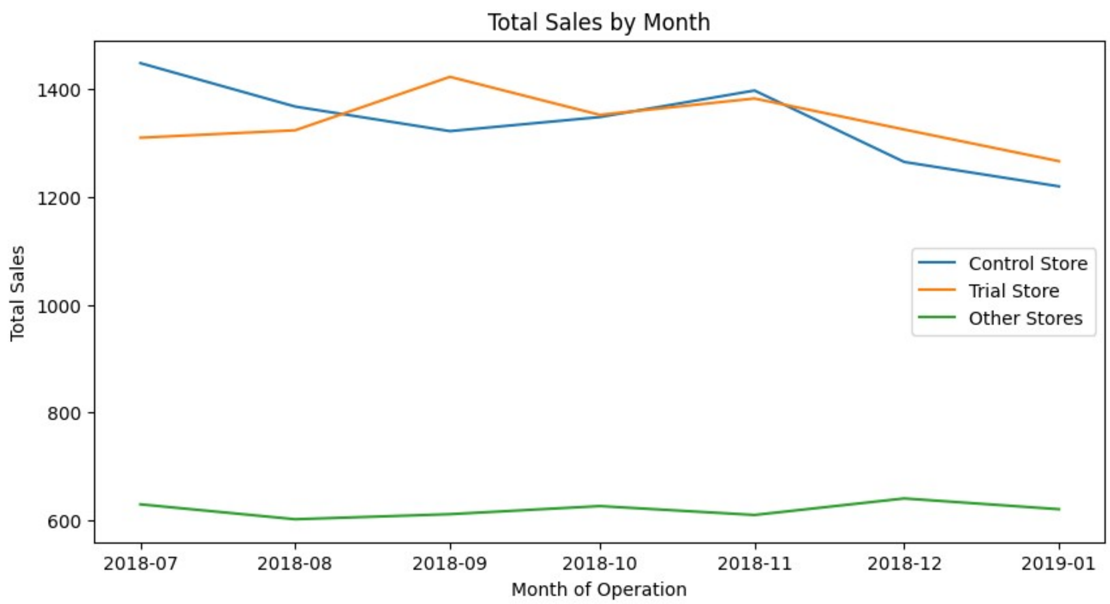
```
# Now create 'totSales' visualisation for control store, trial store
and other stores

# First create relevant dataframes
controlSalesPlot = pastSales.loc[pastSales['store_type'] == 'Control
Store', ['TransactionMonth', 'totSales']]
controlSalesPlot.set_index('TransactionMonth', inplace = True)
controlSalesPlot.rename(columns = {'totSales': 'Control Store'},
inplace = True)
trialSalesPlot = pastSales.loc[pastSales['store_type'] == 'Trial
Store', ['TransactionMonth', 'totSales']]
trialSalesPlot.set_index('TransactionMonth', inplace = True)
trialSalesPlot.rename(columns = {'totSales': 'Trial Store'}, inplace =
True)
otherSalesPlot = pastSales.loc[pastSales['store_type'] == 'Other
Stores', ['TransactionMonth', 'totSales']]
otherSalesPlot =
pd.DataFrame(otherSalesPlot.groupby('TransactionMonth').totSales.mean(
))
otherSalesPlot.rename(columns = {'totSales': 'Other Stores'}, inplace
= True)

# Concatenate
combineSalesPlot = pd.concat([controlSalesPlot, trialSalesPlot,
otherSalesPlot], axis = 1)
combineSalesPlot
```

```
                  Control Store  Trial Store  Other Stores
TransactionMonth
2018-07-01               1448.4       1310.0    629.590310
2018-08-01               1367.8       1323.8    601.889341
2018-09-01               1322.2       1423.0    611.317054
2018-10-01               1348.3       1352.4    626.359302
2018-11-01               1397.6       1382.8    609.858527
```

```
2018-12-01                1265.0       1325.2    640.534884
2019-01-01                1219.7       1266.4    620.528682
```

```
# Plot total sales by month for all 3 types of stores

plt.figure(figsize = (10, 5))
plt.plot(combineSalesPlot)
plt.title('Total Sales by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Total Sales')
plt.legend(['Control Store', 'Trial Store', 'Other Stores'], loc = 5)
```

```
<matplotlib.legend.Legend at 0x136d69a80>
```



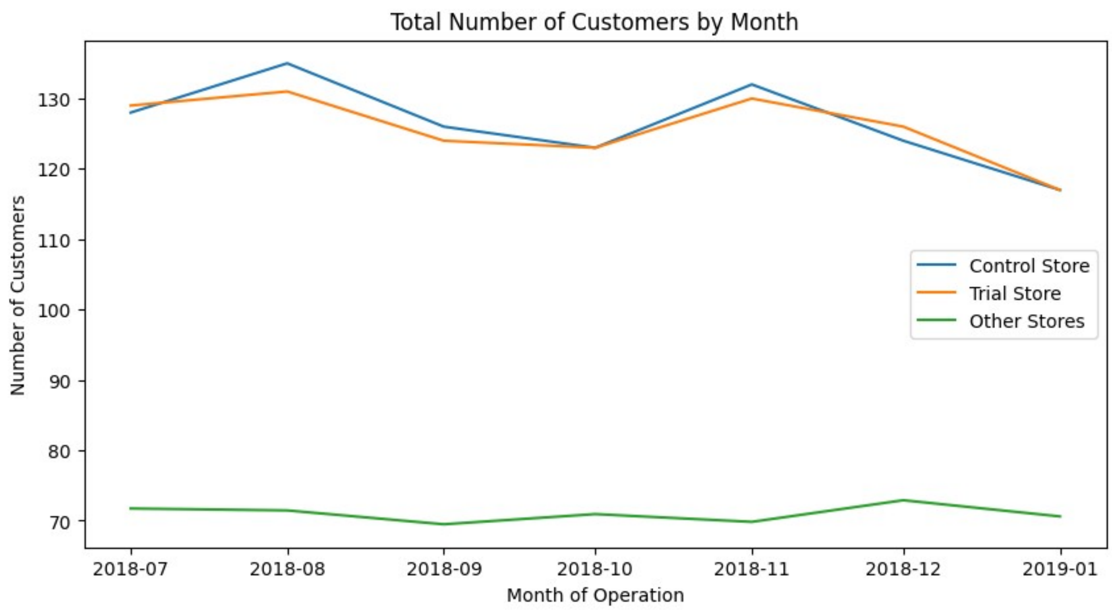

```
# Do the same for 'nCustomers'

# First create relevant dataframes
controlCustomersPlot = pastSales.loc[pastSales['store_type'] ==
'Control Store', ['TransactionMonth', 'nCustomers']]
controlCustomersPlot.set_index('TransactionMonth', inplace = True)
controlCustomersPlot.rename(columns = {'nCustomers': 'Control Store'},
inplace = True)
trialCustomersPlot = pastSales.loc[pastSales['store_type'] == 'Trial
Store', ['TransactionMonth', 'nCustomers']]
trialCustomersPlot.set_index('TransactionMonth', inplace = True)
trialCustomersPlot.rename(columns = {'nCustomers': 'Trial Store'},
inplace = True)
otherCustomersPlot = pastSales.loc[pastSales['store_type'] == 'Other
Stores', ['TransactionMonth', 'nCustomers']]
otherCustomersPlot =
pd.DataFrame(otherCustomersPlot.groupby('TransactionMonth').nCustomers
.mean())
```

```
otherCustomersPlot.rename(columns = {'nCustomers': 'Other Stores'},
inplace = True)

# Concatenate
combineCustomersPlot = pd.concat([controlCustomersPlot,
trialCustomersPlot, otherCustomersPlot], axis = 1)
combineCustomersPlot
```

TransactionMonth	Control Store	Trial Store	Other Stores
2018-07-01	128	129	71.732558
2018-08-01	135	131	71.457364
2018-09-01	126	124	69.488372
2018-10-01	123	123	70.934109
2018-11-01	132	130	69.833333
2018-12-01	124	126	72.906977
2019-01-01	117	117	70.604651

```
# Plot total number of customers for all 3 types of stores

plt.figure(figsize = (10, 5))
plt.plot(combineCustomersPlot)
plt.title('Total Number of Customers by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Number of Customers')
plt.legend(['Control Store', 'Trial Store', 'Other Stores'], loc = 5)
```

```
<matplotlib.legend.Legend at 0x136854dc0>
```



Assessment of trial for trial strore 88

The trial period goes from the start of February 2019 to end of April 2019. We now want to see if there has been an uplift in overall chip sales.

```
# First we need to work out a scaling factor to applied to the control
store
# We compute this by dividing sum of 'totSales' for trial store by sum
of 'totSales' for control store
# Let's call this variable 'scalingFactorSales'

trial_sum = preTrialMeasures.loc[preTrialMeasures['store_type'] ==
'Trial Store' , 'totSales'].sum()
control_sum = preTrialMeasures.loc[preTrialMeasures['store_type'] ==
'Control Store', 'totSales'].sum()
scalingFactorSales = trial_sum / control_sum
scalingFactorSales
```

```
1.001558330664959
```

```
# Create a new dataframe 'scaledControlSales'
# Recall our dataframe before filtering out the trial period is called
'measureOverTime'

measureOverTime.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01
```

```
# Create dataframe and reset index

scaledControlSales = measureOverTime
scaledControlSales.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01
```

```
# We only want control store i.e. store 237

scaledControlSales =
scaledControlSales.loc[scaledControlSales['STORE_NBR'] ==
control_store]
scaledControlSales
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2747        237     201807    1448.4         128       1.265625
2.000000
2748        237     201808    1367.8         135       1.222222
1.896970
2749        237     201809    1322.2         126       1.182540
2.006711
2750        237     201810    1348.3         123       1.195122
2.034014
2751        237     201811    1397.6         132       1.219697
1.987578
2752        237     201812    1265.0         124       1.161290
2.006944
2753        237     201901    1219.7         117       1.188034
1.992806
2754        237     201902    1404.8         126       1.246032
2.000000
2755        237     201903    1208.2         119       1.126050
2.044776
2756        237     201904    1204.6         120       1.125000
2.014815
2757        237     201905    1199.3         129       1.155039
```

```
1.825503
2758        237     201906    1153.6         119       1.100840
2.000000

      avgPricePerUnit TransactionMonth
2747         4.470370       2018-07-01
2748         4.369968       2018-08-01
2749         4.422074       2018-09-01
2750         4.509365       2018-10-01
2751         4.367500       2018-11-01
2752         4.377163       2018-12-01
2753         4.403249       2019-01-01
2754         4.473885       2019-02-01
2755         4.409489       2019-03-01
2756         4.428676       2019-04-01
2757         4.409191       2019-05-01
2758         4.403053       2019-06-01
```

```
# Create 'controlSales' which applies 'scalingFactorSales' to
'totSales' column

scaledControlSales['controlSales'] = scaledControlSales['totSales'] *
scalingFactorSales
scaledControlSales.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2747        237     201807    1448.4         128       1.265625
2.000000
2748        237     201808    1367.8         135       1.222222
1.896970
2749        237     201809    1322.2         126       1.182540
2.006711
2750        237     201810    1348.3         123       1.195122
2.034014
2751        237     201811    1397.6         132       1.219697
1.987578

      avgPricePerUnit TransactionMonth  controlSales
2747         4.470370       2018-07-01   1450.657086
2748         4.369968       2018-08-01   1369.931485
2749         4.422074       2018-09-01   1324.260425
2750         4.509365       2018-10-01   1350.401097
2751         4.367500       2018-11-01   1399.777923
```

```
# Create 'percentageDiff' dataframe
percentageDiff = scaledControlSales[['YEARMONTH', 'controlSales']]
percentageDiff.reset_index(drop = True, inplace = True)

# Concatenate with trial store 'totSales'
```

```python
trialSales = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, 'totSales']
trialSales.reset_index(drop = True, inplace = True)
percentageDiff = pd.concat([percentageDiff, trialSales], axis = 1)
percentageDiff.rename(columns = {'totSales': 'trialSales'}, inplace =
True)

percentageDiff
```

	YEARMONTH	controlSales	trialSales
0	201807	1450.657086	1310.00
1	201808	1369.931485	1323.80
2	201809	1324.260425	1423.00
3	201810	1350.401097	1352.40
4	201811	1399.777923	1382.80
5	201812	1266.971288	1325.20
6	201901	1221.600696	1266.40
7	201902	1406.989143	1370.20
8	201903	1210.082775	1477.20
9	201904	1206.477165	1439.40
10	201905	1201.168906	1308.25
11	201906	1155.397690	1354.60

```python
# Calculate percentage difference and put it in a new column

percentageDiff['percentageDiff'] = abs(percentageDiff.controlSales -
percentageDiff.trialSales) / percentageDiff.controlSales
percentageDiff
```

	YEARMONTH	controlSales	trialSales	percentageDiff
0	201807	1450.657086	1310.00	0.096961
1	201808	1369.931485	1323.80	0.033674
2	201809	1324.260425	1423.00	0.074562
3	201810	1350.401097	1352.40	0.001480
4	201811	1399.777923	1382.80	0.012129
5	201812	1266.971288	1325.20	0.045959
6	201901	1221.600696	1266.40	0.036673
7	201902	1406.989143	1370.20	0.026147
8	201903	1210.082775	1477.20	0.220743
9	201904	1206.477165	1439.40	0.193060
10	201905	1201.168906	1308.25	0.089147
11	201906	1155.397690	1354.60	0.172410

```python
# Our null hypothesis is such that the trial period is the same as the
pre-trial period
# Let's take the standard deviation based on the scaled percentage
difference in the pre-trial period

stdDev = stdev(percentageDiff.loc[percentageDiff['YEARMONTH'] <
201902, 'percentageDiff'])
stdDev
```

```
0.0334678673030788
```

```python
# Define the degrees of freedom
# Since we have 8 pre-trial months, dof = 8 - 1 = 7

dof = 7
```

```python
# We will test with a null hypothesis of there being 0 difference
between trial and control stores
# Create a new column for 'tValue'

percentageDiff['tValue'] = (percentageDiff['percentageDiff'] - 0) /
stdDev
percentageDiff.loc[(percentageDiff['YEARMONTH'] > 201901) &
(percentageDiff['YEARMONTH'] < 201905), 'tValue']
```

```
7    0.781270
8    6.595668
9    5.768527
Name: tValue, dtype: float64
```

```python
# Find the 95th percentile of the t distribution with dof = 7

t.isf(0.05, dof)
```

```
1.8945786050613054
```

```python
# Recall our 'scaledControlSales' dataframe

scaledControlSales.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2747        237     201807    1448.4         128       1.265625
2.000000
2748        237     201808    1367.8         135       1.222222
1.896970
2749        237     201809    1322.2         126       1.182540
2.006711
2750        237     201810    1348.3         123       1.195122
2.034014
2751        237     201811    1397.6         132       1.219697
1.987578

      avgPricePerUnit TransactionMonth  controlSales
2747         4.470370       2018-07-01   1450.657086
2748         4.369968       2018-08-01   1369.931485
2749         4.422074       2018-09-01   1324.260425
2750         4.509365       2018-10-01   1350.401097
2751         4.367500       2018-11-01   1399.777923
```

```python
# Add a new column 'TransactionMonth' to 'scaledControlSales'

scaledControlSales['TransactionMonth'] = 
pd.to_datetime(scaledControlSales['YEARMONTH'].astype(str), format = 
'%Y%m')
scaledControlSales
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust  
nChipsPerTxn  \
2747        237     201807    1448.4         128       1.265625  
2.000000  
2748        237     201808    1367.8         135       1.222222  
1.896970  
2749        237     201809    1322.2         126       1.182540  
2.006711  
2750        237     201810    1348.3         123       1.195122  
2.034014  
2751        237     201811    1397.6         132       1.219697  
1.987578  
2752        237     201812    1265.0         124       1.161290  
2.006944  
2753        237     201901    1219.7         117       1.188034  
1.992806  
2754        237     201902    1404.8         126       1.246032  
2.000000  
2755        237     201903    1208.2         119       1.126050  
2.044776  
2756        237     201904    1204.6         120       1.125000  
2.014815  
2757        237     201905    1199.3         129       1.155039  
1.825503  
2758        237     201906    1153.6         119       1.100840  
2.000000  

      avgPricePerUnit TransactionMonth  controlSales  
2747         4.470370       2018-07-01   1450.657086  
2748         4.369968       2018-08-01   1369.931485  
2749         4.422074       2018-09-01   1324.260425  
2750         4.509365       2018-10-01   1350.401097  
2751         4.367500       2018-11-01   1399.777923  
2752         4.377163       2018-12-01   1266.971288  
2753         4.403249       2019-01-01   1221.600696  
2754         4.473885       2019-02-01   1406.989143  
2755         4.409489       2019-03-01   1210.082775  
2756         4.428676       2019-04-01   1206.477165  
2757         4.409191       2019-05-01   1201.168906  
2758         4.403053       2019-06-01   1155.397690  
```

```python
# Time for some visualisation
# First we need to create the appropriate dataframe
```

```python
# Extract 'controlSales' from 'scaledControlSales' dataframe for
control store

controlSales = scaledControlSales.loc[:, ['TransactionMonth',
'controlSales']]
controlSales.set_index('TransactionMonth', inplace = True)
controlSales.rename(columns = {'controlSales': 'Control Sales'},
inplace = True)
controlSales
```

```
                  Control Sales
TransactionMonth
2018-07-01          1450.657086
2018-08-01          1369.931485
2018-09-01          1324.260425
2018-10-01          1350.401097
2018-11-01          1399.777923
2018-12-01          1266.971288
2019-01-01          1221.600696
2019-02-01          1406.989143
2019-03-01          1210.082775
2019-04-01          1206.477165
2019-05-01          1201.168906
2019-06-01          1155.397690
```

```python
# Recall 'measureOverTime' dataframe

measureOverTime.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01
```

```python
# Create a new column 'TransationMonth' under 'measureOverTime'
dataframe
```

```
measureOverTime['TransactionMonth'] =
pd.to_datetime(measureOverTime['YEARMONTH'].astype(str), format = '%Y
%m')
measureOverTime.head()
```

```
   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
2          1     201809     278.8          59       1.050847
1.209677
3          1     201810     188.1          44       1.022727
1.288889
4          1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01
```

```
# Extract 'totSales' for trial store from 'measureOverTime'

trialSales = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, ['TransactionMonth', 'totSales']]
trialSales.set_index('TransactionMonth', inplace = True)
trialSales.rename(columns = {'totSales': 'Trial Sales'}, inplace =
True)
trialSales
```

```
                  Trial Sales
TransactionMonth
2018-07-01            1310.00
2018-08-01            1323.80
2018-09-01            1423.00
2018-10-01            1352.40
2018-11-01            1382.80
2018-12-01            1325.20
2019-01-01            1266.40
2019-02-01            1370.20
2019-03-01            1477.20
2019-04-01            1439.40
2019-05-01            1308.25
2019-06-01            1354.60
```

```python
# Create two new columns under 'controlSales' which calculates the 5%
and 95% confidence interval

controlSales['Control 5% Confidence Interval'] = controlSales['Control
Sales'] * (1 - stdDev*2)
controlSales['Control 95% Confidence Interval'] =
controlSales['Control Sales'] * (1 + stdDev*2)
controlSales
```

```
                  Control Sales  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01          1450.657086                     1353.556288
2018-08-01          1369.931485                     1278.234114
2018-09-01          1324.260425                     1235.620080
2018-10-01          1350.401097                     1260.011008
2018-11-01          1399.777923                     1306.082759
2018-12-01          1266.971288                     1182.165634
2019-01-01          1221.600696                     1139.831956
2019-02-01          1406.989143                     1312.811291
2019-03-01          1210.082775                     1129.084996
2019-04-01          1206.477165                     1125.720730
2019-05-01          1201.168906                     1120.767783
2019-06-01          1155.397690                     1078.060297

                  Control 95% Confidence Interval
TransactionMonth
2018-07-01                            1547.757884
2018-08-01                            1461.628855
2018-09-01                            1412.900769
2018-10-01                            1440.791187
2018-11-01                            1493.473086
2018-12-01                            1351.776942
2019-01-01                            1303.369436
2019-02-01                            1501.166995
2019-03-01                            1291.080555
2019-04-01                            1287.233600
2019-05-01                            1281.570029
2019-06-01                            1232.735083
```

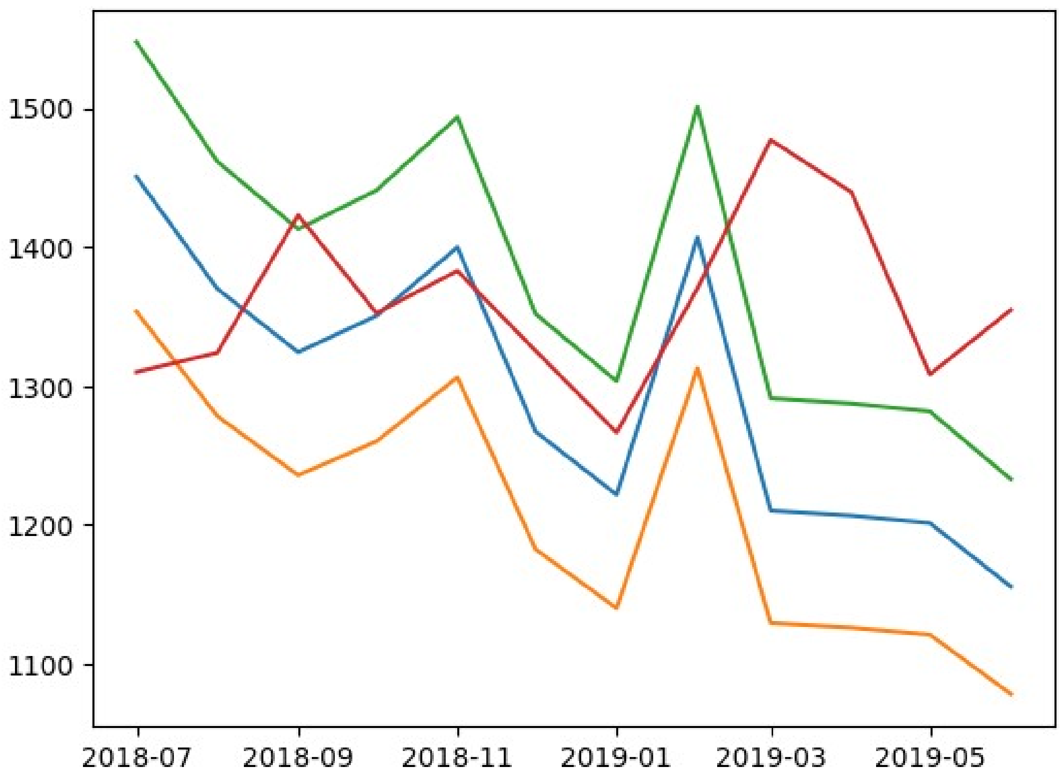
```python
# Merge the two dataframes together 'controlSales' and 'trialSales'

combineSales = pd.merge(controlSales, trialSales, left_index = True,
right_index = True)
combineSales
```

```
                  Control Sales  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01          1450.657086                     1353.556288
2018-08-01          1369.931485                     1278.234114
2018-09-01          1324.260425                     1235.620080
```

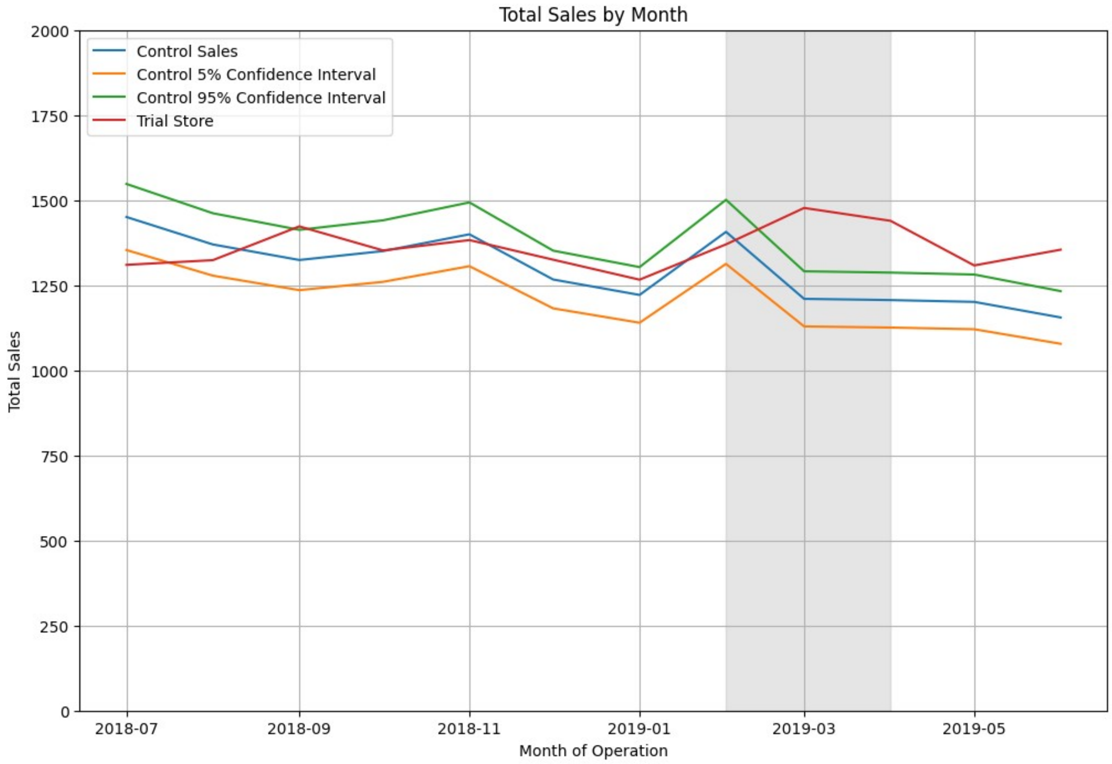
```
2018-10-01        1350.401097                       1260.011008
2018-11-01        1399.777923                       1306.082759
2018-12-01        1266.971288                       1182.165634
2019-01-01        1221.600696                       1139.831956
2019-02-01        1406.989143                       1312.811291
2019-03-01        1210.082775                       1129.084996
2019-04-01        1206.477165                       1125.720730
2019-05-01        1201.168906                       1120.767783
2019-06-01        1155.397690                       1078.060297

                  Control 95% Confidence Interval  Trial Sales
TransactionMonth
2018-07-01                            1547.757884      1310.00
2018-08-01                            1461.628855      1323.80
2018-09-01                            1412.900769      1423.00
2018-10-01                            1440.791187      1352.40
2018-11-01                            1493.473086      1382.80
2018-12-01                            1351.776942      1325.20
2019-01-01                            1303.369436      1266.40
2019-02-01                            1501.166995      1370.20
2019-03-01                            1291.080555      1477.20
2019-04-01                            1287.233600      1439.40
2019-05-01                            1281.570029      1308.25
2019-06-01                            1232.735083      1354.60
```

```
plt.plot(combineSales)
```

```
[<matplotlib.lines.Line2D at 0x1369acc70>,
 <matplotlib.lines.Line2D at 0x1369ad870>,
 <matplotlib.lines.Line2D at 0x1369e1a80>,
 <matplotlib.lines.Line2D at 0x1369e1ab0>]
```




```
# Let's embellish the plot

# Make it bigger
plt.figure(figsize = (12, 8))
plt.plot(combineSales)

# Set graph title and axis title
plt.title('Total Sales by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Total Sales')

# Set legend
plt.legend(['Control Sales', 'Control 5% Confidence Interval',
'Control 95% Confidence Interval', 'Trial Store'], loc = 2)

# Set new y-axis limit
plt.ylim((0, 2000))

# Highlight trial period
plt.axvspan(*mdates.datestr2num(['2019-02-01', '2019-04-01']), color =
'grey', alpha = 0.2)

# Set grid
plt.grid()
plt.show()
```



The results show that the trial in store 88 is significantly different to its control store in the trial period. The trial store performance lies outside the 5% to 95% confidence interval of the control store in two of the three trial months.

```
# Now let's move on to 'nCustomers'
# First, compute scaling factor
# Let's call this variable 'scalingFactorCustomers'

trial_customers = preTrialMeasures.loc[preTrialMeasures['store_type']
== 'Trial Store' , 'nCustomers'].sum()
control_customers =
preTrialMeasures.loc[preTrialMeasures['store_type'] == 'Control
Store', 'nCustomers'].sum()
scalingFactorCustomers = trial_customers / control_customers
scalingFactorCustomers

0.9943502824858758

scaledControlCustomers = measureOverTime
scaledControlCustomers.head()

   STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
0          1     201807     206.9          49       1.061224
1.192308
1          1     201808     176.1          42       1.023810
1.255814
```

```
2           1     201809     278.8          59       1.050847
1.209677
3           1     201810     188.1          44       1.022727
1.288889
4           1     201811     192.6          46       1.021739
1.212766

   avgPricePerUnit TransactionMonth
0         3.337097       2018-07-01
1         3.261111       2018-08-01
2         3.717333       2018-09-01
3         3.243103       2018-10-01
4         3.378947       2018-11-01
```

```
scaledControlCustomers =
scaledControlCustomers.loc[scaledControlCustomers['STORE_NBR'] ==
control_store]
scaledControlCustomers.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2747        237     201807    1448.4         128       1.265625
2.000000
2748        237     201808    1367.8         135       1.222222
1.896970
2749        237     201809    1322.2         126       1.182540
2.006711
2750        237     201810    1348.3         123       1.195122
2.034014
2751        237     201811    1397.6         132       1.219697
1.987578

      avgPricePerUnit TransactionMonth
2747         4.470370       2018-07-01
2748         4.369968       2018-08-01
2749         4.422074       2018-09-01
2750         4.509365       2018-10-01
2751         4.367500       2018-11-01
```

```
scaledControlCustomers['controlCustomers'] =
scaledControlCustomers['nCustomers'] * scalingFactorCustomers
scaledControlCustomers.head()
```

```
      STORE_NBR  YEARMONTH  totSales  nCustomers  nChipsPerCust
nChipsPerTxn  \
2747        237     201807    1448.4         128       1.265625
2.000000
2748        237     201808    1367.8         135       1.222222
1.896970
2749        237     201809    1322.2         126       1.182540
2.006711
```

```
2750         237     201810    1348.3         123       1.195122
2.034014
2751         237     201811    1397.6         132       1.219697
1.987578

      avgPricePerUnit TransactionMonth  controlCustomers
2747         4.470370       2018-07-01        127.276836
2748         4.369968       2018-08-01        134.237288
2749         4.422074       2018-09-01        125.288136
2750         4.509365       2018-10-01        122.305085
2751         4.367500       2018-11-01        131.254237
```

```
# Create 'percentageDiff' dataframe
percentageDiff = scaledControlCustomers[['YEARMONTH',
'controlCustomers']]
percentageDiff.reset_index(drop = True, inplace = True)

# Concatenate with trial store 'nCustomers'
trialCustomers = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, 'nCustomers']
trialCustomers.reset_index(drop = True, inplace = True)
percentageDiff = pd.concat([percentageDiff, trialCustomers], axis = 1)
percentageDiff.rename(columns = {'nCustomers': 'trialCustomers'},
inplace = True)

percentageDiff
```

	YEARMONTH	controlCustomers	trialCustomers
0	201807	127.276836	129
1	201808	134.237288	131
2	201809	125.288136	124
3	201810	122.305085	123
4	201811	131.254237	130
5	201812	123.299435	126
6	201901	116.338983	117
7	201902	125.288136	124
8	201903	118.327684	134
9	201904	119.322034	128
10	201905	128.271186	128
11	201906	118.327684	121

```
# Calculate percentage difference and put it in a new column

percentageDiff['percentageDiff'] = abs(percentageDiff.controlCustomers
- percentageDiff.trialCustomers) / percentageDiff.controlCustomers
percentageDiff
```

	YEARMONTH	controlCustomers	trialCustomers	percentageDiff
0	201807	127.276836	129	0.013539
1	201808	134.237288	131	0.024116
2	201809	125.288136	124	0.010281

```
3      201810       122.305085            123       0.005682
4      201811       131.254237            130       0.009556
5      201812       123.299435            126       0.021902
6      201901       116.338983            117       0.005682
7      201902       125.288136            124       0.010281
8      201903       118.327684            134       0.132448
9      201904       119.322034            128       0.072727
10     201905       128.271186            128       0.002114
11     201906       118.327684            121       0.022584
```

```
# Our null hypothesis is such that the trial period is the same as the
pre-trial period
# Let's take the standard deviation based on the scaled percentage
difference in the pre-trial period

stdDev = stdev(percentageDiff.loc[percentageDiff['YEARMONTH'] <
201902, 'percentageDiff'])
stdDev
```

```
0.00741024435207507
```

```
# Define the degrees of freedom
# Since we have 8 pre-trial months, dof = 8 - 1 = 7

dof = 7

# We will test with a null hypothesis of there being 0 difference
between trial and control stores
# Create a new column for 'tValue'

percentageDiff['tValue'] = (percentageDiff['percentageDiff'] - 0) /
stdDev
percentageDiff.loc[(percentageDiff['YEARMONTH'] > 201901) &
(percentageDiff['YEARMONTH'] < 201905), 'tValue']
```

```
7     1.387456
8    17.873693
9     9.814423
Name: tValue, dtype: float64
```

```
# Find the 95th percentile of the t distribution with dof = 7

t.isf(0.05, dof)
```

```
1.8945786050613054
```

```
# Time for some visualisation
# First we need to create the appropriate dataframe
# Extract 'controlCustomers' from 'scaledControlCustomers' dataframe
for control store
```

```
controlCustomers = scaledControlCustomers.loc[:, ['TransactionMonth',
'controlCustomers']]
controlCustomers.set_index('TransactionMonth', inplace = True)
controlCustomers.rename(columns = {'controlCustomers': 'Control
Customers'}, inplace = True)
controlCustomers

                  Control Customers
TransactionMonth
2018-07-01               127.276836
2018-08-01               134.237288
2018-09-01               125.288136
2018-10-01               122.305085
2018-11-01               131.254237
2018-12-01               123.299435
2019-01-01               116.338983
2019-02-01               125.288136
2019-03-01               118.327684
2019-04-01               119.322034
2019-05-01               128.271186
2019-06-01               118.327684

# Extract 'nCustomers' for trial store from 'measureOverTime'

trialCustomers = measureOverTime.loc[measureOverTime['STORE_NBR'] ==
trial_store, ['TransactionMonth', 'nCustomers']]
trialCustomers.set_index('TransactionMonth', inplace = True)
trialCustomers.rename(columns = {'nCustomers': 'Trial Customers'},
inplace = True)
trialCustomers

                  Trial Customers
TransactionMonth
2018-07-01                    129
2018-08-01                    131
2018-09-01                    124
2018-10-01                    123
2018-11-01                    130
2018-12-01                    126
2019-01-01                    117
2019-02-01                    124
2019-03-01                    134
2019-04-01                    128
2019-05-01                    128
2019-06-01                    121

# Create two new columns under 'controlCustomers' which calculates the
5% and 95% confidence interval

controlCustomers['Control 5% Confidence Interval'] =
controlCustomers['Control Customers'] * (1 - stdDev*2)
```

```
controlCustomers['Control 95% Confidence Interval'] =
controlCustomers['Control Customers'] * (1 + stdDev*2)
controlCustomers
```

```
                  Control Customers  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01               127.276836                      125.390531
2018-08-01               134.237288                      132.247826
2018-09-01               125.288136                      123.431304
2018-10-01               122.305085                      120.492464
2018-11-01               131.254237                      129.308985
2018-12-01               123.299435                      121.472077
2019-01-01               116.338983                      114.614782
2019-02-01               125.288136                      123.431304
2019-03-01               118.327684                      116.574010
2019-04-01               119.322034                      117.553623
2019-05-01               128.271186                      126.370145
2019-06-01               118.327684                      116.574010

                  Control 95% Confidence Interval
TransactionMonth
2018-07-01                             129.163141
2018-08-01                             136.226750
2018-09-01                             127.144967
2018-10-01                             124.117706
2018-11-01                             133.199489
2018-12-01                             125.126793
2019-01-01                             118.063184
2019-02-01                             127.144967
2019-03-01                             120.081358
2019-04-01                             121.090445
2019-05-01                             130.172228
2019-06-01                             120.081358
```

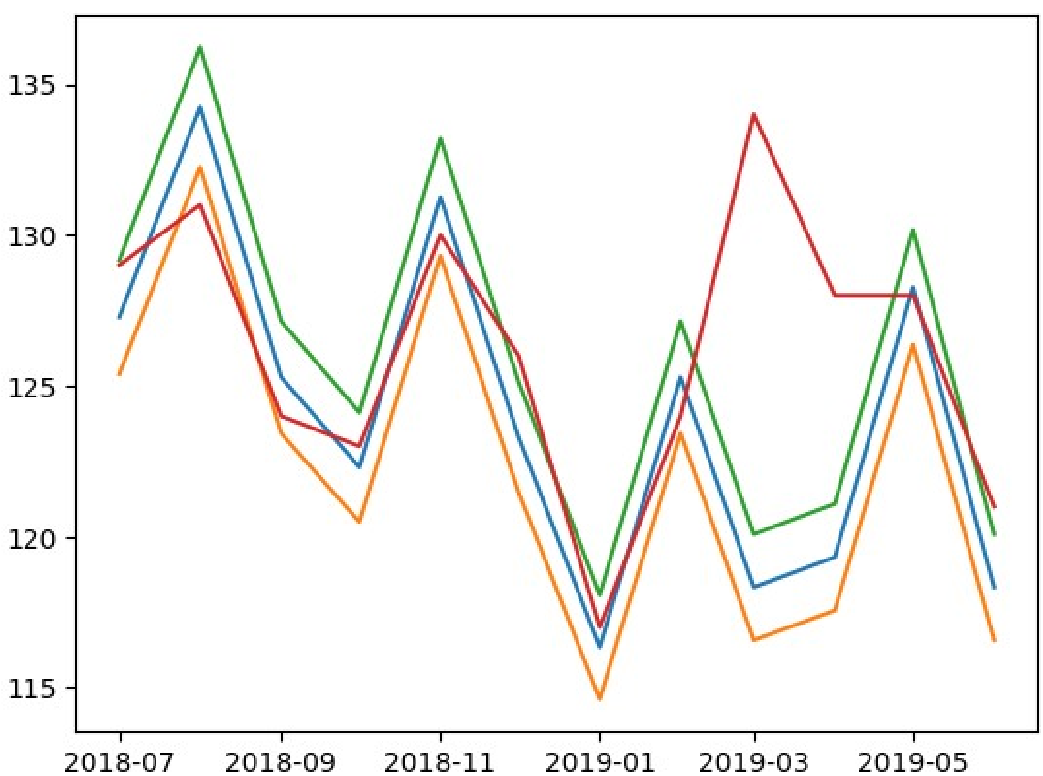
```
# Merge the two dataframes together 'controlSales' and 'trialSales'

combineCustomers = pd.merge(controlCustomers, trialCustomers,
left_index = True, right_index = True)
combineCustomers
```

```
                  Control Customers  Control 5% Confidence Interval  \
TransactionMonth
2018-07-01               127.276836                      125.390531
2018-08-01               134.237288                      132.247826
2018-09-01               125.288136                      123.431304
2018-10-01               122.305085                      120.492464
2018-11-01               131.254237                      129.308985
2018-12-01               123.299435                      121.472077
2019-01-01               116.338983                      114.614782
2019-02-01               125.288136                      123.431304
2019-03-01               118.327684                      116.574010
```

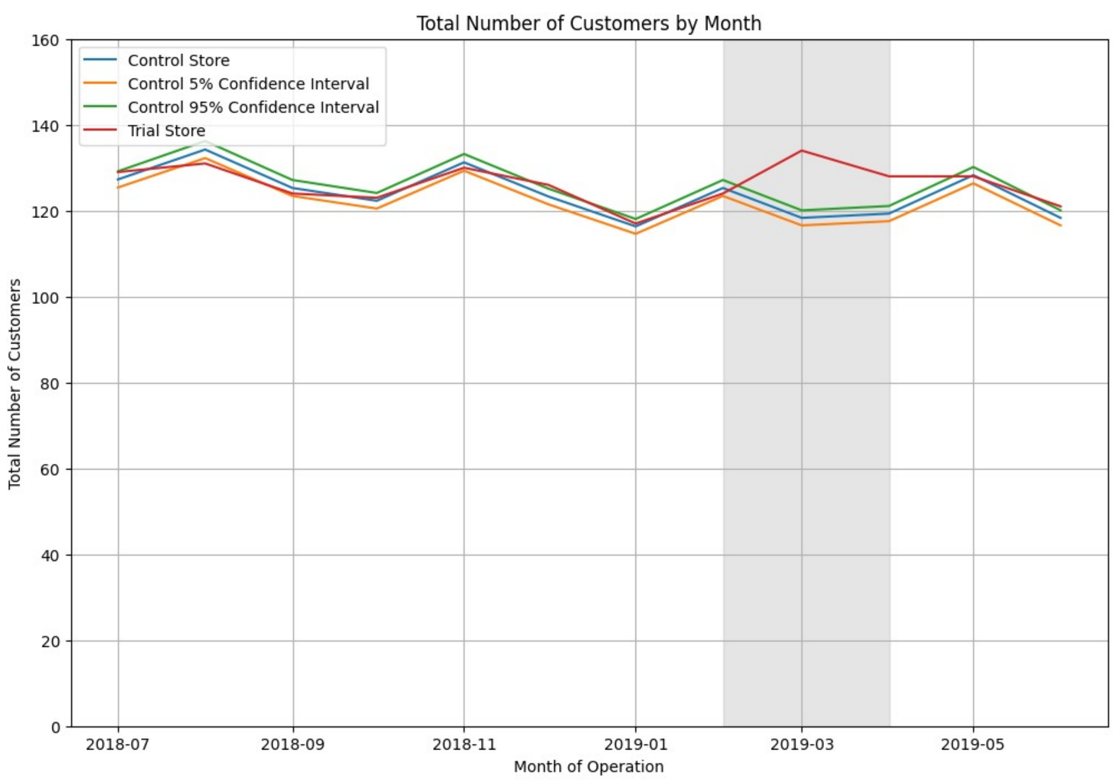
```
2019-04-01              119.322034                      117.553623
2019-05-01              128.271186                      126.370145
2019-06-01              118.327684                      116.574010

                  Control 95% Confidence Interval  Trial Customers
TransactionMonth
2018-07-01                             129.163141              129
2018-08-01                             136.226750              131
2018-09-01                             127.144967              124
2018-10-01                             124.117706              123
2018-11-01                             133.199489              130
2018-12-01                             125.126793              126
2019-01-01                             118.063184              117
2019-02-01                             127.144967              124
2019-03-01                             120.081358              134
2019-04-01                             121.090445              128
2019-05-01                             130.172228              128
2019-06-01                             120.081358              121
```

```
plt.plot(combineCustomers)
```

```
[<matplotlib.lines.Line2D at 0x136ca38e0>,
 <matplotlib.lines.Line2D at 0x136cc5ff0>,
 <matplotlib.lines.Line2D at 0x136ca33d0>,
 <matplotlib.lines.Line2D at 0x136ca31c0>]
```



```python
# Let's embellish the plot

# Make it bigger
plt.figure(figsize = (12, 8))
plt.plot(combineCustomers)

# Set graph title and axis title
plt.title('Total Number of Customers by Month')
plt.xlabel('Month of Operation')
plt.ylabel('Total Number of Customers')

# Set legend
plt.legend(['Control Store', 'Control 5% Confidence Interval',
'Control 95% Confidence Interval', 'Trial Store'], loc = 2)

# Set new y-axis limit
plt.ylim((0, 160))

# Highlight trial period
plt.axvspan(*mdates.datestr2num(['2019-02-01', '2019-04-01']), color =
'grey', alpha = 0.2)

# Set grid
plt.grid()
plt.show()
```



Total number of customers in the trial period for the trial store is significantly higher than the control store for two out of three months, which indicates a positive trial effect.

Conclusions

It looks like the number of customers is significantly higher in all of the three months. This seems to suggest that the trial had a significant impact on increasing the number of customers in trial store 86 but as we saw, sales were not significantly higher. We should check with the Category Manager if there were special deals in the trial store that were may have resulted in lower prices, impacting the results.