Quantium Virtual Internship
Retail Strategy and Analytics
Task 2

Description of Analyses

Stores 76, 86, 88 were selected for a trial layout of a new chips category which commenced at the beginning of February 2019 and concluded at the end of April 2019. To determine whether this trial was a success, comparisons need to be made with other stores with sales during the same time period. To achieve this, a control store with similar sales and numbers of customers per month in the pre-trial period will be selected for each trial store. Total sales and number of customers per month will then be compared in the trial period to determine if each trial store deviates from the control store.

Import Packages

In [1]:
```
import pandas as pd
pd.options.mode.chained_assignment = None
import numpy as np
from datetime import date
from scipy.stats import pearsonr, t
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
```

Create Dataframe from Data File

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

Create Additional Feature

In [3]:
```
# Create new column containing just the year and month
data['YEARMONTH'] = pd.to_datetime(data['DATE']).dt.to_period('M')
```

Create Dataframes with Measure Calculations for Analysis

Dataframe with Measure Calculations for All Stores

The dataframe includes the following measures by month for each store:

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

NB: Only the first two measures will be used in this analysis

In [4]:
```
measure_over_time = (data.groupby(['STORE_NBR','YEARMONTH']).agg(
    Tot_Sales = pd.NamedAgg(column='TOT_SALES', aggfunc='sum'),
    Number_Customers = pd.NamedAgg(column='LYLTY_CARD_NBR', aggfunc='nunique'),
    Number_Txns = pd.NamedAgg(column='TXN_ID', aggfunc='count'),
    Number_Chips = pd.NamedAgg(column='PROD_QTY', aggfunc='sum'),
    Avg_Price_Per_Unit = pd.NamedAgg(column='UNIT_PRICE',
                                     aggfunc='mean'))).reset_index()

measure_over_time['Avg_Txn_Per_Cust'] = measure_over_time['Number_Txns'] / \
                                        measure_over_time['Number_Customers']
measure_over_time['Avg_Chips_Per_Txn'] = measure_over_time['Number_Chips'] / \
                                         measure_over_time['Number_Txns']
measure_over_time.drop(columns=['Number_Txns', 'Number_Chips'], inplace=True)
```

Filter Dataframe to Stores with Sales in All Months of the Pre-Trial Period

The dataframe excludes stores that did not have sales in each month of the financial year. It also only includes months in the pre-trial period.

In [5]:
```
stores_month_count = measure_over_time.groupby(['STORE_NBR']).agg(
    Count = pd.NamedAgg(column='YEARMONTH', aggfunc='count'))
stores_with_full_obs = [int(index)
                        for index, row in stores_month_count.iterrows()
                        if row['Count'] == 12]
pre_trial_measures = measure_over_time[measure_over_time.YEARMONTH < '2019-02']
pre_trial_measures = pre_trial_measures[pre_trial_measures.STORE_NBR.
                                        isin(stores_with_full_obs)]
```

Functions Required for Analysis

In [6]:
```
def calculate_correlation(df, metric_col, store_comparison):
    """
    Creates a new dataframe with correlations for a chosen metric between a
    selected trial store and all remaining stores. The correlations are used
    to help determine which store is most similar to the trial store.
    """
    store1 = df[df.STORE_NBR == store_comparison][metric_col]
    df = df[df.STORE_NBR != store_comparison]
    calculated_measure = []
    for number in df.STORE_NBR.unique():
        store2 = df[df.STORE_NBR == number][metric_col]
        corr, _ = pearsonr(store1, store2)
        calculated_measure.append([store_comparison, number, corr])

    calc_corr_table = pd.DataFrame(calculated_measure)
    calc_corr_table.columns = ['Trial_Store', 'Control_Stores', 'Correlation']
    return calc_corr_table
```

In [7]:

```
def calculate_magnitude_distance(df, metric_col, store_comparison):
    """
    Creates a new dataframe with standardized differences for a chosen metric
    between a selected trial store and each of the remaining stores. The
    calculated difference is used to help determine which store is most
    similar to the trial store.
    """
    calculated_measure = []
    for number in df.STORE_NBR.unique():
        for date in df.YEARMONTH.unique():
            distance1 = df[(df.YEARMONTH == date) &
                           (df.STORE_NBR == number)][metric_col]
            distance2 = df[(df.YEARMONTH == date) &
                           (df.STORE_NBR == store_comparison)][metric_col]
            calculated_measure.append([store_comparison,
                                       number,
                                       date,
                                       abs(float(distance1) -
                                           float(distance2))])

    calc_dist_table = pd.DataFrame(calculated_measure)
    calc_dist_table.columns = ['Trial_Store',
                               'Control_Stores',
                               'YEARMONTH',
                               'Measure']
    calc_dist_table = calc_dist_table[calc_dist_table.Control_Stores !=
                                      store_comparison]
    std_measure = pd.DataFrame(1 - (calc_dist_table.Measure -
                                    min(calc_dist_table.Measure)) /
                               (max(calc_dist_table.Measure -
                                    min(calc_dist_table.Measure))))
    std_measure.columns = ['Std_Measure']
    calc_dist_table = calc_dist_table.join(std_measure, how='outer')
    calc_dist_table.drop(columns=['Measure'], inplace=True)
    return calc_dist_table.groupby(['Trial_Store',
                                    'Control_Stores']).agg({'Std_Measure':
                                                            'mean'}). \
                                                             reset_index()
```

In [8]:
```
def best_control_store(corr_measure1,
                       corr_measure2,
                       dist_measure1,
                       dist_measure2,
                       corr_weight):
    """
    Uses a combination of measures to create a composite score to determine
    which store is most similar to the trial store.
    """
    sales_scores = pd.merge(corr_measure1,
                            dist_measure1,
                            how='left',
                            left_on=['Trial_Store','Control_Stores'],
                            right_on = ['Trial_Store','Control_Stores'])
    sales_scores['Sales_Scores'] = \
                            (abs(corr_measure1.Correlation)*corr_weight) + \
                            (dist_measure1.Std_Measure*corr_weight)

    customers_scores = pd.merge(corr_measure2,
                                dist_measure2,
                                how='left',
                                left_on=['Trial_Store','Control_Stores'],
                                right_on = ['Trial_Store','Control_Stores'])
    customers_scores['Customers_Scores'] = \
                                (abs(corr_measure2.Correlation)*corr_weight) + \
                                (dist_measure2.Std_Measure*corr_weight)

    total_score = pd.merge(sales_scores, customers_scores,
                           how='left',
                           left_on=['Trial_Store','Control_Stores'],
                           right_on = ['Trial_Store','Control_Stores'])
    total_score['Total_Score'] = \
                           (sales_scores.Sales_Scores*corr_weight) + \
                           (customers_scores.Customers_Scores*corr_weight)

    best_store = total_score.sort_values(by='Total_Score',
                                         ascending=False).Control_Stores.iloc[0]
    return best_store
```

In [9]:
```
def add_store_type(df, date, trial, control):
    """
    Adds a column to a dataframe that labels, the selected trial and control
    store with these names repectively. All other stores are labelled
    'Other stores'.
    """
    df = df[df.YEARMONTH < date]
    df['Store_type'] = ['Trial' if store == trial else
                        'Control' if store == control else
                        'Other stores' for store in df.STORE_NBR]
    return df
```

In [10]:
```
def plot_total_sales_by_month(df):
    """
    Plots total sales by month for each store type.
    """
    sns.set(rc={'figure.figsize':(10,6)})
    sns.lineplot(data=df, x='YEARMONTH', y='Tot_Sales', hue='Store_type')
    plt.xlabel('Month of Operation', fontsize = 20)
    plt.xticks(fontsize=15, rotation=70)
    plt.ylabel('Total Sales', fontsize = 20)
    plt.yticks(fontsize=15)
    plt.title('Total Sales by Month', fontsize = 22)
    plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
```

In [11]:
```
def plot_number_of_customers_by_month(df):
    """
    Plots number of customers by month for each store type.
    """
    sns.set(rc={'figure.figsize':(10,6)})
    sns.lineplot(data=df, x='YEARMONTH', y='Number_Customers', hue='Store_type')
    plt.xlabel('Month of Operation', fontsize = 20)
    plt.xticks(fontsize=15, rotation=70)
    plt.ylabel('Number of Customers', fontsize = 20)
    plt.yticks(fontsize=15)
    plt.title('Number of Customers by Month', fontsize = 22)
    plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
```

In [12]:
```
def scale_control_metric(pre_trial_df, full_df, trial, control, metric_col):
    """
    Returns a dataframe with the metric of the control store scaled in
    proportion to the trial store. The scaling is based only on values in
    the pre-trial period. This is required for a more accurate comparison.
    """
    scaling_factor_control_metric = \
                                sum(pre_trial_df[pre_trial_df.STORE_NBR ==
                                                 trial_store][metric_col]) / \
                                sum(pre_trial_df[pre_trial_df.STORE_NBR ==
                                                 control_store][metric_col])
    scaled_control_metric = full_df[full_df.STORE_NBR == control_store]
    scaled_control_metric['Control_Metric'] = \
                                        scaled_control_metric[metric_col] * \
                                        scaling_factor_control_metric
    return scaled_control_metric
```

In [13]:
```
def calculate_perc_diff(scaled_df, full_df, trial, metric_col):
    """
    Returns a dataframe with a calculation of the percentage difference between
    a scaled control metric and the same metric for a trial store.
    """
    control_metric = scaled_df[['YEARMONTH','Control_Metric']]
    trial_metric = full_df[full_df.STORE_NBR == trial][['YEARMONTH',metric_col]]
    perc_diff = pd.merge(control_metric,
                         trial_metric,
                         how='left',
                         left_on=['YEARMONTH'],
                         right_on = ['YEARMONTH'])
    perc_diff.rename(columns={metric_col: 'Trial_Metric'}, inplace=True)
    perc_diff['Percent_Diff'] = (perc_diff.Control_Metric -
                                 perc_diff.Trial_Metric) / \
                                 ((perc_diff.Control_Metric +
                                   perc_diff.Trial_Metric)/2)
    return perc_diff
```

In [14]:
```
def calculate_std_dev_mean(df):
    """
    Returns a standard deviation and mean for the calculated percentage
    difference of the required metric across the months in the pre-trial
    period.
    """
    std_dev = df[df.YEARMONTH < '2019-02']['Percent_Diff'].std()
    u = df[df.YEARMONTH < '2019-02']['Percent_Diff'].mean()
    return std_dev, u
```

In [15]:
```
def calculate_t_values(df, std_dev, u):
    """
    Returns a dataframe with a t-value statistic for the percentage
    differences between the scaled control metric and the same metric for the
    trial store.
    """
    df['T-Value'] = abs((df.Percent_Diff - u) / std_dev)
    return df
```

In [16]:
```
def create_control_trial_dataframe(df, trial, control):
    """
    Returns a datframe that only contains monthly values for the control and
    trial store over the entire financial year.
    """
    df['Store_type'] = ['Trial' if store == trial else
                        'Control' if store == control else
                        None for store in df.STORE_NBR]
    df['YEARMONTH'] = df['YEARMONTH'].astype(str)
    df = df[(df.Store_type == 'Control') | (df.Store_type == 'Trial')]
    return df
```

In [17]:
```
def control_conf_int(df, metric_col):
    """
    Returns a dataframe that adds a 5th and 95th confidence interval for the
    control store metric for each month.
    """
    df_Controls95 = df[df.Store_type == 'Control']
    df_Controls95[metric_col] = df_Controls95[metric_col] * (1 + std_dev * 2)
    df_Controls95.loc[:, 'Store_type'] = 'Control 95th % confidence interval'

    df_Controls5 = df[df.Store_type == 'Control']
    df_Controls5[metric_col] = df_Controls5[metric_col] * (1 - std_dev * 2)
    df_Controls5.loc[:, 'Store_type'] = 'Control 5th % confidence interval'
    return pd.concat([df, df_Controls95, df_Controls5])
```

Analysis for Trial Store 77

Select Control Store and Compare Total Sales and Number of Customers in Pre-Trial Period

Find the Most Similar Store to Trial Store 77

In [18]:
```
trial_store = 77
corr_sales = calculate_correlation(pre_trial_measures,
                                   'Tot_Sales',
                                   trial_store)
corr_customers = calculate_correlation(pre_trial_measures,
                                       'Number_Customers',
                                       trial_store)
std_dist_sales = calculate_magnitude_distance(pre_trial_measures,
                                              'Tot_Sales',
                                              trial_store)
std_dist_customers = calculate_magnitude_distance(pre_trial_measures,
                                                  'Number_Customers',
                                                  trial_store)
corr_weight = 0.5
control_store = best_control_store(corr_sales,
                                   corr_customers,
                                   std_dist_sales,
                                   std_dist_customers,
                                   corr_weight)
control_store
```

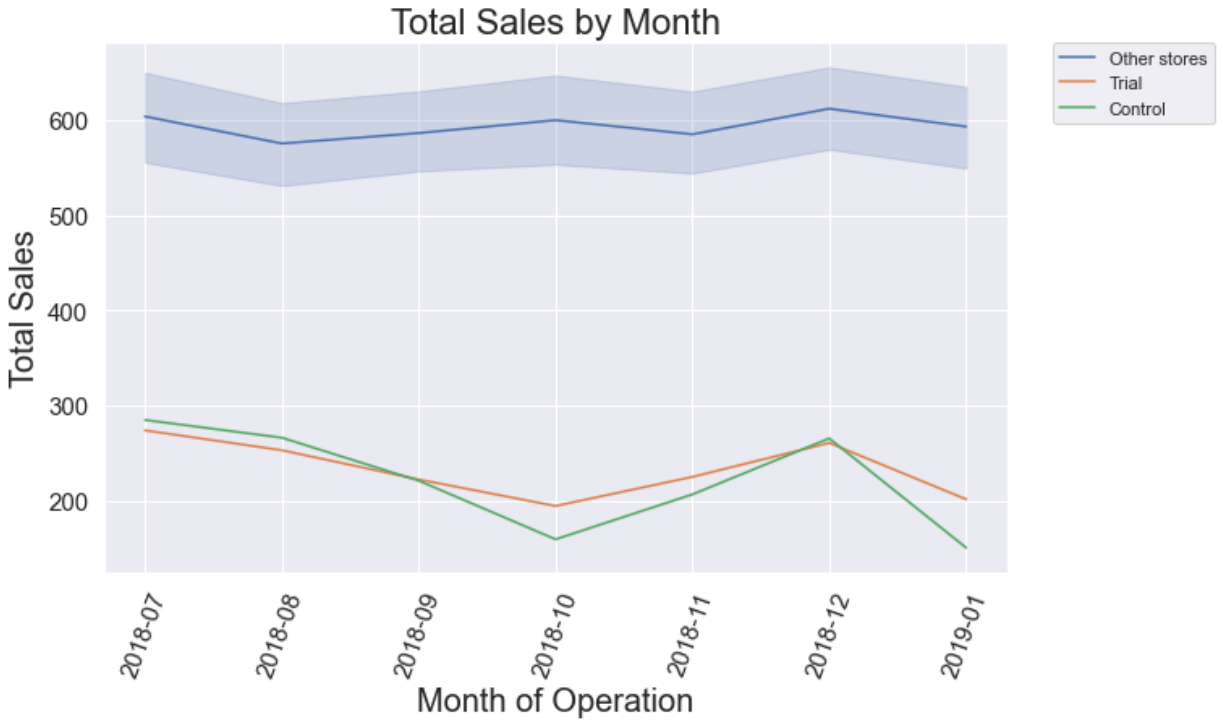
Out[18]:
```
233
```

Create Dataframe and Variable for Plots

In [19]:
```
trial_begin = '2019-02'
pre_trial = add_store_type(pre_trial_measures,
                           trial_begin,
                           trial_store,
                           control_store)
pre_trial['YEARMONTH'] = pre_trial['YEARMONTH'].astype(str)
```

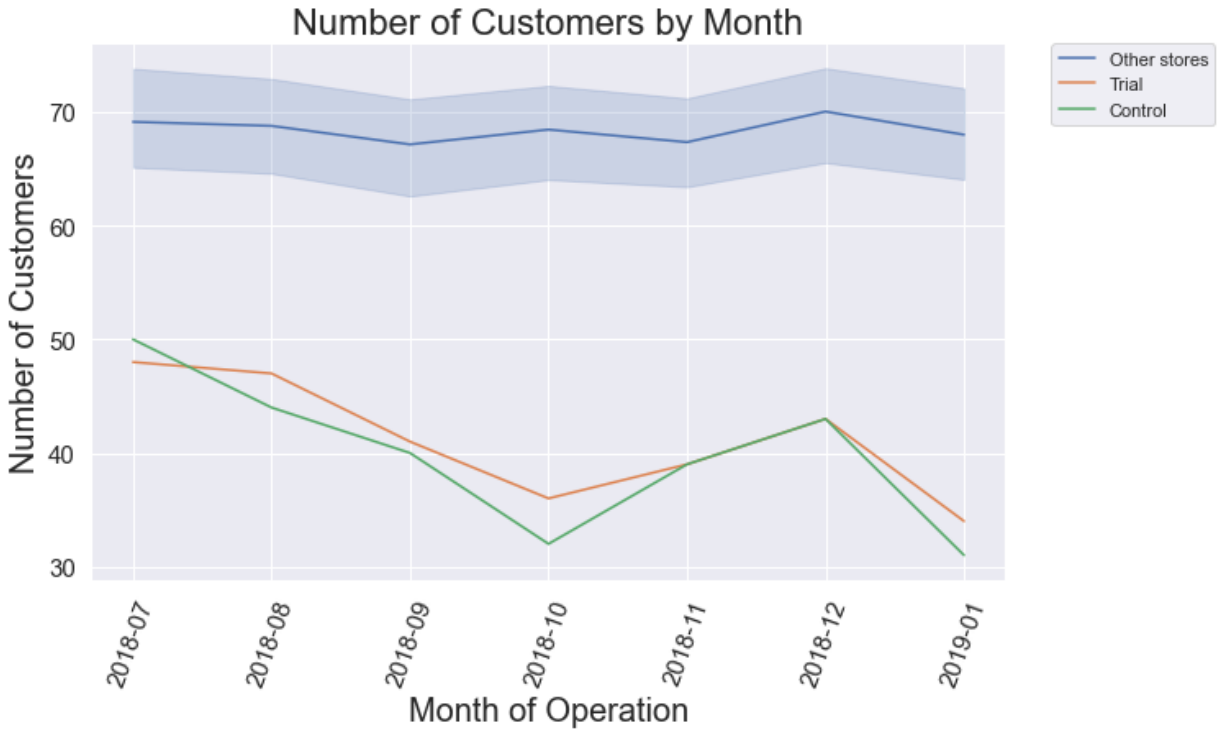
Plot Total Sales by Month in Pre-Trial Period

In [20]:
```
plot_total_sales_by_month(pre_trial)
```



Plot Number of Customers by Month in Pre-Trial Period

In [21]:
```
plot_number_of_customers_by_month(pre_trial)
```



Both graphs confirm that the totals sales and number of customers per month for the control store is similar to the trial store in the pre-trial period.

Assessment of Total Sales for Trial Store 77 in the Trial Period

T-Value Statistic Based On Pre-Trial Period

In [22]:
```
# There are seven months in the pre-trial period so the degrees of freedom are 7
p = 0.95
df = 6
t_dist_value = t.ppf(p, df)
t_dist_value
```

Out[22]:
```
1.9431802803927816
```

Determine if Percentage Difference Between the Control and Trial Total Sales is Statistically Significant

The t-values for March and April are higher than the expected value for a t-distribution with 6 degrees of freedom. Therefore, the higher relative sales for the trial store appear significant.

In [23]:
```
scale_control_sales = scale_control_metric(pre_trial_measures,
                                           measure_over_time,
                                           trial_store,
                                           control_store,
                                           'Tot_Sales')
perc_diff = calculate_perc_diff(scale_control_sales,
                                measure_over_time,
                                trial_store,
                                'Tot_Sales')
std_dev, u = calculate_std_dev_mean(perc_diff)
t_values = calculate_t_values(perc_diff, std_dev, u)
t_values
```

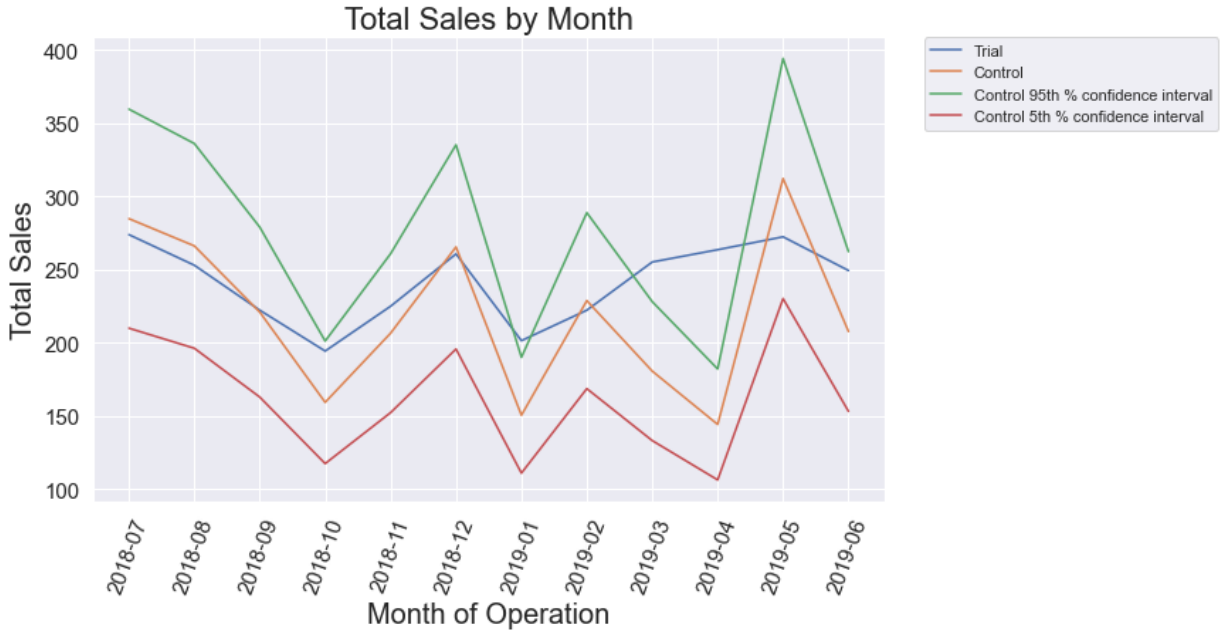
Out[23]:

	YEARMONTH	Control_Metric	Trial_Metric	Percent_Diff	T-Value
0	2018-07	298.757223	273.8	0.087178	0.809929
1	2018-08	279.238837	252.9	0.098992	0.899889
2	2018-09	231.807062	222.2	0.042321	0.468367
3	2018-10	167.165527	194.3	-0.150136	0.997095
4	2018-11	216.696054	224.9	-0.037156	0.136810
5	2018-12	278.504274	260.6	0.066422	0.651885
6	2019-01	157.931022	201.4	-0.241944	1.696166
7	2019-02	239.992191	222.2	0.076990	0.732356
8	2019-03	189.517227	255.1	-0.295008	2.100220
9	2019-04	151.319956	263.5	-0.540861	3.972269
10	2019-05	327.510113	272.3	0.184092	1.547879
11	2019-06	217.955304	249.3	-0.134165	0.875486

Plot Total Sales by Month for the Trial Store, Control Store and the Control Store's 5th and 95th Percentile

The graph below shows that sales for the trial store deviated significantly from the control store during the months of March and April. The increased sales for the trial store were also significantly higher than the 95% confidence interval for the control store. It should also be noted that the total sales for store 77 in the month of January is slightly outside the control stores confidence interval. However, the t-value above for this month was not considered significant and January is also outside the trial period.

In [24]:
```
all_months = create_control_trial_dataframe(measure_over_time,
                                            trial_store,
                                            control_store)
trialAssessment = control_conf_int(all_months, 'Tot_Sales')
plot_total_sales_by_month(trialAssessment)
```



Assessment of Number of Customers for Trial Store 77 in the Trial Period

T-Value Statistic Based On Pre-Trial Period

In [25]:
```
t_dist_value
```

Out[25]:
```
1.9431802803927816
```

Determine if Percentage Difference Between the Control and Trial Customer Numbers is Statistically Significant

The t-values for March and April are higher than the expected value for a t-distribution with 6 degrees of freedom.

In [26]:
```
scale_control_num_cust = scale_control_metric(pre_trial_measures,
                                              measure_over_time,
                                              trial_store,
                                              control_store,
                                              'Number_Customers')
perc_diff = calculate_perc_diff(scale_control_num_cust,
                                measure_over_time,
                                trial_store,
                                'Number_Customers')
std_dev, u = calculate_std_dev_mean(perc_diff)
t_values = calculate_t_values(perc_diff, std_dev, u)
t_values
```

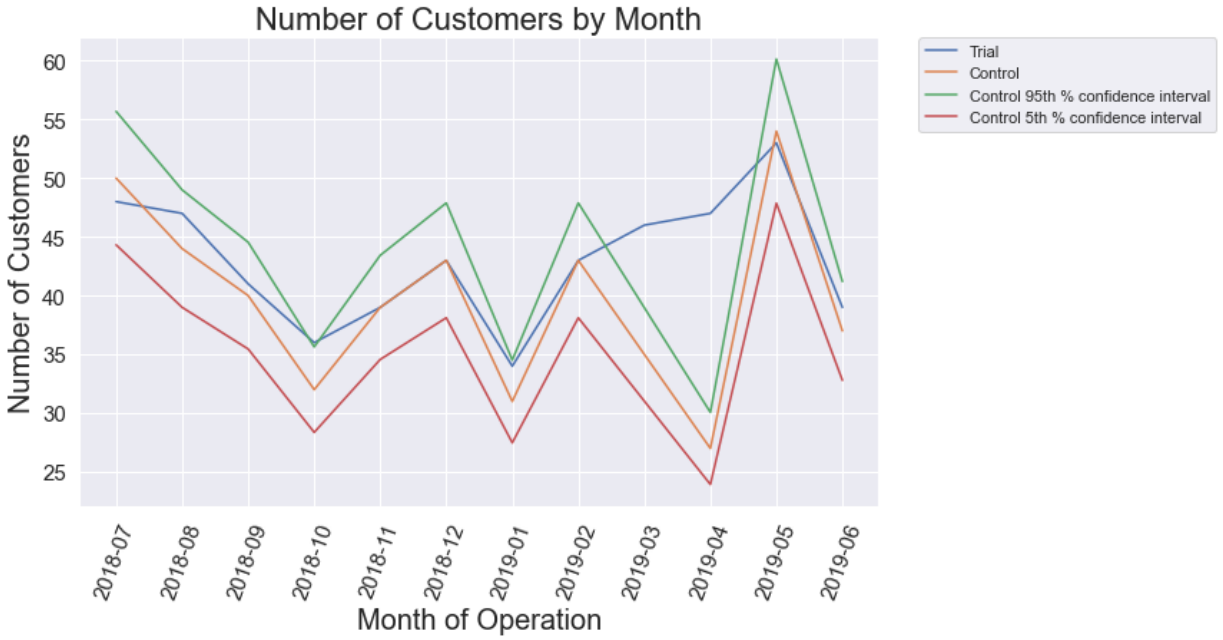
Out[26]:

	YEARMONTH	Control_Metric	Trial_Metric	Percent_Diff	T-Value
0	2018-07	51.612903	48	0.072539	1.371833
1	2018-08	45.419355	47	-0.034206	0.507347
2	2018-09	41.290323	41	0.007056	0.219046
3	2018-10	33.032258	36	-0.085981	1.418823
4	2018-11	40.258065	39	0.031746	0.653699
5	2018-12	44.387097	43	0.031746	0.653699
6	2019-01	32.000000	34	-0.060606	0.972106
7	2019-02	44.387097	43	0.031746	0.653699
8	2019-03	36.129032	46	-0.240377	4.136870
9	2019-04	27.870968	47	-0.510987	8.900795
10	2019-05	55.741935	53	0.050430	0.982622
11	2019-06	38.193548	39	-0.020894	0.273003

Plot Number of Customers by Month for the Trial Store, Control Store and the Control Store's 5th and 95th Percentile

The graph below shows that the number of customers for the trial store deviated significantly from the control store during the months of March and April. The increased number of customers for the trial store were also significantly higher than the 95% confidence interval for the control store.

In [27]:
```
all_months = create_control_trial_dataframe(measure_over_time,
                                            trial_store,
                                            control_store)
trialAssessment = control_conf_int(all_months, 'Number_Customers')
plot_number_of_customers_by_month(trialAssessment)
```



Analysis for Trial Store 86

Select Control Store and Compare Total Sales and Number of Customers in Pre-Trial Period

Find the Most Similar Store to Trial Store 86

In [28]:
```
trial_store = 86
corr_sales = calculate_correlation(pre_trial_measures,
                                   'Tot_Sales',
                                   trial_store)
corr_customers = calculate_correlation(pre_trial_measures,
                                       'Number_Customers',
                                       trial_store)
std_dist_sales = calculate_magnitude_distance(pre_trial_measures,
                                              'Tot_Sales',
                                              trial_store)
std_dist_customers = calculate_magnitude_distance(pre_trial_measures,
                                                  'Number_Customers',
                                                  trial_store)
corr_weight = 0.5
control_store = best_control_store(corr_sales,
                                   corr_customers,
                                   std_dist_sales,
                                   std_dist_customers,
                                   corr_weight)
control_store
```

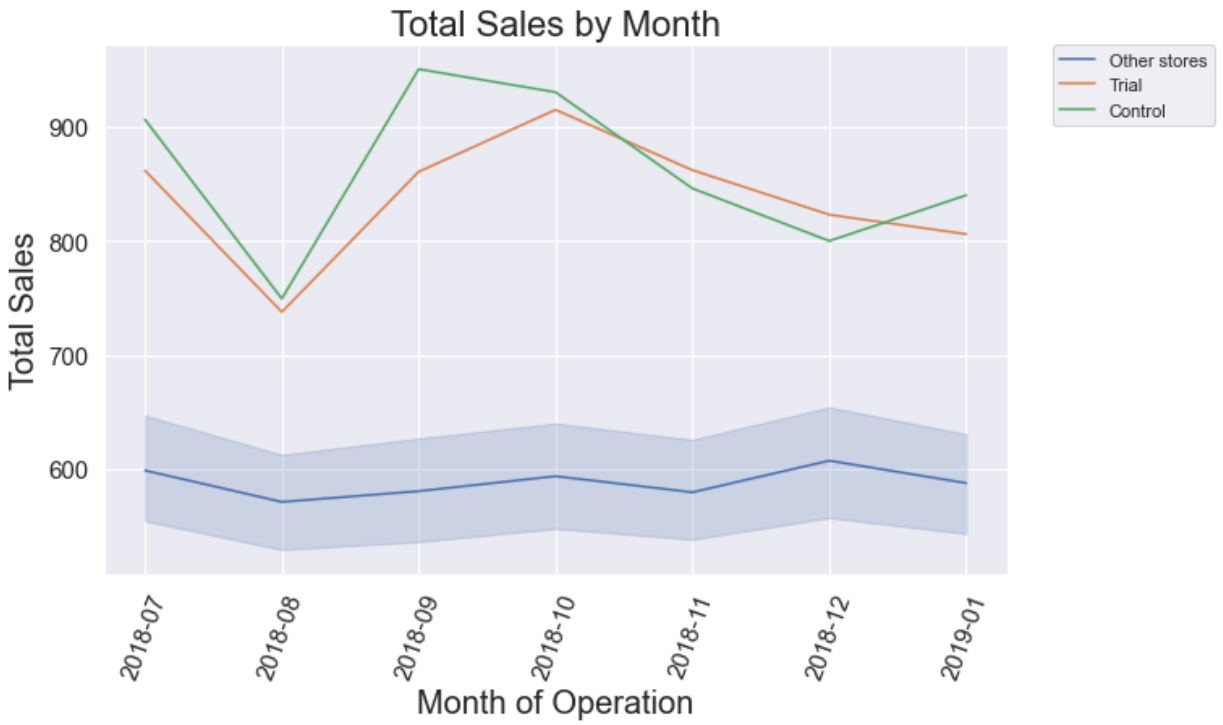
Out[28]:
```
155
```

Create Dataframe and Variable for Plots

In [29]:
```
trial_begin = '2019-02'
pre_trial = add_store_type(pre_trial_measures,
                           trial_begin,
                           trial_store,
                           control_store)
pre_trial['YEARMONTH'] = pre_trial['YEARMONTH'].astype(str)
```

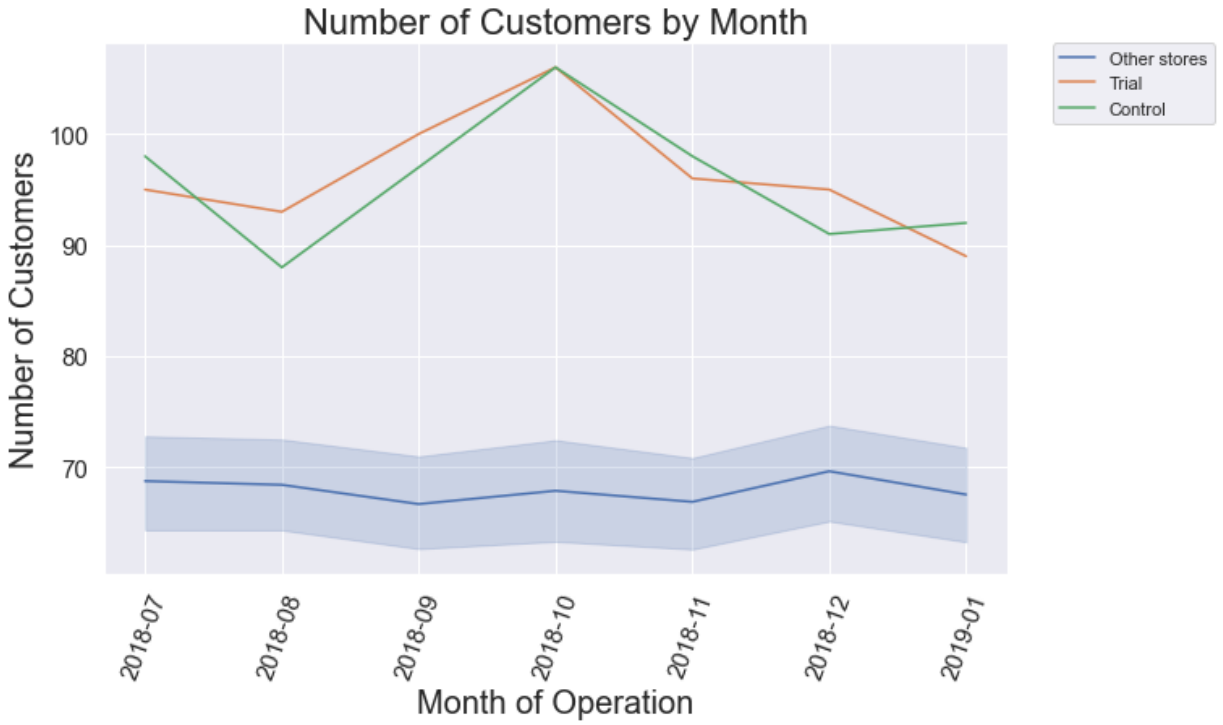
Plot Total Sales by Month in Pre-Trial Period

In [30]:
```
plot_total_sales_by_month(pre_trial)
```



Plot Number of Customers by Month in Pre-Trial Period

In [31]:
```
plot_number_of_customers_by_month(pre_trial)
```



Both graphs confirm that the totals sales and number of customers per month for the control store is similar to the trial store in the pre-trial period.

Assessment of Total Sales for Trial Store 86 in the Trial Period

T-Value Statistic Based On Pre-Trial Period

In [32]:
```
t_dist_value
```

Out[32]:
```
1.9431802803927816
```

Determine if Percentage Difference Between the Control and Trial Total Sales is Statistically Significant

The t-values show a significance difference in the month of March only.

In [33]:
```
scale_control_sales = scale_control_metric(pre_trial_measures,
                                           measure_over_time,
                                           trial_store,
                                           control_store,
                                           'Tot_Sales')
perc_diff = calculate_perc_diff(scale_control_sales,
                                measure_over_time,
                                trial_store,
                                'Tot_Sales')
std_dev, u = calculate_std_dev_mean(perc_diff)
t_values = calculate_t_values(perc_diff, std_dev, u)
t_values
```

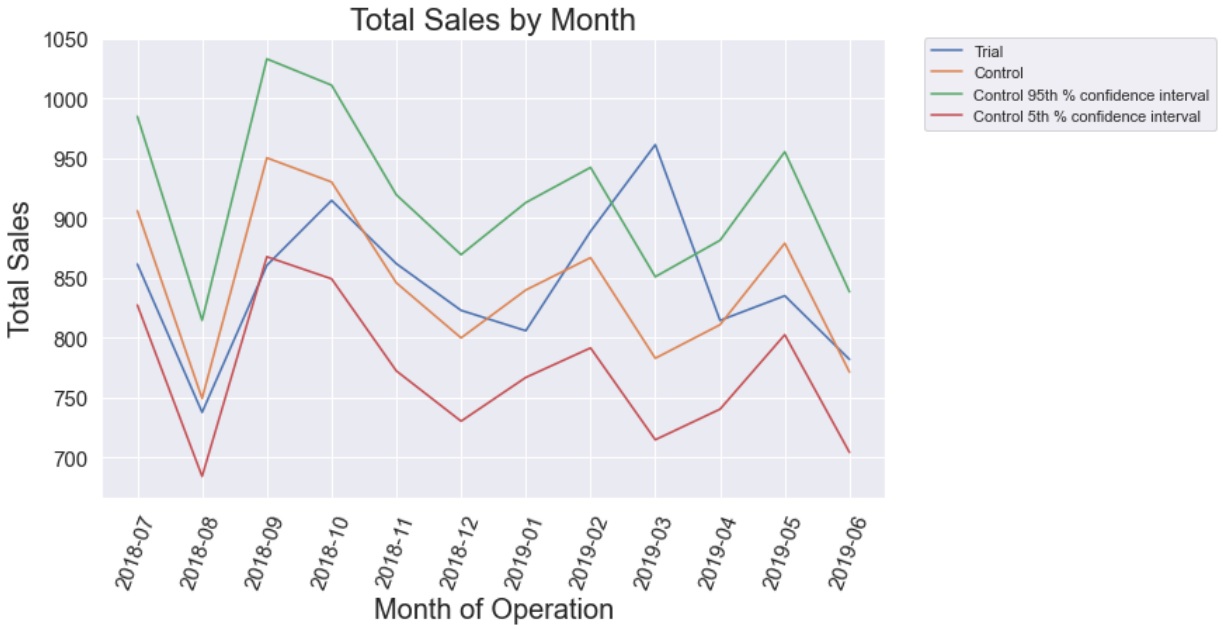
Out[33]:

	YEARMONTH	Control_Metric	Trial_Metric	Percent_Diff	T-Value
0	2018-07	882.458054	861.40	0.024151	0.581625
1	2018-08	729.829824	737.65	-0.010658	0.219026
2	2018-09	925.509540	860.40	0.072915	1.703246
3	2018-10	905.834427	914.60	-0.009630	0.195386
4	2018-11	823.822321	861.80	-0.045061	1.010331
5	2018-12	779.017607	822.80	-0.054666	1.231262
6	2019-01	817.978228	805.80	0.015000	0.371135
7	2019-02	844.276646	888.80	-0.051381	1.155699
8	2019-03	762.459343	961.20	-0.230603	5.278032
9	2019-04	789.731778	814.40	-0.030756	0.681302
10	2019-05	856.013533	835.00	0.024853	0.597773
11	2019-06	751.160763	781.80	-0.039974	0.893329

Plot Total Sales by Month for the Trial Store, Control Store and the Control Store's 5th and 95th Percentile

In the trial period, there is only a significant increase of sales in March for the trial store. All other months are similar to the control store.

In [34]:
```
all_months = create_control_trial_dataframe(measure_over_time,
                                            trial_store,
                                            control_store)
trialAssessment = control_conf_int(all_months, 'Tot_Sales')
plot_total_sales_by_month(trialAssessment)
```



Assessment of Number of Customers for Trial Store 86 in the Trial Period

T-Value Statistic Based On Pre-Trial Period

In [35]:
```
t_dist_value
```

Out[35]:
```
1.9431802803927816
```

Determine if Percentage Difference Between the Control and Trial Customer Numbers is Statistically Significant

The t-values for the months of February and March show a significance increase of customers for the trial store.

In [36]:
```
scale_control_num_cust = scale_control_metric(pre_trial_measures,
                                              measure_over_time,
                                              trial_store,
                                              control_store,
                                              'Number_Customers')
perc_diff = calculate_perc_diff(scale_control_num_cust,
                                measure_over_time,
                                trial_store,
                                'Number_Customers')
std_dev, u = calculate_std_dev_mean(perc_diff)
t_values = calculate_t_values(perc_diff, std_dev, u)
t_values
```

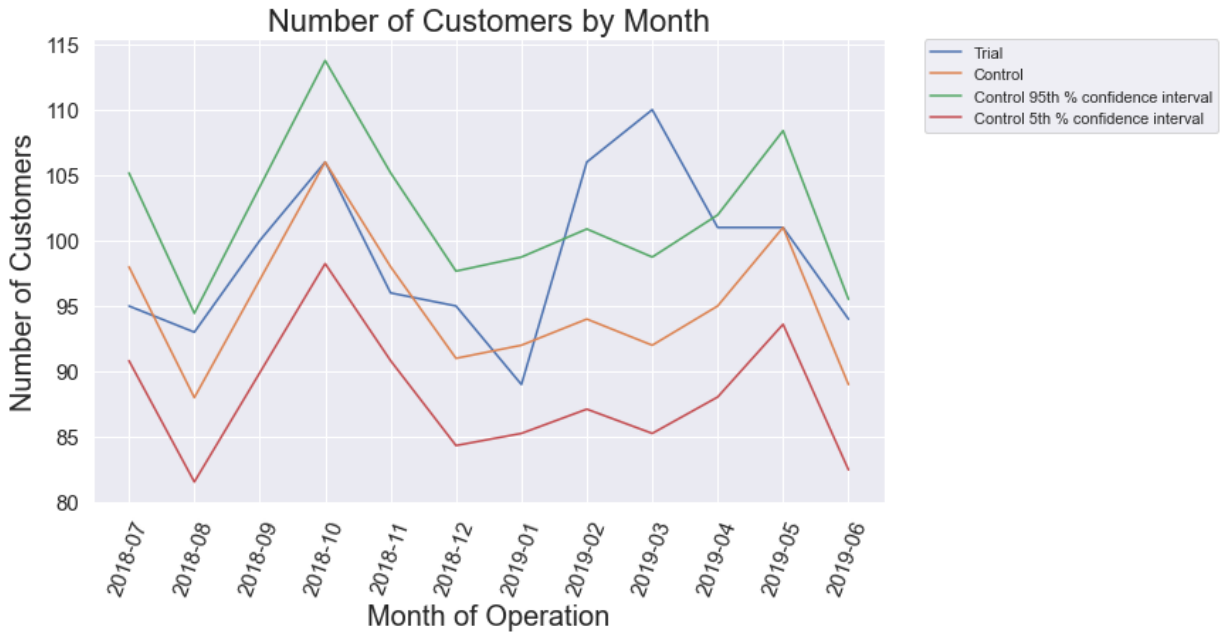
Out[36]:

	YEARMONTH	Control_Metric	Trial_Metric	Percent_Diff	T-Value
0	2018-07	98.585075	95	0.037039	1.020056
1	2018-08	88.525373	93	-0.049300	1.337683
2	2018-09	97.579104	100	-0.024506	0.660591
3	2018-10	106.632836	106	0.005952	0.171152
4	2018-11	98.585075	96	0.026570	0.734179
5	2018-12	91.543284	95	-0.037061	1.003446
6	2019-01	92.549254	89	0.039100	1.076334
7	2019-02	94.561194	106	-0.114068	3.106353
8	2019-03	92.549254	110	-0.172311	4.696851
9	2019-04	95.567164	101	-0.055277	1.500898
10	2019-05	101.602985	101	0.005952	0.171152
11	2019-06	89.531343	94	-0.048696	1.321191

Plot Number of Customers by Month for the Trial Store, Control Store and the Control Store's 5th and 95th Percentile

For February, there was a significant increase of customers for the trial store although this was not reflected in the total sales for the same month. The increased number of customers for March was also outside the 95th percentage confidence interval as was the case for the total sales in that month.

In [37]:
```
all_months = create_control_trial_dataframe(measure_over_time,
                                            trial_store,
                                            control_store)
trialAssessment = control_conf_int(all_months, 'Number_Customers')
plot_number_of_customers_by_month(trialAssessment)
```



Analysis for Trial Store 88

Select Contol Store and Compare Total Sales and Number of Customers in Pre-Trial Period

Find the Most Similar Store to Trial Store 88

In [38]:
```
trial_store = 88
corr_sales = calculate_correlation(pre_trial_measures,
                                   'Tot_Sales',
                                   trial_store)
corr_customers = calculate_correlation(pre_trial_measures,
                                       'Number_Customers',
                                       trial_store)
std_dist_sales = calculate_magnitude_distance(pre_trial_measures,
                                              'Tot_Sales',
                                              trial_store)
std_dist_customers = calculate_magnitude_distance(pre_trial_measures,
                                                  'Number_Customers',
                                                  trial_store)
corr_weight = 0.5
control_store = best_control_store(corr_sales,
                                   corr_customers,
                                   std_dist_sales,
                                   std_dist_customers,
                                   corr_weight)
control_store
```

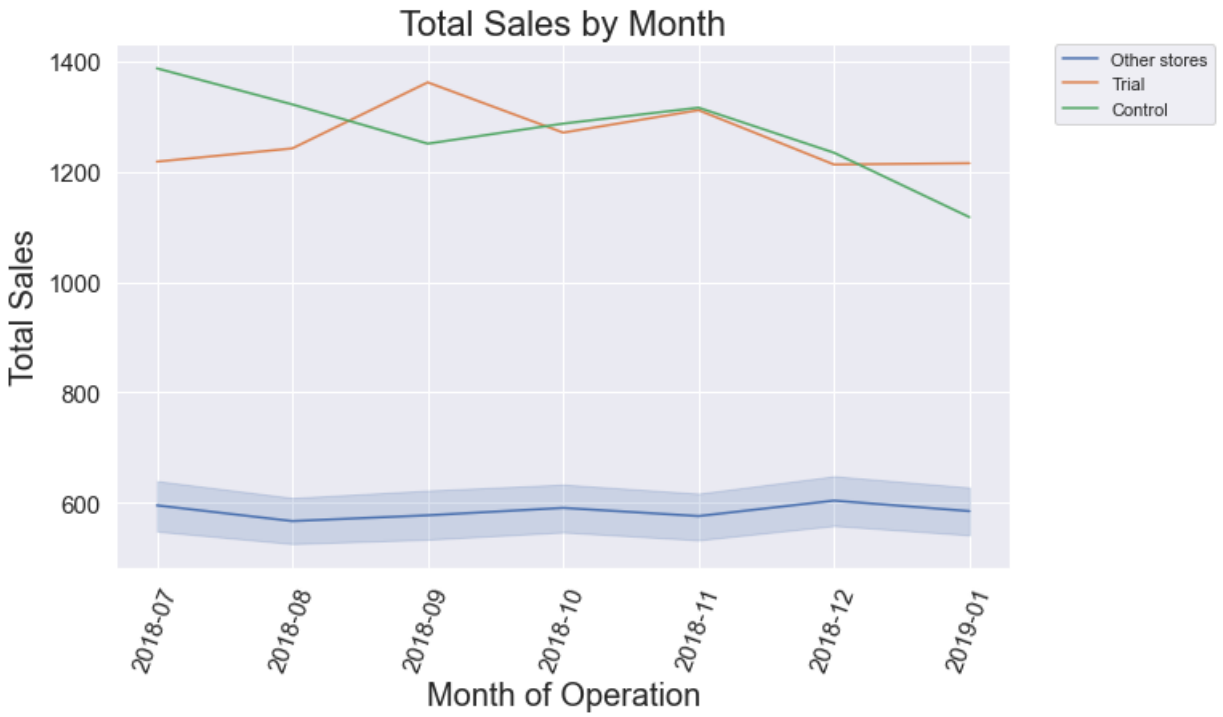
Out[38]:
```
237
```

Create Dataframe and Variable for Plots

In [39]:
```
trial_begin = '2019-02'
pre_trial = add_store_type(pre_trial_measures,
                           trial_begin,
                           trial_store,
                           control_store)
pre_trial['YEARMONTH'] = pre_trial['YEARMONTH'].astype(str)
```

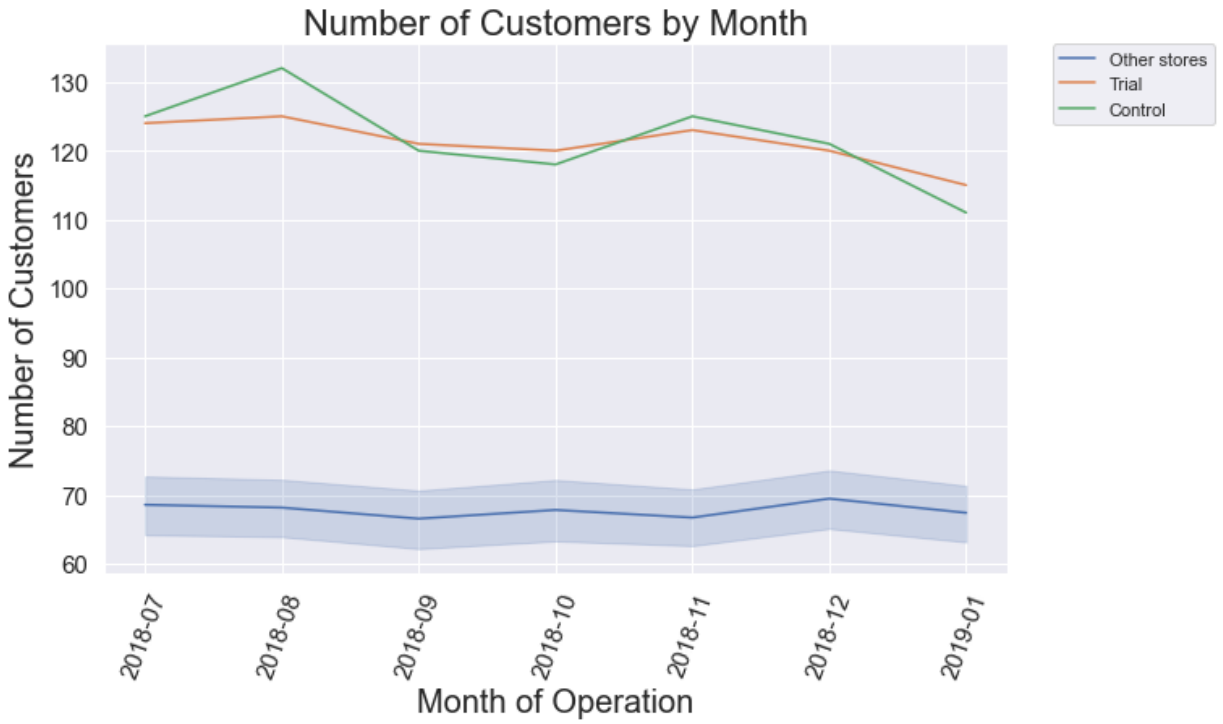
Plot Total Sales by Month in Pre-Trial Period

In [40]:
```
plot_total_sales_by_month(pre_trial)
```



Plot Number of Customers by Month in Pre-Trial Period

In [41]:
```
plot_number_of_customers_by_month(pre_trial)
```



Both graphs confirm that the totals sales and number of customers per month for the control store are similar to the trial store in the pre-trial period.

Assessment of Total Sales for Trial Store 88 in the Trial Period

T-Value Statistic Based On Pre-Trial Period

In [42]:
```
t_dist_value
```

Out[42]:
```
1.9431802803927816
```

Determine if Percentage Difference Between the Control and Trial Total Sales is Statistically Significant

The t-values show a significance difference in the month of March only.

In [43]:
```
scale_control_sales = scale_control_metric(pre_trial_measures,
                                           measure_over_time,
                                           trial_store,
                                           control_store,
                                           'Tot_Sales')
perc_diff = calculate_perc_diff(scale_control_sales,
                                measure_over_time,
                                trial_store,
                                'Tot_Sales')
std_dev, u = calculate_std_dev_mean(perc_diff)
t_values = calculate_t_values(perc_diff, std_dev, u)
t_values
```

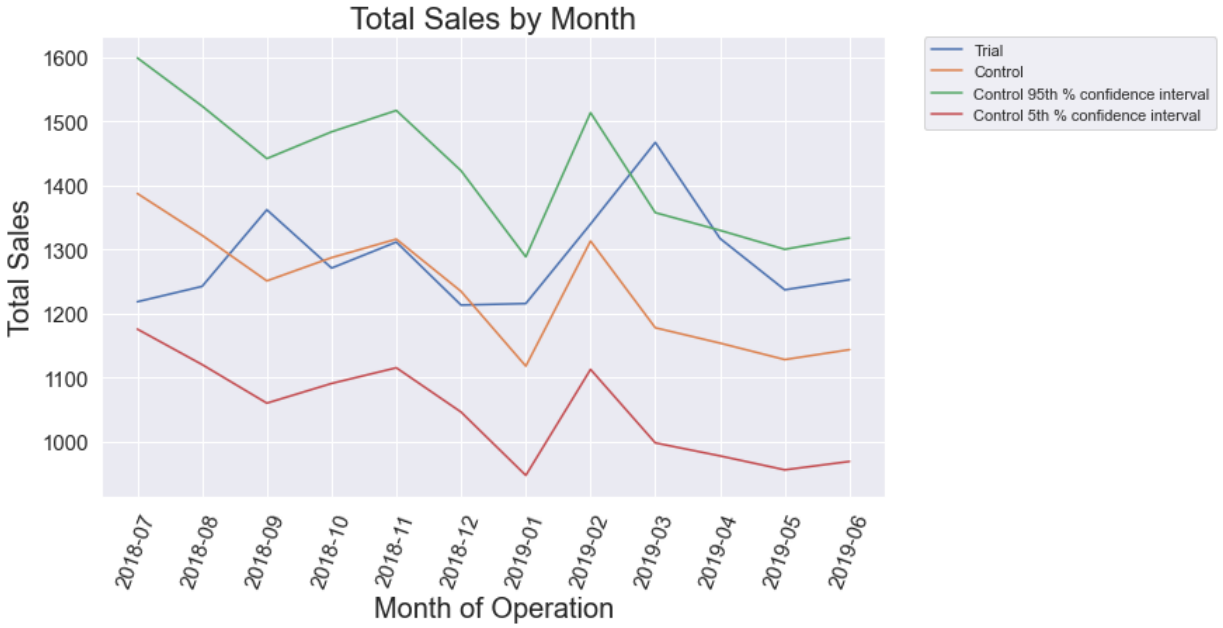
Out[43]:

	YEARMONTH	Control_Metric	Trial_Metric	Percent_Diff	T-Value
0	2018-07	1374.394024	1218.20	0.120492	1.593592
1	2018-08	1309.696842	1242.20	0.052899	0.707958
2	2018-09	1239.253204	1361.80	-0.094229	1.219775
3	2018-10	1275.218100	1270.80	0.003471	0.060321
4	2018-11	1303.851308	1311.40	-0.005773	0.060790
5	2018-12	1223.004601	1213.00	0.008214	0.122471
6	2019-01	1107.381921	1215.40	-0.093008	1.203776
7	2019-02	1300.879003	1339.60	-0.029329	0.369430
8	2019-03	1166.728952	1467.00	-0.228020	2.972763
9	2019-04	1142.950509	1317.00	-0.141506	1.839230
10	2019-05	1117.487759	1236.85	-0.101398	1.313708
11	2019-06	1132.844670	1252.60	-0.100405	1.300702

Plot Total Sales by Month for the Trial Store, Control Store and the Control Store's 5th and 95th Percentile

The plot confirms the t-value result showing total sales were only significantly higher in March. There is also a noticeable difference between the trial and control store in April. However, the trial stores total sales are still within the confidence interval of the control store.

In [44]:
```
all_months = create_control_trial_dataframe(measure_over_time,
                                            trial_store,
                                            control_store)
trialAssessment = control_conf_int(all_months, 'Tot_Sales')
plot_total_sales_by_month(trialAssessment)
```



Assessment of Number of Customers for Trial Store 88 in the Trial Period

T-Value Statistic Based On Pre-Trial Period

In [45]:
```
t_dist_value
```

Out[45]:
```
1.9431802803927816
```

Determine if Percentage Difference Between the Control and Trial Customer Numbers is Statistically Significant

Like with the monthly total sales, there is only a significant difference in March.

In [46]:
```
scale_control_num_cust = scale_control_metric(pre_trial_measures,
                                              measure_over_time,
                                              trial_store,
                                              control_store,
                                              'Number_Customers')
perc_diff = calculate_perc_diff(scale_control_num_cust,
                                measure_over_time,
                                trial_store,
                                'Number_Customers')
std_dev, u = calculate_std_dev_mean(perc_diff)
t_values = calculate_t_values(perc_diff, std_dev, u)
t_values
```

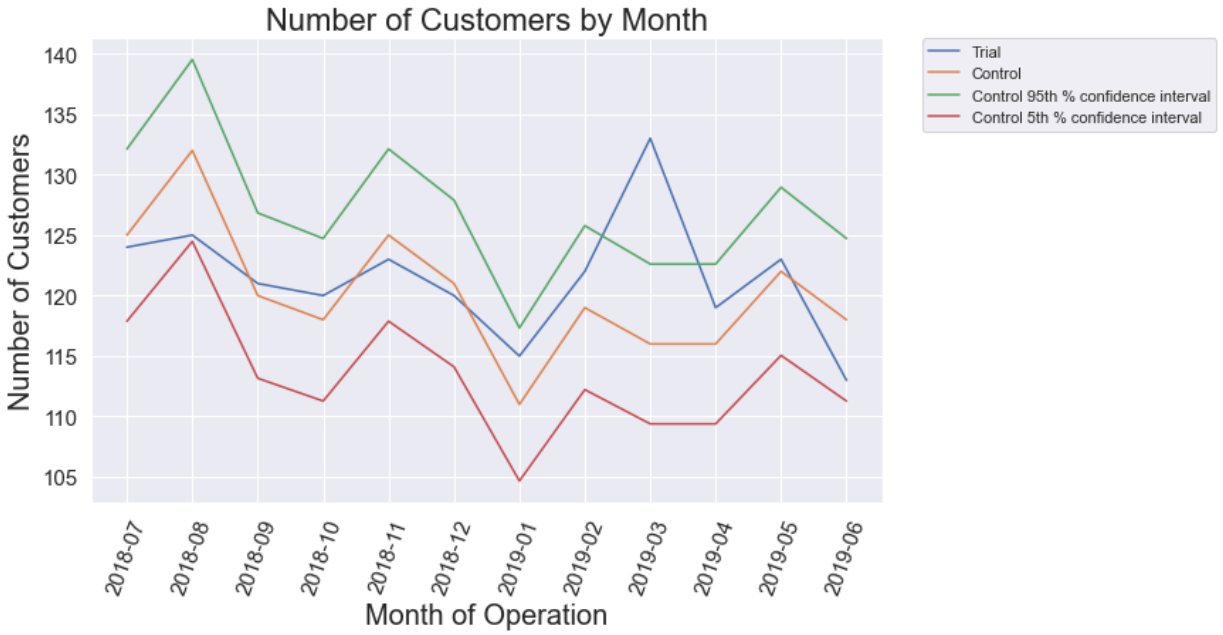
Out[46]:

	YEARMONTH	Control_Metric	Trial_Metric	Percent_Diff	T-Value
0	2018-07	124.413146	124	0.003326	0.149434
1	2018-08	131.380282	125	0.049772	1.780403
2	2018-09	119.436620	121	-0.013005	0.424031
3	2018-10	117.446009	120	-0.021512	0.722782
4	2018-11	124.413146	123	0.011423	0.433768
5	2018-12	120.431925	120	0.003593	0.158797
6	2019-01	110.478873	115	-0.040102	1.375590
7	2019-02	118.441315	122	-0.029601	1.006836
8	2019-03	115.455399	133	-0.141229	4.926720
9	2019-04	115.455399	119	-0.030237	1.029155
10	2019-05	121.427230	123	-0.012869	0.419273
11	2019-06	117.446009	113	0.038586	1.387604

Plot Number of Customers by Month for the Trial Store, Control Store and the Control Store's 5th and 95th Percentile

The plot also shows that there was only a significant difference in the number of customers in March.

In [47]:
```
all_months = create_control_trial_dataframe(measure_over_time,
                                            trial_store,
                                            control_store)
trialAssessment = control_conf_int(all_months, 'Number_Customers')
plot_number_of_customers_by_month(trialAssessment)
```



Conclusion

There appears to be evidence that the trial layout of a new chips category has had some impact on total sales and increased patronage for the trial stores. However, the level of success is varied across the three trial stores.

Store 77 had the greatest improvement. In the trial period, two of the three months resulted in significant increases for total sales and the number of customers for this store. For store 86, there was only a significant increase in total sales in March. This was also reflected by a significant increase in the number of customers in the same month. Curiously, store 86 also had a significant increase in the number of customers in February. However, the increases in total sales for that month, although higher than the control store, were not found to be significant. Finally, store 88 saw significant increases for total sales and number of customers only in the month of March.

Although, all trial stores recorded improvements in total sales and number of customers from the promotion, there was no clear evidence of this until the second month of the trial period. For stores 86 and 88, the increases only lasted for one month during the trial period. Store 77 not only continued with significant increases into April but also further improved on March when the sales and number of customers for the control store where declining over the same time.

The promotion in the trial stores overall can be considered a success. However, some changes may need to be made to sustain the increased sales and number of customers for longer than a month. This problem was clearly evident for stores 86 and 88.