Quantium Virtual Internship - Retail Strategy and Analytics

Task 2

Load required libraries and datasets

In [121]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt

%matplotlib inline

from sklearn.preprocessing import MinMaxScaler

import statistics

from scipy.stats import t

import math
```

In [2]:
```
data = pd.read_csv('QVI_data.csv')
```

In [3]:
```
data
```

Out[3]:

	LYLTY_CARD_NBR	DATE	STORE_NBR	TXN_ID	PROD_NBR	PROD_NAME	PROD_QTY
0	1000	2018-10-17	1	1	5	Natural Chip Compny SeaSalt175g	2
1	1002	2018-09-16	1	2	58	Red Rock Deli Chikn&Garlic Aioli 150g	1
2	1003	2019-03-07	1	3	52	Grain Waves Sour Cream&Chives 210G	1
3	1003	2019-03-08	1	4	106	Natural ChipCo Hony Soy Chckn175g	1
4	1004	2018-11-02	1	5	96	WW Original Stacked Chips 160g	1
...	...	...	...	...	...	...	...
264829	2370701	2018-12-08	88	240378	24	Grain Waves Sweet Chilli 210g	2
264830	2370751	2018-10-01	88	240394	60	Kettle Tortilla ChpsFeta&Garlic 150g	2
264831	2370961	2018-10-24	88	240480	70	Tyrrells Crisps Lightly Salted 165g	2
264832	2370961	2018-10-27	88	240481	65	Old El Paso Salsa Dip Chnky Tom Ht300g	2
264833	2373711	2018-12-14	88	241815	16	Smiths Crinkle Chips Salt & Vinegar 330g	2

264834 rows × 12 columns

Select Control Stores

In [4]:
```
# The client has selected store numbers 77, 86 and 88 as trial stores and want
# control stores to be established stores that are operational for the entire obs

# We would want to match trial stores to control stores that are similar to the t
# store prior to the trial period of Feb 2019 in terms of :
#  - Monthly overall sales revenue
#  - Monthly number of customers
#  - Monthly number of transactions per customer
```

In [5]:
```
year_month = []
for d in data['DATE']:
    month = d[:-3].replace("-","")
    year_month.append(month)

data['MONTH_ID'] = year_month
data['MONTH_ID'] = data['MONTH_ID'].astype(int)
```

Filter Stores

In [6]:
```
store_operate = data.groupby('STORE_NBR').nunique()['MONTH_ID'].reset_index()
store_operate.rename(columns={'MONTH_ID': 'Operate_Months'}, inplace=True)
store_operate.head()
```

Out[6]:

	STORE_NBR	Operate_Months
0	1	12
1	2	12
2	3	12
3	4	12
4	5	12

In [7]:
```
i = store_operate.loc[store_operate['Operate_Months']<12].index
store_qualified = store_operate.drop(i)
store_qualified
```

Out[7]:

	STORE_NBR	Operate_Months
0	1	12
1	2	12
2	3	12
3	4	12
4	5	12
...	...	...
267	268	12
268	269	12
269	270	12
270	271	12
271	272	12

260 rows × 2 columns

In [499]:
```
data_Filter = pd.merge(data, store_qualified, on = 'STORE_NBR', how = 'inner')
del data_Filter['Operate_Months']
data_Filter
```

Out[499]:

	LYLTY_CARD_NBR	DATE	STORE_NBR	TXN_ID	PROD_NBR	PROD_NAME	PROD_QTY
0	1000	2018-10-17	1	1	5	Natural Chip Compny SeaSalt175g	2
1	1002	2018-09-16	1	2	58	Red Rock Deli Chikn&Garlic Aioli 150g	1
2	1003	2019-03-07	1	3	52	Grain Waves Sour Cream&Chives 210G	1
3	1003	2019-03-08	1	4	106	Natural ChipCo Hony Soy Chckn175g	1
4	1004	2018-11-02	1	5	96	WW Original Stacked Chips 160g	1
...	...	...	...	...	...	...	...
264640	272391	2018-12-07	272	270205	63	Kettle 135g Swt Pot Sea Salt	2
264641	272392	2018-09-26	272	270206	70	Tyrrells Crisps Lightly Salted 165g	2
264642	272392	2018-09-29	272	270207	75	Cobs Popd Sea Salt Chips 110g	2
264643	272392	2018-10-31	272	270208	81	Pringles Original Crisps 134g	2
264644	272392	2019-02-17	272	270209	78	Thins Chips Salt & Vinegar 175g	2

264645 rows × 13 columns

Measure Calculations

In [500]:
```
TotalSale = data_Filter.groupby(['STORE_NBR','MONTH_ID']).sum()[['TOT_SALES','PRC
TotalSale
```

Out[500]:

	STORE_NBR	MONTH_ID	TOT_SALES	PROD_QTY
0	1	201807	206.9	62
1	1	201808	176.1	54
2	1	201809	278.8	75
3	1	201810	188.1	58
4	1	201811	192.6	57
...	...	...	...	...
3115	272	201902	395.5	91
3116	272	201903	442.3	101
3117	272	201904	445.1	105
3118	272	201905	314.6	71
3119	272	201906	312.1	70

3120 rows × 4 columns

In [501]:
```
NumCustomer = data_Filter.groupby(['STORE_NBR','MONTH_ID']).nunique()['LYLTY_CARD
NumCustomer
```

Out[501]:

	STORE_NBR	MONTH_ID	LYLTY_CARD_NBR
0	1	201807	49
1	1	201808	42
2	1	201809	59
3	1	201810	44
4	1	201811	46
...	...	...	...
3115	272	201902	45
3116	272	201903	50
3117	272	201904	54
3118	272	201905	34
3119	272	201906	34

3120 rows × 3 columns

In [502]:
```
CountTrans = data_Filter.groupby(['STORE_NBR','MONTH_ID']).nunique()['TXN_ID'].re
CountTrans
```

Out[502]:

	STORE_NBR	MONTH_ID	TXN_ID
0	1	201807	52
1	1	201808	43
2	1	201809	62
3	1	201810	45
4	1	201811	47
...	...	...	...
3115	272	201902	48
3116	272	201903	53
3117	272	201904	55
3118	272	201905	40
3119	272	201906	37

3120 rows × 3 columns

In [503]:
```
Store_Data = pd.merge(TotalSale,NumCustomer, on = ['STORE_NBR','MONTH_ID'])
```

In [504]:
```
Store_Data = pd.merge(Store_Data, CountTrans, on= ['STORE_NBR','MONTH_ID'] )
Store_Data.rename(columns={'LYLTY_CARD_NBR': 'Num_Cus','TXN_ID':'Tot_Trans'}, inp
Store_Data['Trans_PerCus'] = Store_Data['Tot_Trans']/Store_Data['Num_Cus']
Store_Data['nChips_PerTrans'] = Store_Data['PROD_QTY']/Store_Data['Tot_Trans']
Store_Data['AvgPrice'] = Store_Data['TOT_SALES'] / Store_Data['PROD_QTY']
Store_Data
```

Out[504]:

	STORE_NBR	MONTH_ID	TOT_SALES	PROD_QTY	Num_Cus	Tot_Trans	Trans_PerCus	nCh
0	1	201807	206.9	62	49	52	1.061224	
1	1	201808	176.1	54	42	43	1.023810	
2	1	201809	278.8	75	59	62	1.050847	
3	1	201810	188.1	58	44	45	1.022727	
4	1	201811	192.6	57	46	47	1.021739	
...	...	...	...	...	...	...	...	
3115	272	201902	395.5	91	45	48	1.066667	
3116	272	201903	442.3	101	50	53	1.060000	
3117	272	201904	445.1	105	54	55	1.018519	
3118	272	201905	314.6	71	34	40	1.176471	
3119	272	201906	312.1	70	34	37	1.088235	

3120 rows × 9 columns

Separate Data by Trial/Control segments

In [505]:
```
store_measures = Store_Data[['STORE_NBR','MONTH_ID','TOT_SALES','Num_Cus','Trans_
store_measures
```

Out[505]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3115	272	201902	395.5	45	1.066667	1.895833	4.346154
3116	272	201903	442.3	50	1.060000	1.905660	4.379208
3117	272	201904	445.1	54	1.018519	1.909091	4.239048
3118	272	201905	314.6	34	1.176471	1.775000	4.430986
3119	272	201906	312.1	34	1.088235	1.891892	4.458571

3120 rows × 7 columns

In [248]:
```
trial_index = store_measures.loc[store_measures['MONTH_ID'] >= 201903].index
preTrial = store_measures.drop(trial_index)
preTrial
```

Out[248]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2080 rows × 7 columns

In [609]:
```
trial_store_77_i = preTrial.loc[preTrial['STORE_NBR'] !=77].index
trial_store_77 = preTrial.drop(trial_store_77_i)

trial_store_86_i = preTrial.loc[preTrial['STORE_NBR'] !=86].index
trial_store_86 = preTrial.drop(trial_store_86_i)

trial_store_88_i = preTrial.loc[preTrial['STORE_NBR'] !=88].index
trial_store_88 = preTrial.drop(trial_store_88_i)

trial_stores = pd.concat([trial_store_77,trial_store_86,trial_store_88])

control_store_i_1 = preTrial.loc[preTrial['STORE_NBR'] == 77].index
control_store_i_2 = preTrial.loc[preTrial['STORE_NBR'] == 86].index
control_store_i_3 = preTrial.loc[preTrial['STORE_NBR'] == 88].index
control_stores1 = preTrial.drop(control_store_i_1)
control_stores2 = control_stores1.drop(control_store_i_2)
control_stores = control_stores2.drop(control_store_i_3)
control_stores
```

Out[609]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2056 rows × 7 columns

Calculate Correlations

In [610]:

```
def getCorr(control, measure, trial):

    d1 = control_stores.loc[control_stores['STORE_NBR']!=control].index
    get1 = control_stores.drop(d1)

    d2 = trial_stores.loc[trial_stores['STORE_NBR']!=trial].index
    get2 = trial_stores.drop(d2)

    newframe = pd.merge(get1, get2, on = 'MONTH_ID')

    col_num = [measure, (measure + 6)]
    measure_col = newframe[newframe.columns[col_num]]

    correlation_M = measure_col.corr()
    corr_val = correlation_M.iloc[0][1]
    return corr_val
```

In [611]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [77,86,88]

m = 2

C_Stores = []
T_Stores = []
Corr_Results = []
for t in trial_num:
    for c in store_num:
        result = getCorr(c,m,t)
        C_Stores.append(c)
        T_Stores.append(t)
        Corr_Results.append(result)

Correlation_Matrix = pd.DataFrame({'Trial' : T_Stores,
                                   'Control' : C_Stores,
                                   'Correlation' : Corr_Results },
                                   columns=['Trial','Control', 'Correlation'])
Correlation_Matrix
```

Out[611]:

	Trial	Control	Correlation
0	77	1	0.050163
1	77	2	-0.200796
2	77	3	0.616574
3	77	4	-0.094125
4	77	5	-0.045765
...	...	...	...
766	88	268	-0.100489
767	88	269	-0.165132
768	88	270	-0.737748
769	88	271	-0.166019
770	88	272	-0.747878

771 rows × 3 columns

In [612]:
```
Correlation_Matrix.sort_values('Correlation', ascending = False).head(10)
```

Out[612]:

	Trial	Control	Correlation
662	88	159	0.895637
218	77	233	0.894375
15	77	17	0.843806
401	86	155	0.841589
108	77	119	0.831832
514	88	1	0.823306
67	77	71	0.792931
596	88	91	0.783157
501	86	260	0.736378
691	88	188	0.731655

Calculate Magnitude Distance

In [613]:
```
def getMag(control, measure, trial):
    d1 = control_stores.loc[control_stores['STORE_NBR']!=control].index
    get1 = control_stores.drop(d1)

    d2 = trial_stores.loc[trial_stores['STORE_NBR']!=trial].index
    get2 = trial_stores.drop(d2)

    newframe = pd.merge(get1, get2, on = 'MONTH_ID')
    newframe['Magnitude'] = abs(newframe[newframe.columns[(measure+6)]]-newframe[

    #newframe

    col_num = [0,7,1,13]
    measure_col = newframe[newframe.columns[col_num]]
    return measure_col
```

In [614]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [77,86,88]

m = 2

mag_list = []
for t in trial_num:
    for c in store_num:
        result = getMag(c,m,t)
        mag_list.append(result)
mag_matrix = pd.concat(mag_list)

mag_matrix.rename(columns={'STORE_NBR_x': 'Control', 'STORE_NBR_y': 'Trial'}, inp
```

In [615]:
```
minDist = mag_matrix.groupby(['Control','Trial']).min()['Magnitude'].reset_index(
maxDist = mag_matrix.groupby(['Control','Trial']).max()['Magnitude'].reset_index(

MinMaxDist = pd.merge(minDist, maxDist, on = ('Control','Trial'))

MinMaxDist.rename(columns={'Magnitude_x': 'Min','Magnitude_y':'Max'}, inplace=Tru

standard_mag = pd.merge(mag_matrix,MinMaxDist, on = ('Control','Trial'))
standard_mag['Mag_Measure'] = 1 - (standard_mag['Magnitude'] -standard_mag['Min']

finalDist = standard_mag.groupby(['Control','Trial']).mean()['Mag_Measure'].reset
finalDist
```

Out[615]:

	Control	Trial	Mag_Measure
0	1	77	0.451899
1	1	86	0.479874
2	1	88	0.545494
3	2	77	0.573994
4	2	86	0.285031
...	...	...	...
766	271	86	0.514646
767	271	88	0.382504
768	272	77	0.514112
769	272	86	0.563557
770	272	88	0.605879

771 rows × 3 columns

Select Control Stores

Correlation Against Store 77 Based on Total Sales and Number of Customers

In [616]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [77]

# Total Sales: m = 2
m = 2

C_Stores = []
T_Stores = []
Corr_Results = []
for t in trial_num:
    for c in store_num:
        result = getCorr(c,m,t)
        C_Stores.append(c)
        T_Stores.append(t)
        Corr_Results.append(result)

Correlation_Matrix1 = pd.DataFrame({'Trial' : T_Stores,
                                    'Control' : C_Stores,
                                    'Correlation' : Corr_Results },
                                    columns=['Trial','Control', 'Correlation'])
Correlation_Matrix1.sort_values('Correlation', ascending = False)
```

Out[616]:

	Trial	Control	Correlation
218	77	233	0.894375
15	77	17	0.843806
108	77	119	0.831832
67	77	71	0.792931
146	77	157	0.722332
...	...	...	...
158	77	169	-0.633658
227	77	242	-0.642253
22	77	24	-0.645190
17	77	19	-0.657963
229	77	244	-0.674915

257 rows × 3 columns

In [617]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [77]

# Number of Customers: m = 3
m = 3

C_Stores = []
T_Stores = []
Corr_Results = []
for t in trial_num:
    for c in store_num:
        result = getCorr(c,m,t)
        C_Stores.append(c)
        T_Stores.append(t)
        Corr_Results.append(result)

Correlation_Matrix2 = pd.DataFrame({'Trial' : T_Stores,
                                    'Control' : C_Stores,
                                    'Correlation' : Corr_Results },
                                    columns=['Trial','Control', 'Correlation'])
Correlation_Matrix2.sort_values('Correlation', ascending = False)
```

Out[617]:

	Trial	Control	Correlation
218	77	233	0.990542
108	77	119	0.977709
38	77	41	0.811844
2	77	3	0.756913
15	77	17	0.741196
...	...	...	...
175	77	186	-0.644356
251	77	267	-0.651727
92	77	102	-0.662607
50	77	54	-0.680967
8	77	9	-0.700131

257 rows × 3 columns

Magnitude Distance Against Store 77 Based on Total Sales

In [618]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [77]

# Total Sale
m = 2

mag_list1 = []
for t in trial_num:
    for c in store_num:
        result = getMag(c,m,t)
        mag_list1.append(result)
mag_matrix1 = pd.concat(mag_list1)

mag_matrix1.rename(columns={'STORE_NBR_x': 'Control', 'STORE_NBR_y': 'Trial'}, ir
mag_matrix1
```

Out[618]:

	Control	Trial	MONTH_ID	Magnitude
0	1	77	201807	89.9
1	1	77	201808	79.4
2	1	77	201809	53.6
3	1	77	201810	16.4
4	1	77	201811	52.7
...	...	...	...	...
3	272	77	201810	226.1
4	272	77	201811	130.9
5	272	77	201812	136.6
6	272	77	201901	218.6
7	272	77	201902	160.5

2056 rows × 4 columns

In [619]:
```
minDist = mag_matrix1.groupby(['Control','Trial']).min()['Magnitude'].reset_index
maxDist = mag_matrix1.groupby(['Control','Trial']).max()['Magnitude'].reset_index

MinMaxDist = pd.merge(minDist, maxDist, on = ('Control','Trial'))

MinMaxDist.rename(columns={'Magnitude_x': 'Min','Magnitude_y':'Max'}, inplace=Tru

standard_mag = pd.merge(mag_matrix1,MinMaxDist, on = ('Control','Trial'))
standard_mag['Mag_Measure'] = 1 - (standard_mag['Magnitude'] -standard_mag['Min']

finalDist1 = standard_mag.groupby(['Control','Trial']).mean()['Mag_Measure'].rese
finalDist1
```

Out[619]:

	Control	Trial	Mag_Measure
0	1	77	0.451899
1	2	77	0.573994
2	3	77	0.569844
3	4	77	0.462734
4	5	77	0.575124
...	...	...	...
252	268	77	0.382680
253	269	77	0.554494
254	270	77	0.631867
255	271	77	0.378727
256	272	77	0.514112

257 rows × 3 columns

Magnitude Distance Against Store 77 Based on Number of Customers

In [620]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [77]

# Number of Customers
m = 3

mag_list = []
for t in trial_num:
    for c in store_num:
        result = getMag(c,m,t)
        mag_list.append(result)
mag_matrix2 = pd.concat(mag_list)

mag_matrix2.rename(columns={'STORE_NBR_x': 'Control', 'STORE_NBR_y': 'Trial'}, ir
```

In [621]:
```
minDist = mag_matrix2.groupby(['Control','Trial']).min()['Magnitude'].reset_index
maxDist = mag_matrix2.groupby(['Control','Trial']).max()['Magnitude'].reset_index

MinMaxDist = pd.merge(minDist, maxDist, on = ('Control','Trial'))

MinMaxDist.rename(columns={'Magnitude_x': 'Min','Magnitude_y':'Max'}, inplace=Tru

standard_mag = pd.merge(mag_matrix2,MinMaxDist, on = ('Control','Trial'))
standard_mag['Mag_Measure'] = 1 - (standard_mag['Magnitude'] -standard_mag['Min']

finalDist2 = standard_mag.groupby(['Control','Trial']).mean()['Mag_Measure'].rese
finalDist2
```

Out[621]:

	Control	Trial	Mag_Measure
0	1	77	0.654412
1	2	77	0.544643
2	3	77	0.590909
3	4	77	0.462264
4	5	77	0.573529
...	...	...	...
252	268	77	0.527778
253	269	77	0.516304
254	270	77	0.581081
255	271	77	0.387500
256	272	77	0.602273

257 rows × 3 columns

In [622]:
```
corr_weight = 0.5
combined_tot = pd.merge(Correlation_Matrix1,finalDist1, on = ['Control','Trial']
combined_tot['Combined_Score'] = corr_weight*combined_tot['Correlation'] + (1-cor
combined_tot
```

Out[622]:

	Trial	Control	Correlation	Mag_Measure	Combined_Score
0	77	1	0.050163	0.451899	0.251031
1	77	2	-0.200796	0.573994	0.186599
2	77	3	0.616574	0.569844	0.593209
3	77	4	-0.094125	0.462734	0.184304
4	77	5	-0.045765	0.575124	0.264679
...	...	...	...	...	...
252	77	268	0.350807	0.382680	0.366743
253	77	269	-0.315842	0.554494	0.119326
254	77	270	0.324937	0.631867	0.478402
255	77	271	0.362891	0.378727	0.370809
256	77	272	0.114645	0.514112	0.314378

257 rows × 5 columns

In [623]:
```
corr_weight = 0.5
combined_nCus = pd.merge(Correlation_Matrix2,finalDist2, on = ['Control','Trial']
combined_nCus['Combined_Score'] = corr_weight*combined_nCus['Correlation'] + (1-c
combined_nCus
```

Out[623]:

	Trial	Control	Correlation	Mag_Measure	Combined_Score
0	77	1	0.350572	0.654412	0.502492
1	77	2	-0.455226	0.544643	0.044708
2	77	3	0.756913	0.590909	0.673911
3	77	4	-0.302046	0.462264	0.080109
4	77	5	0.277619	0.573529	0.425574
...	...	...	...	...	...
252	77	268	0.283287	0.527778	0.405533
253	77	269	-0.492708	0.516304	0.011798
254	77	270	-0.176932	0.581081	0.202074
255	77	271	-0.056788	0.387500	0.165356
256	77	272	0.238448	0.602273	0.420361

257 rows × 5 columns

In [624]:
```
combined_77 = pd.merge(combined_tot,combined_nCus, on = ['Control','Trial'] )
combined_77['Overall_Score'] = 0.5*combined_77['Combined_Score_x'] + 0.5*combinec
combined_77.sort_values('Overall_Score', ascending = False)
```

Out[624]:

	Trial	Control	Correlation_x	Mag_Measure_x	Combined_Score_x	Correlation_y	Mag_Measure
218	77	233	0.894375	0.531353	0.712864	0.990542	0.6875
108	77	119	0.831832	0.362428	0.597130	0.977709	0.5416
15	77	17	0.843806	0.415347	0.629577	0.741196	0.6250
105	77	115	0.684763	0.750262	0.717513	0.625048	0.5625
67	77	71	0.792931	0.589911	0.691421	0.719435	0.5000
...	...	...	...	...	...	...	
229	77	244	-0.674915	0.529916	-0.072499	-0.422064	0.5069
175	77	186	-0.484694	0.529107	0.022206	-0.644356	0.4937
227	77	242	-0.642253	0.460725	-0.090764	-0.614857	0.6000
158	77	169	-0.633658	0.475890	-0.078884	-0.612676	0.5555
92	77	102	-0.417963	0.402639	-0.007662	-0.662607	0.4375

257 rows × 9 columns

The store with the highest score is Store No.233, which is selected as the control store.

Visual checks on trends based on Total Sales

In [625]:
```
preTrial
```

Out[625]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2080 rows × 7 columns

In [626]:
```
def classification(row):
    if row['STORE_NBR'] == 77:
        return 'Trial'
    elif row['STORE_NBR'] == 233:
        return 'Control'
    else:
        return 'Other Stores'

preTrial['STORE_TYPE'] = preTrial.apply(classification, axis=1)

preTrial
```

Out[626]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2080 rows × 8 columns

In [627]:
```
preTrial['MONTH'] = pd.to_datetime(preTrial['MONTH_ID'].astype(int),format='%Y%m'
```

In [628]:
```
tot_by_month = preTrial.groupby(['MONTH','STORE_TYPE']).mean()['TOT_SALES'].reset
tot_by_month.head()
```

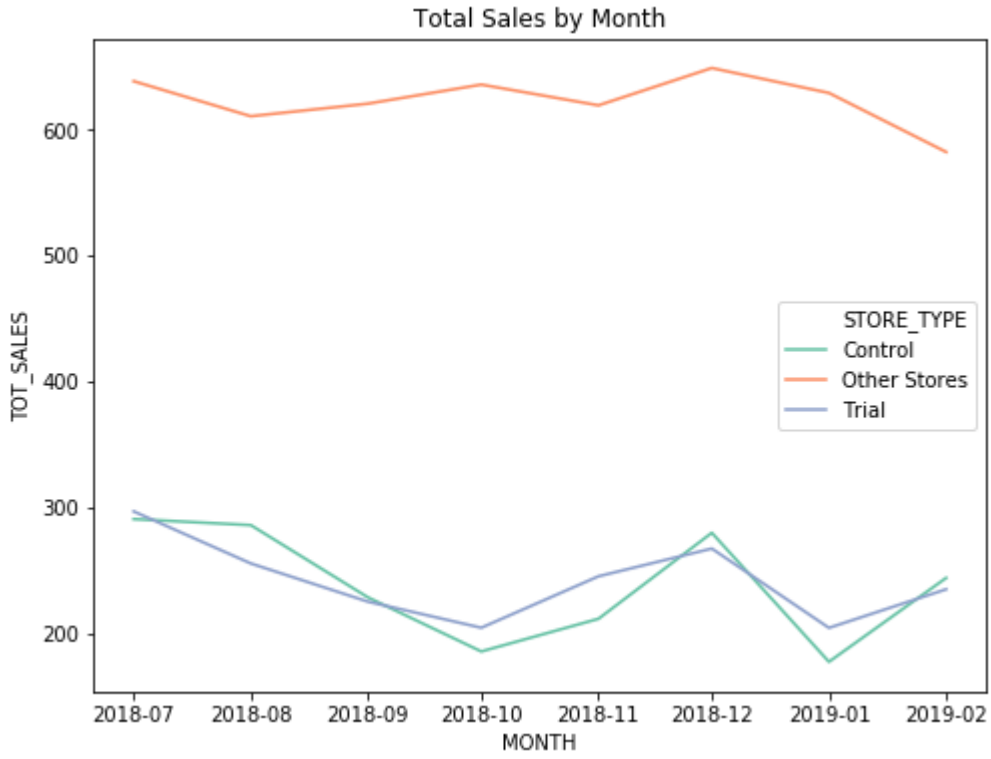
Out[628]:

	MONTH	STORE_TYPE	TOT_SALES
0	2018-07-01	Control	290.700000
1	2018-07-01	Other Stores	638.004651
2	2018-07-01	Trial	296.800000
3	2018-08-01	Control	285.900000
4	2018-08-01	Other Stores	610.223450

In [629]:
```
plt.figure(figsize=(8,6))


TotalSale = sns.lineplot(x='MONTH',y='TOT_SALES', hue = 'STORE_TYPE', data=tot_by
TotalSale.set_title('Total Sales by Month')
```

Out[629]: Text(0.5, 1.0, 'Total Sales by Month')



Visual checks on trends based on Number of Customers

In [630]:
```
nCustomers = preTrial.groupby(['MONTH','STORE_TYPE']).mean()['Num_Cus'].reset_inc
nCustomers
```

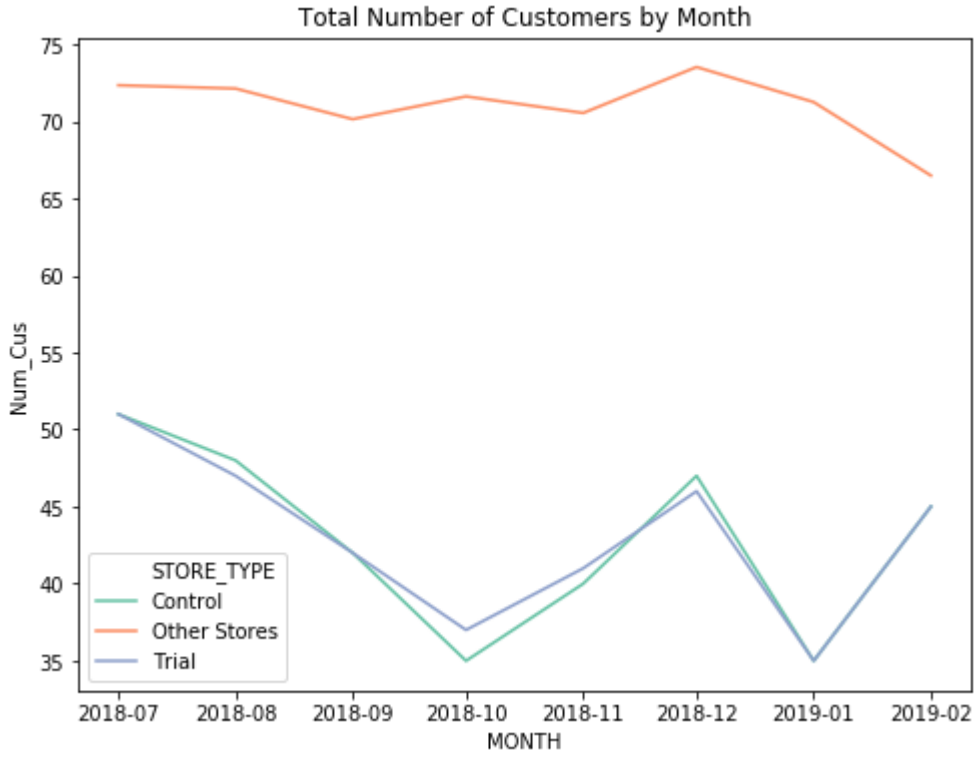
Out[630]:

	MONTH	STORE_TYPE	Num_Cus
0	2018-07-01	Control	51.000000
1	2018-07-01	Other Stores	72.333333
2	2018-07-01	Trial	51.000000
3	2018-08-01	Control	48.000000
4	2018-08-01	Other Stores	72.120155
5	2018-08-01	Trial	47.000000
6	2018-09-01	Control	42.000000
7	2018-09-01	Other Stores	70.131783
8	2018-09-01	Trial	42.000000
9	2018-10-01	Control	35.000000
10	2018-10-01	Other Stores	71.608527
11	2018-10-01	Trial	37.000000
12	2018-11-01	Control	40.000000
13	2018-11-01	Other Stores	70.534884
14	2018-11-01	Trial	41.000000
15	2018-12-01	Control	47.000000
16	2018-12-01	Other Stores	73.515504
17	2018-12-01	Trial	46.000000
18	2019-01-01	Control	35.000000
19	2019-01-01	Other Stores	71.240310
20	2019-01-01	Trial	35.000000
21	2019-02-01	Control	45.000000
22	2019-02-01	Other Stores	66.476744
23	2019-02-01	Trial	45.000000

In [631]:
```
plt.figure(figsize=(8,6))

tot_cus = sns.lineplot(x='MONTH',y='Num_Cus', hue = 'STORE_TYPE', data=nCustomers
tot_cus.set_title('Total Number of Customers by Month')
```

Out[631]: Text(0.5, 1.0, 'Total Number of Customers by Month')



Scale the control store's sales

In [632]:
```
trial_index = store_measures.loc[store_measures['MONTH_ID'] >= 201902].index
preTrial = store_measures.drop(trial_index)
preTrial
```

Out[632]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3110	272	201809	304.7	32	1.125000	1.972222	4.291549
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250

1820 rows × 7 columns

In [633]:
```
pre_tot = preTrial.groupby('STORE_NBR').sum()['TOT_SALES'].reset_index()

pre_i = pre_tot.loc[pre_tot['STORE_NBR'] !=77].index
pre_77 = pre_tot.drop(pre_i)

pre_j = pre_tot.loc[pre_tot['STORE_NBR'] !=233].index
pre_233 = pre_tot.drop(pre_j)
```

In [634]:
```
scalingFactor = pre_77.iloc[0]['TOT_SALES'] /pre_233.iloc[0]['TOT_SALES']
scalingFactor
```

Out[634]:
```
1.023617303289553
```

In [635]:
```
t_j = store_measures.loc[store_measures['STORE_NBR'] !=233].index
t_233 = store_measures.drop(t_j)

t_i = store_measures.loc[store_measures['STORE_NBR'] !=77].index
t_77 = store_measures.drop(t_i)

t_233['Control_Sale'] = t_233['TOT_SALES']* scalingFactor
t_233
```

Out[635]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
2652	233	201807	290.7	51	1.058824	1.629630	3.303409
2653	233	201808	285.9	48	1.041667	1.600000	3.573750
2654	233	201809	228.6	42	1.071429	1.555556	3.265714
2655	233	201810	185.7	35	1.028571	1.555556	3.316071
2656	233	201811	211.6	40	1.025000	1.512195	3.412903
2657	233	201812	279.8	47	1.063830	1.500000	3.730667
2658	233	201901	177.5	35	1.000000	1.342857	3.776596
2659	233	201902	244.0	45	1.044444	1.489362	3.485714
2660	233	201903	199.1	40	1.025000	1.439024	3.374576
2661	233	201904	158.6	30	1.066667	1.437500	3.447826
2662	233	201905	344.4	57	1.087719	1.483871	3.743478
2663	233	201906	221.0	41	1.000000	1.487805	3.622951

In [636]:
```
tot_combine = pd.merge(t_233, t_77, on ='MONTH_ID')
tot_combine = tot_combine.drop(tot_combine.columns[[2,3,4,5,6,10,11,12,13]], axis
tot_combine
```

Out[636]:

	STORE_NBR_x	MONTH_ID	Control_Sale	STORE_NBR_y	TOT_SALES_y
0	233	201807	297.565550	77	296.8
1	233	201808	292.652187	77	255.5
2	233	201809	233.998916	77	225.2
3	233	201810	190.085733	77	204.5
4	233	201811	216.597421	77	245.3
5	233	201812	286.408121	77	267.3
6	233	201901	181.692071	77	204.4
7	233	201902	249.762622	77	235.0
8	233	201903	203.802205	77	278.5
9	233	201904	162.345704	77	263.5
10	233	201905	352.533799	77	299.3
11	233	201906	226.219424	77	264.7

In [637]:
```
tot_combine['Percent_Diff'] = abs(tot_combine['Control_Sale'] - tot_combine['TOT_
tot_combine
```

Out[637]:

	STORE_NBR_x	MONTH_ID	Control_Sale	STORE_NBR_y	TOT_SALES_y	Percent_Diff
0	233	201807	297.565550	77	296.8	0.002573
1	233	201808	292.652187	77	255.5	0.126950
2	233	201809	233.998916	77	225.2	0.037602
3	233	201810	190.085733	77	204.5	0.075830
4	233	201811	216.597421	77	245.3	0.132516
5	233	201812	286.408121	77	267.3	0.066716
6	233	201901	181.692071	77	204.4	0.124980
7	233	201902	249.762622	77	235.0	0.059107
8	233	201903	203.802205	77	278.5	0.366521
9	233	201904	162.345704	77	263.5	0.623080
10	233	201905	352.533799	77	299.3	0.151003
11	233	201906	226.219424	77	264.7	0.170103

In [638]:
```
trial_index = tot_combine.loc[tot_combine['MONTH_ID'] >= 201902].index
preTrial = tot_combine.drop(trial_index)

pre_index = tot_combine.loc[tot_combine['MONTH_ID'] < 201902].index
Trial = tot_combine.drop(pre_index)
```

As our null hypothesis is 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

In [639]:
```
stdDev = statistics.stdev(preTrial['Percent_Diff'])
stdDev
```

Out[639]:
```
0.049940762641425544
```

We will test with a null hypothesis of there being 0 difference between trial and control stores

In [640]:
```
d_index = Trial.loc[Trial['MONTH_ID'] >= 201905].index
test = Trial.drop(d_index)
test['tValue'] = ( test['Percent_Diff'] - 0) / stdDev
test
```

Out[640]:

	STORE_NBR_x	MONTH_ID	Control_Sale	STORE_NBR_y	TOT_SALES_y	Percent_Diff	tValue
7	233	201902	249.762622	77	235.0	0.059107	1.18353
8	233	201903	203.802205	77	278.5	0.366521	7.33911
9	233	201904	162.345704	77	263.5	0.623080	12.47637

Find the 95th percentile of the t distribution with the appropriate degrees of freedom to compare against

In [641]:
```
percentile = 0.95
dof = 7
scipy.stats.t.ppf(percentile,dof)
```

Out[641]:
```
1.894578605061305
```

We can observe that the t-value is much larger than the 95th percentile value of the t-distribution for March and April - i.e. the increase in sales in the trial store in March and April is statistically greater than in the control store.

Let's create a more visual version of this by plotting the sales of the control store, the sales of the trial stores and the 95th percentile value of sales of the control store.

In [642]:
```
store_measures
```

Out[642]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3115	272	201902	395.5	45	1.066667	1.895833	4.346154
3116	272	201903	442.3	50	1.060000	1.905660	4.379208
3117	272	201904	445.1	54	1.018519	1.909091	4.239048
3118	272	201905	314.6	34	1.176471	1.775000	4.430986
3119	272	201906	312.1	34	1.088235	1.891892	4.458571

3120 rows × 7 columns

In [643]:
```
past_Sales = store_measures.drop(store_measures.columns[[3,4,5,6]], axis=1)
past_Sales
```

Out[643]:

	STORE_NBR	MONTH_ID	TOT_SALES
0	1	201807	206.9
1	1	201808	176.1
2	1	201809	278.8
3	1	201810	188.1
4	1	201811	192.6
...	...	...	...
3115	272	201902	395.5
3116	272	201903	442.3
3117	272	201904	445.1
3118	272	201905	314.6
3119	272	201906	312.1

3120 rows × 3 columns

In [644]:
```
def classification(row):
    if row['STORE_NBR'] == 77:
        return 'Trial'
    elif row['STORE_NBR'] == 233:
        return 'Control'
    else:
        return 'Other Stores'

past_Sales['STORE_TYPE'] = past_Sales.apply(classification, axis=1)


i = past_Sales.loc[past_Sales['STORE_TYPE']=='Other Stores'].index
past_Sales = past_Sales.drop(i)
past_Sales
```

Out[644]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE
864	77	201807	296.8	Trial
865	77	201808	255.5	Trial
866	77	201809	225.2	Trial
867	77	201810	204.5	Trial
868	77	201811	245.3	Trial
869	77	201812	267.3	Trial
870	77	201901	204.4	Trial
871	77	201902	235.0	Trial
872	77	201903	278.5	Trial
873	77	201904	263.5	Trial
874	77	201905	299.3	Trial
875	77	201906	264.7	Trial
2652	233	201807	290.7	Control
2653	233	201808	285.9	Control
2654	233	201809	228.6	Control
2655	233	201810	185.7	Control
2656	233	201811	211.6	Control
2657	233	201812	279.8	Control
2658	233	201901	177.5	Control
2659	233	201902	244.0	Control
2660	233	201903	199.1	Control
2661	233	201904	158.6	Control
2662	233	201905	344.4	Control
2663	233	201906	221.0	Control

In [645]:
```
i = past_Sales.loc[past_Sales['STORE_NBR']!=233].index
measure_95 = past_Sales.drop(i)
measure_95['TOT_SALES'] = measure_95['TOT_SALES'] * (1 + stdDev * 2)
measure_95['STORE_TYPE'] = 'Control 95th % confidence'
measure_95
```

Out[645]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE
2652	233	201807	319.735559	Control 95th % confidence
2653	233	201808	314.456128	Control 95th % confidence
2654	233	201809	251.432917	Control 95th % confidence
2655	233	201810	204.247999	Control 95th % confidence
2656	233	201811	232.734931	Control 95th % confidence
2657	233	201812	307.746851	Control 95th % confidence
2658	233	201901	195.228971	Control 95th % confidence
2659	233	201902	268.371092	Control 95th % confidence
2660	233	201903	218.986412	Control 95th % confidence
2661	233	201904	174.441210	Control 95th % confidence
2662	233	201905	378.799197	Control 95th % confidence
2663	233	201906	243.073817	Control 95th % confidence

In [646]:
```
j = past_Sales.loc[past_Sales['STORE_NBR']!=233].index
measure_5 = past_Sales.drop(j)
measure_5['TOT_SALES'] = measure_5['TOT_SALES'] * (1 - stdDev * 2)
measure_5['STORE_TYPE'] = 'Control 5th % confidence'
measure_5
```

Out[646]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE
2652	233	201807	261.664441	Control 5th % confidence
2653	233	201808	257.343872	Control 5th % confidence
2654	233	201809	205.767083	Control 5th % confidence
2655	233	201810	167.152001	Control 5th % confidence
2656	233	201811	190.465069	Control 5th % confidence
2657	233	201812	251.853149	Control 5th % confidence
2658	233	201901	159.771029	Control 5th % confidence
2659	233	201902	219.628908	Control 5th % confidence
2660	233	201903	179.213588	Control 5th % confidence
2661	233	201904	142.758790	Control 5th % confidence
2662	233	201905	310.000803	Control 5th % confidence
2663	233	201906	198.926183	Control 5th % confidence

In [647]:
```
assessment = pd.concat([past_Sales, measure_95, measure_5])
assessment['MONTH'] = pd.to_datetime(assessment['MONTH_ID'].astype(int),format='%
assessment.head()
```

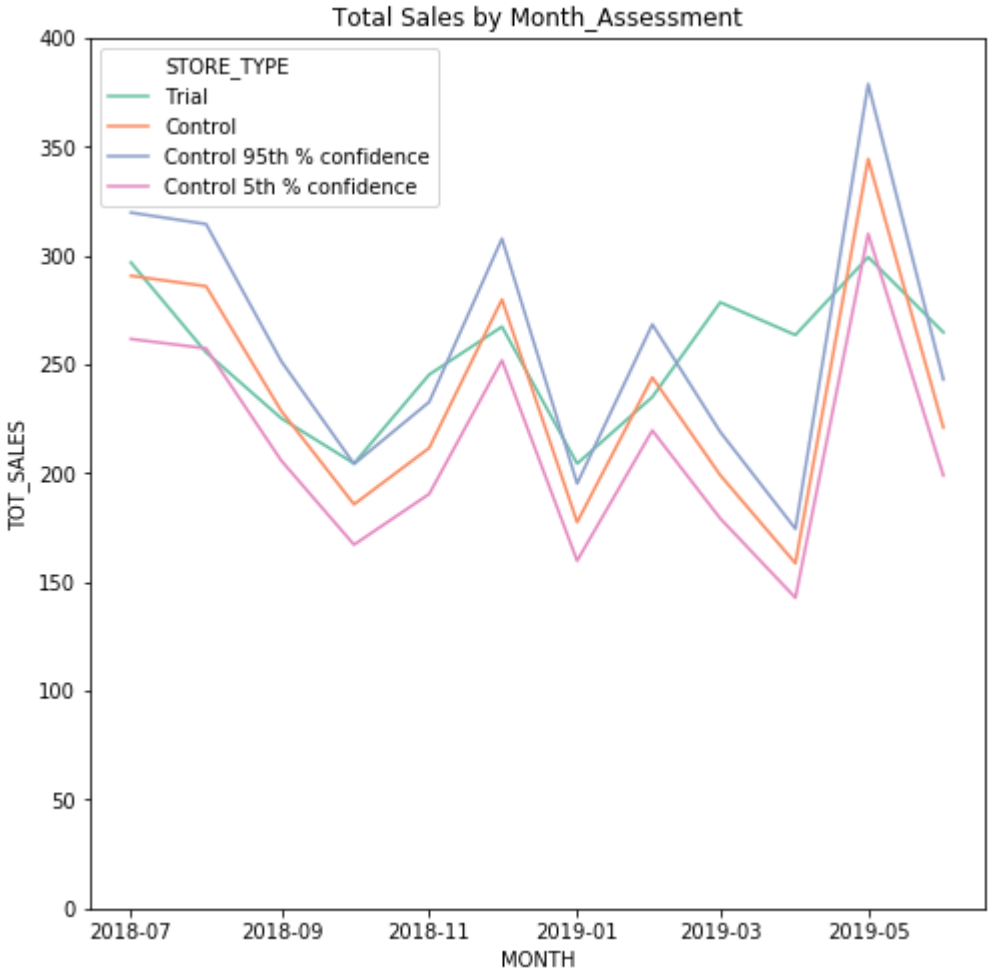
Out[647]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE	MONTH
864	77	201807	296.8	Trial	2018-07-01
865	77	201808	255.5	Trial	2018-08-01
866	77	201809	225.2	Trial	2018-09-01
867	77	201810	204.5	Trial	2018-10-01
868	77	201811	245.3	Trial	2018-11-01

In [648]:
```
plt.figure(figsize=(8,8))

ass = sns.lineplot(x='MONTH',y='TOT_SALES', hue = 'STORE_TYPE', data=assessment,
ass.set_title('Total Sales by Month_Assessment')
ass. set(ylim=(0, 400))
```

Out[648]:
```
[(0, 400)]
```



The results show that the trial in store 77 is significantly different to its control store in the trial period as the trial store performance lies outside the 5% to 95% confidence interval of the control store in two of the three trial months

Scale the control store's number of customers

In [649]:
```
trial_index = store_measures.loc[store_measures['MONTH_ID'] >= 201902].index
preTrial = store_measures.drop(trial_index)
preTrial
```

Out[649]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3110	272	201809	304.7	32	1.125000	1.972222	4.291549
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250

1820 rows × 7 columns

In [650]:
```
pre_cus = preTrial.groupby('STORE_NBR').sum()['Num_Cus'].reset_index()

pre_i = pre_cus.loc[pre_cus['STORE_NBR'] !=77].index
pre_77 = pre_cus.drop(pre_i)

pre_j = pre_cus.loc[pre_cus['STORE_NBR'] !=233].index
pre_233 = pre_cus.drop(pre_j)
```

In [651]:
```
scalingFactor = pre_77.iloc[0]['Num_Cus'] /pre_233.iloc[0]['Num_Cus']
scalingFactor
```

Out[651]:
```
1.0033557046979866
```

In [652]:
```
t_j = store_measures.loc[store_measures['STORE_NBR'] !=233].index
t_233 = store_measures.drop(t_j)

t_i = store_measures.loc[store_measures['STORE_NBR'] !=77].index
t_77 = store_measures.drop(t_i)

t_233['Control_nCus'] = t_233['Num_Cus']* scalingFactor
t_233
```

Out[652]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
2652	233	201807	290.7	51	1.058824	1.629630	3.303409
2653	233	201808	285.9	48	1.041667	1.600000	3.573750
2654	233	201809	228.6	42	1.071429	1.555556	3.265714
2655	233	201810	185.7	35	1.028571	1.555556	3.316071
2656	233	201811	211.6	40	1.025000	1.512195	3.412903
2657	233	201812	279.8	47	1.063830	1.500000	3.730667
2658	233	201901	177.5	35	1.000000	1.342857	3.776596
2659	233	201902	244.0	45	1.044444	1.489362	3.485714
2660	233	201903	199.1	40	1.025000	1.439024	3.374576
2661	233	201904	158.6	30	1.066667	1.437500	3.447826
2662	233	201905	344.4	57	1.087719	1.483871	3.743478
2663	233	201906	221.0	41	1.000000	1.487805	3.622951

In [653]:
```
tot_combine = pd.merge(t_233, t_77, on ='MONTH_ID')
tot_combine = tot_combine.drop(tot_combine.columns[[2,3,4,5,6,9,11,12,13]], axis=
tot_combine
```

Out[653]:

	STORE_NBR_x	MONTH_ID	Control_nCus	STORE_NBR_y	Num_Cus_y
0	233	201807	51.171141	77	51
1	233	201808	48.161074	77	47
2	233	201809	42.140940	77	42
3	233	201810	35.117450	77	37
4	233	201811	40.134228	77	41
5	233	201812	47.157718	77	46
6	233	201901	35.117450	77	35
7	233	201902	45.151007	77	45
8	233	201903	40.134228	77	50
9	233	201904	30.100671	77	47
10	233	201905	57.191275	77	55
11	233	201906	41.137584	77	41

In [654]:
```
tot_combine['Percent_Diff'] = abs(tot_combine['Control_nCus'] - tot_combine['Num_
tot_combine
```

Out[654]:

	STORE_NBR_x	MONTH_ID	Control_nCus	STORE_NBR_y	Num_Cus_y	Percent_Diff
0	233	201807	51.171141	77	51	0.003344
1	233	201808	48.161074	77	47	0.024108
2	233	201809	42.140940	77	42	0.003344
3	233	201810	35.117450	77	37	0.053607
4	233	201811	40.134228	77	41	0.021572
5	233	201812	47.157718	77	46	0.024550
6	233	201901	35.117450	77	35	0.003344
7	233	201902	45.151007	77	45	0.003344
8	233	201903	40.134228	77	50	0.245819
9	233	201904	30.100671	77	47	0.561427
10	233	201905	57.191275	77	55	0.038315
11	233	201906	41.137584	77	41	0.003344

In [655]:
```
trial_index = tot_combine.loc[tot_combine['MONTH_ID'] >= 201902].index
preTrial = tot_combine.drop(trial_index)

pre_index = tot_combine.loc[tot_combine['MONTH_ID'] < 201902].index
Trial = tot_combine.drop(pre_index)
```

In [656]:
```
stdDev = statistics.stdev(preTrial['Percent_Diff'])
stdDev
```

Out[656]: 0.018240748558243945

In [657]:
```
d_index = Trial.loc[Trial['MONTH_ID'] >= 201905].index
test = Trial.drop(d_index)
test['tValue'] = ( test['Percent_Diff'] - 0) / stdDev
test
```

Out[657]:

	STORE_NBR_x	MONTH_ID	Control_nCus	STORE_NBR_y	Num_Cus_y	Percent_Diff	tValue
7	233	201902	45.151007	77	45	0.003344	0.183352
8	233	201903	40.134228	77	50	0.245819	13.476388
9	233	201904	30.100671	77	47	0.561427	30.778725

In [658]:
```
percentile = 0.95
dof = 7
scipy.stats.t.ppf(percentile,dof)
```

Out[658]: 1.894578605061305

Visual checks on trends based on Number of Customers

In [659]:
```
store_measures
```

Out[659]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3115	272	201902	395.5	45	1.066667	1.895833	4.346154
3116	272	201903	442.3	50	1.060000	1.905660	4.379208
3117	272	201904	445.1	54	1.018519	1.909091	4.239048
3118	272	201905	314.6	34	1.176471	1.775000	4.430986
3119	272	201906	312.1	34	1.088235	1.891892	4.458571

3120 rows × 7 columns

In [660]:
```
past_nCus = store_measures.drop(store_measures.columns[[2,4,5,6]], axis=1)
past_nCus
```

Out[660]:

	STORE_NBR	MONTH_ID	Num_Cus
0	1	201807	49
1	1	201808	42
2	1	201809	59
3	1	201810	44
4	1	201811	46
...	...	...	...
3115	272	201902	45
3116	272	201903	50
3117	272	201904	54
3118	272	201905	34
3119	272	201906	34

3120 rows × 3 columns

In [661]:
```
def classification(row):
    if row['STORE_NBR'] == 77:
        return 'Trial'
    elif row['STORE_NBR'] == 233:
        return 'Control'
    else:
        return 'Other Stores'

past_nCus['STORE_TYPE'] = past_nCus.apply(classification, axis=1)


i = past_nCus.loc[past_nCus['STORE_TYPE']=='Other Stores'].index
past_nCus = past_nCus.drop(i)
past_nCus
```

Out[661]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE
864	77	201807	51	Trial
865	77	201808	47	Trial
866	77	201809	42	Trial
867	77	201810	37	Trial
868	77	201811	41	Trial
869	77	201812	46	Trial
870	77	201901	35	Trial
871	77	201902	45	Trial
872	77	201903	50	Trial
873	77	201904	47	Trial
874	77	201905	55	Trial
875	77	201906	41	Trial
2652	233	201807	51	Control
2653	233	201808	48	Control
2654	233	201809	42	Control
2655	233	201810	35	Control
2656	233	201811	40	Control
2657	233	201812	47	Control
2658	233	201901	35	Control
2659	233	201902	45	Control
2660	233	201903	40	Control
2661	233	201904	30	Control
2662	233	201905	57	Control
2663	233	201906	41	Control

In [662]:
```
i = past_nCus.loc[past_nCus['STORE_NBR']!=233].index
measure_95 = past_nCus.drop(i)
measure_95['Num_Cus'] = measure_95['Num_Cus'] * (1 + stdDev * 2)
measure_95['STORE_TYPE'] = 'Control 95th % confidence'
measure_95
```

Out[662]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE
2652	233	201807	52.860556	Control 95th % confidence
2653	233	201808	49.751112	Control 95th % confidence
2654	233	201809	43.532223	Control 95th % confidence
2655	233	201810	36.276852	Control 95th % confidence
2656	233	201811	41.459260	Control 95th % confidence
2657	233	201812	48.714630	Control 95th % confidence
2658	233	201901	36.276852	Control 95th % confidence
2659	233	201902	46.641667	Control 95th % confidence
2660	233	201903	41.459260	Control 95th % confidence
2661	233	201904	31.094445	Control 95th % confidence
2662	233	201905	59.079445	Control 95th % confidence
2663	233	201906	42.495741	Control 95th % confidence

In [663]:
```
j = past_nCus.loc[past_nCus['STORE_NBR']!=233].index
measure_5 = past_nCus.drop(i)
measure_5['Num_Cus'] = measure_5['Num_Cus'] * (1 - stdDev * 2)
measure_5['STORE_TYPE'] = 'Control 5th % confidence'
measure_5
```

Out[663]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE
2652	233	201807	49.139444	Control 5th % confidence
2653	233	201808	46.248888	Control 5th % confidence
2654	233	201809	40.467777	Control 5th % confidence
2655	233	201810	33.723148	Control 5th % confidence
2656	233	201811	38.540740	Control 5th % confidence
2657	233	201812	45.285370	Control 5th % confidence
2658	233	201901	33.723148	Control 5th % confidence
2659	233	201902	43.358333	Control 5th % confidence
2660	233	201903	38.540740	Control 5th % confidence
2661	233	201904	28.905555	Control 5th % confidence
2662	233	201905	54.920555	Control 5th % confidence
2663	233	201906	39.504259	Control 5th % confidence

In [664]:
```
assessment = pd.concat([past_nCus, measure_95, measure_5])
assessment['MONTH'] = pd.to_datetime(assessment['MONTH_ID'].astype(int),format='%
assessment.head()
```

Out[664]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE	MONTH
864	77	201807	51.0	Trial	2018-07-01
865	77	201808	47.0	Trial	2018-08-01
866	77	201809	42.0	Trial	2018-09-01
867	77	201810	37.0	Trial	2018-10-01
868	77	201811	41.0	Trial	2018-11-01

In [665]:
```
plt.figure(figsize=(8,8))

ass = sns.lineplot(x='MONTH',y='Num_Cus', hue = 'STORE_TYPE', data=assessment, pa
ass.set_title('Total Number of Customers by Month_Assessment')
ass. set(ylim=(0, 60))
```

Out[665]: [(0, 60)]

Select Control Stores for Trial Store 86

Correlation Against Store 86 Based on Total Sales and Number of Customers

In [867]:
```
trial_index = store_measures.loc[store_measures['MONTH_ID'] >= 201903].index
preTrial = store_measures.drop(trial_index)
preTrial
```

Out[867]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2080 rows × 7 columns

In [868]:
```
trial_store_77_i = preTrial.loc[preTrial['STORE_NBR'] !=77].index
trial_store_77 = preTrial.drop(trial_store_77_i)

trial_store_86_i = preTrial.loc[preTrial['STORE_NBR'] !=86].index
trial_store_86 = preTrial.drop(trial_store_86_i)

trial_store_88_i = preTrial.loc[preTrial['STORE_NBR'] !=88].index
trial_store_88 = preTrial.drop(trial_store_88_i)

trial_stores = pd.concat([trial_store_77,trial_store_86,trial_store_88])

control_store_i_1 = preTrial.loc[preTrial['STORE_NBR'] == 77].index
control_store_i_2 = preTrial.loc[preTrial['STORE_NBR'] == 86].index
control_store_i_3 = preTrial.loc[preTrial['STORE_NBR'] == 88].index
control_stores1 = preTrial.drop(control_store_i_1)
control_stores2 = control_stores1.drop(control_store_i_2)
control_stores = control_stores2.drop(control_store_i_3)
control_stores
```

Out[868]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2056 rows × 7 columns

In [869]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [86]

# Total Sales: m = 2
m = 2

C_Stores = []
T_Stores = []
Corr_Results = []
for t in trial_num:
    for c in store_num:
        result = getCorr(c,m,t)
        C_Stores.append(c)
        T_Stores.append(t)
        Corr_Results.append(result)

Correlation_Matrix1 = pd.DataFrame({'Trial' : T_Stores,
                                    'Control' : C_Stores,
                                    'Correlation' : Corr_Results },
                                    columns=['Trial','Control', 'Correlation'])
Correlation_Matrix1.sort_values('Correlation', ascending = False)
```

Out[869]:

	Trial	Control	Correlation
144	86	155	0.841589
244	86	260	0.736378
20	86	22	0.722506
5	86	6	0.683779
253	86	269	0.681775
...	...	...	...
174	86	185	-0.776159
238	86	254	-0.780106
200	86	214	-0.783369
240	86	256	-0.849045
109	86	120	-0.876296

257 rows × 3 columns

In [870]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [86]

# Number of Customers: m = 3
m = 3

C_Stores = []
T_Stores = []
Corr_Results = []
for t in trial_num:
    for c in store_num:
        result = getCorr(c,m,t)
        C_Stores.append(c)
        T_Stores.append(t)
        Corr_Results.append(result)

Correlation_Matrix2 = pd.DataFrame({'Trial' : T_Stores,
                                    'Control' : C_Stores,
                                    'Correlation' : Corr_Results },
                                    columns=['Trial','Control', 'Correlation'])
Correlation_Matrix2.sort_values('Correlation', ascending = False)
```

Out[870]:

	Trial	Control	Correlation
244	86	260	0.772289
136	86	147	0.728606
165	86	176	0.710471
70	86	74	0.701439
144	86	155	0.646118
...	...	...	...
25	86	27	-0.785631
254	86	270	-0.803394
109	86	120	-0.814822
44	86	48	-0.815227
243	86	259	-0.877478

257 rows × 3 columns

Magnitude Distance Against Store 86 Based on Total Sales

In [871]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [86]

# Total Sale
m = 2

mag_list1 = []
for t in trial_num:
    for c in store_num:
        result = getMag(c,m,t)
        mag_list1.append(result)
mag_matrix1 = pd.concat(mag_list1)

mag_matrix1.rename(columns={'STORE_NBR_x': 'Control', 'STORE_NBR_y': 'Trial'}, ir
mag_matrix1
```

Out[871]:

	Control	Trial	MONTH_ID	Magnitude
0	1	86	201807	685.30
1	1	86	201808	587.95
2	1	86	201809	635.80
3	1	86	201810	760.30
4	1	86	201811	725.40
...	...	...	...	...
3	272	86	201810	517.80
4	272	86	201811	541.80
5	272	86	201812	437.30
6	272	86	201901	418.40
7	272	86	201902	517.70

2056 rows × 4 columns

In [872]:
```
minDist = mag_matrix1.groupby(['Control','Trial']).min()['Magnitude'].reset_index
maxDist = mag_matrix1.groupby(['Control','Trial']).max()['Magnitude'].reset_index

MinMaxDist = pd.merge(minDist, maxDist, on = ('Control','Trial'))

MinMaxDist.rename(columns={'Magnitude_x': 'Min','Magnitude_y':'Max'}, inplace=Tru

standard_mag = pd.merge(mag_matrix1,MinMaxDist, on = ('Control','Trial'))
standard_mag['Mag_Measure'] = 1 - (standard_mag['Magnitude'] -standard_mag['Min']

finalDist1 = standard_mag.groupby(['Control','Trial']).mean()['Mag_Measure'].rese
finalDist1
```

Out[872]:

	Control	Trial	Mag_Measure
0	1	86	0.479874
1	2	86	0.285031
2	3	86	0.461317
3	4	86	0.464945
4	5	86	0.579356
...	...	...	...
252	268	86	0.271594
253	269	86	0.530061
254	270	86	0.572281
255	271	86	0.514646
256	272	86	0.563557

257 rows × 3 columns

Magnitude Distance Against Store 86 Based on Number of Customers

In [873]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [86]

# Number of Customers
m = 3

mag_list = []
for t in trial_num:
    for c in store_num:
        result = getMag(c,m,t)
        mag_list.append(result)
mag_matrix2 = pd.concat(mag_list)

mag_matrix2.rename(columns={'STORE_NBR_x': 'Control', 'STORE_NBR_y': 'Trial'}, ir
```

In [874]:
```
minDist = mag_matrix2.groupby(['Control','Trial']).min()['Magnitude'].reset_index
maxDist = mag_matrix2.groupby(['Control','Trial']).max()['Magnitude'].reset_index

MinMaxDist = pd.merge(minDist, maxDist, on = ('Control','Trial'))

MinMaxDist.rename(columns={'Magnitude_x': 'Min','Magnitude_y':'Max'}, inplace=Tru

standard_mag = pd.merge(mag_matrix2,MinMaxDist, on = ('Control','Trial'))
standard_mag['Mag_Measure'] = 1 - (standard_mag['Magnitude'] -standard_mag['Min']

finalDist2 = standard_mag.groupby(['Control','Trial']).mean()['Mag_Measure'].rese
finalDist2
```

Out[874]:

	Control	Trial	Mag_Measure
0	1	86	0.505952
1	2	86	0.560185
2	3	86	0.558824
3	4	86	0.558824
4	5	86	0.631579
...	...	...	...
252	268	86	0.500000
253	269	86	0.616071
254	270	86	0.638889
255	271	86	0.607143
256	272	86	0.603261

257 rows × 3 columns

In [875]:
```
corr_weight = 0.5
combined_tot = pd.merge(Correlation_Matrix1,finalDist1, on = ['Control','Trial']
combined_tot['Combined_Score'] = corr_weight*combined_tot['Correlation'] + (1-cor
combined_tot
```

Out[875]:

	Trial	Control	Correlation	Mag_Measure	Combined_Score
0	86	1	0.478355	0.479874	0.479114
1	86	2	-0.453556	0.285031	-0.084263
2	86	3	-0.081104	0.461317	0.190107
3	86	4	-0.204603	0.464945	0.130171
4	86	5	0.067263	0.579356	0.323310
...	...	...	...	...	...
252	86	268	-0.494257	0.271594	-0.111331
253	86	269	0.681775	0.530061	0.605918
254	86	270	-0.747037	0.572281	-0.087378
255	86	271	0.409585	0.514646	0.462116
256	86	272	0.011432	0.563557	0.287495

257 rows × 5 columns

In [876]:
```
corr_weight = 0.5
combined_nCus = pd.merge(Correlation_Matrix2,finalDist2, on = ['Control','Trial']
combined_nCus['Combined_Score'] = corr_weight*combined_nCus['Correlation'] + (1-c
combined_nCus
```

Out[876]:

	Trial	Control	Correlation	Mag_Measure	Combined_Score
0	86	1	0.559062	0.505952	0.532507
1	86	2	-0.428881	0.560185	0.065652
2	86	3	0.026475	0.558824	0.292649
3	86	4	-0.462982	0.558824	0.047921
4	86	5	-0.391022	0.631579	0.120279
...	...	...	...	...	...
252	86	268	-0.203460	0.500000	0.148270
253	86	269	-0.236966	0.616071	0.189553
254	86	270	-0.803394	0.638889	-0.082253
255	86	271	-0.024829	0.607143	0.291157
256	86	272	-0.247201	0.603261	0.178030

257 rows × 5 columns

In [877]:
```
combined_86 = pd.merge(combined_tot,combined_nCus, on = ['Control','Trial'] )
combined_86['Overall_Score'] = 0.5*combined_86['Combined_Score_x'] + 0.5*combinec
combined_86.sort_values('Overall_Score', ascending = False)
```

Out[877]:

	Trial	Control	Correlation_x	Mag_Measure_x	Combined_Score_x	Correlation_y	Mag_Measure
144	86	155	0.841589	0.752673	0.797131	0.646118	0.7708
99	86	109	0.674976	0.557134	0.616055	0.404255	0.7416
244	86	260	0.736378	0.410996	0.573687	0.772289	0.4134
217	86	232	0.542806	0.752006	0.647406	0.309274	0.7058
214	86	229	0.418894	0.552198	0.485546	0.575004	0.7045
...	...	...	...	...	...	...	
238	86	254	-0.780106	0.349959	-0.215073	-0.637747	0.4958
25	86	27	-0.762542	0.427863	-0.167339	-0.785631	0.5439
240	86	256	-0.849045	0.324515	-0.262265	-0.601597	0.4375
174	86	185	-0.776159	0.320819	-0.227670	-0.746259	0.4051
109	86	120	-0.876296	0.346762	-0.264767	-0.814822	0.4460

257 rows × 9 columns

Looks like store 155 will be a control store for trial store 86.

Visual checks on trends based on Total Sales

In [878]:
```
preTrial
```

Out[878]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2080 rows × 7 columns

In [879]:
```
def classification(row):
    if row['STORE_NBR'] == 86:
        return 'Trial'
    elif row['STORE_NBR'] == 155:
        return 'Control'
    else:
        return 'Other Stores'

preTrial['STORE_TYPE'] = preTrial.apply(classification, axis=1)

preTrial
```

Out[879]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2080 rows × 8 columns

In [880]:
```
preTrial['MONTH'] = pd.to_datetime(preTrial['MONTH_ID'].astype(int),format='%Y%m'
```

In [881]:
```
tot_by_month = preTrial.groupby(['MONTH','STORE_TYPE']).mean()['TOT_SALES'].reset
tot_by_month.head()
```

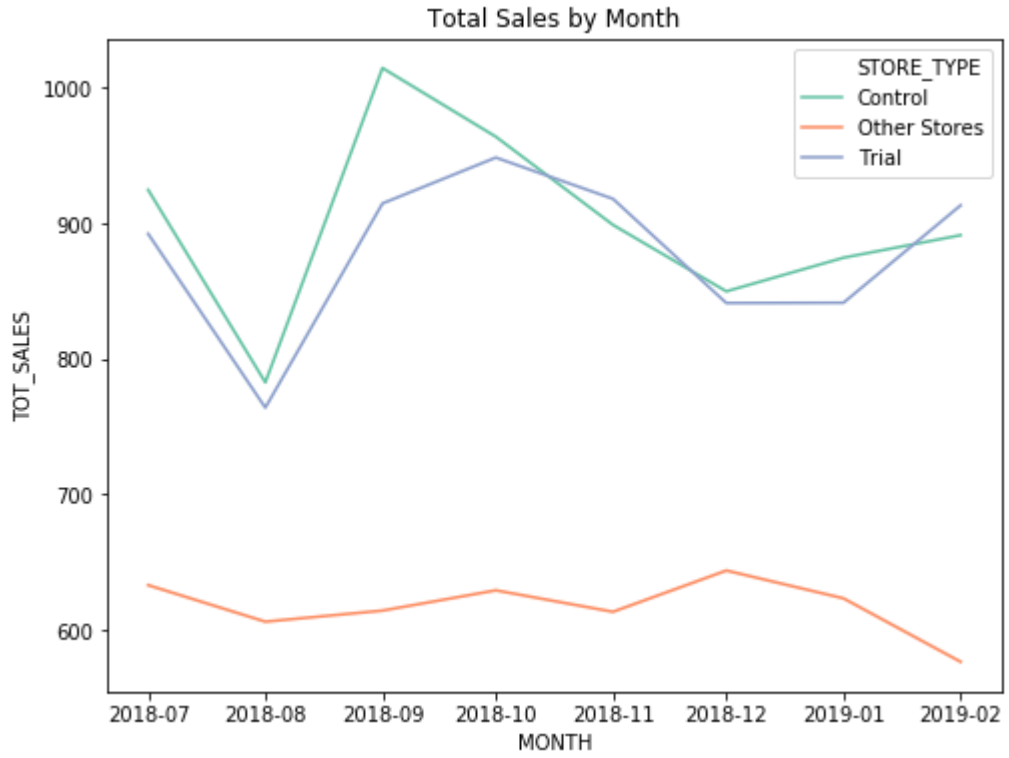
Out[881]:

	MONTH	STORE_TYPE	TOT_SALES
0	2018-07-01	Control	924.600000
1	2018-07-01	Other Stores	633.239922
2	2018-07-01	Trial	892.200000
3	2018-08-01	Control	782.700000
4	2018-08-01	Other Stores	606.326744

In [882]:
```
plt.figure(figsize=(8,6))


TotalSale = sns.lineplot(x='MONTH',y='TOT_SALES', hue = 'STORE_TYPE', data=tot_by
TotalSale.set_title('Total Sales by Month')
```

Out[882]: Text(0.5, 1.0, 'Total Sales by Month')



Visual checks on trends based on Number of Customers

In [883]:
```
nCustomers = preTrial.groupby(['MONTH','STORE_TYPE']).mean()['Num_Cus'].reset_inc
nCustomers.head()
```

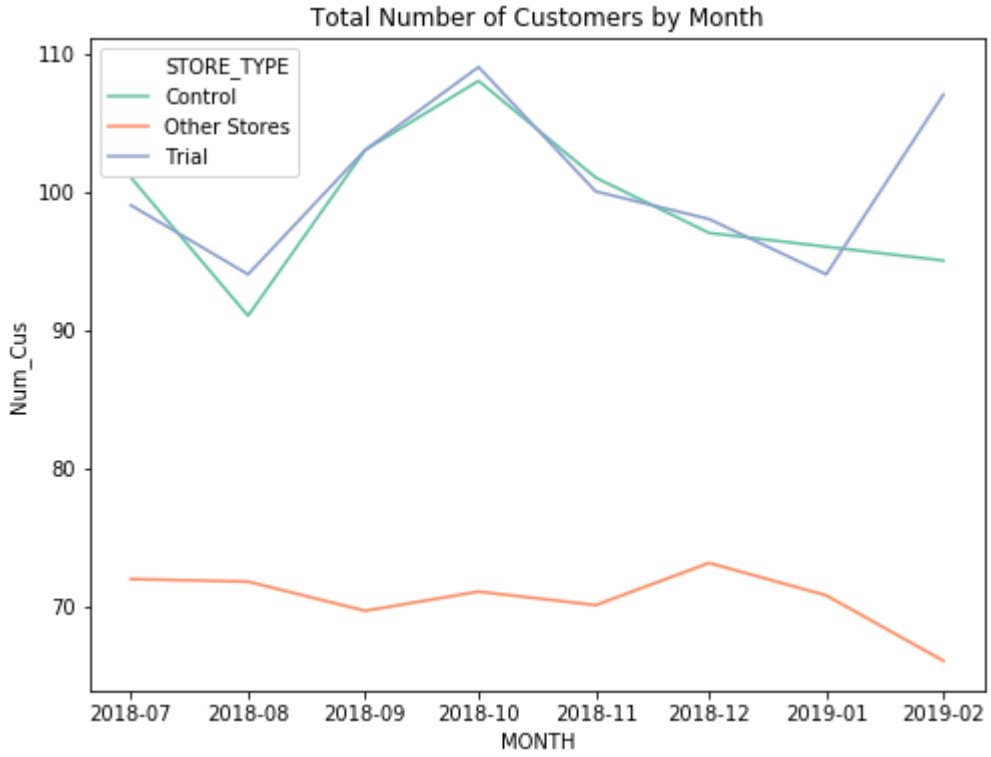
Out[883]:

	MONTH	STORE_TYPE	Num_Cus
0	2018-07-01	Control	101.000000
1	2018-07-01	Other Stores	71.953488
2	2018-07-01	Trial	99.000000
3	2018-08-01	Control	91.000000
4	2018-08-01	Other Stores	71.771318

In [884]:
```
plt.figure(figsize=(8,6))

tot_cus = sns.lineplot(x='MONTH',y='Num_Cus', hue = 'STORE_TYPE', data=nCustomers
tot_cus.set_title('Total Number of Customers by Month')
```

Out[884]:
```
Text(0.5, 1.0, 'Total Number of Customers by Month')
```



Scale the control store's sales

In [885]:
```
trial_index = store_measures.loc[store_measures['MONTH_ID'] >= 201902].index
preTrial = store_measures.drop(trial_index)
preTrial
```

Out[885]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3110	272	201809	304.7	32	1.125000	1.972222	4.291549
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250

1820 rows × 7 columns

In [886]:
```
pre_tot = preTrial.groupby('STORE_NBR').sum()['TOT_SALES'].reset_index()

pre_i = pre_tot.loc[pre_tot['STORE_NBR'] !=86].index
pre_86 = pre_tot.drop(pre_i)

pre_j = pre_tot.loc[pre_tot['STORE_NBR'] !=155].index
pre_155 = pre_tot.drop(pre_j)
```

In [887]:
```
scalingFactor = pre_86.iloc[0]['TOT_SALES'] /pre_155.iloc[0]['TOT_SALES']
scalingFactor
```

Out[887]:
```
0.9700651481287746
```

In [888]:
```
t_j = store_measures.loc[store_measures['STORE_NBR'] !=155].index
t_155 = store_measures.drop(t_j)

t_i = store_measures.loc[store_measures['STORE_NBR'] !=86].index
t_86 = store_measures.drop(t_i)

t_155['Control_Sale'] = t_155['TOT_SALES']* scalingFactor
t_155
```

Out[888]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
1764	155	201807	924.60	101	1.217822	2.032520	3.698400
1765	155	201808	782.70	91	1.307692	1.924370	3.417904
1766	155	201809	1014.40	103	1.398058	2.013889	3.497931
1767	155	201810	963.80	108	1.259259	2.000000	3.543382
1768	155	201811	898.80	101	1.316832	2.030075	3.328889
1769	155	201812	849.80	97	1.237113	2.016667	3.511570
1770	155	201901	874.60	96	1.302083	2.016000	3.470635
1771	155	201902	891.20	95	1.315789	2.032000	3.508661
1772	155	201903	804.40	94	1.255319	2.033898	3.351667
1773	155	201904	844.60	99	1.212121	2.016667	3.490083
1774	155	201905	922.85	106	1.283019	1.948529	3.482453
1775	155	201906	857.20	95	1.273684	2.016529	3.513115

In [889]:
```
tot_combine = pd.merge(t_155, t_86, on ='MONTH_ID')
tot_combine = tot_combine.drop(tot_combine.columns[[2,3,4,5,6,10,11,12,13]], axis
tot_combine
```

Out[889]:

	STORE_NBR_x	MONTH_ID	Control_Sale	STORE_NBR_y	TOT_SALES_y
0	155	201807	896.922236	86	892.20
1	155	201808	759.269991	86	764.05
2	155	201809	984.034086	86	914.60
3	155	201810	934.948790	86	948.40
4	155	201811	871.894555	86	918.00
5	155	201812	824.361363	86	841.20
6	155	201901	848.418979	86	841.40
7	155	201902	864.522060	86	913.20
8	155	201903	780.320405	86	1026.80
9	155	201904	819.317024	86	848.20
10	155	201905	895.224622	86	889.30
11	155	201906	831.539845	86	838.00

In [890]:
```
tot_combine['Percent_Diff'] = abs(tot_combine['Control_Sale'] - tot_combine['TOT_
tot_combine
```

Out[890]:

	STORE_NBR_x	MONTH_ID	Control_Sale	STORE_NBR_y	TOT_SALES_y	Percent_Diff
0	155	201807	896.922236	86	892.20	0.005265
1	155	201808	759.269991	86	764.05	0.006296
2	155	201809	984.034086	86	914.60	0.070561
3	155	201810	934.948790	86	948.40	0.014387
4	155	201811	871.894555	86	918.00	0.052880
5	155	201812	824.361363	86	841.20	0.020426
6	155	201901	848.418979	86	841.40	0.008273
7	155	201902	864.522060	86	913.20	0.056306
8	155	201903	780.320405	86	1026.80	0.315870
9	155	201904	819.317024	86	848.20	0.035253
10	155	201905	895.224622	86	889.30	0.006618
11	155	201906	831.539845	86	838.00	0.007769

In [891]:
```
trial_index = tot_combine.loc[tot_combine['MONTH_ID'] >= 201902].index
preTrial = tot_combine.drop(trial_index)

pre_index = tot_combine.loc[tot_combine['MONTH_ID'] < 201902].index
Trial = tot_combine.drop(pre_index)
```

As our null hypothesis is 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

In [892]:
```
stdDev = statistics.stdev(preTrial['Percent_Diff'])
stdDev
```

Out[892]:
```
0.025833952854772586
```

Let's create a more visual version of this by plotting the sales of the control store, the sales of the trial stores and the 95th percentile value of sales of the control store.

In [893]:
```
store_measures
```

Out[893]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3115	272	201902	395.5	45	1.066667	1.895833	4.346154
3116	272	201903	442.3	50	1.060000	1.905660	4.379208
3117	272	201904	445.1	54	1.018519	1.909091	4.239048
3118	272	201905	314.6	34	1.176471	1.775000	4.430986
3119	272	201906	312.1	34	1.088235	1.891892	4.458571

3120 rows × 7 columns

In [894]:
```
past_Sales = store_measures.drop(store_measures.columns[[3,4,5,6]], axis=1)
past_Sales
```

Out[894]:

	STORE_NBR	MONTH_ID	TOT_SALES
0	1	201807	206.9
1	1	201808	176.1
2	1	201809	278.8
3	1	201810	188.1
4	1	201811	192.6
...	...	...	...
3115	272	201902	395.5
3116	272	201903	442.3
3117	272	201904	445.1
3118	272	201905	314.6
3119	272	201906	312.1

3120 rows × 3 columns

In [895]:
```
def classification(row):
    if row['STORE_NBR'] == 86:
        return 'Trial'
    elif row['STORE_NBR'] == 155:
        return 'Control'
    else:
        return 'Other Stores'

past_Sales['STORE_TYPE'] = past_Sales.apply(classification, axis=1)


i = past_Sales.loc[past_Sales['STORE_TYPE']=='Other Stores'].index
past_Sales = past_Sales.drop(i)
past_Sales
```

Out[895]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE
960	86	201807	892.20	Trial
961	86	201808	764.05	Trial
962	86	201809	914.60	Trial
963	86	201810	948.40	Trial
964	86	201811	918.00	Trial
965	86	201812	841.20	Trial
966	86	201901	841.40	Trial
967	86	201902	913.20	Trial
968	86	201903	1026.80	Trial
969	86	201904	848.20	Trial
970	86	201905	889.30	Trial
971	86	201906	838.00	Trial
1764	155	201807	924.60	Control
1765	155	201808	782.70	Control
1766	155	201809	1014.40	Control
1767	155	201810	963.80	Control
1768	155	201811	898.80	Control
1769	155	201812	849.80	Control
1770	155	201901	874.60	Control
1771	155	201902	891.20	Control
1772	155	201903	804.40	Control
1773	155	201904	844.60	Control
1774	155	201905	922.85	Control
1775	155	201906	857.20	Control

In [896]:
```
i = past_Sales.loc[past_Sales['STORE_NBR']!=155].index
measure_95 = past_Sales.drop(i)
measure_95['TOT_SALES'] = measure_95['TOT_SALES'] * (1 + stdDev * 2)
measure_95['STORE_TYPE'] = 'Control 95th % confidence'
measure_95
```

Out[896]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE
1764	155	201807	972.372146	Control 95th % confidence
1765	155	201808	823.140470	Control 95th % confidence
1766	155	201809	1066.811924	Control 95th % confidence
1767	155	201810	1013.597528	Control 95th % confidence
1768	155	201811	945.239114	Control 95th % confidence
1769	155	201812	893.707386	Control 95th % confidence
1770	155	201901	919.788750	Control 95th % confidence
1771	155	201902	937.246438	Control 95th % confidence
1772	155	201903	845.961663	Control 95th % confidence
1773	155	201904	888.238713	Control 95th % confidence
1774	155	201905	970.531727	Control 95th % confidence
1775	155	201906	901.489729	Control 95th % confidence

In [897]:
```
j = past_Sales.loc[past_Sales['STORE_NBR']!=155].index
measure_5 = past_Sales.drop(j)
measure_5['TOT_SALES'] = measure_5['TOT_SALES'] * (1 - stdDev * 2)
measure_5['STORE_TYPE'] = 'Control 5th % confidence'
measure_5
```

Out[897]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE
1764	155	201807	876.827854	Control 5th % confidence
1765	155	201808	742.259530	Control 5th % confidence
1766	155	201809	961.988076	Control 5th % confidence
1767	155	201810	914.002472	Control 5th % confidence
1768	155	201811	852.360886	Control 5th % confidence
1769	155	201812	805.892614	Control 5th % confidence
1770	155	201901	829.411250	Control 5th % confidence
1771	155	201902	845.153562	Control 5th % confidence
1772	155	201903	762.838337	Control 5th % confidence
1773	155	201904	800.961287	Control 5th % confidence
1774	155	201905	875.168273	Control 5th % confidence
1775	155	201906	812.910271	Control 5th % confidence

In [898]:
```
assessment = pd.concat([past_Sales, measure_95, measure_5])
assessment['MONTH'] = pd.to_datetime(assessment['MONTH_ID'].astype(int),format='%
assessment.head()
```

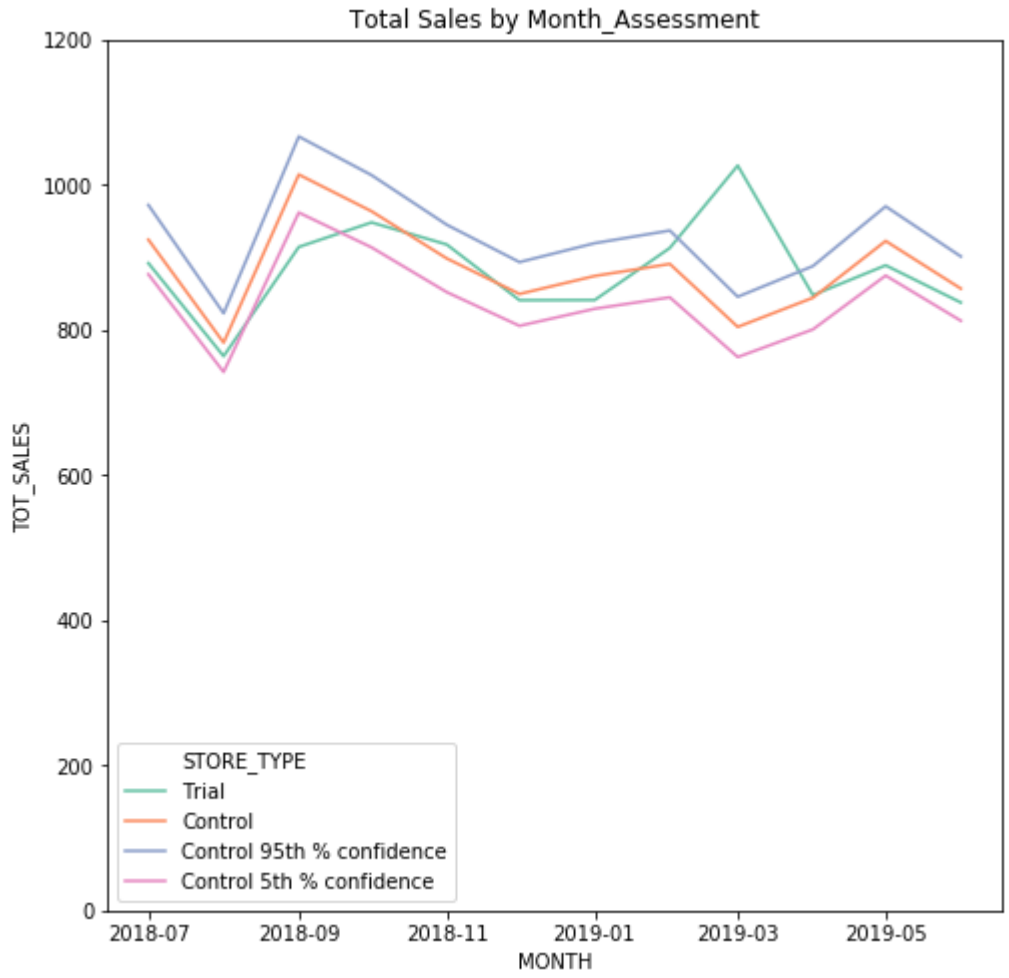
Out[898]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE	MONTH
960	86	201807	892.20	Trial	2018-07-01
961	86	201808	764.05	Trial	2018-08-01
962	86	201809	914.60	Trial	2018-09-01
963	86	201810	948.40	Trial	2018-10-01
964	86	201811	918.00	Trial	2018-11-01

In [899]:
```
plt.figure(figsize=(8,8))

ass = sns.lineplot(x='MONTH',y='TOT_SALES', hue = 'STORE_TYPE', data=assessment,
ass.set_title('Total Sales by Month_Assessment')
ass. set(ylim=(0, 1200))
```

Out[899]: [(0, 1200)]



The results show that the trial in store 86 is not significantly different to its control store in

the trial period as the trial store performance lies inside the 5% to 95% confidence interval of the control store in two of the three trial months.

Assessing for Number of Customers as well

Scale the control store's number of customers

In [900]:
```
trial_index = store_measures.loc[store_measures['MONTH_ID'] >= 201902].index
preTrial = store_measures.drop(trial_index)
preTrial
```

Out[900]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3110	272	201809	304.7	32	1.125000	1.972222	4.291549
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250

1820 rows × 7 columns

In [901]:
```
pre_cus = preTrial.groupby('STORE_NBR').sum()['Num_Cus'].reset_index()

pre_i = pre_cus.loc[pre_cus['STORE_NBR'] !=86].index
pre_86 = pre_cus.drop(pre_i)

pre_j = pre_cus.loc[pre_cus['STORE_NBR'] !=155].index
pre_155 = pre_cus.drop(pre_j)
```

In [902]:
```
scalingFactor = pre_86.iloc[0]['Num_Cus'] /pre_155.iloc[0]['Num_Cus']
scalingFactor
```

Out[902]: 1.0

In [903]:
```
t_j = store_measures.loc[store_measures['STORE_NBR'] !=155].index
t_155 = store_measures.drop(t_j)

t_i = store_measures.loc[store_measures['STORE_NBR'] !=86].index
t_86 = store_measures.drop(t_i)

t_155['Control_nCus'] = t_155['Num_Cus']* scalingFactor
t_155
```

Out[903]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
1764	155	201807	924.60	101	1.217822	2.032520	3.698400
1765	155	201808	782.70	91	1.307692	1.924370	3.417904
1766	155	201809	1014.40	103	1.398058	2.013889	3.497931
1767	155	201810	963.80	108	1.259259	2.000000	3.543382
1768	155	201811	898.80	101	1.316832	2.030075	3.328889
1769	155	201812	849.80	97	1.237113	2.016667	3.511570
1770	155	201901	874.60	96	1.302083	2.016000	3.470635
1771	155	201902	891.20	95	1.315789	2.032000	3.508661
1772	155	201903	804.40	94	1.255319	2.033898	3.351667
1773	155	201904	844.60	99	1.212121	2.016667	3.490083
1774	155	201905	922.85	106	1.283019	1.948529	3.482453
1775	155	201906	857.20	95	1.273684	2.016529	3.513115

In [904]:
```
tot_combine = pd.merge(t_155, t_86, on ='MONTH_ID')
tot_combine = tot_combine.drop(tot_combine.columns[[2,3,4,5,6,9,11,12,13]], axis=
tot_combine
```

Out[904]:

	STORE_NBR_x	MONTH_ID	Control_nCus	STORE_NBR_y	Num_Cus_y
0	155	201807	101.0	86	99
1	155	201808	91.0	86	94
2	155	201809	103.0	86	103
3	155	201810	108.0	86	109
4	155	201811	101.0	86	100
5	155	201812	97.0	86	98
6	155	201901	96.0	86	94
7	155	201902	95.0	86	107
8	155	201903	94.0	86	115
9	155	201904	99.0	86	105
10	155	201905	106.0	86	104
11	155	201906	95.0	86	98

In [905]:
```
tot_combine['Percent_Diff'] = abs(tot_combine['Control_nCus'] - tot_combine['Num_
tot_combine
```

Out[905]:

	STORE_NBR_x	MONTH_ID	Control_nCus	STORE_NBR_y	Num_Cus_y	Percent_Diff
0	155	201807	101.0	86	99	0.019802
1	155	201808	91.0	86	94	0.032967
2	155	201809	103.0	86	103	0.000000
3	155	201810	108.0	86	109	0.009259
4	155	201811	101.0	86	100	0.009901
5	155	201812	97.0	86	98	0.010309
6	155	201901	96.0	86	94	0.020833
7	155	201902	95.0	86	107	0.126316
8	155	201903	94.0	86	115	0.223404
9	155	201904	99.0	86	105	0.060606
10	155	201905	106.0	86	104	0.018868
11	155	201906	95.0	86	98	0.031579

In [906]:
```
trial_index = tot_combine.loc[tot_combine['MONTH_ID'] >= 201902].index
preTrial = tot_combine.drop(trial_index)

pre_index = tot_combine.loc[tot_combine['MONTH_ID'] < 201902].index
Trial = tot_combine.drop(pre_index)
```

In [907]:
```
stdDev = statistics.stdev(preTrial['Percent_Diff'])
stdDev
```

Out[907]: 0.010687444701395236

Visual checks on trends based on Number of Customers

In [908]:
```
store_measures
```

Out[908]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3115	272	201902	395.5	45	1.066667	1.895833	4.346154
3116	272	201903	442.3	50	1.060000	1.905660	4.379208
3117	272	201904	445.1	54	1.018519	1.909091	4.239048
3118	272	201905	314.6	34	1.176471	1.775000	4.430986
3119	272	201906	312.1	34	1.088235	1.891892	4.458571

3120 rows × 7 columns

In [909]:
```
past_nCus = store_measures.drop(store_measures.columns[[2,4,5,6]], axis=1)
past_nCus
```

Out[909]:

	STORE_NBR	MONTH_ID	Num_Cus
0	1	201807	49
1	1	201808	42
2	1	201809	59
3	1	201810	44
4	1	201811	46
...	...	...	...
3115	272	201902	45
3116	272	201903	50
3117	272	201904	54
3118	272	201905	34
3119	272	201906	34

3120 rows × 3 columns

In [910]:
```
def classification(row):
    if row['STORE_NBR'] == 86:
        return 'Trial'
    elif row['STORE_NBR'] == 155:
        return 'Control'
    else:
        return 'Other Stores'

past_nCus['STORE_TYPE'] = past_nCus.apply(classification, axis=1)


i = past_nCus.loc[past_nCus['STORE_TYPE']=='Other Stores'].index
past_nCus = past_nCus.drop(i)
past_nCus
```

Out[910]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE
960	86	201807	99	Trial
961	86	201808	94	Trial
962	86	201809	103	Trial
963	86	201810	109	Trial
964	86	201811	100	Trial
965	86	201812	98	Trial
966	86	201901	94	Trial
967	86	201902	107	Trial
968	86	201903	115	Trial
969	86	201904	105	Trial
970	86	201905	104	Trial
971	86	201906	98	Trial
1764	155	201807	101	Control
1765	155	201808	91	Control
1766	155	201809	103	Control
1767	155	201810	108	Control
1768	155	201811	101	Control
1769	155	201812	97	Control
1770	155	201901	96	Control
1771	155	201902	95	Control
1772	155	201903	94	Control
1773	155	201904	99	Control
1774	155	201905	106	Control
1775	155	201906	95	Control

In [911]:
```
i = past_nCus.loc[past_nCus['STORE_NBR']!=155].index
measure_95 = past_nCus.drop(i)
measure_95['Num_Cus'] = measure_95['Num_Cus'] * (1 + stdDev * 2)
measure_95['STORE_TYPE'] = 'Control 95th % confidence'
measure_95
```

Out[911]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE
1764	155	201807	103.158864	Control 95th % confidence
1765	155	201808	92.945115	Control 95th % confidence
1766	155	201809	105.201614	Control 95th % confidence
1767	155	201810	110.308488	Control 95th % confidence
1768	155	201811	103.158864	Control 95th % confidence
1769	155	201812	99.073364	Control 95th % confidence
1770	155	201901	98.051989	Control 95th % confidence
1771	155	201902	97.030614	Control 95th % confidence
1772	155	201903	96.009240	Control 95th % confidence
1773	155	201904	101.116114	Control 95th % confidence
1774	155	201905	108.265738	Control 95th % confidence
1775	155	201906	97.030614	Control 95th % confidence

In [912]:
```
j = past_nCus.loc[past_nCus['STORE_NBR']!=155].index
measure_5 = past_nCus.drop(i)
measure_5['Num_Cus'] = measure_5['Num_Cus'] * (1 - stdDev * 2)
measure_5['STORE_TYPE'] = 'Control 5th % confidence'
measure_5
```

Out[912]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE
1764	155	201807	98.841136	Control 5th % confidence
1765	155	201808	89.054885	Control 5th % confidence
1766	155	201809	100.798386	Control 5th % confidence
1767	155	201810	105.691512	Control 5th % confidence
1768	155	201811	98.841136	Control 5th % confidence
1769	155	201812	94.926636	Control 5th % confidence
1770	155	201901	93.948011	Control 5th % confidence
1771	155	201902	92.969386	Control 5th % confidence
1772	155	201903	91.990760	Control 5th % confidence
1773	155	201904	96.883886	Control 5th % confidence
1774	155	201905	103.734262	Control 5th % confidence
1775	155	201906	92.969386	Control 5th % confidence

In [913]:
```
assessment = pd.concat([past_nCus, measure_95, measure_5])
assessment['MONTH'] = pd.to_datetime(assessment['MONTH_ID'].astype(int),format='%
assessment.head()
```

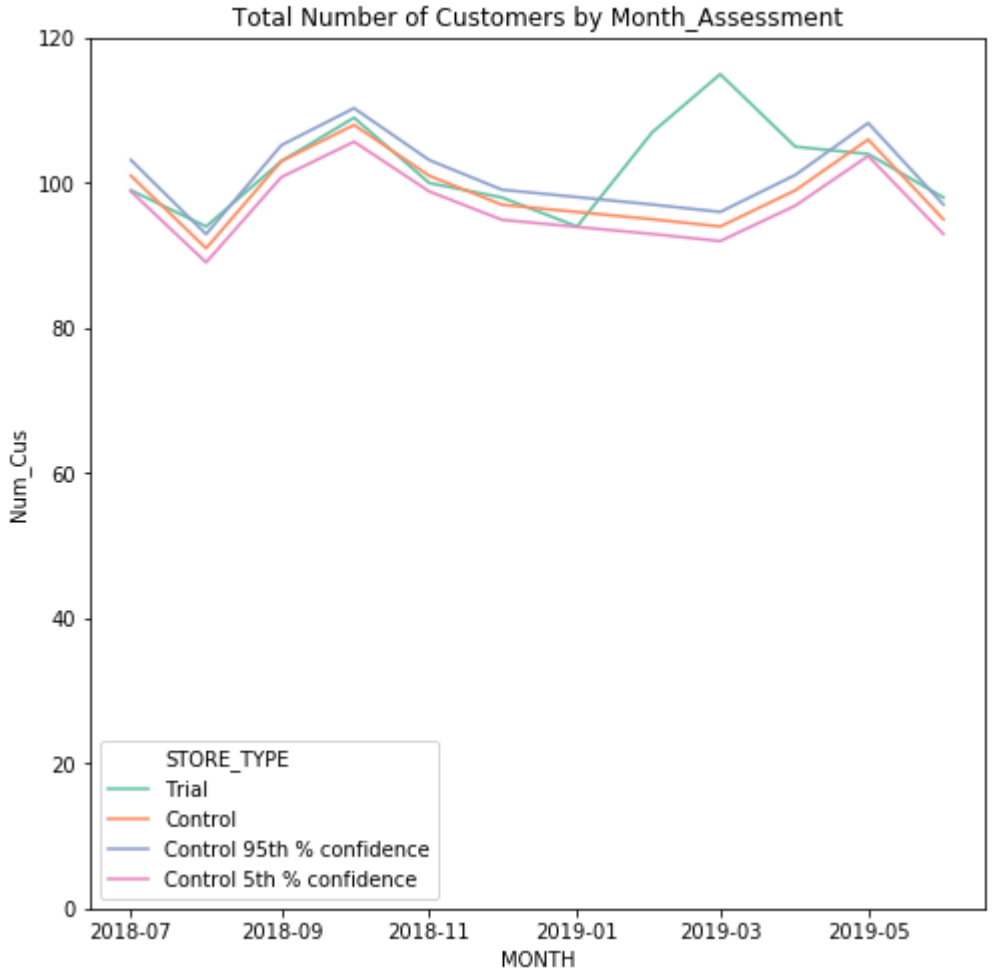
Out[913]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE	MONTH
960	86	201807	99.0	Trial	2018-07-01
961	86	201808	94.0	Trial	2018-08-01
962	86	201809	103.0	Trial	2018-09-01
963	86	201810	109.0	Trial	2018-10-01
964	86	201811	100.0	Trial	2018-11-01

In [914]:
```
plt.figure(figsize=(8,8))

ass = sns.lineplot(x='MONTH',y='Num_Cus', hue = 'STORE_TYPE', data=assessment, pa
ass.set_title('Total Number of Customers by Month_Assessment')
ass. set(ylim=(0, 120))
```

Out[914]: [(0, 120)]



Select Control Stores for Trial Store 88

In [915]:
```
trial_index = store_measures.loc[store_measures['MONTH_ID'] >= 201903].index
preTrial = store_measures.drop(trial_index)
preTrial
```

Out[915]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2080 rows × 7 columns

In [916]:
```
trial_store_77_i = preTrial.loc[preTrial['STORE_NBR'] !=77].index
trial_store_77 = preTrial.drop(trial_store_77_i)

trial_store_86_i = preTrial.loc[preTrial['STORE_NBR'] !=86].index
trial_store_86 = preTrial.drop(trial_store_86_i)

trial_store_88_i = preTrial.loc[preTrial['STORE_NBR'] !=88].index
trial_store_88 = preTrial.drop(trial_store_88_i)

trial_stores = pd.concat([trial_store_77,trial_store_86,trial_store_88])

control_store_i_1 = preTrial.loc[preTrial['STORE_NBR'] == 77].index
control_store_i_2 = preTrial.loc[preTrial['STORE_NBR'] == 86].index
control_store_i_3 = preTrial.loc[preTrial['STORE_NBR'] == 88].index
control_stores1 = preTrial.drop(control_store_i_1)
control_stores2 = control_stores1.drop(control_store_i_2)
control_stores = control_stores2.drop(control_store_i_3)
control_stores
```

Out[916]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2056 rows × 7 columns

In [919]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [88]

# Total Sales: m = 2
m = 2

C_Stores = []
T_Stores = []
Corr_Results = []
for t in trial_num:
    for c in store_num:
        result = getCorr(c,m,t)
        C_Stores.append(c)
        T_Stores.append(t)
        Corr_Results.append(result)

Correlation_Matrix1 = pd.DataFrame({'Trial' : T_Stores,
                                    'Control' : C_Stores,
                                    'Correlation' : Corr_Results },
                                    columns=['Trial','Control', 'Correlation'])
Correlation_Matrix1.sort_values('Correlation', ascending = False)
```

Out[919]:

	Trial	Control	Correlation
148	88	159	0.895637
0	88	1	0.823306
82	88	91	0.783157
177	88	188	0.731655
57	88	61	0.726877
...	...	...	...
254	88	270	-0.737748
256	88	272	-0.747878
44	88	48	-0.769634
21	88	23	-0.785574
7	88	8	-0.825262

257 rows × 3 columns

In [920]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [88]

# Number of Customers: m = 3
m = 3

C_Stores = []
T_Stores = []
Corr_Results = []
for t in trial_num:
    for c in store_num:
        result = getCorr(c,m,t)
        C_Stores.append(c)
        T_Stores.append(t)
        Corr_Results.append(result)

Correlation_Matrix2 = pd.DataFrame({'Trial' : T_Stores,
                                    'Control' : C_Stores,
                                    'Correlation' : Corr_Results },
                                    columns=['Trial','Control', 'Correlation'])
Correlation_Matrix2.sort_values('Correlation', ascending = False)
```

Out[920]:

	Trial	Control	Correlation
222	88	237	0.942232
12	88	14	0.928985
32	88	35	0.901397
167	88	178	0.873835
249	88	265	0.842573
...	...	...	...
136	88	147	-0.629198
17	88	19	-0.635319
224	88	239	-0.666731
232	88	247	-0.792942
242	88	258	-0.827778

257 rows × 3 columns

Magnitude Distance Against Store 88 Based on Total Sales

In [921]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [88]

# Total Sale
m = 2

mag_list1 = []
for t in trial_num:
    for c in store_num:
        result = getMag(c,m,t)
        mag_list1.append(result)
mag_matrix1 = pd.concat(mag_list1)

mag_matrix1.rename(columns={'STORE_NBR_x': 'Control', 'STORE_NBR_y': 'Trial'}, ir
mag_matrix1.sort_values('Magnitude')
```

Out[921]:

	Control	Trial	MONTH_ID	Magnitude
6	58	88	201901	0.0
1	250	88	201808	0.9
5	199	88	201812	1.0
3	237	88	201810	4.1
3	4	88	201810	6.0
...	...	...	...	...
2	139	88	201809	1401.8
2	42	88	201809	1401.8
2	198	88	201809	1402.3
2	146	88	201809	1403.0
2	224	88	201809	1411.2

2056 rows × 4 columns

In [922]:
```
minDist = mag_matrix1.groupby(['Control','Trial']).min()['Magnitude'].reset_index
maxDist = mag_matrix1.groupby(['Control','Trial']).max()['Magnitude'].reset_index

MinMaxDist = pd.merge(minDist, maxDist, on = ('Control','Trial'))

MinMaxDist.rename(columns={'Magnitude_x': 'Min','Magnitude_y':'Max'}, inplace=Tru

standard_mag = pd.merge(mag_matrix1,MinMaxDist, on = ('Control','Trial'))
standard_mag['Mag_Measure'] = 1 - (standard_mag['Magnitude'] -standard_mag['Min']

finalDist1 = standard_mag.groupby(['Control','Trial']).mean()['Mag_Measure'].rese
finalDist1.sort_values('Mag_Measure')
```

Out[922]:

	Control	Trial	Mag_Measure
17	19	88	0.226285
190	202	88	0.295537
154	165	88	0.296067
169	180	88	0.323321
231	246	88	0.340321
...	...	...	...
206	221	88	0.670791
191	203	88	0.672021
204	219	88	0.714696
123	134	88	0.721492
37	40	88	0.764082

257 rows × 3 columns

Magnitude Distance Against Store 86 Based on Number of Customers

In [923]:
```
store_num = control_stores['STORE_NBR'].unique()

trial_num = [88]

# Number of Customers
m = 3

mag_list = []
for t in trial_num:
    for c in store_num:
        result = getMag(c,m,t)
        mag_list.append(result)
mag_matrix2 = pd.concat(mag_list)

mag_matrix2.rename(columns={'STORE_NBR_x': 'Control', 'STORE_NBR_y': 'Trial'}, ir
```

In [924]:
```
minDist = mag_matrix2.groupby(['Control','Trial']).min()['Magnitude'].reset_index
maxDist = mag_matrix2.groupby(['Control','Trial']).max()['Magnitude'].reset_index

MinMaxDist = pd.merge(minDist, maxDist, on = ('Control','Trial'))

MinMaxDist.rename(columns={'Magnitude_x': 'Min','Magnitude_y':'Max'}, inplace=Tru

standard_mag = pd.merge(mag_matrix2,MinMaxDist, on = ('Control','Trial'))
standard_mag['Mag_Measure'] = 1 - (standard_mag['Magnitude'] -standard_mag['Min']

finalDist2 = standard_mag.groupby(['Control','Trial']).mean()['Mag_Measure'].rese
finalDist2.sort_values('Mag_Measure')
```

Out[924]:

	Control	Trial	Mag_Measure
17	19	88	0.179487
174	185	88	0.273810
52	56	88	0.288462
7	8	88	0.297619
166	177	88	0.305556
...	...	...	...
94	104	88	0.707031
204	219	88	0.711957
37	40	88	0.718750
155	166	88	0.758621
221	236	88	0.774194

257 rows × 3 columns

In [938]:
```
corr_weight = 0.5
combined_tot = pd.merge(Correlation_Matrix1,finalDist1, on = ['Control','Trial']
combined_tot['Combined_Score'] = corr_weight*combined_tot['Correlation'] + (1-cor
combined_tot
```

Out[938]:

	Trial	Control	Correlation	Mag_Measure	Combined_Score
0	88	1	0.823306	0.545494	0.684400
1	88	2	-0.151853	0.502197	0.175172
2	88	3	-0.288716	0.497161	0.104222
3	88	4	-0.619880	0.637999	0.009059
4	88	5	0.038594	0.499593	0.269093
...	...	...	...	...	...
252	88	268	-0.100489	0.479415	0.189463
253	88	269	-0.165132	0.552234	0.193551
254	88	270	-0.737748	0.474242	-0.131753
255	88	271	-0.166019	0.382504	0.108242
256	88	272	-0.747878	0.605879	-0.070999

257 rows × 5 columns

In [939]:
```
corr_weight = 0.5
combined_nCus = pd.merge(Correlation_Matrix2,finalDist2, on = ['Control','Trial']
combined_nCus['Combined_Score'] = corr_weight*combined_nCus['Correlation'] + (1-c
combined_nCus
```

Out[939]:

	Trial	Control	Correlation	Mag_Measure	Combined_Score
0	88	1	0.242805	0.401042	0.321924
1	88	2	-0.156135	0.339286	0.091576
2	88	3	0.341899	0.523810	0.432854
3	88	4	-0.122544	0.628788	0.253122
4	88	5	0.028866	0.534091	0.281478
...	...	...	...	...	...
252	88	268	0.668599	0.588235	0.628417
253	88	269	-0.214158	0.348684	0.067263
254	88	270	-0.045451	0.333333	0.143941
255	88	271	0.048096	0.625000	0.336548
256	88	272	0.009256	0.470238	0.239747

257 rows × 5 columns

In [940]:
```
combined_88 = pd.merge(combined_tot,combined_nCus, on = ['Control','Trial'] )
combined_88['Overall_Score'] = 0.5*combined_88['Combined_Score_x'] + 0.5*combinec
combined_88.sort_values('Overall_Score', ascending = False)
```

Out[940]:

	Trial	Control	Correlation_x	Mag_Measure_x	Combined_Score_x	Correlation_y	Mag_Measure
12	88	14	0.622809	0.558419	0.590614	0.928985	0.4305
222	88	237	0.353432	0.617647	0.485539	0.942232	0.5937
176	88	187	0.589869	0.606051	0.597960	0.647647	0.5468
167	88	178	0.614742	0.419538	0.517140	0.873835	0.4375
32	88	35	0.096093	0.617582	0.356837	0.901397	0.6666
...	...	...	...	...	...	...	
220	88	235	-0.710786	0.469598	-0.120594	-0.423848	0.4259
7	88	8	-0.825262	0.511423	-0.156920	-0.238504	0.2976
224	88	239	-0.505711	0.428398	-0.038657	-0.666731	0.4285
130	88	141	-0.705709	0.441121	-0.132294	-0.506265	0.4250
17	88	19	-0.426729	0.226285	-0.100222	-0.635319	0.1794

257 rows × 9 columns

We've now found store 237 to be a suitable control store for trial store 88.

Visual checks on trends based on Total Sales

In [941]:
```
preTrial
```

Out[941]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2080 rows × 9 columns

In [946]:
```
def classification(row):
    if row['STORE_NBR'] == 88:
        return 'Trial'
    elif row['STORE_NBR'] == 237:
        return 'Control'
    else:
        return 'Other Stores'

preTrial['STORE_TYPE'] = preTrial.apply(classification, axis=1)

preTrial
```

Out[946]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250
3115	272	201902	395.5	45	1.066667	1.895833	4.346154

2080 rows × 9 columns

In [947]:
```
preTrial['MONTH'] = pd.to_datetime(preTrial['MONTH_ID'].astype(int),format='%Y%m'
```

In [948]:
```
tot_by_month = preTrial.groupby(['MONTH','STORE_TYPE']).mean()['TOT_SALES'].reset
tot_by_month.head()
```

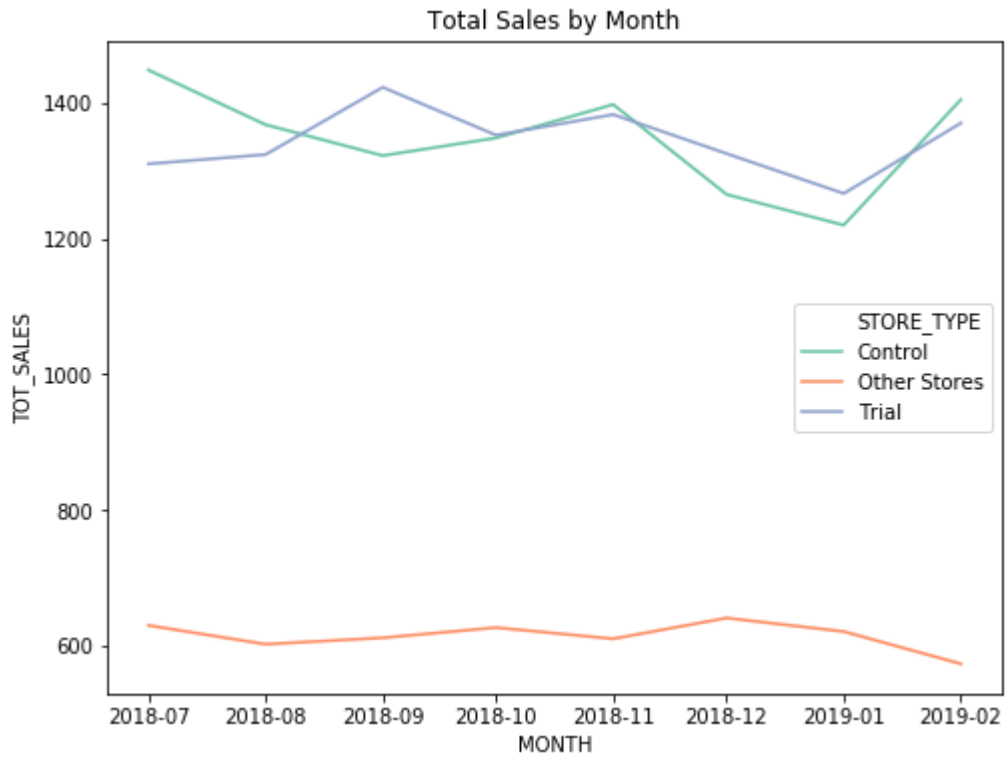
Out[948]:

	MONTH	STORE_TYPE	TOT_SALES
0	2018-07-01	Control	1448.400000
1	2018-07-01	Other Stores	629.590310
2	2018-07-01	Trial	1310.000000
3	2018-08-01	Control	1367.800000
4	2018-08-01	Other Stores	601.889341

In [949]:
```
plt.figure(figsize=(8,6))


TotalSale = sns.lineplot(x='MONTH',y='TOT_SALES', hue = 'STORE_TYPE', data=tot_by
TotalSale.set_title('Total Sales by Month')
```

Out[949]:
```
Text(0.5, 1.0, 'Total Sales by Month')
```



Scale the control store's sales

In [950]:
```
trial_index = store_measures.loc[store_measures['MONTH_ID'] >= 201902].index
preTrial = store_measures.drop(trial_index)
preTrial
```

Out[950]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3110	272	201809	304.7	32	1.125000	1.972222	4.291549
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250

1820 rows × 7 columns

In [952]:
```
pre_tot = preTrial.groupby('STORE_NBR').sum()['TOT_SALES'].reset_index()

pre_i = pre_tot.loc[pre_tot['STORE_NBR'] !=88].index
pre_88 = pre_tot.drop(pre_i)

pre_j = pre_tot.loc[pre_tot['STORE_NBR'] !=237].index
pre_237 = pre_tot.drop(pre_j)
```

In [953]:
```
scalingFactor = pre_88.iloc[0]['TOT_SALES'] /pre_237.iloc[0]['TOT_SALES']
scalingFactor
```

Out[953]:
```
1.0015583306649594
```

In [956]:
```
t_j = store_measures.loc[store_measures['STORE_NBR'] !=237].index
t_237 = store_measures.drop(t_j)

t_i = store_measures.loc[store_measures['STORE_NBR'] !=88].index
t_88 = store_measures.drop(t_i)

t_237['Control_Sale'] = t_237['TOT_SALES']* scalingFactor
t_237
```

Out[956]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
2700	237	201807	1448.4	128	1.265625	2.000000	4.470370
2701	237	201808	1367.8	135	1.222222	1.896970	4.369968
2702	237	201809	1322.2	126	1.182540	2.006711	4.422074
2703	237	201810	1348.3	123	1.195122	2.034014	4.509365
2704	237	201811	1397.6	132	1.219697	1.987578	4.367500
2705	237	201812	1265.0	124	1.161290	2.006944	4.377163
2706	237	201901	1219.7	117	1.188034	1.992806	4.403249
2707	237	201902	1404.8	126	1.246032	2.000000	4.473885
2708	237	201903	1208.2	119	1.126050	2.044776	4.409489
2709	237	201904	1204.6	120	1.125000	2.014815	4.428676
2710	237	201905	1199.3	129	1.155039	1.825503	4.409191
2711	237	201906	1153.6	119	1.100840	2.000000	4.403053

In [957]:
```
tot_combine = pd.merge(t_237, t_88, on ='MONTH_ID')
tot_combine = tot_combine.drop(tot_combine.columns[[2,3,4,5,6,10,11,12,13]], axis
tot_combine
```

Out[957]:

	STORE_NBR_x	MONTH_ID	Control_Sale	STORE_NBR_y	TOT_SALES_y
0	237	201807	1450.657086	88	1310.00
1	237	201808	1369.931485	88	1323.80
2	237	201809	1324.260425	88	1423.00
3	237	201810	1350.401097	88	1352.40
4	237	201811	1399.777923	88	1382.80
5	237	201812	1266.971288	88	1325.20
6	237	201901	1221.600696	88	1266.40
7	237	201902	1406.989143	88	1370.20
8	237	201903	1210.082775	88	1477.20
9	237	201904	1206.477165	88	1439.40
10	237	201905	1201.168906	88	1308.25
11	237	201906	1155.397690	88	1354.60

In [958]:
```
tot_combine['Percent_Diff'] = abs(tot_combine['Control_Sale'] - tot_combine['TOT_
tot_combine
```

Out[958]:

	STORE_NBR_x	MONTH_ID	Control_Sale	STORE_NBR_y	TOT_SALES_y	Percent_Diff
0	237	201807	1450.657086	88	1310.00	0.096961
1	237	201808	1369.931485	88	1323.80	0.033674
2	237	201809	1324.260425	88	1423.00	0.074562
3	237	201810	1350.401097	88	1352.40	0.001480
4	237	201811	1399.777923	88	1382.80	0.012129
5	237	201812	1266.971288	88	1325.20	0.045959
6	237	201901	1221.600696	88	1266.40	0.036673
7	237	201902	1406.989143	88	1370.20	0.026147
8	237	201903	1210.082775	88	1477.20	0.220743
9	237	201904	1206.477165	88	1439.40	0.193060
10	237	201905	1201.168906	88	1308.25	0.089147
11	237	201906	1155.397690	88	1354.60	0.172410

In [959]:
```
trial_index = tot_combine.loc[tot_combine['MONTH_ID'] >= 201902].index
preTrial = tot_combine.drop(trial_index)

pre_index = tot_combine.loc[tot_combine['MONTH_ID'] < 201902].index
Trial = tot_combine.drop(pre_index)
```

As our null hypothesis is 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

In [960]:
```
stdDev = statistics.stdev(preTrial['Percent_Diff'])
stdDev
```

Out[960]:
```
0.03346786730307888
```

Let's create a more visual version of this by plotting the sales of the control store, the sales of the trial stores and the 95th percentile value of sales of the control store.

In [961]:
```
store_measures
```

Out[961]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3115	272	201902	395.5	45	1.066667	1.895833	4.346154
3116	272	201903	442.3	50	1.060000	1.905660	4.379208
3117	272	201904	445.1	54	1.018519	1.909091	4.239048
3118	272	201905	314.6	34	1.176471	1.775000	4.430986
3119	272	201906	312.1	34	1.088235	1.891892	4.458571

3120 rows × 7 columns

In [962]:
```
past_Sales = store_measures.drop(store_measures.columns[[3,4,5,6]], axis=1)
past_Sales
```

Out[962]:

	STORE_NBR	MONTH_ID	TOT_SALES
0	1	201807	206.9
1	1	201808	176.1
2	1	201809	278.8
3	1	201810	188.1
4	1	201811	192.6
...	...	...	...
3115	272	201902	395.5
3116	272	201903	442.3
3117	272	201904	445.1
3118	272	201905	314.6
3119	272	201906	312.1

3120 rows × 3 columns

In [963]:
```
def classification(row):
    if row['STORE_NBR'] == 88:
        return 'Trial'
    elif row['STORE_NBR'] == 237:
        return 'Control'
    else:
        return 'Other Stores'

past_Sales['STORE_TYPE'] = past_Sales.apply(classification, axis=1)


i = past_Sales.loc[past_Sales['STORE_TYPE']=='Other Stores'].index
past_Sales = past_Sales.drop(i)
past_Sales
```

Out[963]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE
984	88	201807	1310.00	Trial
985	88	201808	1323.80	Trial
986	88	201809	1423.00	Trial
987	88	201810	1352.40	Trial
988	88	201811	1382.80	Trial
989	88	201812	1325.20	Trial
990	88	201901	1266.40	Trial
991	88	201902	1370.20	Trial
992	88	201903	1477.20	Trial
993	88	201904	1439.40	Trial
994	88	201905	1308.25	Trial
995	88	201906	1354.60	Trial
2700	237	201807	1448.40	Control
2701	237	201808	1367.80	Control
2702	237	201809	1322.20	Control
2703	237	201810	1348.30	Control
2704	237	201811	1397.60	Control
2705	237	201812	1265.00	Control
2706	237	201901	1219.70	Control
2707	237	201902	1404.80	Control
2708	237	201903	1208.20	Control
2709	237	201904	1204.60	Control
2710	237	201905	1199.30	Control
2711	237	201906	1153.60	Control

In [964]:
```
i = past_Sales.loc[past_Sales['STORE_NBR']!=237].index
measure_95 = past_Sales.drop(i)
measure_95['TOT_SALES'] = measure_95['TOT_SALES'] * (1 + stdDev * 2)
measure_95['STORE_TYPE'] = 'Control 95th % confidence'
measure_95
```

Out[964]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE
2700	237	201807	1545.349718	Control 95th % confidence
2701	237	201808	1459.354698	Control 95th % confidence
2702	237	201809	1410.702428	Control 95th % confidence
2703	237	201810	1438.549451	Control 95th % confidence
2704	237	201811	1491.149383	Control 95th % confidence
2705	237	201812	1349.673704	Control 95th % confidence
2706	237	201901	1301.341515	Control 95th % confidence
2707	237	201902	1498.831320	Control 95th % confidence
2708	237	201903	1289.071755	Control 95th % confidence
2709	237	201904	1285.230786	Control 95th % confidence
2710	237	201905	1279.576027	Control 95th % confidence
2711	237	201906	1230.817063	Control 95th % confidence

In [965]:
```
j = past_Sales.loc[past_Sales['STORE_NBR']!=237].index
measure_5 = past_Sales.drop(j)
measure_5['TOT_SALES'] = measure_5['TOT_SALES'] * (1 - stdDev * 2)
measure_5['STORE_TYPE'] = 'Control 5th % confidence'
measure_5
```

Out[965]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE
2700	237	201807	1351.450282	Control 5th % confidence
2701	237	201808	1276.245302	Control 5th % confidence
2702	237	201809	1233.697572	Control 5th % confidence
2703	237	201810	1258.050549	Control 5th % confidence
2704	237	201811	1304.050617	Control 5th % confidence
2705	237	201812	1180.326296	Control 5th % confidence
2706	237	201901	1138.058485	Control 5th % confidence
2707	237	201902	1310.768680	Control 5th % confidence
2708	237	201903	1127.328245	Control 5th % confidence
2709	237	201904	1123.969214	Control 5th % confidence
2710	237	201905	1119.023973	Control 5th % confidence
2711	237	201906	1076.382937	Control 5th % confidence

In [966]:
```
assessment = pd.concat([past_Sales, measure_95, measure_5])
assessment['MONTH'] = pd.to_datetime(assessment['MONTH_ID'].astype(int),format='%
assessment.head()
```

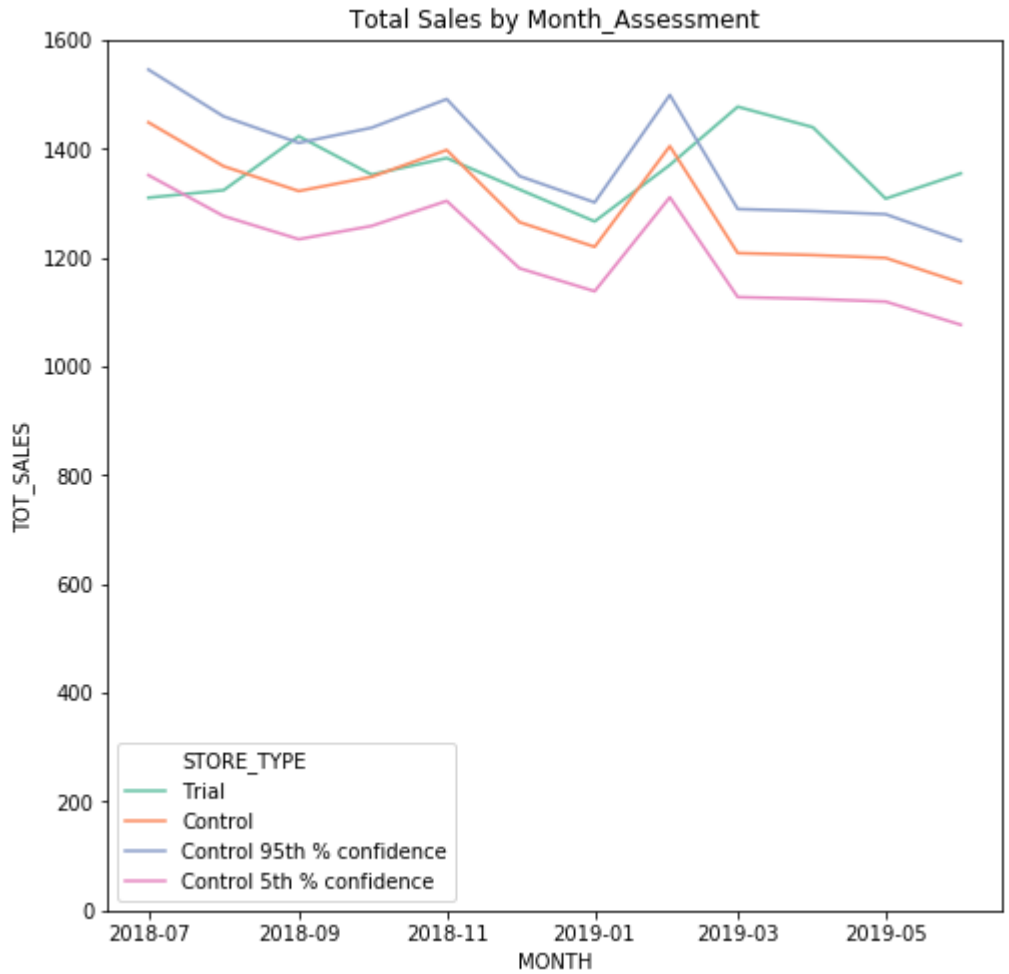
Out[966]:

	STORE_NBR	MONTH_ID	TOT_SALES	STORE_TYPE	MONTH
984	88	201807	1310.0	Trial	2018-07-01
985	88	201808	1323.8	Trial	2018-08-01
986	88	201809	1423.0	Trial	2018-09-01
987	88	201810	1352.4	Trial	2018-10-01
988	88	201811	1382.8	Trial	2018-11-01

In [969]:
```
plt.figure(figsize=(8,8))

ass = sns.lineplot(x='MONTH',y='TOT_SALES', hue = 'STORE_TYPE', data=assessment,
ass.set_title('Total Sales by Month_Assessment')
ass. set(ylim=(0, 1600))
```

Out[969]: [(0, 1600)]



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

of the control store in two of the three trial months.

Assessing for number of customers as well

Scale the control store's number of customers

In [971]:
```
trial_index = store_measures.loc[store_measures['MONTH_ID'] >= 201902].index
preTrial = store_measures.drop(trial_index)
preTrial
```

Out[971]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3110	272	201809	304.7	32	1.125000	1.972222	4.291549
3111	272	201810	430.6	44	1.136364	1.980000	4.349495
3112	272	201811	376.2	41	1.097561	1.933333	4.324138
3113	272	201812	403.9	47	1.000000	1.893617	4.538202
3114	272	201901	423.0	46	1.086957	1.920000	4.406250

1820 rows × 7 columns

In [972]:
```
pre_cus = preTrial.groupby('STORE_NBR').sum()['Num_Cus'].reset_index()

pre_i = pre_cus.loc[pre_cus['STORE_NBR'] !=88].index
pre_88 = pre_cus.drop(pre_i)

pre_j = pre_cus.loc[pre_cus['STORE_NBR'] !=237].index
pre_237 = pre_cus.drop(pre_j)
```

In [974]:
```
scalingFactor = pre_88.iloc[0]['Num_Cus'] /pre_237.iloc[0]['Num_Cus']
scalingFactor
```

Out[974]:
```
0.9943502824858758
```

In [975]:
```
t_j = store_measures.loc[store_measures['STORE_NBR'] !=237].index
t_237 = store_measures.drop(t_j)

t_i = store_measures.loc[store_measures['STORE_NBR'] !=88].index
t_88 = store_measures.drop(t_i)

t_237['Control_nCus'] = t_237['Num_Cus']* scalingFactor
t_237
```

Out[975]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
2700	237	201807	1448.4	128	1.265625	2.000000	4.470370
2701	237	201808	1367.8	135	1.222222	1.896970	4.369968
2702	237	201809	1322.2	126	1.182540	2.006711	4.422074
2703	237	201810	1348.3	123	1.195122	2.034014	4.509365
2704	237	201811	1397.6	132	1.219697	1.987578	4.367500
2705	237	201812	1265.0	124	1.161290	2.006944	4.377163
2706	237	201901	1219.7	117	1.188034	1.992806	4.403249
2707	237	201902	1404.8	126	1.246032	2.000000	4.473885
2708	237	201903	1208.2	119	1.126050	2.044776	4.409489
2709	237	201904	1204.6	120	1.125000	2.014815	4.428676
2710	237	201905	1199.3	129	1.155039	1.825503	4.409191
2711	237	201906	1153.6	119	1.100840	2.000000	4.403053

In [976]:
```
tot_combine = pd.merge(t_237, t_88, on ='MONTH_ID')
tot_combine = tot_combine.drop(tot_combine.columns[[2,3,4,5,6,9,11,12,13]], axis=
tot_combine
```

Out[976]:

	STORE_NBR_x	MONTH_ID	Control_nCus	STORE_NBR_y	Num_Cus_y
0	237	201807	127.276836	88	129
1	237	201808	134.237288	88	131
2	237	201809	125.288136	88	124
3	237	201810	122.305085	88	123
4	237	201811	131.254237	88	130
5	237	201812	123.299435	88	126
6	237	201901	116.338983	88	117
7	237	201902	125.288136	88	124
8	237	201903	118.327684	88	134
9	237	201904	119.322034	88	128
10	237	201905	128.271186	88	128
11	237	201906	118.327684	88	121

In [977]:
```
tot_combine['Percent_Diff'] = abs(tot_combine['Control_nCus'] - tot_combine['Num_
tot_combine
```

Out[977]:

	STORE_NBR_x	MONTH_ID	Control_nCus	STORE_NBR_y	Num_Cus_y	Percent_Diff
0	237	201807	127.276836	88	129	0.013539
1	237	201808	134.237288	88	131	0.024116
2	237	201809	125.288136	88	124	0.010281
3	237	201810	122.305085	88	123	0.005682
4	237	201811	131.254237	88	130	0.009556
5	237	201812	123.299435	88	126	0.021902
6	237	201901	116.338983	88	117	0.005682
7	237	201902	125.288136	88	124	0.010281
8	237	201903	118.327684	88	134	0.132448
9	237	201904	119.322034	88	128	0.072727
10	237	201905	128.271186	88	128	0.002114
11	237	201906	118.327684	88	121	0.022584

In [978]:
```
trial_index = tot_combine.loc[tot_combine['MONTH_ID'] >= 201902].index
preTrial = tot_combine.drop(trial_index)

pre_index = tot_combine.loc[tot_combine['MONTH_ID'] < 201902].index
Trial = tot_combine.drop(pre_index)
```

In [979]:
```
stdDev = statistics.stdev(preTrial['Percent_Diff'])
stdDev
```

Out[979]:
```
0.00741024435207507
```

Visual checks on trends based on Number of Customers

In [980]:
```
store_measures
```

Out[980]:

	STORE_NBR	MONTH_ID	TOT_SALES	Num_Cus	Trans_PerCus	nChips_PerTrans	AvgPrice
0	1	201807	206.9	49	1.061224	1.192308	3.337097
1	1	201808	176.1	42	1.023810	1.255814	3.261111
2	1	201809	278.8	59	1.050847	1.209677	3.717333
3	1	201810	188.1	44	1.022727	1.288889	3.243103
4	1	201811	192.6	46	1.021739	1.212766	3.378947
...	...	...	...	...	...	...	...
3115	272	201902	395.5	45	1.066667	1.895833	4.346154
3116	272	201903	442.3	50	1.060000	1.905660	4.379208
3117	272	201904	445.1	54	1.018519	1.909091	4.239048
3118	272	201905	314.6	34	1.176471	1.775000	4.430986
3119	272	201906	312.1	34	1.088235	1.891892	4.458571

3120 rows × 7 columns

In [981]:
```
past_nCus = store_measures.drop(store_measures.columns[[2,4,5,6]], axis=1)
past_nCus
```

Out[981]:

	STORE_NBR	MONTH_ID	Num_Cus
0	1	201807	49
1	1	201808	42
2	1	201809	59
3	1	201810	44
4	1	201811	46
...	...	...	...
3115	272	201902	45
3116	272	201903	50
3117	272	201904	54
3118	272	201905	34
3119	272	201906	34

3120 rows × 3 columns

In [982]:
```
def classification(row):
    if row['STORE_NBR'] == 88:
        return 'Trial'
    elif row['STORE_NBR'] == 237:
        return 'Control'
    else:
        return 'Other Stores'

past_nCus['STORE_TYPE'] = past_nCus.apply(classification, axis=1)


i = past_nCus.loc[past_nCus['STORE_TYPE']=='Other Stores'].index
past_nCus = past_nCus.drop(i)
past_nCus
```

Out[982]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE
984	88	201807	129	Trial
985	88	201808	131	Trial
986	88	201809	124	Trial
987	88	201810	123	Trial
988	88	201811	130	Trial
989	88	201812	126	Trial
990	88	201901	117	Trial
991	88	201902	124	Trial
992	88	201903	134	Trial
993	88	201904	128	Trial
994	88	201905	128	Trial
995	88	201906	121	Trial
2700	237	201807	128	Control
2701	237	201808	135	Control
2702	237	201809	126	Control
2703	237	201810	123	Control
2704	237	201811	132	Control
2705	237	201812	124	Control
2706	237	201901	117	Control
2707	237	201902	126	Control
2708	237	201903	119	Control
2709	237	201904	120	Control
2710	237	201905	129	Control
2711	237	201906	119	Control

In [983]:
```
i = past_nCus.loc[past_nCus['STORE_NBR']!=237].index
measure_95 = past_nCus.drop(i)
measure_95['Num_Cus'] = measure_95['Num_Cus'] * (1 + stdDev * 2)
measure_95['STORE_TYPE'] = 'Control 95th % confidence'
measure_95
```

Out[983]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE
2700	237	201807	129.897023	Control 95th % confidence
2701	237	201808	137.000766	Control 95th % confidence
2702	237	201809	127.867382	Control 95th % confidence
2703	237	201810	124.822920	Control 95th % confidence
2704	237	201811	133.956305	Control 95th % confidence
2705	237	201812	125.837741	Control 95th % confidence
2706	237	201901	118.733997	Control 95th % confidence
2707	237	201902	127.867382	Control 95th % confidence
2708	237	201903	120.763638	Control 95th % confidence
2709	237	201904	121.778459	Control 95th % confidence
2710	237	201905	130.911843	Control 95th % confidence
2711	237	201906	120.763638	Control 95th % confidence

In [984]:
```
j = past_nCus.loc[past_nCus['STORE_NBR']!=237].index
measure_5 = past_nCus.drop(i)
measure_5['Num_Cus'] = measure_5['Num_Cus'] * (1 - stdDev * 2)
measure_5['STORE_TYPE'] = 'Control 5th % confidence'
measure_5
```

Out[984]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE
2700	237	201807	126.102977	Control 5th % confidence
2701	237	201808	132.999234	Control 5th % confidence
2702	237	201809	124.132618	Control 5th % confidence
2703	237	201810	121.177080	Control 5th % confidence
2704	237	201811	130.043695	Control 5th % confidence
2705	237	201812	122.162259	Control 5th % confidence
2706	237	201901	115.266003	Control 5th % confidence
2707	237	201902	124.132618	Control 5th % confidence
2708	237	201903	117.236362	Control 5th % confidence
2709	237	201904	118.221541	Control 5th % confidence
2710	237	201905	127.088157	Control 5th % confidence
2711	237	201906	117.236362	Control 5th % confidence

In [985]:
```
assessment = pd.concat([past_nCus, measure_95, measure_5])
assessment['MONTH'] = pd.to_datetime(assessment['MONTH_ID'].astype(int),format='%
assessment.head()
```

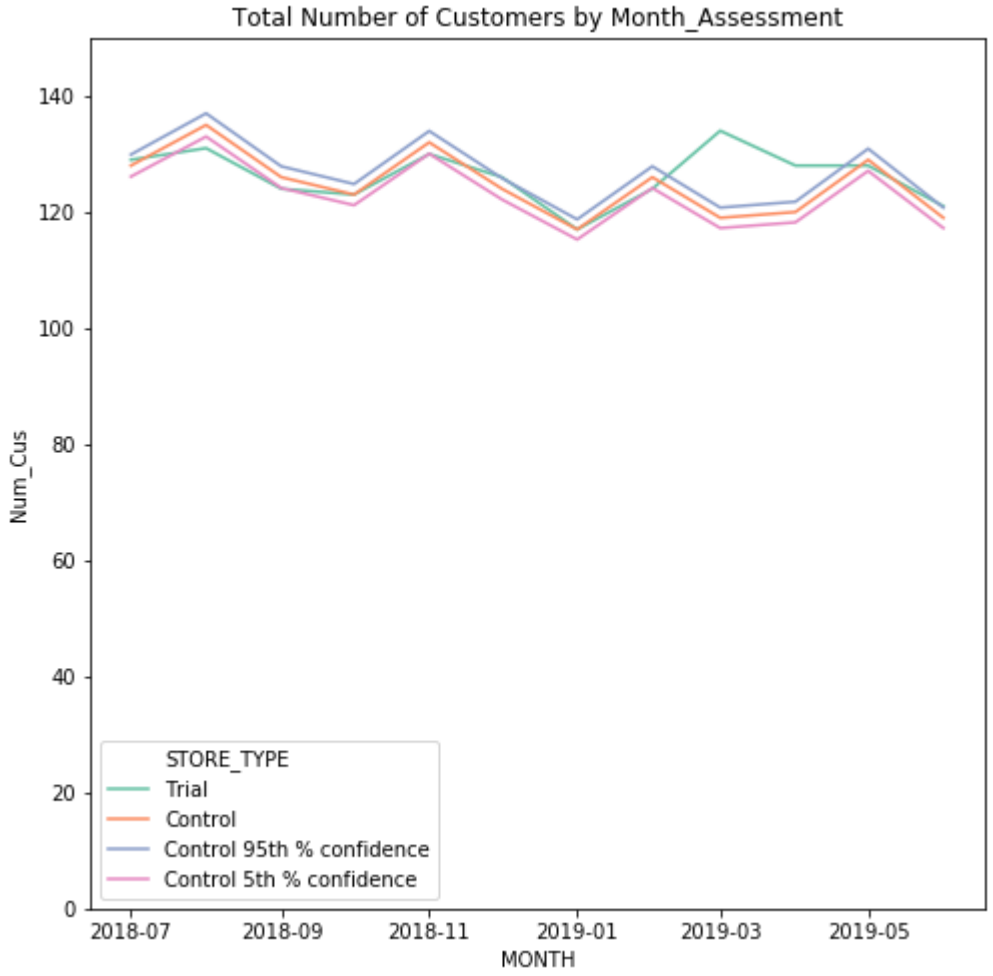
Out[985]:

	STORE_NBR	MONTH_ID	Num_Cus	STORE_TYPE	MONTH
984	88	201807	129.0	Trial	2018-07-01
985	88	201808	131.0	Trial	2018-08-01
986	88	201809	124.0	Trial	2018-09-01
987	88	201810	123.0	Trial	2018-10-01
988	88	201811	130.0	Trial	2018-11-01

In [989]:
```
plt.figure(figsize=(8,8))

ass = sns.lineplot(x='MONTH',y='Num_Cus', hue = 'STORE_TYPE', data=assessment, pa
ass.set_title('Total Number of Customers by Month_Assessment')
ass. set(ylim=(0, 150))
```

Out[989]: [(0, 150)]



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.

Conclusion

We've found control stores 233, 155, 237 for trial stores 77, 86 and 88 respectively.

The results for trial stores 77 and 88 during the trial period show a significant difference in at least two of the three trial months but this is not the case for trial store 86. We can check with the client if the implementation of the trial was different in trial store 86 but overall, the trial shows a significant increase in sales.

In [ ]: