In [1]:

```
#importing libraries
import numpy as np # linear algebra
import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
import os #operating system dependent modules of Python
import matplotlib.pyplot as plt #visualization
import seaborn as sns #visualization
%matplotlib inline
import itertools
import plotly.offline as py#visualization
py.init_notebook_mode(connected=True)#visualization
import plotly.graph_objs as go#visualization
import plotly.tools as tls#visualization
import plotly.figure_factory as ff#visualization
import warnings
warnings.filterwarnings("ignore")
```

In [2]:

```
#loading time series data of chicago
data_complete=pd.read_csv("D://Taxi_Trips.csv.fdmdownload", nrows=20000000)
```

In [3]:

```
#features present in taxi fare data
data_complete.columns
```

Out[3]:

```
Index(['Trip ID', 'Taxi ID', 'Trip Start Timestamp', 'Trip End Timestamp',
       'Trip Seconds', 'Trip Miles', 'Pickup Census Tract',
       'Dropoff Census Tract', 'Pickup Community Area',
       'Dropoff Community Area', 'Fare', 'Tips', 'Tolls', 'Extras',
       'Trip Total', 'Payment Type', 'Company', 'Pickup Centroid Latitude',
       'Pickup Centroid Longitude', 'Pickup Centroid Location',
       'Dropoff Centroid Latitude', 'Dropoff Centroid Longitude',
       'Dropoff Centroid  Location'],
      dtype='object')
```

In [5]:
```
#getting first hand idea of the data
data_complete.describe()
```

Out[5]:

	Trip Seconds	Trip Miles	Pickup Census Tract	Dropoff Census Tract	Pickup Community Area	Dropoff Community Area	Fare	Tips	Tolls	Extras	Tr
count	1.628003e+07	1.628105e+07	1.201806e+07	1.192147e+07	1.627869e+07	1.587400e+07	1.628072e+07	1.628072e+07	8.943330e+06	1.628072e+07	1.628C
mean	7.997748e+02	3.497085e+00	1.703138e+10	1.703136e+10	2.403175e+01	2.202636e+01	1.290479e+01	1.418779e+00	3.289088e-03	9.504636e-01	1.532€
std	1.036150e+03	5.521356e+00	3.434064e+05	3.339522e+05	1.977851e+01	1.783219e+01	3.812855e+01	2.633587e+00	5.728440e-01	1.258253e+01	4.108€
min	0.000000e+00	0.000000e+00	1.703101e+10	1.703101e+10	1.000000e+00	1.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000C
25%	3.570000e+02	7.000000e-01	1.703108e+10	1.703108e+10	8.000000e+00	8.000000e+00	6.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	7.000C
50%	5.610000e+02	1.400000e+00	1.703128e+10	1.703128e+10	2.400000e+01	2.200000e+01	8.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	9.500C
75%	9.600000e+02	3.400000e+00	1.703184e+10	1.703183e+10	3.200000e+01	3.200000e+01	1.325000e+01	2.000000e+00	0.000000e+00	1.000000e+00	1.505C
max	8.635500e+04	1.870000e+03	1.703198e+10	1.703198e+10	7.700000e+01	7.700000e+01	9.900280e+03	8.810000e+02	1.024990e+03	8.889880e+03	9.975:

In [4]:
```
#extracting useful features from the data
data=data_complete.drop(columns=['Trip ID','Taxi ID','Pickup Census Tract','Dropoff Census Tract','Pickup Centroid Location','D
ropoff Centroid  Location'])
```

In [5]:
```
#Date Manipulation extracting date,month,year
data["Trip Start Timestamp"]=data["Trip Start Timestamp"].apply(lambda row: row.replace(' ','/'))
data["Trip Start Timestamp"]=data["Trip Start Timestamp"].apply(lambda row: row.replace('-','/'))
data["Tripstart_month"]=data["Trip Start Timestamp"].apply(lambda row: row.split('/')[0])
data["Tripstart_year"]=data["Trip Start Timestamp"].apply(lambda row: row.split('/')[2])
data["Tripstart_day"]=data["Trip Start Timestamp"].apply(lambda row: row.split('/')[1])

#merging date to form date time object
data['Tripstart_time']=pd.to_datetime(data['Tripstart_year']+data['Tripstart_month']+data['Tripstart_day'],format='%Y%m%d')
```

In [7]:

```
#calculating missing values for each feature
data.isnull().sum()
```

Out[7]:

```
Trip Start Timestamp                0
Trip End Timestamp                191
Trip Seconds                        0
Trip Miles                          0
Pickup Community Area            2600
Dropoff Community Area         407293
Fare                              570
Tips                              570
Tolls                         7337958
Extras                            570
Trip Total                          0
Payment Type                        0
Company                         14384
Pickup Centroid Latitude            0
Pickup Centroid Longitude           0
Dropoff Centroid Latitude      362015
Dropoff Centroid Longitude     362015
Tripstart_month                     0
Tripstart_year                      0
Tripstart_day                       0
Tripstart_time                      0
dtype: int64
```

In [6]:

```
#filling missing values of fares

#First filling missing values in trip time based on avg trip time
avg_triptime=data['Trip Seconds'].mean()
data['Trip Seconds'].fillna(avg_triptime, inplace= True)

#filling trip miles based on avg distance
avg_speed = data['Trip Miles'].div(data['Trip Seconds']).replace([np.inf, -np.inf], np.nan).mean()
data['Trip Miles'].fillna(avg_speed * data['Trip Seconds'], inplace=True)

#filling fare based on average cost
avg_mon = data['Trip Total'].div(data['Trip Seconds']).replace([np.inf, -np.inf], np.nan).mean()
data['Trip Total'].fillna(avg_mon * data['Trip Miles'], inplace=True)
```

In [11]:

```
data.columns
```

Out[11]:

```
Index(['Trip Start Timestamp', 'Trip End Timestamp', 'Trip Seconds',
       'Trip Miles', 'Pickup Community Area', 'Dropoff Community Area', 'Fare',
       'Tips', 'Tolls', 'Extras', 'Trip Total', 'Payment Type', 'Company',
       'Pickup Centroid Latitude', 'Pickup Centroid Longitude',
       'Dropoff Centroid Latitude', 'Dropoff Centroid Longitude',
       'Tripstart_month', 'Tripstart_year', 'Tripstart_day', 'Tripstart_time'],
      dtype='object')
```

In [8]:

```
data=data[data['Trip Total']!=0]
```

In [9]:

```
data=data[data['Trip Miles']!=0]
```

```
In [10]: #variable summary
         summary = data.describe().transpose().reset_index().rename(columns = {"index" :
                                                                          "variable"})

         summary  = np.around(summary,2)

         var_lst = [summary["variable"],summary["count"],summary['mean'],summary['std'],
                    summary["min"],summary["25%"],summary["50%"],summary["75%"],summary["max"]]

         table = go.Table(header = dict(values = summary.columns.tolist(),
                                        line = dict(color = ['#506784']),
                                        fill = dict(color = ['#119DFF']),
                                       ),
                          cells  = dict(values = var_lst,
                                        line = dict(color = ['#506784']),
                                        fill = dict(color = ["lightgrey",'#F5F8FF']),
                                       ),
                          columnwidth = [130,80,80,80,80,80,80,80,80])

         layout = go.Layout(dict(title = "Variable Summary"))
         figure = go.Figure(data=[table],layout=layout)
         py.iplot(figure)
```

Variable Summary

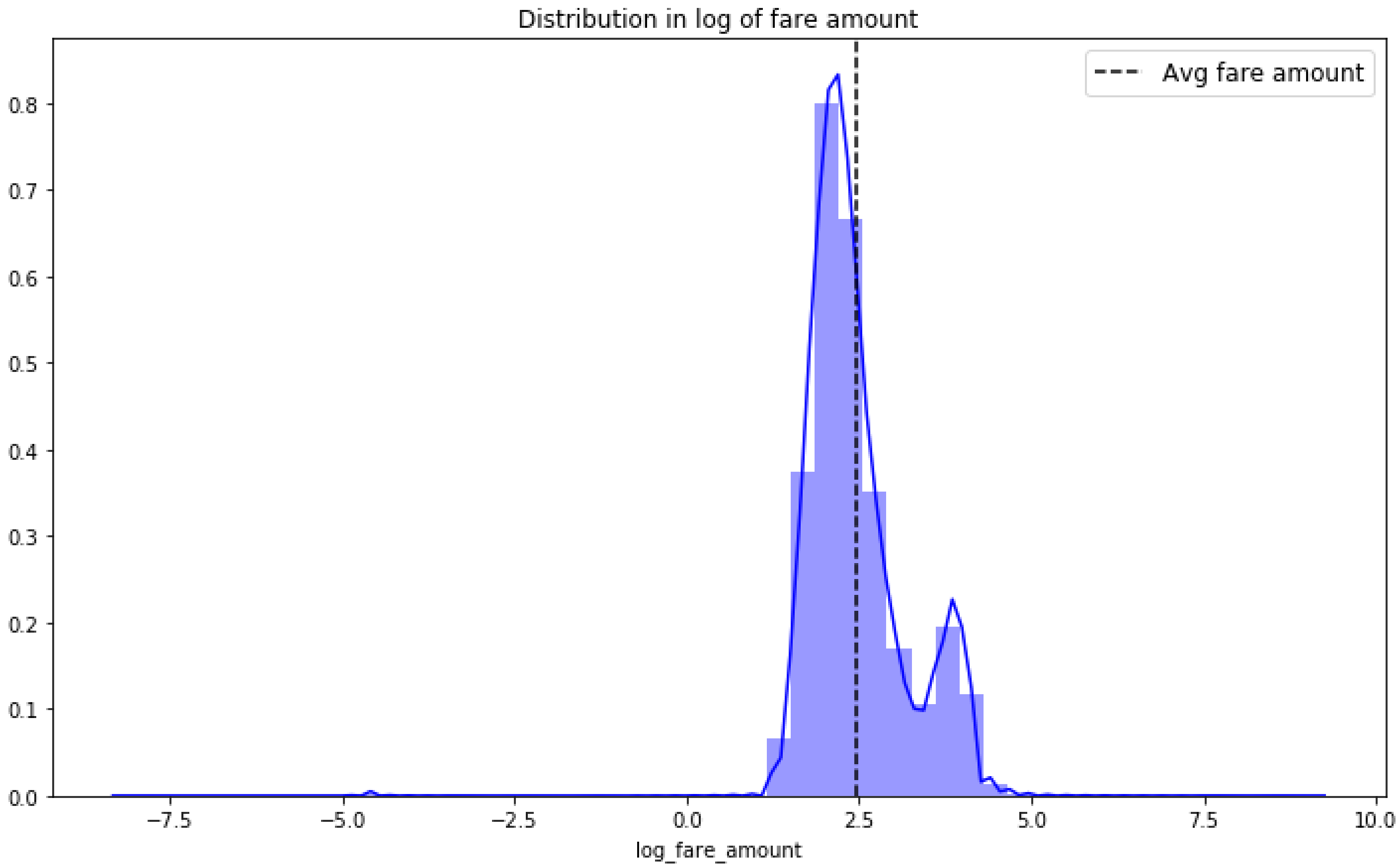
variable	count	mean	std	min	25%	50%	75%	max
Trip Seconds	14241789	843.2	981.68	0	369	600	1004	86097
Trip Miles	14241789	4	5.68	0	0.9	1.7	4.1	1870
Pickup Community Area	14241032	24.11	19.88	1	8	24	32	77
Dropoff Community Area	13875371	21.94	17.74	1	8	22	32	77
Fare	14241394	13.39	29.65	0	6.25	8.45	14	9742.75
Tips	14241394	1.49	2.65	0	0	0	2	881
Tolls	7262332	0	0.43	0	0	0	0	1024.99
Extras	14241394	0.93	8.01	0	0	0	1	8889.88
Trip Total	14241789	15.87	31.97	0	7.25	10	15.9	9746.85
Pickup Centroid Latitude	14241789	41.9	0.04	41.66	41.88	41.89	41.91	42.02
Pickup Centroid Longitude	14241789	-87.66	0.07	-87.91	-87.66	-87.63	-87.63	-87.53

In [ ]:

```python
# Distribuion plots for numerical features

cols = ['Trip Total','Pickup Centroid Longitude', 'Dropoff Centroid Longitude','Pickup Centroid Latitude', 'Dropoff Centroid Latitude']

length=len(cols)

cs     = [(0.8941176470588236, 0.10196078431372549, 0.10980392156862745),
          (0.21568627450980393, 0.49411764705882355, 0.7215686274509804),
          (0.30196078431372547, 0.6862745098039216, 0.2901960784313726),
          (0.596078431372549, 0.3058823529411765, 0.6392156862745098),
          (1.0, 0.4980392156862745, 0.0),"b"]

sns.set_style("darkgrid")
plt.figure(figsize = (13,15))
for i,j,k in itertools.zip_longest(cols,range(length),cs) :
    plt.subplot(length/2,length/3,j+1)
    sns.distplot(data[i],color = k)
    plt.axvline(data[i].mean(),linewidth  = 2 ,
                linestyle = "dashed",color = "k" ,
                label = "Mean")
    plt.legend(loc = "best")
    plt.title(i,color = "b")
    plt.xlabel("")
```

In [11]:

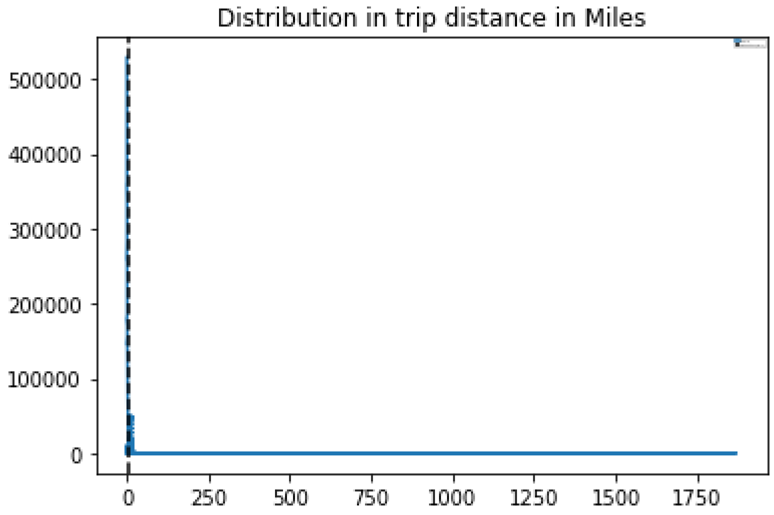
```
# Distribution of log fare amount

data['log_fare_amount']=np.log(data['Trip Total'])
plt.figure(figsize = (12,7))
sns.distplot(data["log_fare_amount"],color = "b")
plt.axvline(data["log_fare_amount"].mean(),color = "k",
            linestyle = "dashed",label = "Avg fare amount")
plt.title("Distribution in log of fare amount")
plt.legend(loc = "best",prop = {"size" : 12})
plt.show()
```



In [12]:

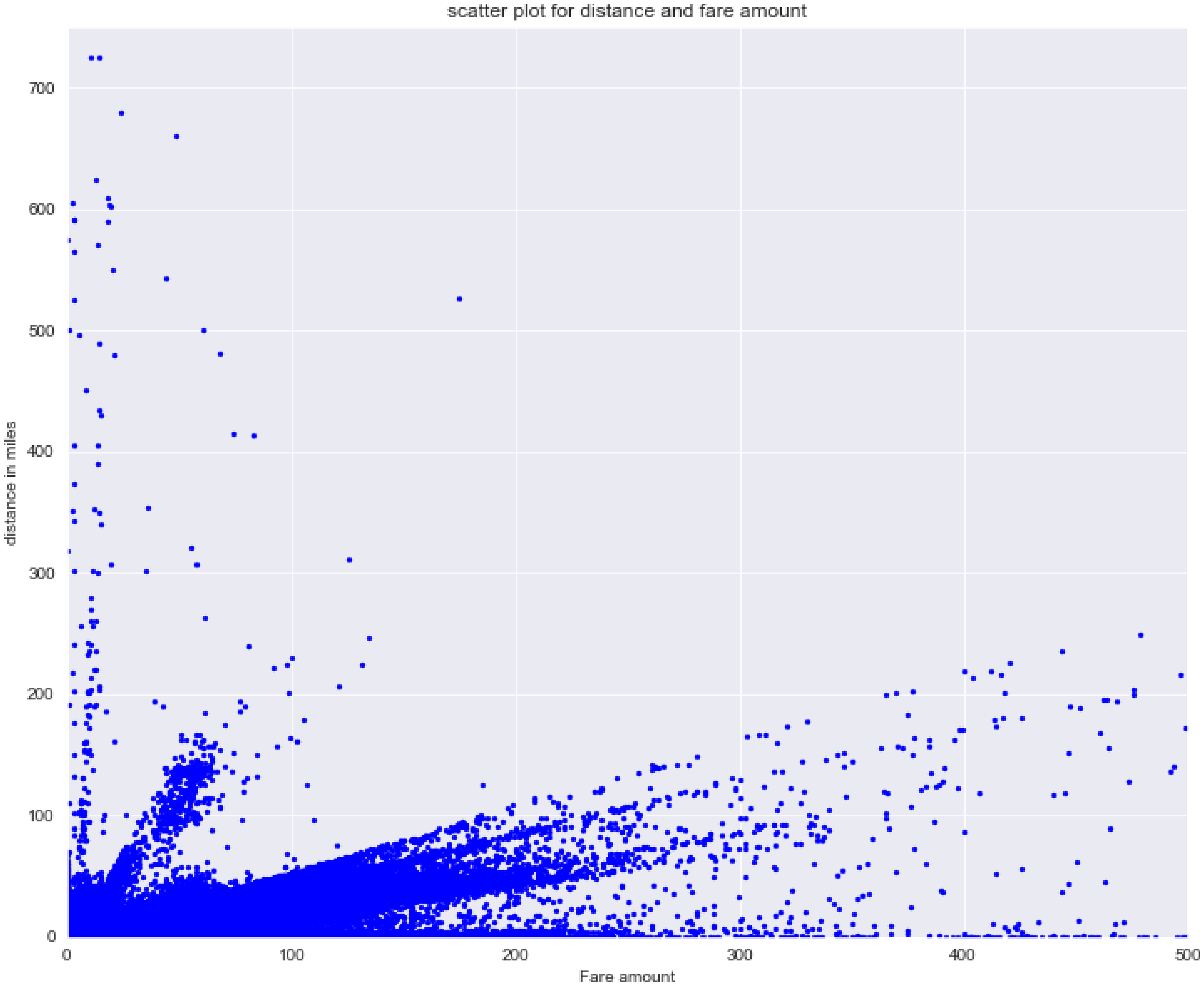
```python
# Distribution of distance in miles
import matplotlib.pyplot as plt
plt.figure(figsize = (12,7))
# axes=plt.gca()
# axes.set_xlim([0,10])
# axes.set_ylim([0,750])
fig, ax = plt.subplots()
# data['Trip Miles'].value_counts().plot(ax=ax, kind='bar')
plt.plot(data["Trip Miles"].value_counts())
plt.axvline(data["Trip Miles"].mean(),color = "k",
            linestyle = "dashed",label = "Avg trip distance (Miles)")
plt.title("Distribution in trip distance in Miles")
plt.legend(loc = "best",prop = {"size" : 1})
plt.show()
```

```
<Figure size 864x504 with 0 Axes>
```



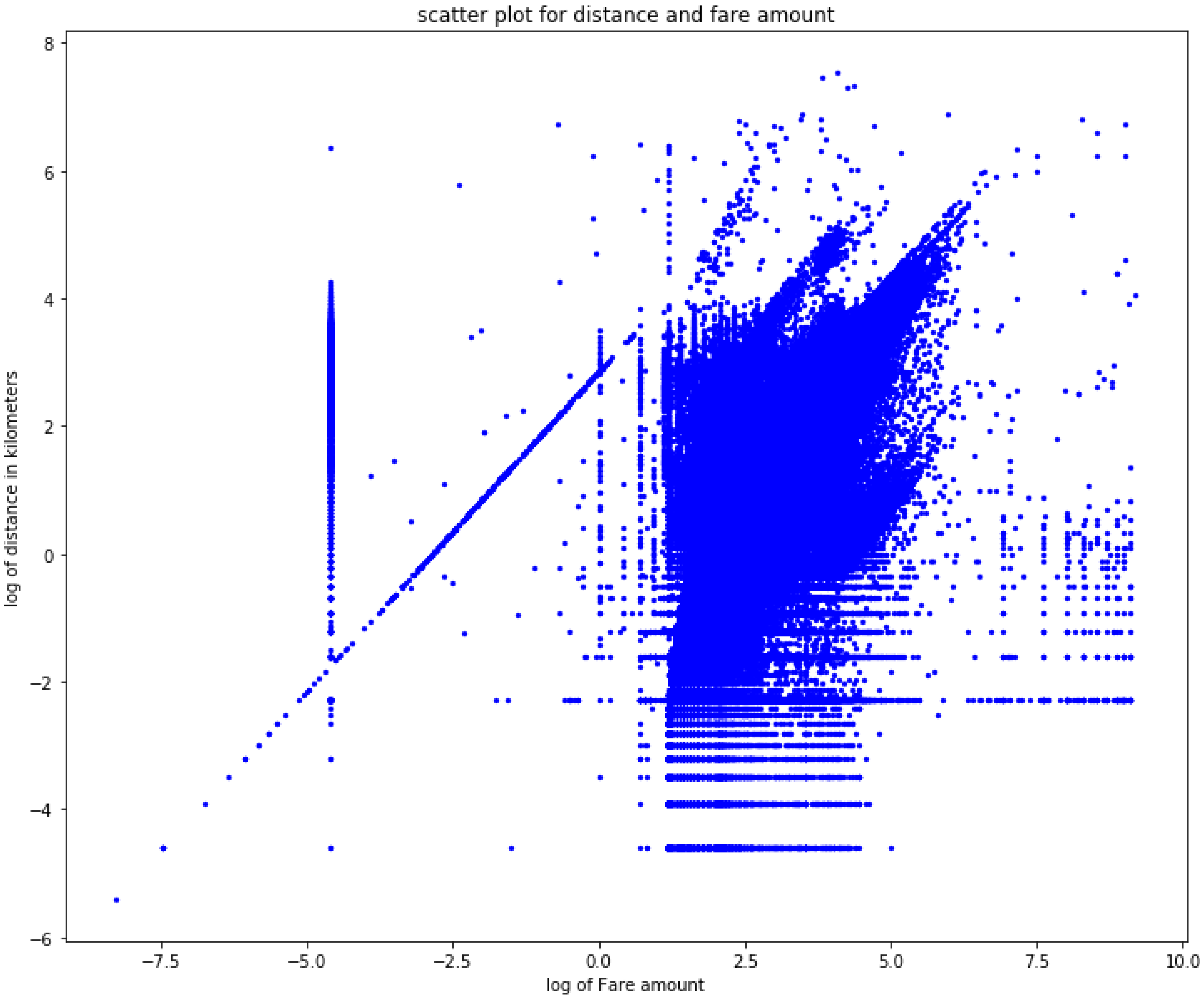
In [29]:

```
# Scatter plot for distance and fare amount

plt.figure(figsize = (12,10))
axes=plt.gca()
plt.scatter(data["Trip Total"],
            data["Trip Miles"],s = 5,
            linewidths=1, c = "b")
plt.ylabel("distance in miles")
plt.xlabel("Fare amount")
plt.title("scatter plot for distance and fare amount")
axes.set_xlim([0,500])
axes.set_ylim([0,750])
plt.show()
```


scatter plot for distance and fare amount
distance in miles
0
100
200
300
400
500
600
700
Fare amount
0
100
200
300
400
500

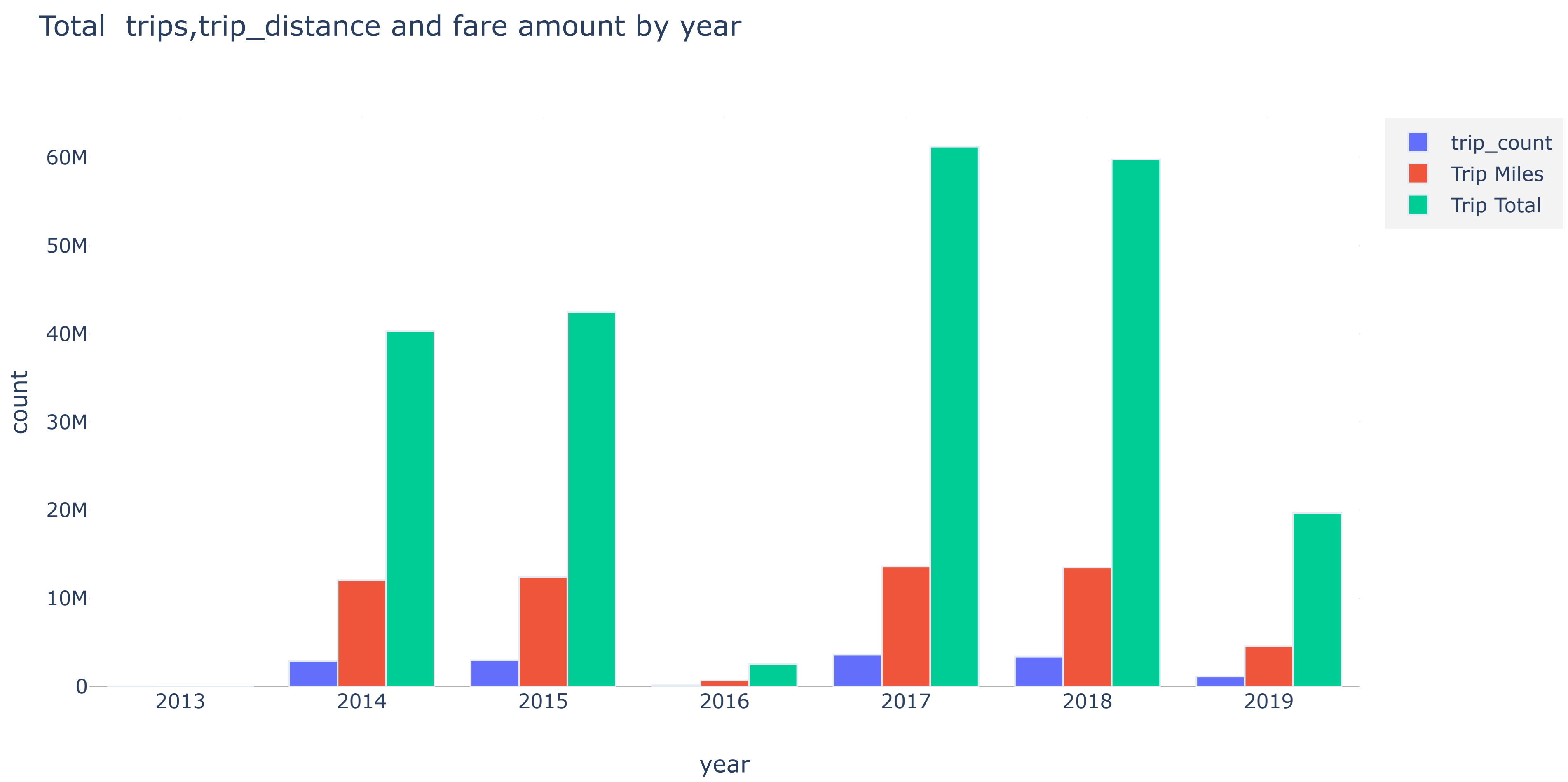
In [13]:

```
# Scatter plot of log of distance vs log of fare amount

data['log_trip_distance']=np.log(data['Trip Miles'])
plt.figure(figsize = (12,10))
plt.scatter(data["log_fare_amount"],
            data["log_trip_distance"],s = 5,
            linewidths=1, c = "b")
plt.ylabel("log of distance in kilometers")
plt.xlabel("log of Fare amount")
plt.title("scatter plot for distance and fare amount")
plt.show()
```


scatter plot for distance and fare amount
log of distance in kilometers
8
6
4
2
0
−2
−4
−6
−7.5
−5.0
−2.5
0.0
2.5
5.0
7.5
10.0
log of Fare amount

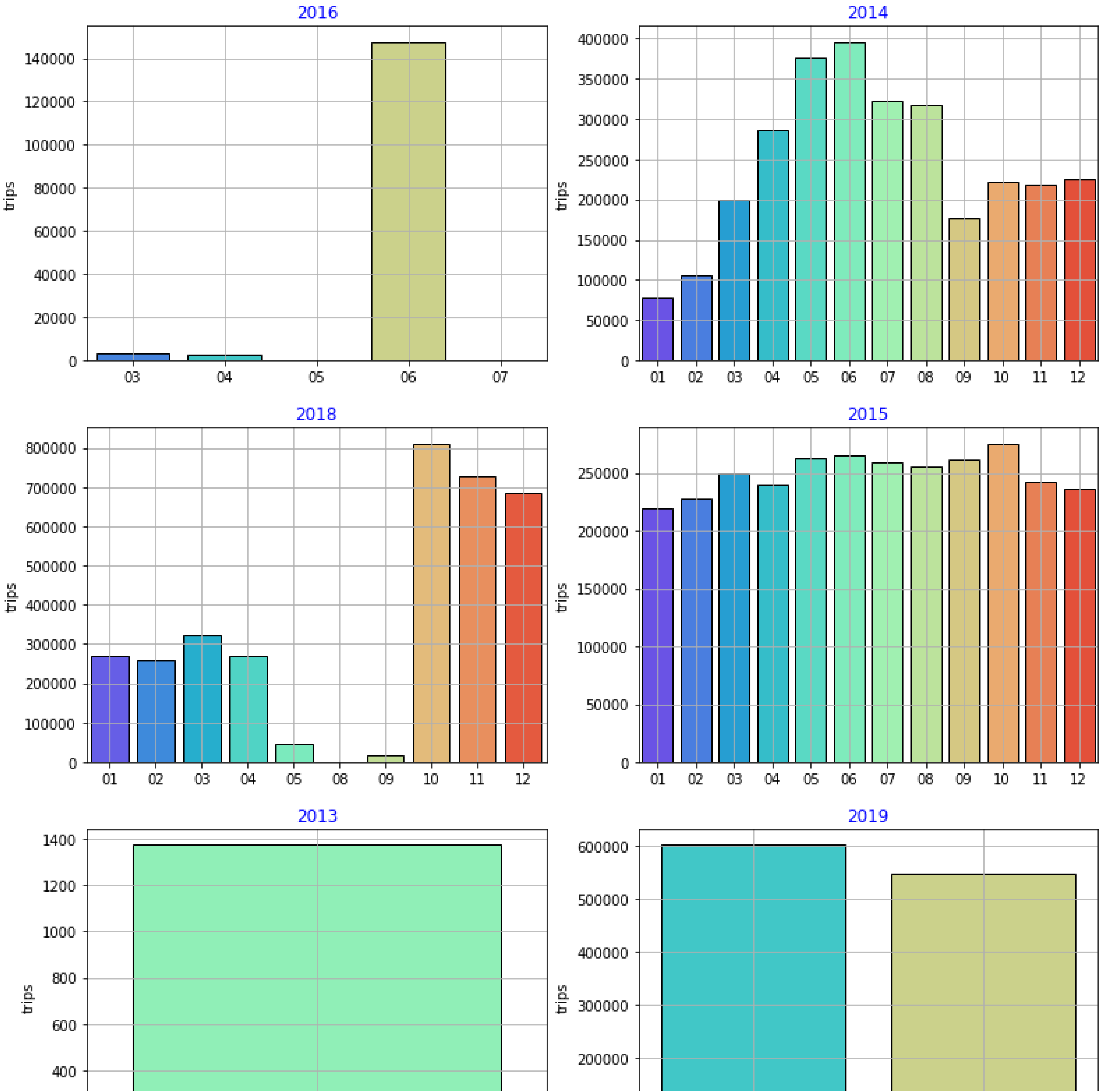
In [16]:

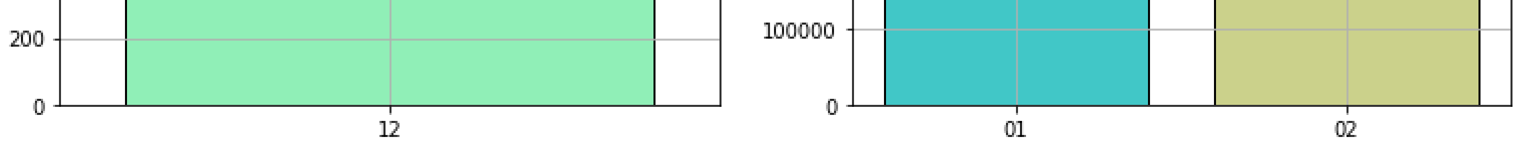
```
# Total Trips and fare amount by each year

yearly_analysis  = data.groupby("Tripstart_year").agg({"Trip Start Timestamp":"count","Trip Total":"sum","Trip Miles" : "sum"})
.reset_index()
#aggregating by year
yearly_analysis = yearly_analysis.rename(columns = {"Trip Start Timestamp" : "trip_count"})

def plotting(column) :
    tracer = go.Bar(x= yearly_analysis["Tripstart_year"],y = yearly_analysis[column],
                    marker = dict(line = dict(width = 1)),
                    name = column
                   )
    return tracer

#layout
layout = go.Layout(dict(title = "Total  trips,trip_distance and fare amount by year",
                        plot_bgcolor  = "rgb(243,243,243)",
                        paper_bgcolor = "rgb(243,243,243)",
                        xaxis = dict(gridcolor = 'rgb(255, 255, 255)',title = "year",
                                     zerolinewidth=1,ticklen=5,gridwidth=2),
                        yaxis = dict(gridcolor = 'rgb(255, 255, 255)',title = "count",
                                     zerolinewidth=1,ticklen=5,gridwidth=2),
                       )
                  )

data_new = [plotting("trip_count"),plotting("Trip Miles"),plotting("Trip Total")]
fig  = go.Figure(data=data_new,layout=layout)
py.iplot(fig)
```


Total trips,trip_distance and fare amount by year
trip_count
Trip Miles
Trip Total
count
60M
50M
40M
30M
20M
10M
0
2013
2014
2015
2016
2017
2018
2019
year

In [30]:

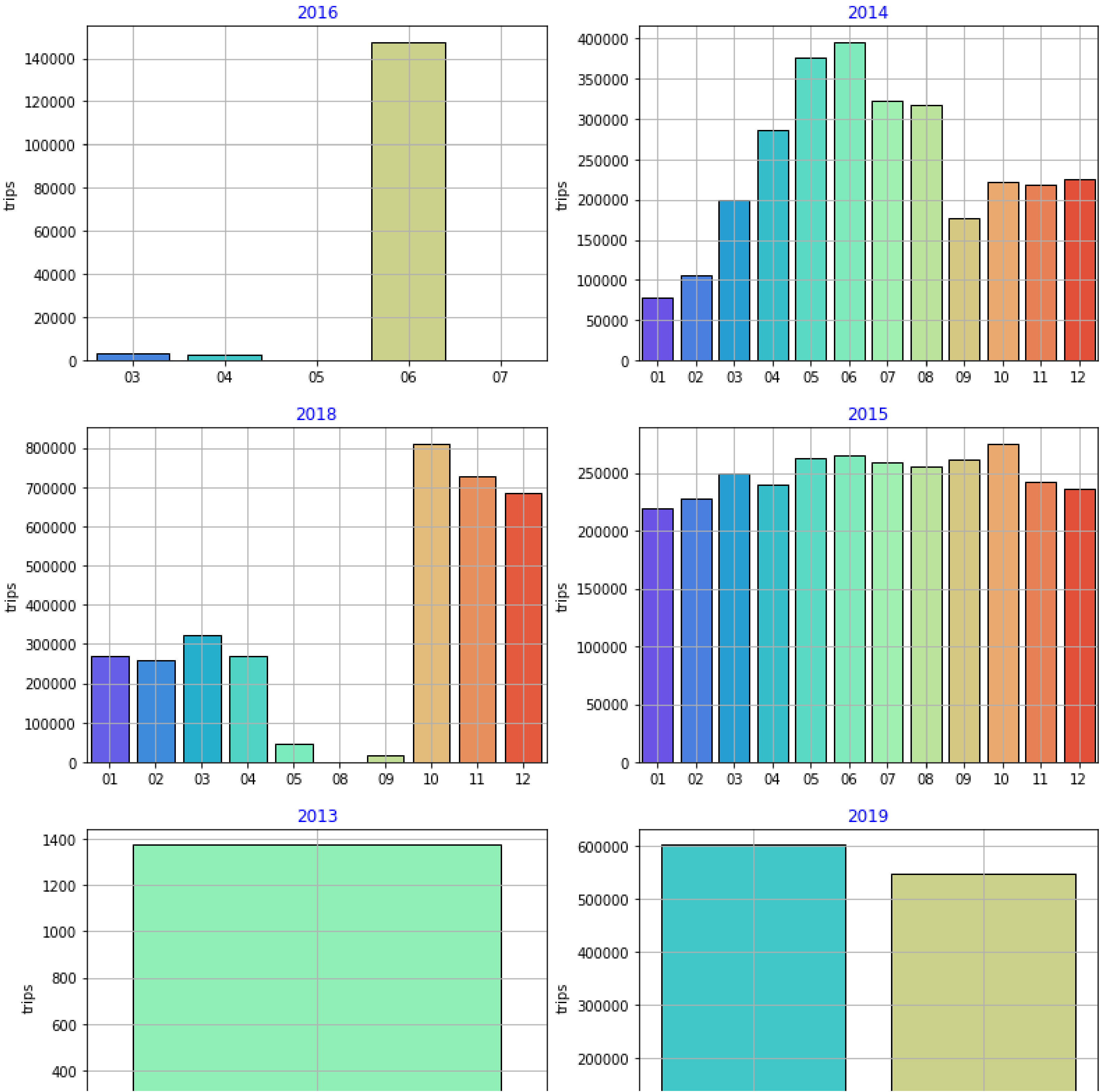
```
# Trend in Trip by months

yrs = [i for i in data["Tripstart_year"].unique().tolist()]
yrs=yrs[1:]

#subset data without year 2015
complete_dat = data[data["Tripstart_year"].isin(yrs)]
# length_years=len(yrs)-1

plt.figure(figsize = (13,15))
for i,j in itertools.zip_longest(yrs,range(len(yrs))):
    plt.subplot(3,2,j+1)
    trip_counts_mn = complete_dat[complete_dat["Tripstart_year"] == i]["Tripstart_month"].value_counts()
    trip_counts_mn = trip_counts_mn.reset_index()
    sns.barplot(trip_counts_mn["index"],trip_counts_mn["Tripstart_month"],
                palette = "rainbow",linewidth = 1,
                edgecolor = "k"*complete_dat["Tripstart_month"].nunique()
               )
    plt.title(i,color = "b",fontsize = 12)
    plt.grid(True)
    plt.xlabel("")
    plt.ylabel("trips")
```

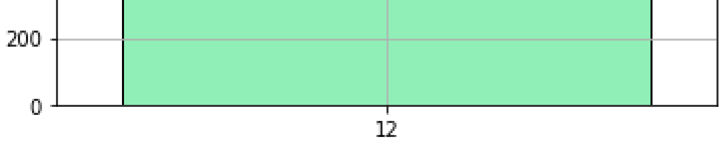

2016
trips
0
20000
40000
60000
80000
100000
120000
140000
03
04
05
06
07
2014
trips
0
50000
100000
150000
200000
250000
300000
350000
400000
01
02
03
04
05
06
07
08
09
10
11
12
2018
trips
0
100000
200000
300000
400000
500000
600000
700000
800000
01
02
03
04
05
08
09
10
11
12
2015
trips
0
50000
100000
150000
200000
250000
01
02
03
04
05
06
07
08
09
10
11
12
2013
trips
400
600
800
1000
1200
1400
2019
trips
200000
300000
400000
500000
600000


200
0
12
100000
0
01
02

In [33]:

```
# Trend in Trip by months

yrs = [i for i in data["Tripstart_year"].unique().tolist()]
yrs=yrs[1:]
complete_dat = data[data["Tripstart_year"].isin(yrs)]


plt.figure(figsize = (13,15))
for i,j in itertools.zip_longest(yrs,range(len(yrs))) :
    plt.subplot(3,2,j+1)
    trip_counts_mn = complete_dat[complete_dat["Tripstart_year"] == i]["Tripstart_month"].value_counts()
    trip_counts_mn = trip_counts_mn.reset_index()
    sns.barplot(trip_counts_mn["index"],trip_counts_mn["Tripstart_month"],
                palette = "rainbow",linewidth = 1,
                edgecolor = "k"*complete_dat["Tripstart_month"].nunique()
               )
    plt.title(i,color = "b",fontsize = 12)
    plt.grid(True)
    plt.xlabel("")
    plt.ylabel("trips")
```

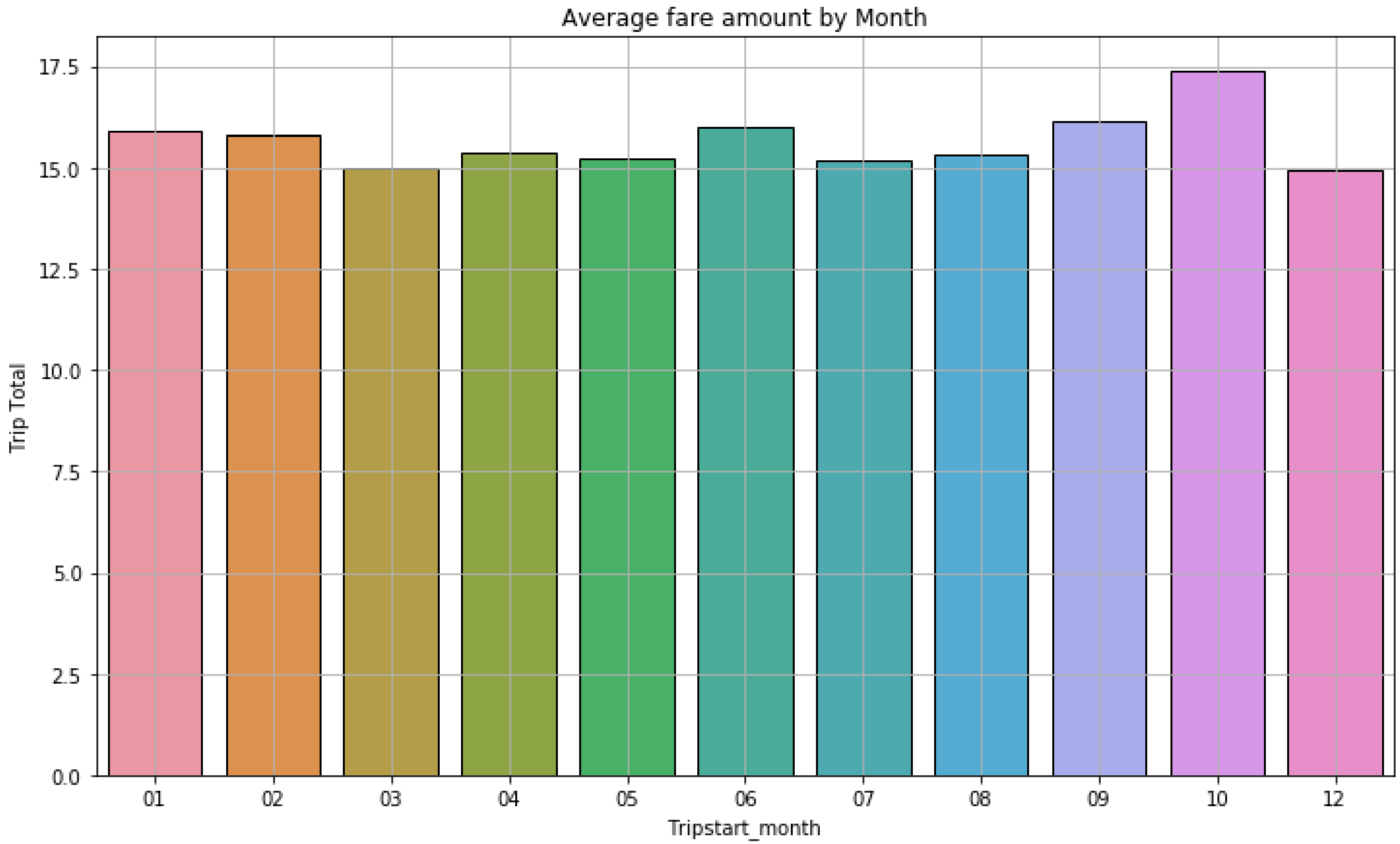

2016
trips
0
20000
40000
60000
80000
100000
120000
140000
03
04
05
06
07
2014
trips
0
50000
100000
150000
200000
250000
300000
350000
400000
01
02
03
04
05
06
07
08
09
10
11
12
2018
trips
0
100000
200000
300000
400000
500000
600000
700000
800000
01
02
03
04
05
08
09
10
11
12
2015
trips
0
50000
100000
150000
200000
250000
01
02
03
04
05
06
07
08
09
10
11
12
2013
trips
400
600
800
1000
1200
1400
2019
trips
200000
300000
400000
500000
600000


200
0
12

100000
0
01
02

In [39]:

```
# Avergae fare amount by month

fare_mn = data.groupby("Tripstart_month")["Trip Total"].mean().reset_index()

mnth_ord = ['01','02','03','04','05','06','07','08','09','10','12']

plt.figure(figsize = (12,7))
sns.barplot("Tripstart_month","Trip Total",
            data = fare_mn,order = mnth_ord,
            linewidth =1,edgecolor = "k"*len(mnth_ord)
           )
plt.grid(True)
plt.title("Average fare amount by Month")
plt.show()
```



In [ ]:

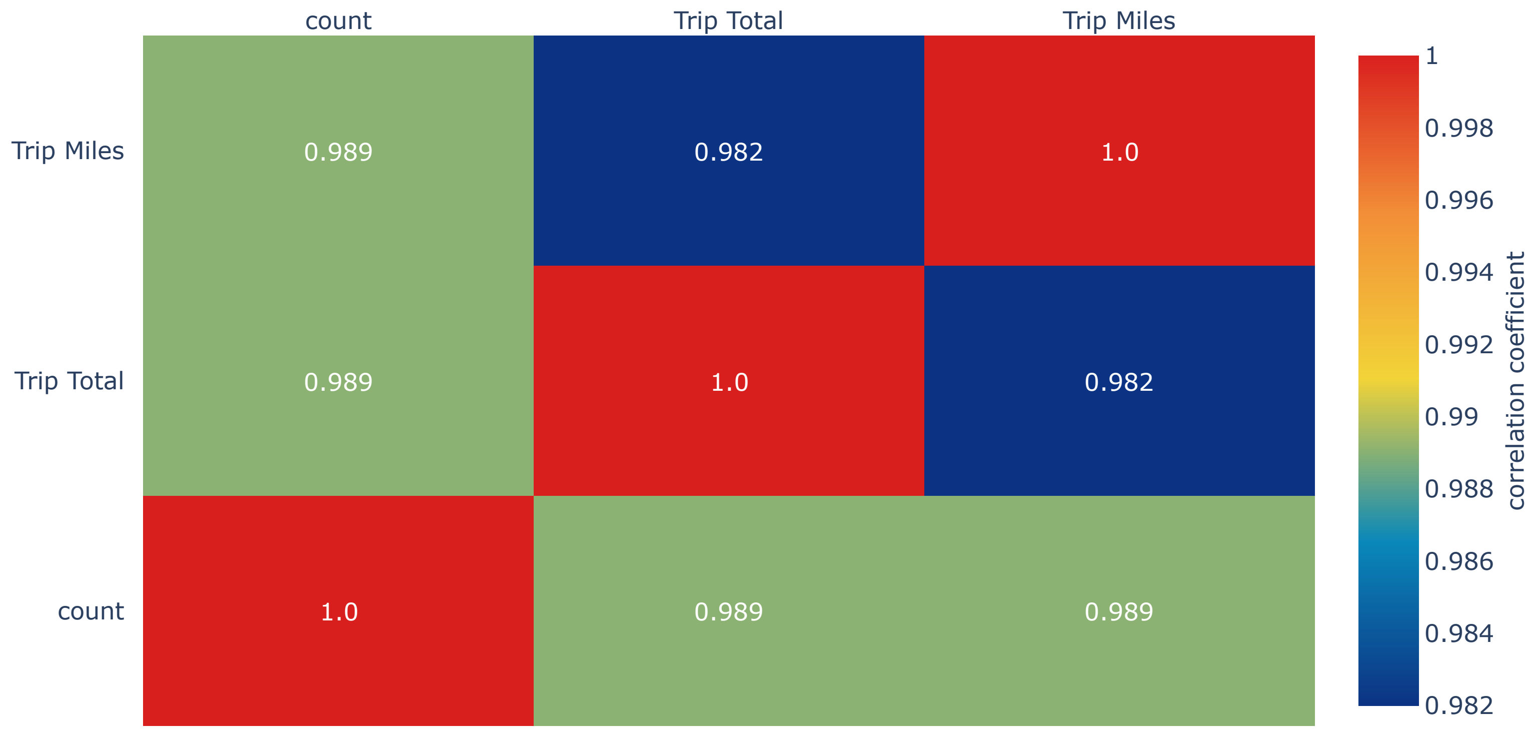
```
# Seasonal Trend in trips, passengers and fare amount
data['month_year']=data['Tripstart_month'].map(str)+'-'+data['Tripstart_year'].map(str)

#aggregate by year-month(trips)
trip_count = data.groupby(["Tripstart_year","Tripstart_month"])["month_year"].value_counts().to_frame()
trip_count.columns = ["count"]
trip_count = trip_count.reset_index()

#aggregate by year-month(fare amount)
total_fare = (data.groupby(["Tripstart_year","Tripstart_month","month_year"])["Trip Total"].sum().reset_index())

#aggregate by year-month(total trip distance)
total_trip_dist = (data.groupby(["Tripstart_year","Tripstart_month","month_year"])["Trip Miles"].sum().reset_index())


#plotting
def trend_scatter(data_frame,column) :
    tracer = go.Scatter(x = data_frame["month_year"],y = data_frame[column],
                        mode = "lines+markers",
                        marker = dict(color = data_frame["Tripstart_month"],size = 7,
                                      colorscale = "Picnic",
                                      line = dict(width =1 ,color = "black")
                                     ),
                        line = dict(color = "grey" ),
                   )
    return tracer

def layout_plot(title) :
    layout = go.Layout(dict(title = title,
                            plot_bgcolor  = "rgb(243,243,243)",
                            paper_bgcolor = "rgb(243,243,243)",
                            xaxis = dict(gridcolor = 'rgb(255, 255, 255)',
                                         zerolinewidth=1,ticklen=5,gridwidth=2),
                            yaxis = dict(gridcolor = 'rgb(255, 255, 255)',title = "count",
                                         zerolinewidth=1,ticklen=5,gridwidth=2),
                            margin = dict(b = 100)
                           )
                      )
    return layout

#figure 1
data    = [trend_scatter(trip_count,"count")]
layout  = layout_plot("Trend in trip count from 2014-Jan to 2019-May")
fig = go.Figure(data = data,layout = layout)
py.iplot(fig)
```

```
#figure 2
data2    = [trend_scatter(total_fare,"fare_amount")]
layout2  = layout_plot("Trend in total fare amount from 2014-Jan to 2019-May")
fig2 = go.Figure(data = data2,layout = layout2)
py.iplot(fig2)

#figure 3
data3    = [trend_scatter(total_trip_dist,"trip_distance_km")]
layout3  = layout_plot("Trend in trip distance from 2014-Jan to 2019-May")
fig3 = go.Figure(data = data3,layout = layout3)
py.iplot(fig3)
```

In [67]:

```
#Correlation Matrix

#Merge passenger_count,trip_count and fare_amount data
trip_count=data.groupby('month_year').count()
total_fare=data.groupby('month_year')['Trip Total'].agg(['sum'])
merge1  = trip_count.merge(total_fare,left_on = "month_year",
                           right_on = "month_year",how= "left")

merge2  = data.groupby('month_year')['Trip Miles'].agg(['sum'])

final_my_dat = merge1.merge(merge2,left_on = "month_year",
                           right_on = "month_year",how= "left")


final_my_dat = final_my_dat[["Trip Start Timestamp","sum_x","sum_y"]]

# #correlation
corr  =  np.array(final_my_dat.corr())
corr  =  np.around(corr,3)

# #x & y ticks
ticks =  ['count', 'Trip Total', "Trip Miles"]

# #plot heatmap
fig = ff.create_annotated_heatmap(z = corr,x = ticks,y = ticks,showscale=True,
                                   colorscale = "Portland",
                                   colorbar    = dict(title = "correlation coefficient",
                                                      titleside = "right"
                                      )
                                  )
fig.layout.title  = "Correlation Matrix"
fig.layout.margin = dict(l = 200,r = 200)
py.iplot(fig)
```

Correlation Matrix

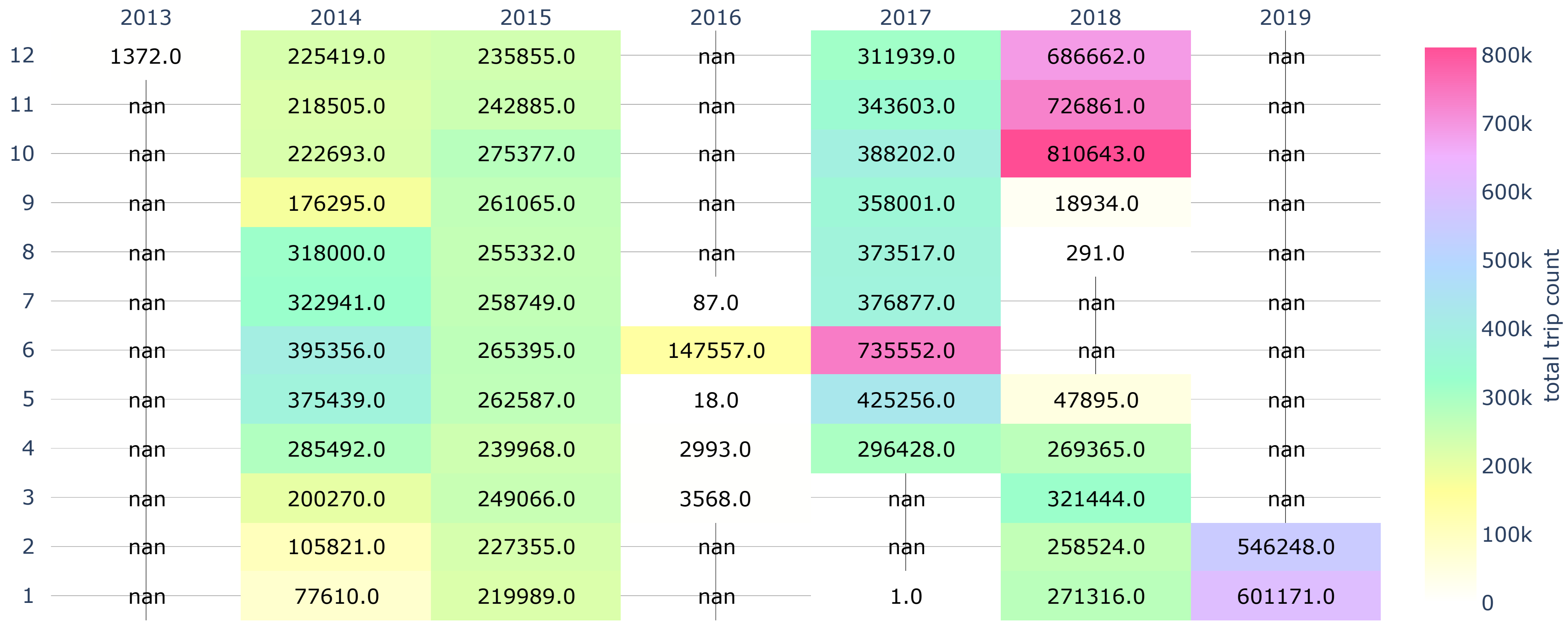


	count	Trip Total	Trip Miles
Trip Miles	0.989	0.982	1.0
Trip Total	0.989	1.0	0.982
count	1.0	0.989	0.989

In [70]:
```
# HEAT MAP
def plot_heat_map(column,aggregate_function,title) :
    #pivot table
    pivot_table = pd.pivot_table(data = data,columns="Tripstart_month",index = "Tripstart_year",
                                values = column,aggfunc = aggregate_function)

    mnth_ord = ['01','02','03','04','05','06','07','08','09','10','11','12']

    #reverse mnth order list
    def reverse(data_list) :
        return data_list[::-1]

    mnth_ord_rev = reverse(mnth_ord)

    pivot_table  = pivot_table[mnth_ord_rev].sort_values(by = "Tripstart_year",ascending = True)
    pivot_table  = pivot_table.transpose()

    #convert array
    pivot_array  = np.around(np.array(pivot_table))

    #color scale
    colorscale=[[0.0, 'rgb(255,255,255)'], [.2, 'rgb(255, 255, 153)'],
                [.4, 'rgb(153, 255, 204)'], [.6, 'rgb(179, 217, 255)'],
                [.8, 'rgb(240, 179, 255)'],[1.0, 'rgb(255, 77, 148)']]
    #plot heat map
    figure = ff.create_annotated_heatmap(z = pivot_array,
                                         x = pivot_table.columns.tolist(),
                                         y = pivot_table.index.tolist(),
                                         font_colors = ["black"],
                                         showscale = True,
                                         colorscale = colorscale,
                                         colorbar   = dict(title = "total " + title,
                                                           titleside = "right")
                                        )
    #title
    figure.layout.title = "Total " + title + " by  month - year ."
    figure.layout.plot_bgcolor  = "white"
    figure.layout.paper_bgcolor = "white"

    return py.iplot(figure)

#plot1
plot_heat_map("Tripstart_time","count","trip count")
# #plot2
# plot_heat_map("passenger_count","sum","passengers count")
```

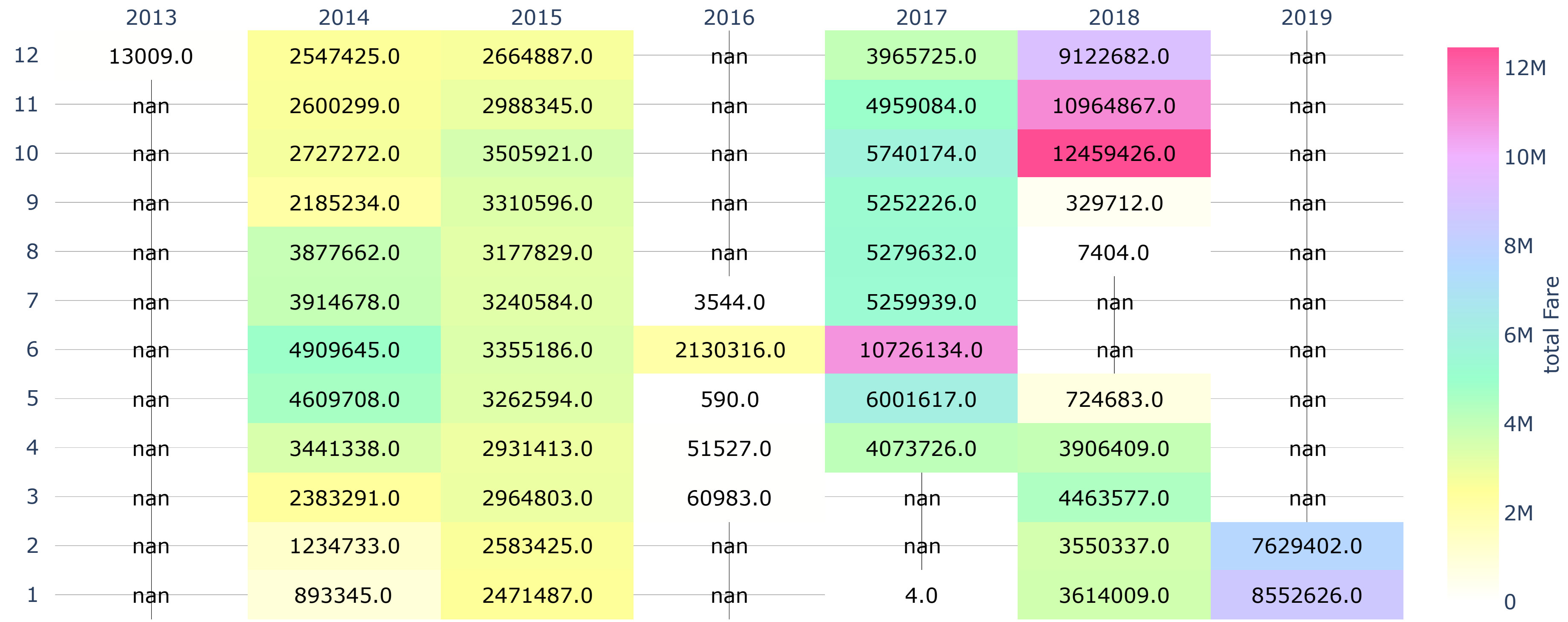
```
#plot3
plot_heat_map("Fare","sum","Fare")
#plot4
plot_heat_map("Trip Miles","sum","Trip Miles")
```

Total trip count by month - year .



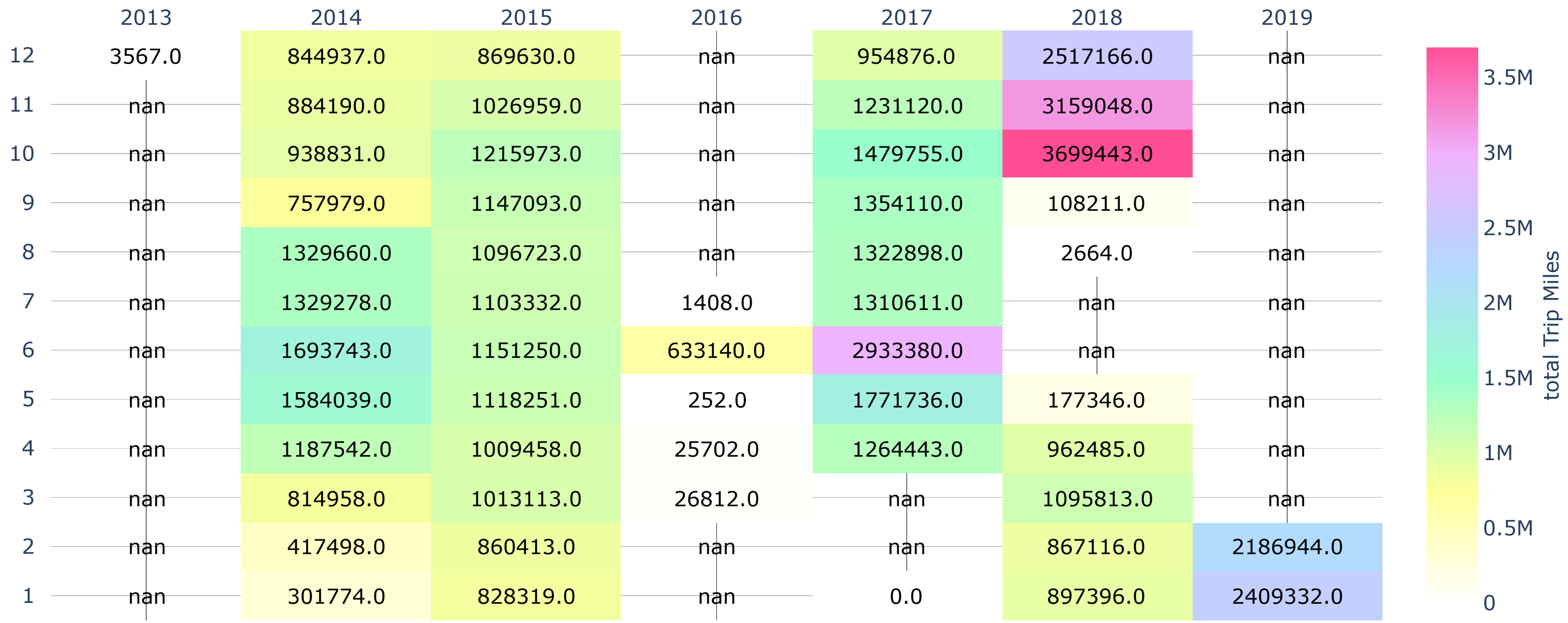
	2013	2014	2015	2016	2017	2018	2019
12	1372.0	225419.0	235855.0	nan	311939.0	686662.0	nan
11	nan	218505.0	242885.0	nan	343603.0	726861.0	nan
10	nan	222693.0	275377.0	nan	388202.0	810643.0	nan
9	nan	176295.0	261065.0	nan	358001.0	18934.0	nan
8	nan	318000.0	255332.0	nan	373517.0	291.0	nan
7	nan	322941.0	258749.0	87.0	376877.0	nan	nan
6	nan	395356.0	265395.0	147557.0	735552.0	nan	nan
5	nan	375439.0	262587.0	18.0	425256.0	47895.0	nan
4	nan	285492.0	239968.0	2993.0	296428.0	269365.0	nan
3	nan	200270.0	249066.0	3568.0	nan	321444.0	nan
2	nan	105821.0	227355.0	nan	nan	258524.0	546248.0
1	nan	77610.0	219989.0	nan	1.0	271316.0	601171.0

Total Fare by month - year .



	2013	2014	2015	2016	2017	2018	2019
12	13009.0	2547425.0	2664887.0	nan	3965725.0	9122682.0	nan
11	nan	2600299.0	2988345.0	nan	4959084.0	10964867.0	nan
10	nan	2727272.0	3505921.0	nan	5740174.0	12459426.0	nan
9	nan	2185234.0	3310596.0	nan	5252226.0	329712.0	nan
8	nan	3877662.0	3177829.0	nan	5279632.0	7404.0	nan
7	nan	3914678.0	3240584.0	3544.0	5259939.0	nan	nan
6	nan	4909645.0	3355186.0	2130316.0	10726134.0	nan	nan
5	nan	4609708.0	3262594.0	590.0	6001617.0	724683.0	nan
4	nan	3441338.0	2931413.0	51527.0	4073726.0	3906409.0	nan
3	nan	2383291.0	2964803.0	60983.0	nan	4463577.0	nan
2	nan	1234733.0	2583425.0	nan	nan	3550337.0	7629402.0
1	nan	893345.0	2471487.0	nan	4.0	3614009.0	8552626.0

Total Trip Miles by month - year .

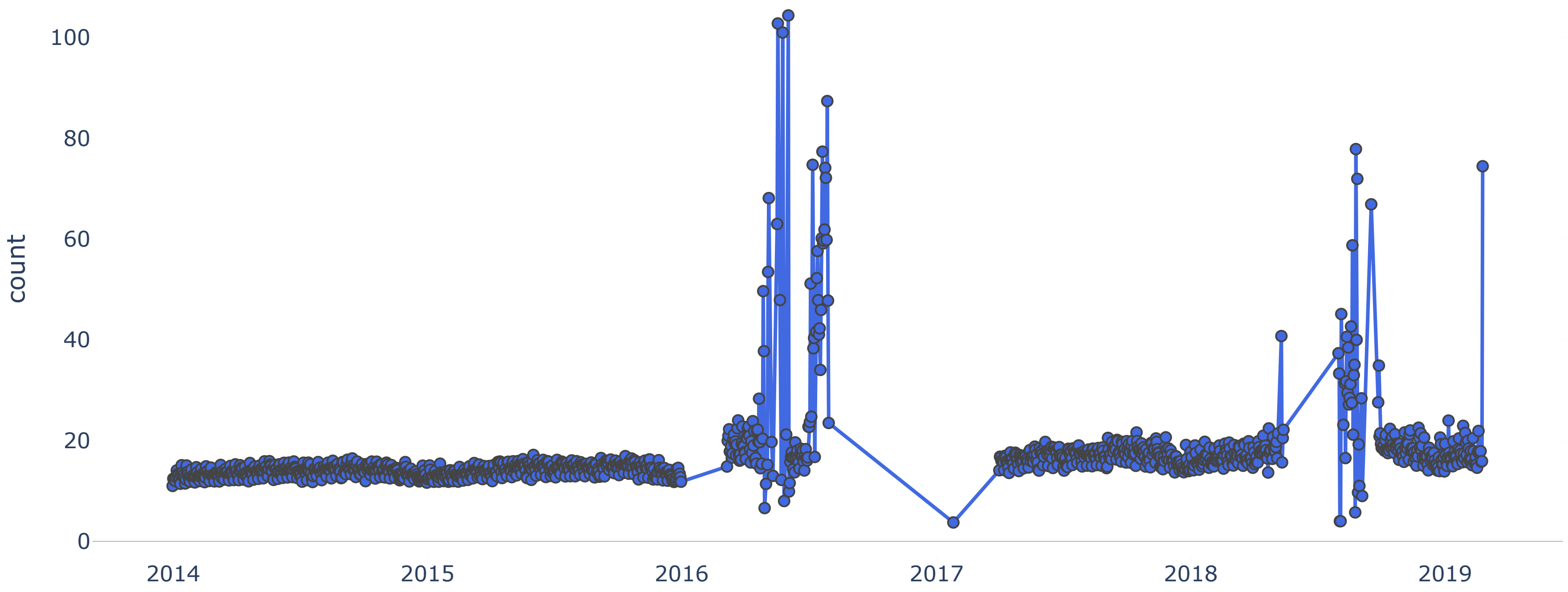


	2013	2014	2015	2016	2017	2018	2019
12	3567.0	844937.0	869630.0	nan	954876.0	2517166.0	nan
11	nan	884190.0	1026959.0	nan	1231120.0	3159048.0	nan
10	nan	938831.0	1215973.0	nan	1479755.0	3699443.0	nan
9	nan	757979.0	1147093.0	nan	1354110.0	108211.0	nan
8	nan	1329660.0	1096723.0	nan	1322898.0	2664.0	nan
7	nan	1329278.0	1103332.0	1408.0	1310611.0	nan	nan
6	nan	1693743.0	1151250.0	633140.0	2933380.0	nan	nan
5	nan	1584039.0	1118251.0	252.0	1771736.0	177346.0	nan
4	nan	1187542.0	1009458.0	25702.0	1264443.0	962485.0	nan
3	nan	814958.0	1013113.0	26812.0	nan	1095813.0	nan
2	nan	417498.0	860413.0	nan	nan	867116.0	2186944.0
1	nan	301774.0	828319.0	nan	0.0	897396.0	2409332.0

In [85]:

```
### Time Series forecasting of Fare Amount

import datetime
#Data - total fare amount by month from 2009 to 2015-06
ts_fare = (data.groupby(["Tripstart_year","Tripstart_month","Tripstart_day","Tripstart_time"])["Trip Total"].mean().reset_index
())[["Tripstart_time","Trip Total"]]
# ts_fare["date"] = ts_fare["year"].astype(str) + "-" + ts_fare["month"].astype(str)
#selecting columns
#convert to date format
# ts_fare["date"] = pd.to_datetime(ts_fare["date"],format = "%Y-%m")
ts_fare.index   = ts_fare["Tripstart_time"]
ts_fare = ts_fare.drop(columns  = ["Tripstart_time"],axis = 1)
ts_fare.head(10)

### Visualizing Time Series

trace = go.Scatter(x = ts_fare.index,y = ts_fare["Trip Total"],
                   mode = "lines+markers",
                   marker = dict(color = "royalblue",line = dict(width =1))
                  )
layout = go.Layout(dict(title = "Visualizing time series",
                        plot_bgcolor  = "rgb(243,243,243)",
                        paper_bgcolor = "rgb(243,243,243)",
                        xaxis = dict(gridcolor = 'rgb(255, 255, 255)',
                                     zerolinewidth=1,ticklen=5,gridwidth=2),
                        yaxis = dict(gridcolor = 'rgb(255, 255, 255)',title = "count",
                                     zerolinewidth=1,ticklen=5,gridwidth=2),
                        margin = dict(b = 100)
                       )
                  )
fig = go.Figure(data = [trace],layout = layout)
py.iplot(fig)
```

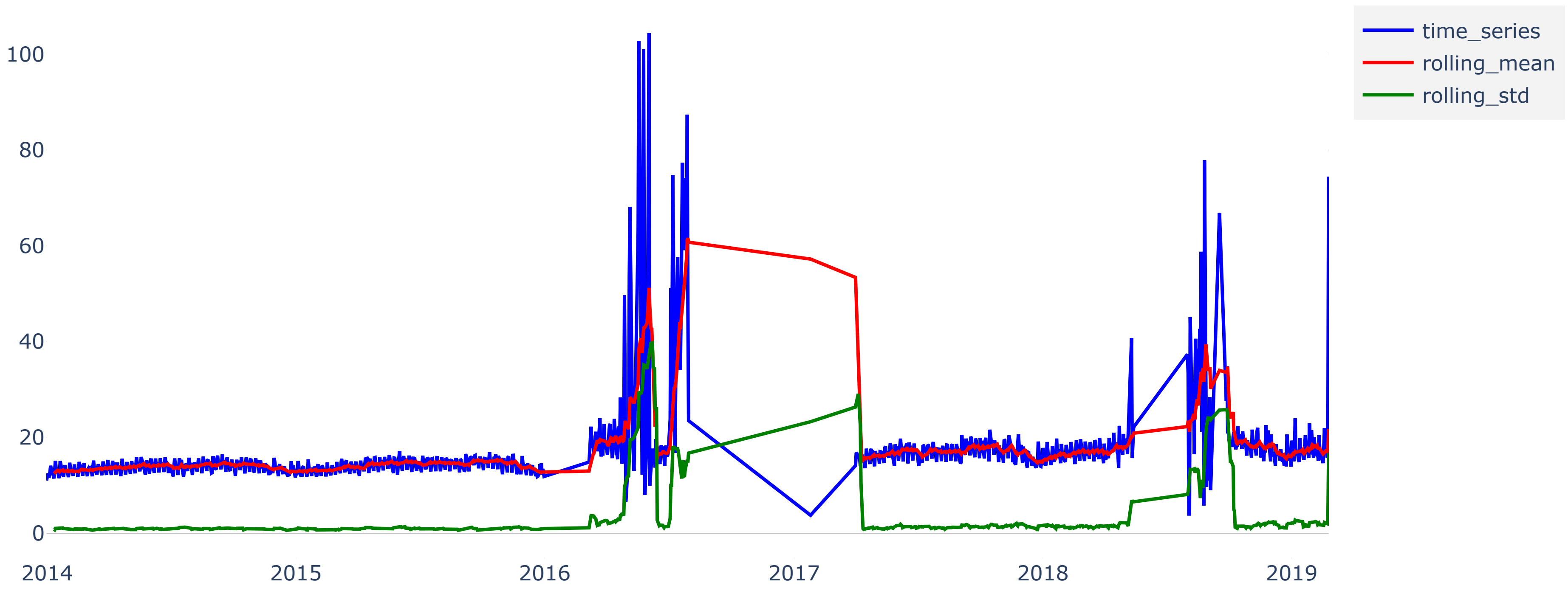
Visualizing time series



In [88]:

```
### Check Stationarity of Time Series

from statsmodels.tsa.stattools import adfuller

def plot_line(x,y,color,name) :
    tracer = go.Scatter(x = x,y = y,mode = "lines",
                        marker = dict(color = color,
                                      line = dict(width =1)),
                       name = name)
    return tracer

def plot_layout(title) :
    layout = go.Layout(dict(title = title,
                            plot_bgcolor  = "rgb(243,243,243)",
                            paper_bgcolor = "rgb(243,243,243)",
                            xaxis = dict(gridcolor = 'rgb(255, 255, 255)',
                                         zerolinewidth=1,ticklen=5,gridwidth=2),
                            yaxis = dict(gridcolor = 'rgb(255, 255, 255)',
                                            zerolinewidth=1,ticklen=5,gridwidth=2),
                        margin = dict(b = 100)
                       )
                  )
    return layout


def stationary_test(timeseries) :
    #rolling mean
    rol_mean = timeseries["Trip Total"].rolling(window = 12,
                                                 center = False).mean()
    #rolling standard deviation
    rol_std  = timeseries["Trip Total"].rolling(window = 12,
                                                 center = False).std()

    #plotting
    trace1  = plot_line(timeseries.index,timeseries["Trip Total"],
                        "blue","time_series")
    trace2  = plot_line(rol_mean.index,rol_mean.values,
                        "red","rolling_mean")
    trace3  = plot_line(rol_std.index,rol_std.values,
                        "green", "rolling_std")
    layout  = plot_layout("rolling mean and standard deviation for timeseries")
    figure  = go.Figure(data = [trace1,trace2,trace3],layout = layout)

    test_results = adfuller(timeseries["Trip Total"])
    res_list     = ["Test Statistic","p-value",
                    "lags used","no of observations"]
    res_df = pd.Series(test_results[:4],index = res_list)

    for key,value in test_results[4].items() :
        res_df["Critical value (%s)"%key] = value

    print ("Results - Dickey fuller test")
    print (res_df)
    return py.iplot(figure)

stationary_test(ts_fare)
```

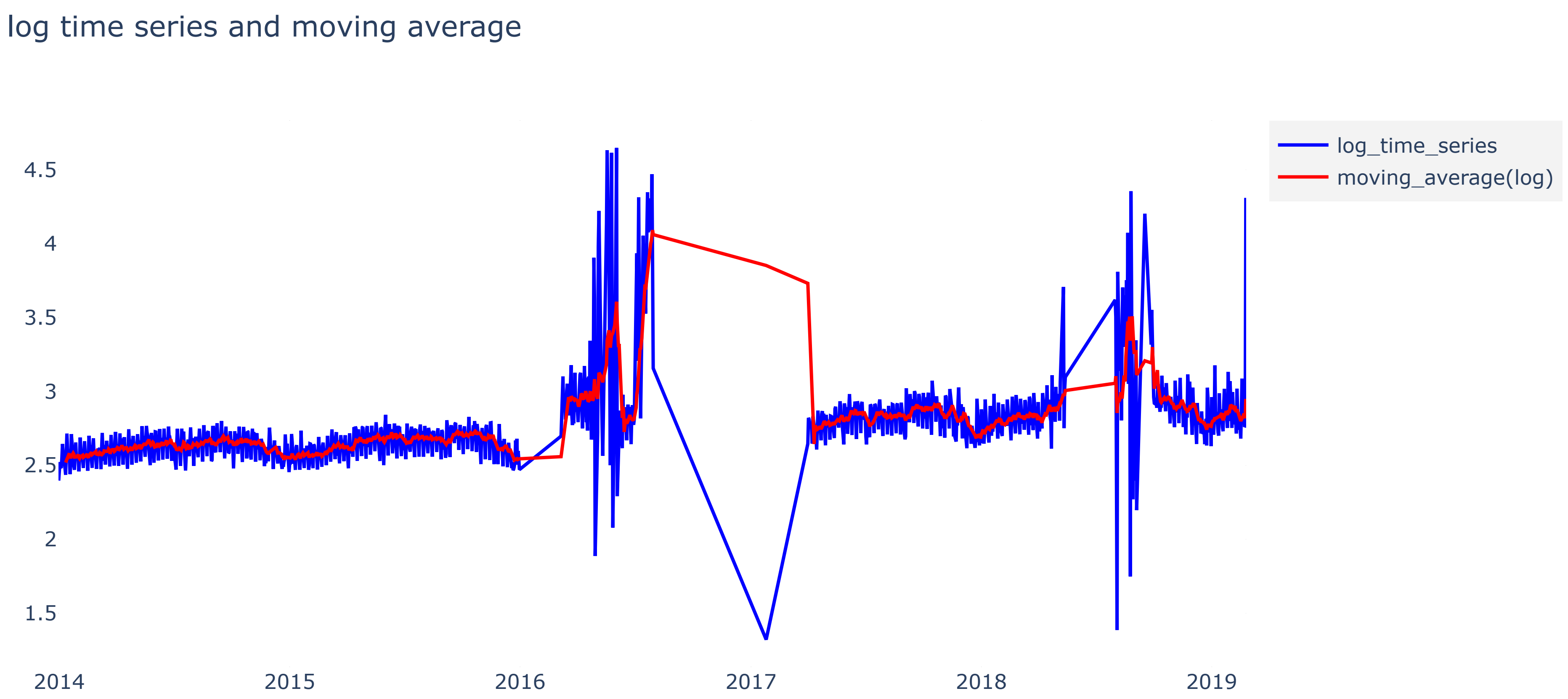
```
Results - Dickey fuller test
Test Statistic             -5.636058
p-value                     0.000001
lags used                  18.000000
no of observations       1423.000000
Critical value (1%)        -3.434954
Critical value (5%)        -2.863573
Critical value (10%)       -2.567852
dtype: float64
```


rolling mean and standard deviation for timeseries

Elimating Trend

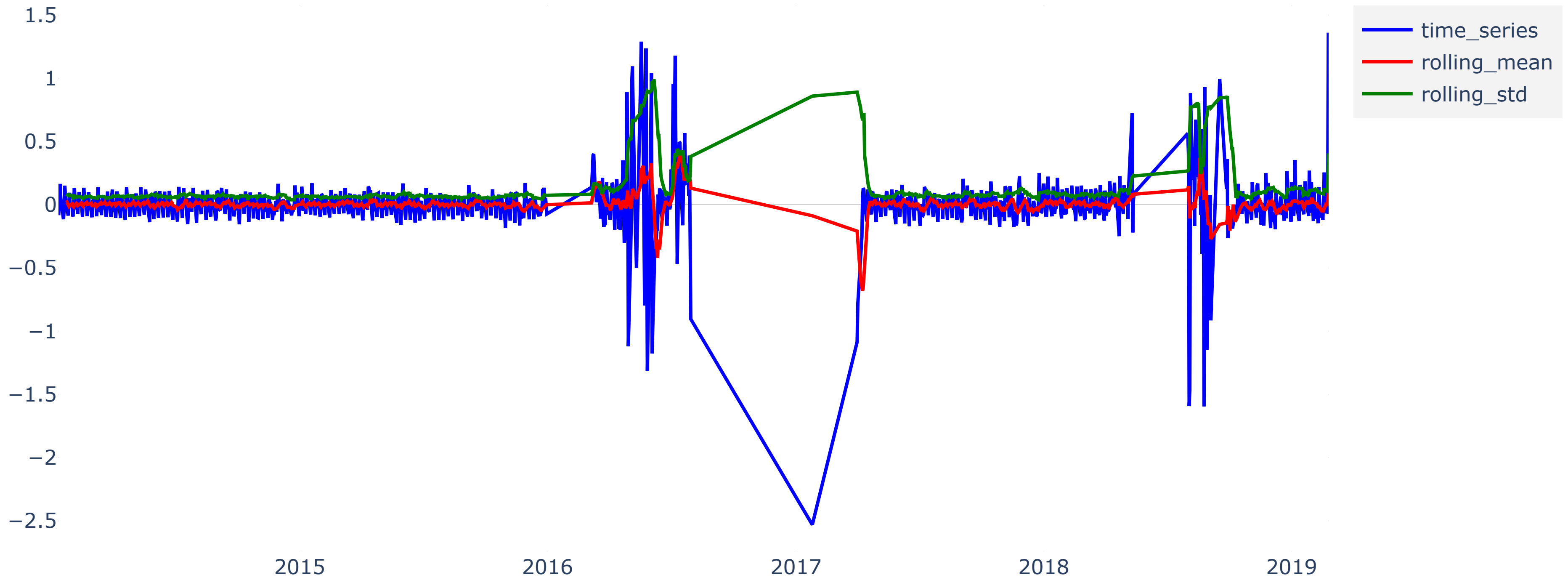
In [89]:

```
## Moving Average

#log of timeseries
log_ts_fare = np.log(ts_fare)

#rolling average of log timeseries
rol_avg_log_ts = log_ts_fare["Trip Total"].rolling(window = 12,center = False).mean()

#plotting log timeseries and rolling mean
t1 = plot_line(log_ts_fare.index,log_ts_fare["Trip Total"],
                "blue","log_time_series")
t2 = plot_line(rol_avg_log_ts.index,rol_avg_log_ts.values,
               "red","moving_average(log)")
lay = plot_layout("log time series and moving average")
fig = go.Figure(data = [t1,t2],layout = lay)
py.iplot(fig)

#difference
log_ts_fare_diff = log_ts_fare - rol_avg_log_ts.to_frame()
log_ts_fare_diff.dropna(inplace = True)
stationary_test(log_ts_fare_diff)
```



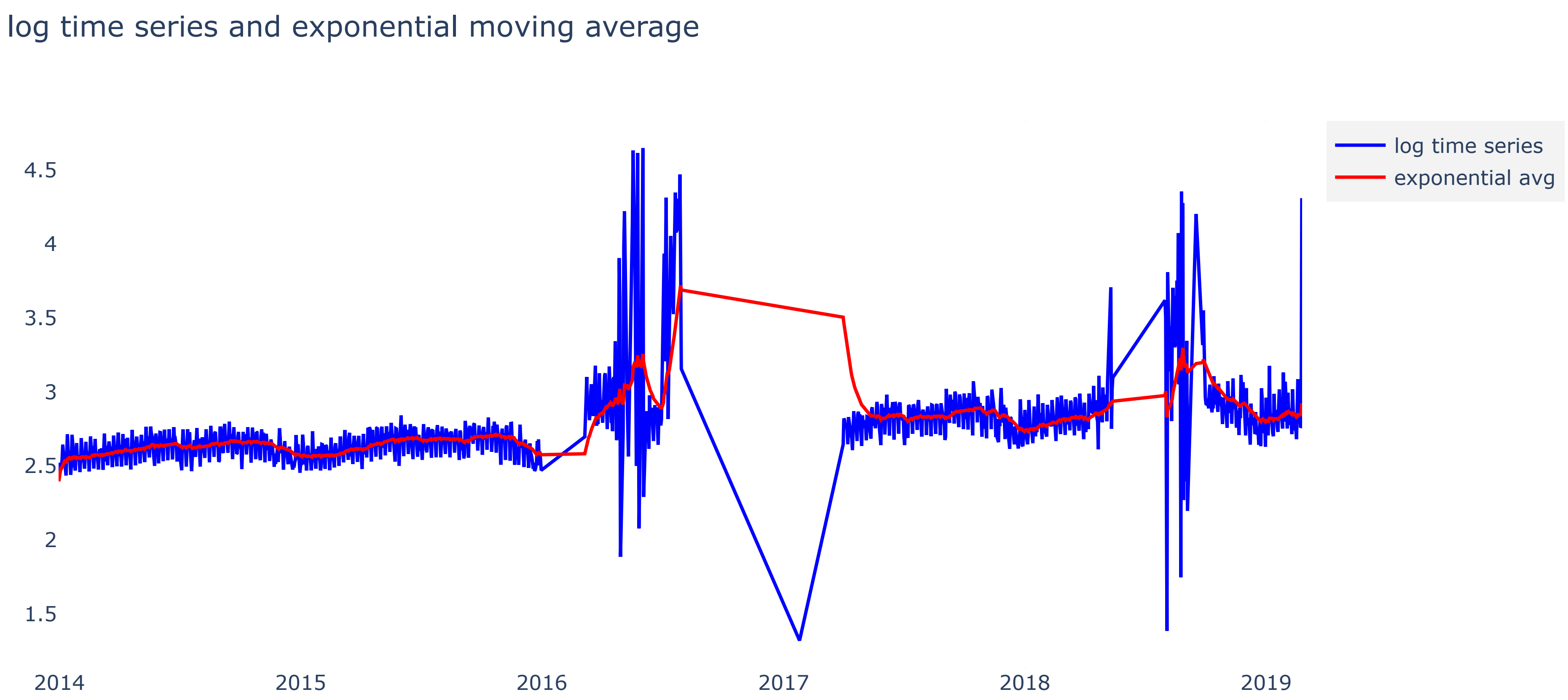
```
Results - Dickey fuller test
Test Statistic           -9.774604e+00
p-value                   6.988897e-17
lags used                 2.400000e+01
no of observations        1.406000e+03
Critical value (1%)      -3.435010e+00
Critical value (5%)      -2.863598e+00
Critical value (10%)     -2.567866e+00
dtype: float64
```

rolling mean and standard deviation for timeseries



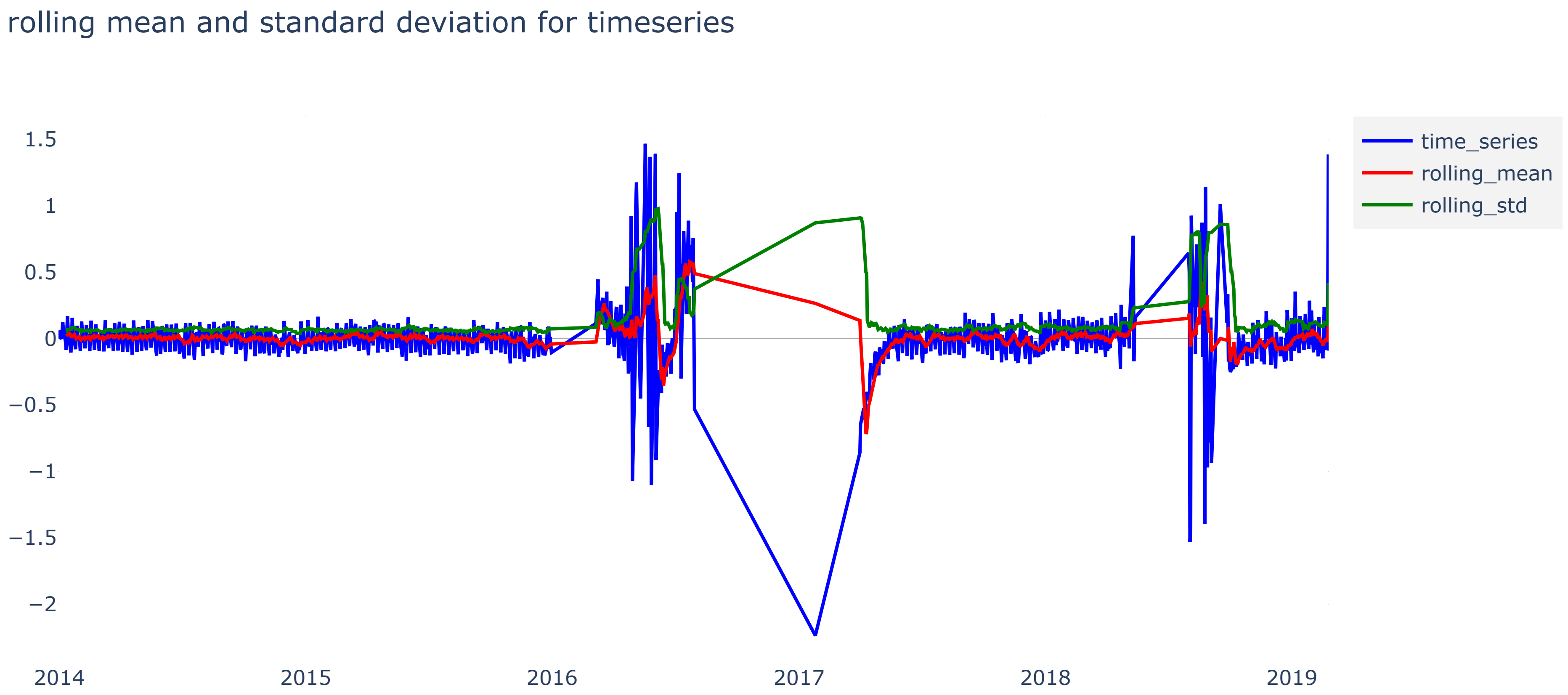
In [90]:

```
### Exponential Weighted Moving Average

#exponential moving average of log time series
exp_log_avg = log_ts_fare["Trip Total"].ewm(halflife = 12).mean()

#plotting
t1 = plot_line(log_ts_fare.index,log_ts_fare["Trip Total"],
               "blue","log time series")
t2 = plot_line(exp_log_avg.index,exp_log_avg.values,
               "red","exponential avg")
lay = plot_layout("log time series and exponential moving average")
fig = go.Figure(data = [t1,t2],layout = lay)
py.iplot(fig)

#difference
exp_ts_diff = log_ts_fare - exp_log_avg.to_frame()
stationary_test(exp_ts_diff)
```



log time series and exponential moving average

```
Results - Dickey fuller test
Test Statistic         -8.936648e+00
p-value                 9.494577e-15
lags used               2.400000e+01
no of observations      1.417000e+03
Critical value (1%)    -3.434973e+00
Critical value (5%)    -2.863582e+00
Critical value (10%)   -2.567857e+00
dtype: float64
```

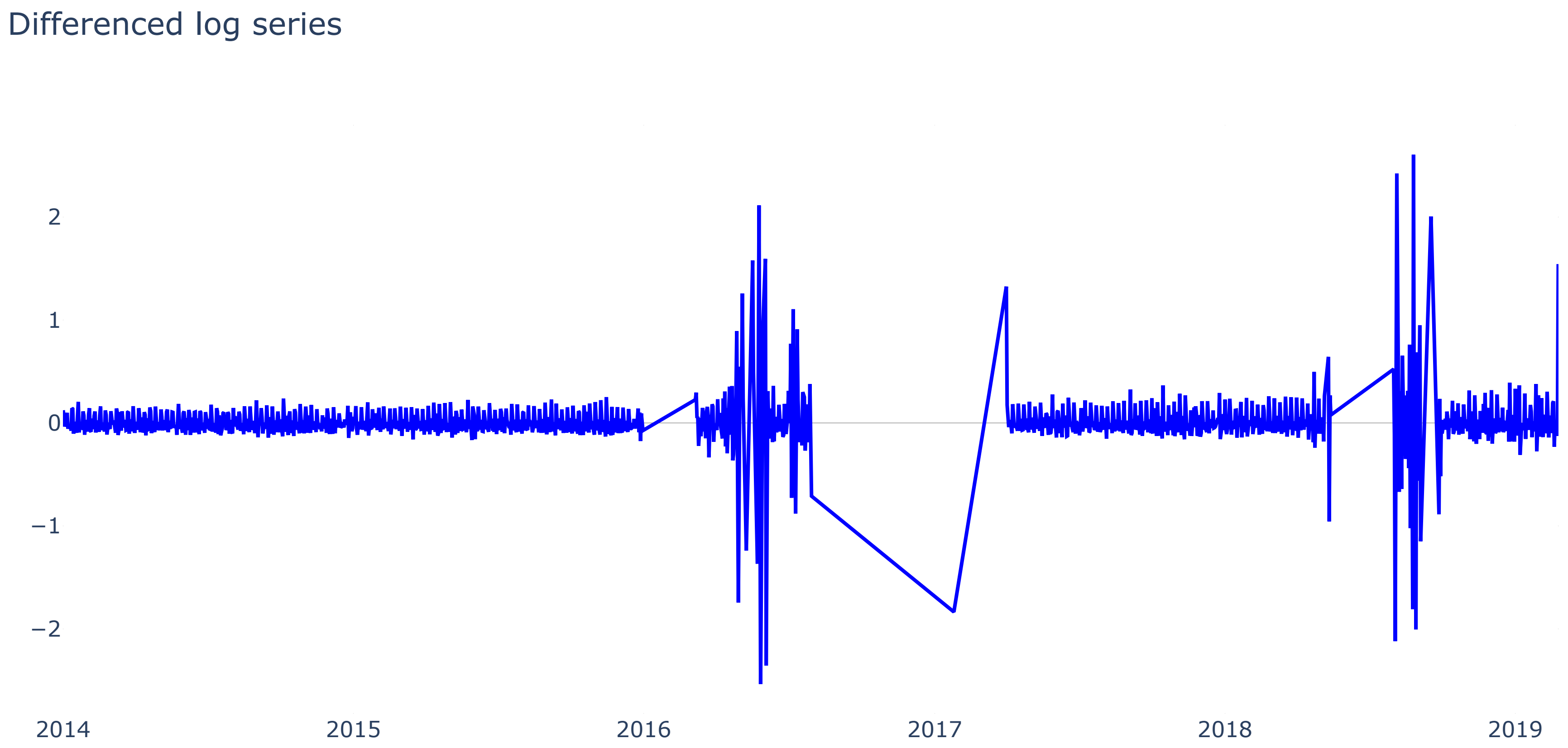


In [98]:

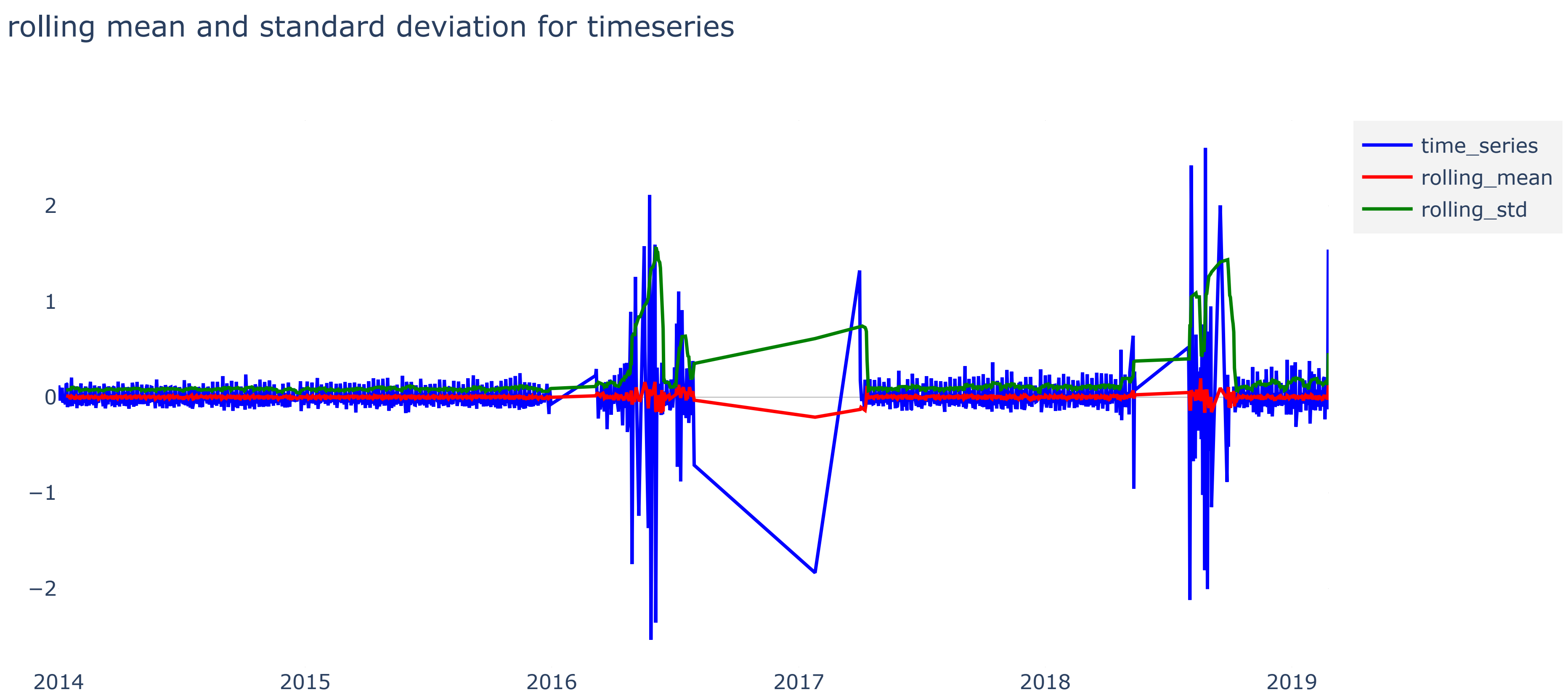
```
ts_fare_diff = log_ts_fare - log_ts_fare.shift()
```

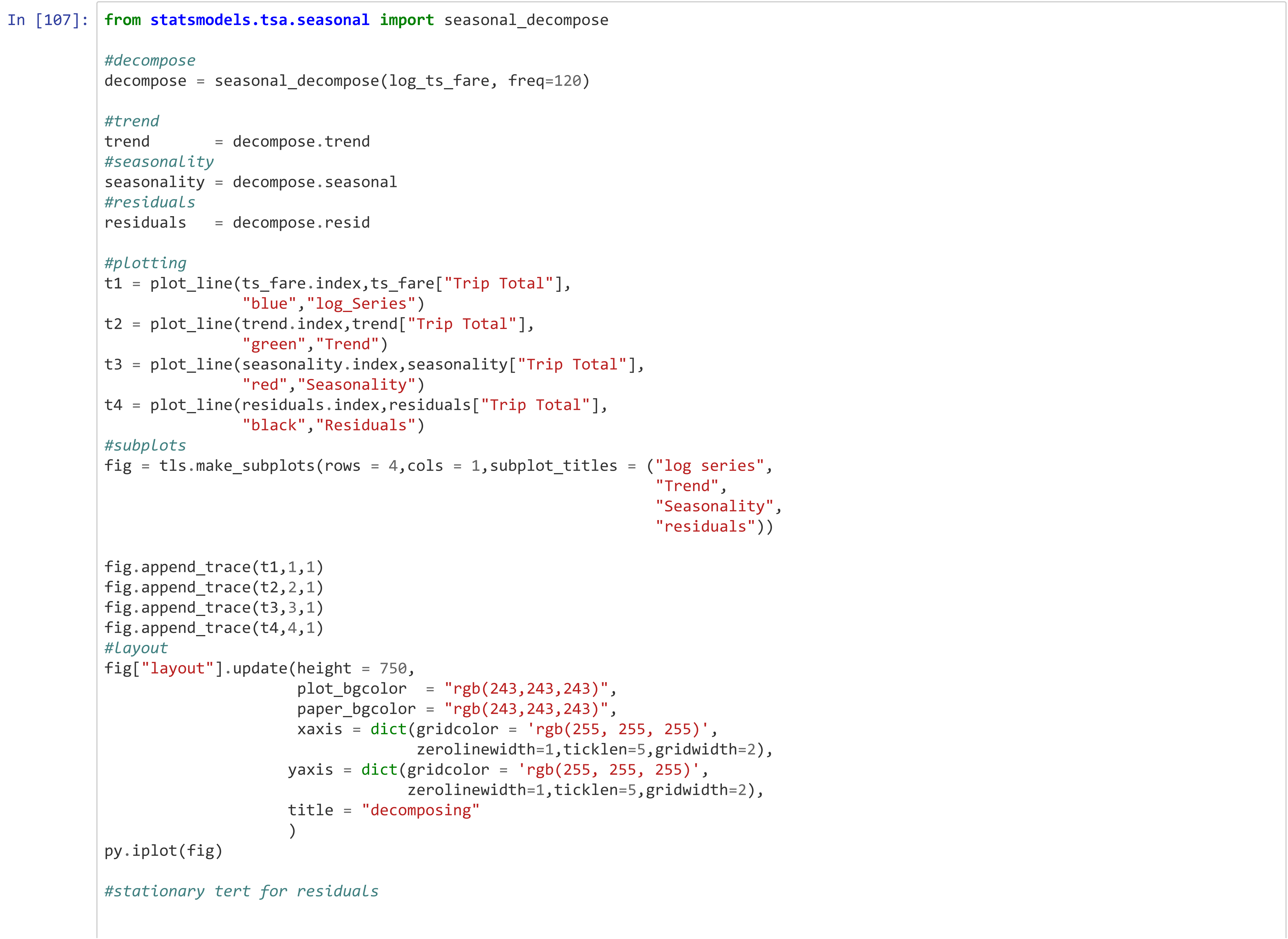
In [102]:

```
ts_fare_diff = log_ts_fare - log_ts_fare.shift()
ts_fare_diff.dropna(inplace = True)

#plotting
t1 = plot_line(ts_fare_diff.index,ts_fare_diff["Trip Total"],
              "blue","Differenced log series")
lay = plot_layout("Differenced log series")
fig = go.Figure(data = [t1],layout=lay)
py.iplot(fig)

#stationary test
stationary_test(ts_fare_diff)
```



```
Results - Dickey fuller test
Test Statistic          -8.998682e+00
p-value                  6.587452e-15
lags used                2.300000e+01
no of observations       1.417000e+03
Critical value (1%)     -3.434973e+00
Critical value (5%)     -2.863582e+00
Critical value (10%)    -2.567857e+00
dtype: float64
```

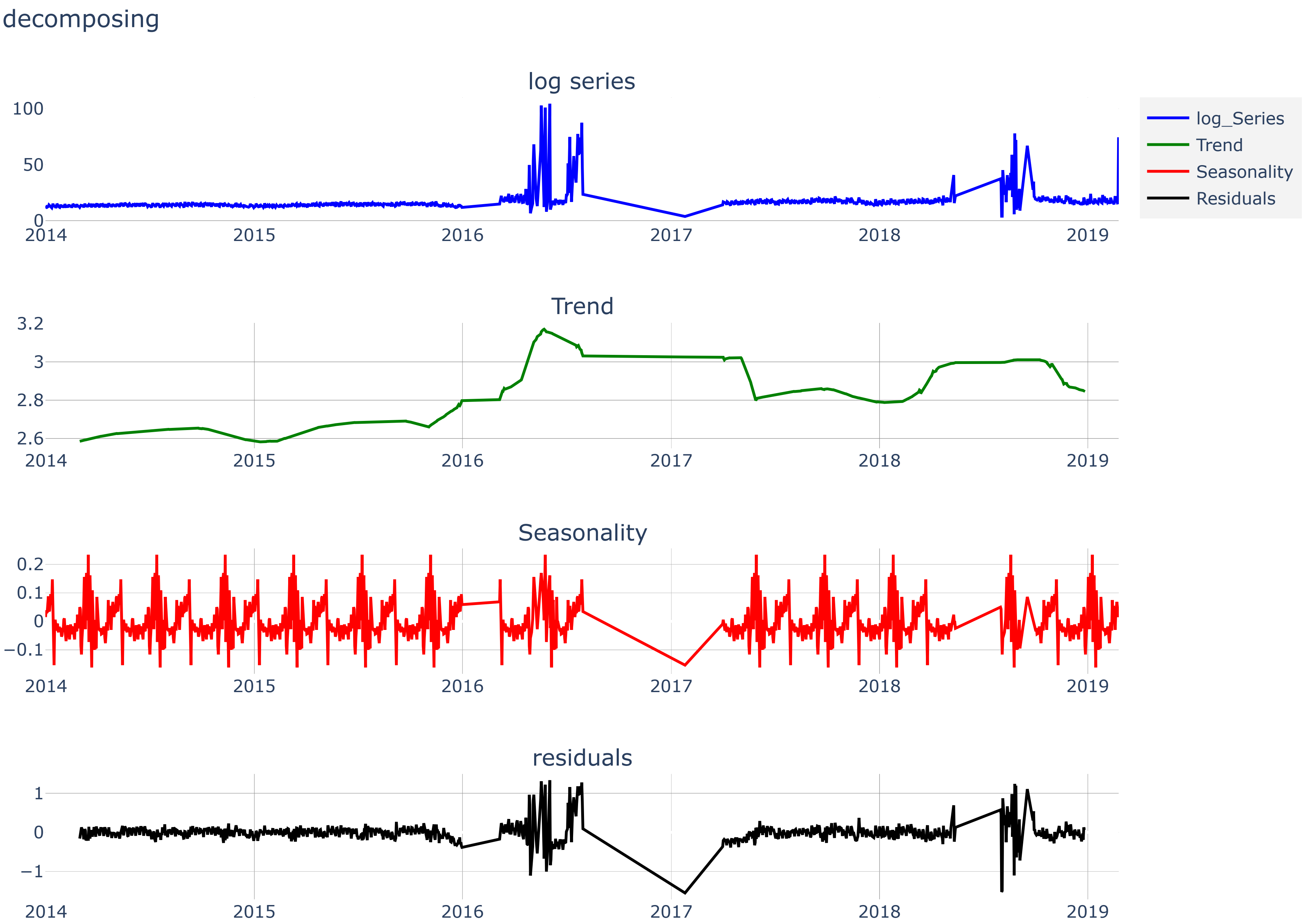

rolling mean and standard deviation for timeseries
time_series
rolling_mean
rolling_std
2
1
0
−1
−2
2014
2015
2016
2017
2018
2019



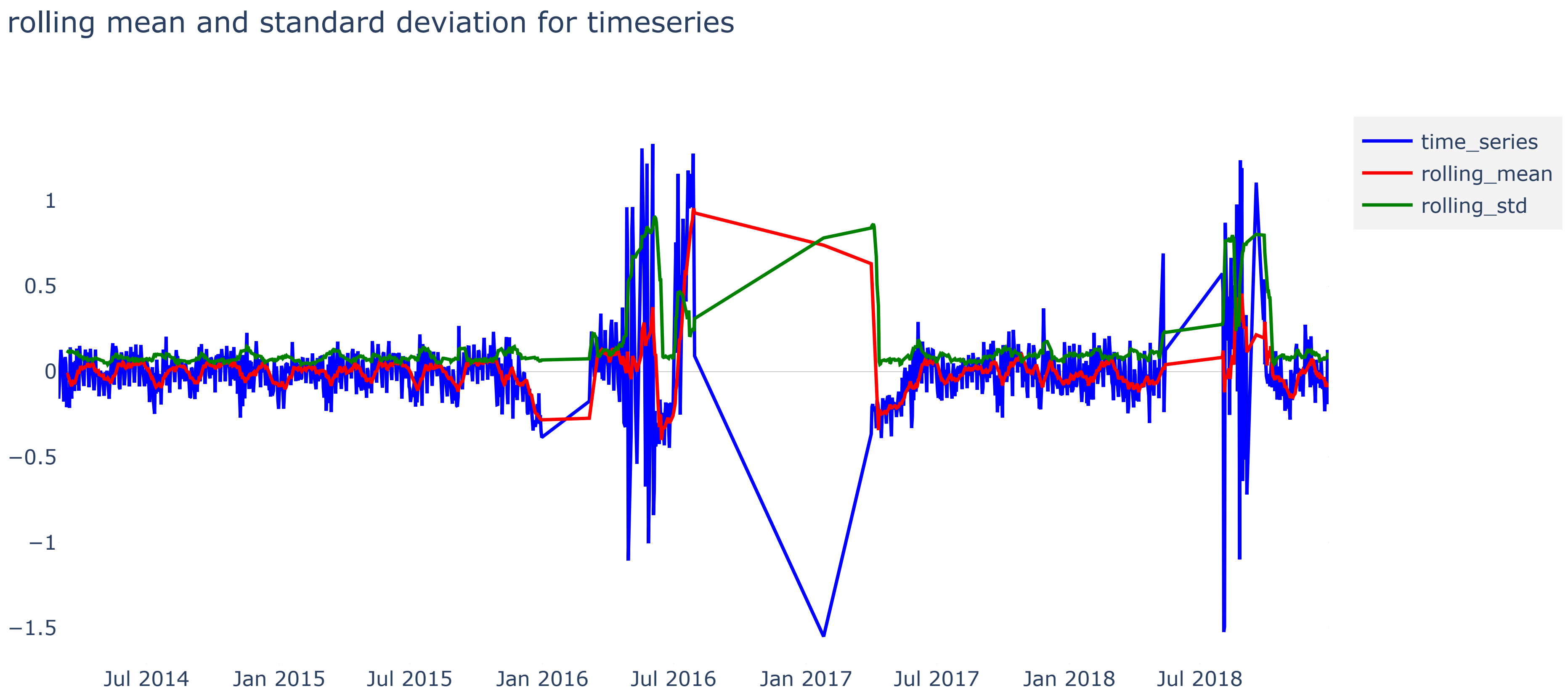
In [107]:

```
from statsmodels.tsa.seasonal import seasonal_decompose

#decompose
decompose = seasonal_decompose(log_ts_fare, freq=120)

#trend
trend       = decompose.trend
#seasonality
seasonality = decompose.seasonal
#residuals
residuals   = decompose.resid

#plotting
t1 = plot_line(ts_fare.index,ts_fare["Trip Total"],
               "blue","log_Series")
t2 = plot_line(trend.index,trend["Trip Total"],
               "green","Trend")
t3 = plot_line(seasonality.index,seasonality["Trip Total"],
               "red","Seasonality")
t4 = plot_line(residuals.index,residuals["Trip Total"],
               "black","Residuals")
#subplots
fig = tls.make_subplots(rows = 4,cols = 1,subplot_titles = ("log series",
                                                            "Trend",
                                                            "Seasonality",
                                                            "residuals"))


fig.append_trace(t1,1,1)
fig.append_trace(t2,2,1)
fig.append_trace(t3,3,1)
fig.append_trace(t4,4,1)
#layout
fig["layout"].update(height = 750,
                     plot_bgcolor  = "rgb(243,243,243)",
                     paper_bgcolor = "rgb(243,243,243)",
                     xaxis = dict(gridcolor = 'rgb(255, 255, 255)',
                                  zerolinewidth=1,ticklen=5,gridwidth=2),
                    yaxis = dict(gridcolor = 'rgb(255, 255, 255)',
                                 zerolinewidth=1,ticklen=5,gridwidth=2),
                    title = "decomposing"
                    )
py.iplot(fig)

#stationary tert for residuals
```

```
residuals.dropna(inplace = True)
stationary_test(residuals)
```


decomposing
log series
100
50
0
2014
2015
2016
2017
2018
2019
log_Series
Trend
Seasonality
Residuals
Trend
3.2
3
2.8
2.6
2014
2015
2016
2017
2018
2019
Seasonality
0.2
0.1
0
−0.1
2014
2015
2016
2017
2018
2019
residuals
1
0
−1
2014
2015
2016
2017
2018
2019

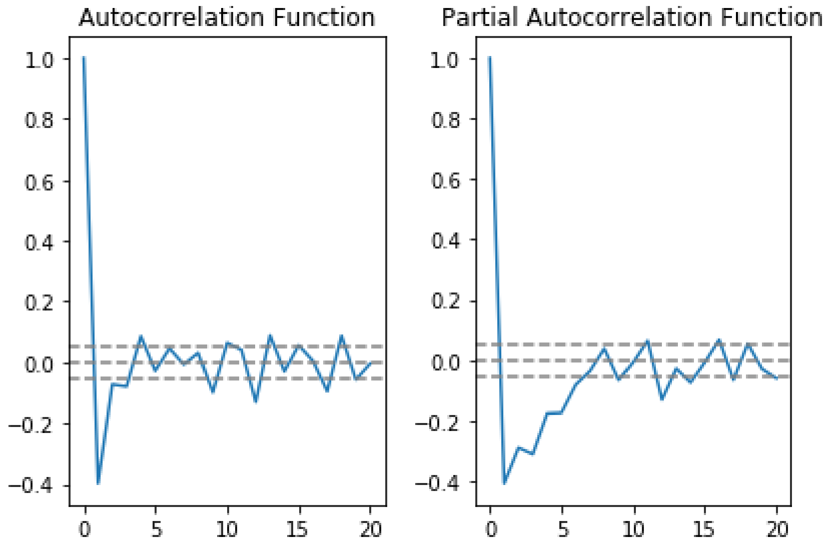
```
Results - Dickey fuller test
Test Statistic           -8.154227e+00
p-value                   9.515083e-13
lags used                 2.200000e+01
no of observations        1.299000e+03
Critical value (1%)      -3.435394e+00
Critical value (5%)      -2.863768e+00
Critical value (10%)     -2.567956e+00
dtype: float64
```



```
In [77]: mydata=data[data['Tripstart_time'].dt.year>2013][['Tripstart_time','Trip Total']]
         usedata=mydata.groupby(['Tripstart_time'])['Trip Total'].mean().reset_index()
         usedata=usedata.set_index('Tripstart_time')
         usedata=usedata[usedata['Trip Total']!=0]
         usedata=np.log(usedata)
         ts_fare_diff = usedata - usedata.shift()
         ts_fare_diff.dropna(inplace = True)
```

In [78]:

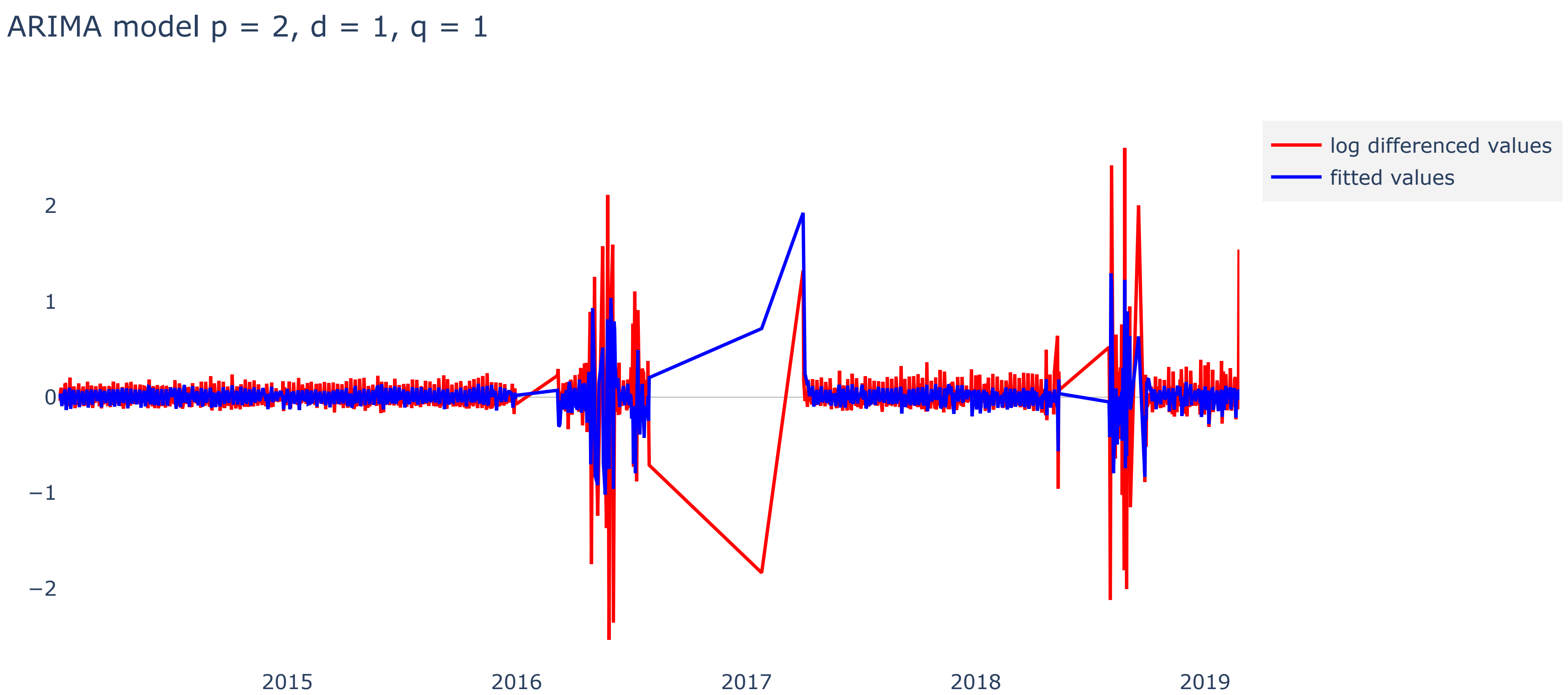
```
#PACF ACF Plots
from statsmodels.tsa.arima_model import ARIMA
from statsmodels.tsa.stattools import acf, pacf
ts_log_diff=ts_fare_diff
lag_acf = acf(ts_log_diff, nlags=20)
lag_pacf= pacf(ts_log_diff, nlags=20, method='ols')

plt.subplot(121)
plt.plot(lag_acf)
plt.axhline(y=0,linestyle='--',color='gray')
plt.axhline(y=-1.96/np.sqrt(len(ts_log_diff)), linestyle='--',color='gray')
plt.axhline(y=1.96/np.sqrt(len(ts_log_diff)), linestyle='--',color='gray')
plt.title('Autocorrelation Function')

#Plot PACF
plt.subplot(122)
plt.plot(lag_pacf)
plt.axhline(y=0,linestyle='--',color='gray')
plt.axhline(y=-1.96/np.sqrt(len(ts_log_diff)), linestyle='--',color='gray')
plt.axhline(y=1.96/np.sqrt(len(ts_log_diff)), linestyle='--',color='gray')
plt.title('Partial Autocorrelation Function')
plt.tight_layout()
```



In [108]:

```
# Fitting ARIMA Model on the data

usedata=mydata.groupby(['Tripstart_time'])['Trip Total'].mean().reset_index()
usedata=usedata.set_index('Tripstart_time')
usedata=usedata[usedata['Trip Total']!=0]
usedata=np.log(usedata)

ts_fare_diff = usedata - usedata.shift()
ts_fare_diff.dropna(inplace = True)

def plot_line(x,y,color,name) :
    tracer = go.Scatter(x = x,y = y,mode = "lines",
                        marker = dict(color = color,
                                      line = dict(width =1)),
                       name = name)
    return tracer

def plot_layout(title) :
    layout = go.Layout(dict(title = title,
                            plot_bgcolor  = "rgb(243,243,243)",
                            paper_bgcolor = "rgb(243,243,243)",
                            xaxis = dict(gridcolor = 'rgb(255, 255, 255)',
                                         zerolinewidth=1,ticklen=5,gridwidth=2),
                            yaxis = dict(gridcolor = 'rgb(255, 255, 255)',
                                            zerolinewidth=1,ticklen=5,gridwidth=2),
                        margin = dict(b = 100)
                       )
                  )
    return layout

from statsmodels.tsa.arima_model import ARIMA
# global fitted_values
#ARIMA model
def arima_model(time_series,p,d,q) :
    arima_model   = ARIMA(time_series , order = (p,d,q))
    results_arima = arima_model.fit(disp = -1)
    fitted_values = results_arima.fittedvalues

    trace1 = plot_line(fitted_values.index,
                       fitted_values.values,
                       "blue","fitted values")

    trace2 = plot_line(ts_fare_diff.index,
                       ts_fare_diff["Trip Total"],
                       "red","log differenced values")
    layout = plot_layout(("ARIMA model p = " + str(p) +
                          ", d = " + str(d) + ", q = " + str(q)))
    data  = [trace2,trace1]
    fig   = go.Figure(data = data,layout = layout)
    py.iplot(fig)

    print (results_arima.summary())
    return fitted_values



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

```
In [109]: fitted_values=arima_model(usedata,2,1,1)
```


ARIMA model p = 2, d = 1, q = 1
log differenced values
fitted values
2
1
0
−1
−2
2015
2016
2017
2018
2019

```
                             ARIMA Model Results
==============================================================================
Dep. Variable:           D.Trip Total   No. Observations:                 1440
Model:                 ARIMA(2, 1, 1)   Log Likelihood                 177.169
Method:                       css-mle   S.D. of innovations              0.214
Date:                Tue, 12 Nov 2019   AIC                           -344.337
Time:                        05:16:10   BIC                           -317.975
Sample:                             1   HQIC                          -334.496

======================================================================================
                         coef    std err          z      P>|z|      [0.025      0.975]
--------------------------------------------------------------------------------------
const                  0.0004      0.001      0.352      0.725      -0.002       0.003
ar.L1.D.Trip Total     0.0671      0.036      1.842      0.066      -0.004       0.138
ar.L2.D.Trip Total    -0.0871      0.033     -2.674      0.008      -0.151      -0.023
ma.L1.D.Trip Total    -0.7787      0.026    -29.628      0.000      -0.830      -0.727
                                    Roots
=============================================================================
                  Real          Imaginary           Modulus         Frequency
-----------------------------------------------------------------------------
AR.1            0.3850           -3.3661j            3.3880           -0.2319
AR.2            0.3850           +3.3661j            3.3880            0.2319
MA.1            1.2841           +0.0000j            1.2841            0.0000
-----------------------------------------------------------------------------
```

In [ ]: