Appendix C

Jupyter Notebook part 3(the page number is only for this Notebook)

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import folium
from folium.plugins import FastMarkerCluster
from folium.plugins import HeatMap
from statsmodels.formula.api import *
import matplotlib.image as mpimg
import io
from PIL import Image
```

[2]:
```
df = pd.read_feather('data/yellow_tripdata_01_weather.feather')
df["income"] = df['tip_amount'] + df['fare_amount']
df['income/duration'] = df['income'] / df['duration']
```

1 Data cleaning

[3]:
```
df.describe()
```

[3]:

	VendorID	passenger_count	trip_distance	pickup_longitude	\
count	1.090686e+07	1.090686e+07	1.090686e+07	1.090686e+07	
mean	1.535024e+00	1.670847e+00	4.648197e+00	-7.281869e+01	
std	4.987718e-01	1.324891e+00	2.981095e+03	9.168964e+00	
min	1.000000e+00	0.000000e+00	0.000000e+00	-1.219343e+02	
25%	1.000000e+00	1.000000e+00	1.000000e+00	-7.399151e+01	
50%	2.000000e+00	1.000000e+00	1.670000e+00	-7.398138e+01	
75%	2.000000e+00	2.000000e+00	3.080000e+00	-7.396610e+01	
max	2.000000e+00	9.000000e+00	8.000010e+06	0.000000e+00	

	pickup_latitude	RatecodeID	dropoff_longitude	dropoff_latitude	\
count	1.090686e+07	1.090686e+07	1.090686e+07	1.090686e+07	
mean	4.011494e+01	1.039350e+00	-7.288659e+01	4.015315e+01	
std	5.051022e+00	5.186309e-01	8.900841e+00	4.903456e+00	
min	0.000000e+00	1.000000e+00	-1.219335e+02	0.000000e+00	
25%	4.073630e+01	1.000000e+00	-7.399107e+01	4.073481e+01	

```
50%       4.075369e+01  1.000000e+00      -7.397942e+01      4.075413e+01
75%       4.076808e+01  1.000000e+00      -7.396196e+01      4.076962e+01
max       6.090876e+01  9.900000e+01       0.000000e+00      6.090876e+01

       payment_type   fare_amount         extra       mta_tax    tip_amount  \
count  1.090686e+07  1.090686e+07  1.090686e+07  1.090686e+07  1.090686e+07
mean   1.347536e+00  1.248693e+01  3.130757e-01  4.976705e-01  1.750663e+00
std    4.910804e-01  3.556400e+01  4.156792e-01  5.046685e-02  2.623546e+00
min    1.000000e+00 -9.576000e+02 -4.261000e+01 -5.000000e-01 -2.208000e+02
25%    1.000000e+00  6.500000e+00  0.000000e+00  5.000000e-01  0.000000e+00
50%    1.000000e+00  9.000000e+00  0.000000e+00  5.000000e-01  1.260000e+00
75%    2.000000e+00  1.400000e+01  5.000000e-01  5.000000e-01  2.320000e+00
max    5.000000e+00  1.112709e+05  6.488700e+02  8.970000e+01  9.981400e+02

       tolls_amount  improvement_surcharge  total_amount      duration  \
count  1.090686e+07           1.090686e+07  1.090686e+07  1.090686e+07
mean   2.933453e-01           2.997245e-01  1.564140e+01  1.520518e+01
std    1.694572e+00           1.232553e-02  3.641280e+01  5.424797e+01
min   -1.740000e+01          -3.000000e-01 -9.584000e+02  0.000000e+00
25%    0.000000e+00           3.000000e-01  8.300000e+00  6.333333e+00
50%    0.000000e+00           3.000000e-01  1.162000e+01  1.046667e+01
75%    0.000000e+00           3.000000e-01  1.716000e+01  1.688333e+01
max    9.801500e+02           3.000000e-01  1.112716e+05  1.439967e+03

         start_hour        income  income/duration
count  1.090686e+07  1.090686e+07     1.090636e+07
mean   1.354638e+01  1.423759e+01              NaN
std    6.391860e+00  3.609683e+01              NaN
min    0.000000e+00 -9.576000e+02             -inf
25%    9.000000e+00  7.350000e+00     8.976378e-01
50%    1.400000e+01  1.046000e+01     1.065217e+00
75%    1.900000e+01  1.600000e+01     1.303579e+00
max    2.300000e+01  1.112709e+05              inf
```

[4]:
```
rid = df['RatecodeID'].value_counts()
rid
```

[4]:
```
1     10626315
2       225019
5        33688
3        16822
4         4696
99         216
6          102
Name: RatecodeID, dtype: int64
```

[5]:
```
df = df.loc[(df['RatecodeID'] != 99)]
```

[6]:
```
# group payment type
def group_rid(x):
    if x != 1:
        return 2
    else:
        return 1
df['RatecodeID'] = df['RatecodeID'].apply(group_rid)
```

[7]:
```
swf = df['store_and_fwd_flag'].value_counts()
swf
```

[7]:
```
N    10843513
Y       63129
Name: store_and_fwd_flag, dtype: int64
```

[8]:
```
pt = df['payment_type'].value_counts()
pt
```

[8]:
```
1    7181337
2    3673602
3      38292
4      13410
5          1
Name: payment_type, dtype: int64
```

[9]:
```
# group payment type
def group_payment_type(x):
    if x != 1:
        return 2
    else:
        return 1
df['payment_type'] = df['payment_type'].apply(group_payment_type)
```

[10]:
```
passenger = df['passenger_count'].value_counts()
passenger
```

[10]:
```
1    7726830
2    1561966
5     601079
3     436429
6     369155
4     210641
0        471
8         26
9         23
7         22
Name: passenger_count, dtype: int64
```

[11]:
```
df = df.loc[(df["duration"] >= 0.25) &  (df["fare_amount"] > 0) & (df["extra"]␣
↪>= 0) & (df["mta_tax"] >= 0)
            & (df["tip_amount"] >= 0) & (df["tolls_amount"] >=0)  &␣
↪(df["total_amount"]>0) & (df["income"] > 0)
            & (df["improvement_surcharge"] >= 0) & (df["trip_distance"] >= 0.
↪01)]
```

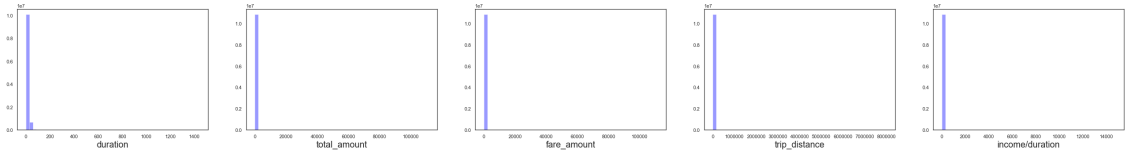
[12]:
```
# lat, long
start_coords = ['pickup_latitude', 'pickup_longitude']
end_coords = ['dropoff_latitude', 'dropoff_longitude']
df[start_coords+ end_coords].describe()
```

[12]:

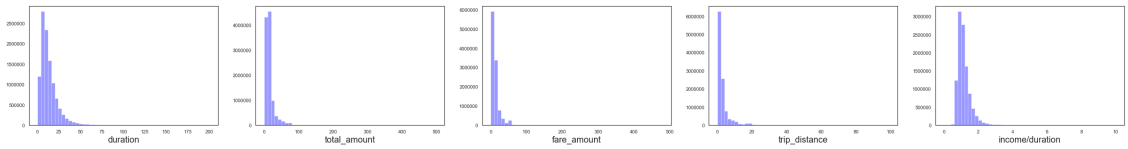
	pickup_latitude	pickup_longitude	dropoff_latitude	dropoff_longitude
count	1.082888e+07	1.082888e+07	1.082888e+07	1.082888e+07
mean	4.016214e+01	-7.290432e+01	4.022927e+01	-7.302472e+01
std	4.863079e+00	8.827634e+00	4.585772e+00	8.323998e+00
min	0.000000e+00	-1.008229e+02	0.000000e+00	-1.008229e+02
25%	4.073648e+01	-7.399152e+01	4.073501e+01	-7.399110e+01
50%	4.075378e+01	-7.398141e+01	4.075424e+01	-7.397948e+01
75%	4.076812e+01	-7.396624e+01	4.076968e+01	-7.396216e+01
max	6.090876e+01	0.000000e+00	6.090876e+01	0.000000e+00

[13]:
```
sns.set(rc={'figure.figsize':(11.7,8.27),"font.size":20,"axes.titlesize":
↪20,"axes.labelsize":20},style="white")
```

[14]:
```
fig, ax = plt.subplots(1, 5)
sns.distplot(df['duration'], kde = False, label = "duration", color ="blue", ax␣
↪= ax[0])
sns.distplot(df['total_amount'], kde = False, label = "total_amount", color␣
↪="blue", ax = ax[1])
sns.distplot(df['fare_amount'], kde = False, label = 'fare_amount', color␣
↪="blue", ax = ax[2])
sns.distplot(df['trip_distance'], kde = False, label = "duration", color␣
↪="blue", ax = ax[3])
sns.distplot(df['income/duration'], kde = False, label = "duration", color␣
↪="blue", ax = ax[4])


fig.set_figheight(5)
fig.set_figwidth(15)
fig.set_figwidth(25)
fig.set_figwidth(35)
fig.set_figwidth(45)
```



[15]:
```
df = df.loc[(df["duration"] <= 200) & (df["total_amount"]<= 500)
            & (df['fare_amount'] <= 500) & (df['trip_distance'] <= 100) &␣
 ↪(df["income/duration"] <= 10)]

fig, ax = plt.subplots(1, 5)
sns.distplot(df['duration'], kde = False, label = "duration", color ="blue", ax␣
 ↪= ax[0])
sns.distplot(df['total_amount'], kde = False, label = "total_amount", color␣
 ↪="blue", ax = ax[1])
sns.distplot(df['fare_amount'], kde = False, label = 'fare_amount', color␣
 ↪="blue", ax = ax[2])
sns.distplot(df['trip_distance'], kde = False, label = "duration", color␣
 ↪="blue", ax = ax[3])
sns.distplot(df['income/duration'], kde = False, label = "duration", color␣
 ↪="blue", ax = ax[4])

fig.set_figheight(5)
fig.set_figwidth(15)
fig.set_figwidth(25)
fig.set_figwidth(35)
fig.set_figwidth(45)
```

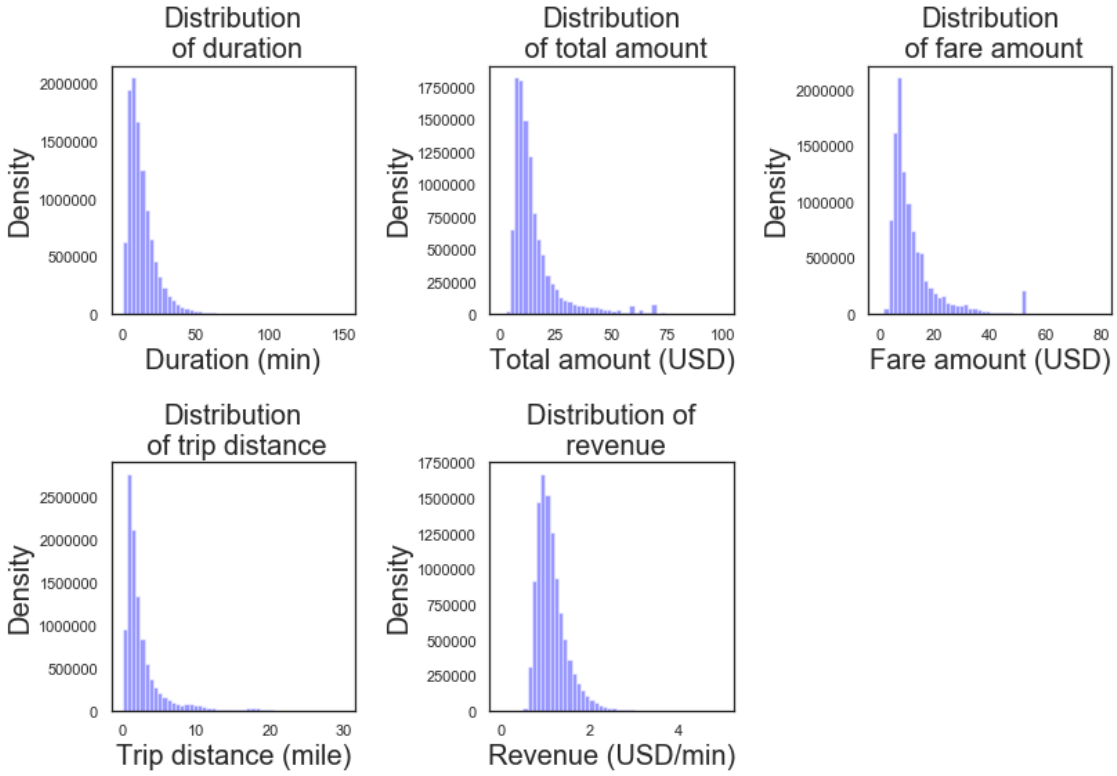


[16]:
```
df = df.loc[(df["duration"] <= 150) & (df["total_amount"]<=100) &␣
 ↪(df['fare_amount'] <=80) & (df['trip_distance'] <= 30) & (df["income/
 ↪duration"] <= 5)]

fig, ax = plt.subplots(1, 5)
sns.distplot(df['duration'], kde = False,  color ="blue", ax = ax[0])
sns.distplot(df['total_amount'], kde = False,  color ="blue", ax = ax[1])
sns.distplot(df['fare_amount'], kde = False, color ="blue", ax = ax[2])
sns.distplot(df['trip_distance'], kde = False,  color ="blue", ax = ax[3])
sns.distplot(df['income/duration'], kde = False,  color ="blue", ax = ax[4])
```

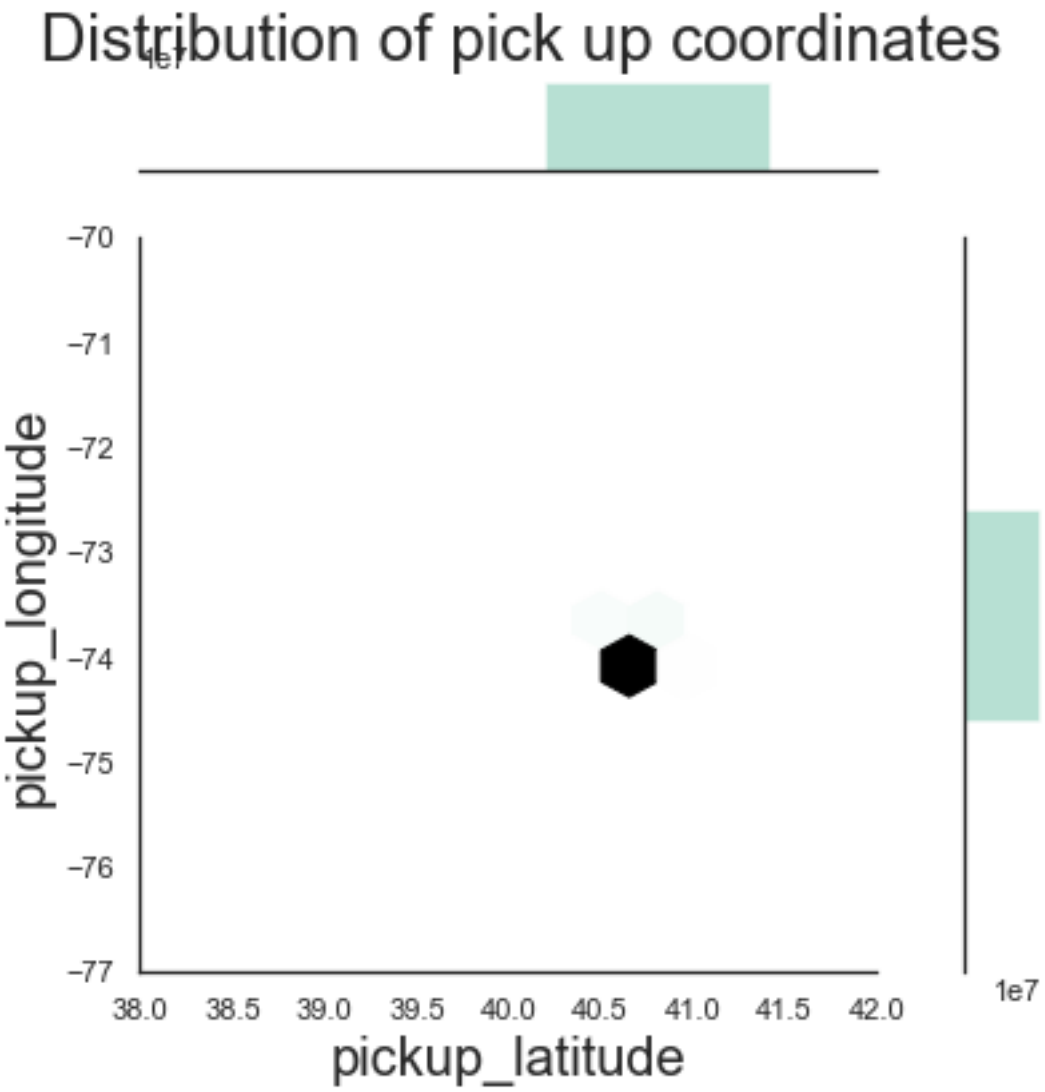
```
ax[0].set_title("Distribution of duration ")
ax[1].set_title("Distribution of total amount ")
ax[2].set_title("Distribution of fare amount ")
ax[3].set_title("Distribution of trip distance ")
ax[4].set_title("Distribution of income per minute")

ax[0].set_xlabel("Duration (min)")
ax[1].set_xlabel("Total amount (USD)")
ax[2].set_xlabel("Fare amount (USD)")
ax[3].set_xlabel("Trip distance (mile)")
ax[4].set_xlabel("Income per minute (USD/min)")

ax[0].set_ylabel("Density")
ax[1].set_ylabel("Density")
ax[2].set_ylabel("Density")
ax[3].set_ylabel("Density")
ax[4].set_ylabel("Density")

fig.set_figheight(5)
fig.set_figwidth(15)
fig.set_figwidth(25)
fig.set_figwidth(35)
fig.set_figwidth(45)


fig.savefig('plots/distibution_narrowed_value.png')
```

[17]:
```
plt.subplot(231)
sns.distplot(df['duration'], kde = False, label = "duration", color ="blue")
plt.title("Distribution\n of duration")
plt.xlabel('Duration (min)')
plt.ylabel("Density")

plt.subplot(232)
sns.distplot(df['total_amount'], kde = False, label = "total_amount", color␣
 ↪="blue")
plt.title("Distribution\n of total amount")
plt.xlabel('Total amount (USD)')
plt.ylabel("Density")
```

```
plt.subplot(233)
sns.distplot(df['fare_amount'], kde = False, label = 'fare_amount', color␣
 ↪="blue")
plt.title("Distribution\n of fare amount")
plt.xlabel('Fare amount (USD)')
plt.ylabel("Density")

plt.subplot(234)
sns.distplot(df['trip_distance'], kde = False, label = "duration", color␣
 ↪="blue")
plt.title("Distribution\n of trip distance")
plt.xlabel('Trip distance (mile)')
plt.ylabel("Density")

plt.subplot(235)
sns.distplot(df['income/duration'], kde = False, label = "duration", color␣
 ↪="blue")
plt.title("Distribution of\n revenue")
plt.xlabel('Revenue (USD/min)')
plt.ylabel("Density")

plt.tight_layout()
plt.show()
```



[18]:
```
p = sns.jointplot(x='pickup_latitude',y='pickup_longitude' , data=␣
↪df,kind="hex",
                  color="#4CB391", xlim=(38,42), ylim=(-77, -70), gridsize=200)

p.fig.suptitle("Distribution of pick up coordinates")
p.fig.tight_layout()
```



[19]:
```
df = df.loc[(df["pickup_longitude"] < -73) & (df["pickup_longitude"] > -74.5) &
            (df["pickup_latitude"] > 40.5) & (df["pickup_latitude"] < 41) &
            (df["dropoff_longitude"] < -73) & (df["dropoff_longitude"] > -74.5)␣
↪&
```

```
            (df["dropoff_latitude"] > 40.5) & (df["dropoff_latitude"] < 41)]
```

[20]:
```
df.reset_index(inplace=True, drop=True)
df
```

[20]:

```
          VendorID tpep_pickup_datetime tpep_dropoff_datetime  \
0                2  2016-01-01 00:00:00   2016-01-01 00:18:30
1                2  2016-01-01 00:00:00   2016-01-01 00:26:45
2                1  2016-01-01 00:00:01   2016-01-01 00:11:55
3                1  2016-01-01 00:00:02   2016-01-01 00:11:14
4                2  2016-01-01 00:00:02   2016-01-01 00:11:08
…              …                   …                   …
10624517         2  2016-01-31 21:28:59   2016-01-31 22:01:58
10624518         2  2016-01-31 22:36:41   2016-01-31 22:45:04
10624519         2  2016-01-31 22:53:00   2016-01-31 22:59:37
10624520         2  2016-01-31 23:00:11   2016-01-31 23:12:08
10624521         2  2016-01-31 23:30:32   2016-01-31 23:38:18

          passenger_count  trip_distance  pickup_longitude  pickup_latitude  \
0                       2           5.52        -73.980118        40.743050
1                       2           7.45        -73.994057        40.719990
2                       1           1.20        -73.979424        40.744614
3                       1           6.00        -73.947151        40.791046
4                       1           3.21        -73.998344        40.723896
…                     …             …                 …                …
10624517                1           7.83        -74.002953        40.750481
10624518                1           2.50        -74.009277        40.717049
10624519                1           1.68        -74.003578        40.750751
10624520                1           2.65        -74.002159        40.734852
10624521                1           2.20        -74.003578        40.751011

          RatecodeID store_and_fwd_flag  dropoff_longitude  …  tip_amount  \
0                  1                  N        -73.913490  …        0.00
1                  1                  N        -73.966362  …        0.00
2                  1                  N        -73.992035  …        0.00
3                  1                  N        -73.920769  …        0.00
4                  1                  N        -73.995850  …        0.00
…                …                  …                  …  …          …
10624517           1                  N        -73.958153  …        5.00
10624518           1                  N        -73.994637  …        2.16
10624519           1                  N        -74.002159  …        1.00
10624520           1                  N        -73.999680  …        1.00
10624521           1                  N        -73.982651  …        0.00

          tolls_amount  improvement_surcharge  total_amount   duration  \
0                  0.0                    0.3         20.30  18.500000
1                  0.0                    0.3         27.30  26.750000
```

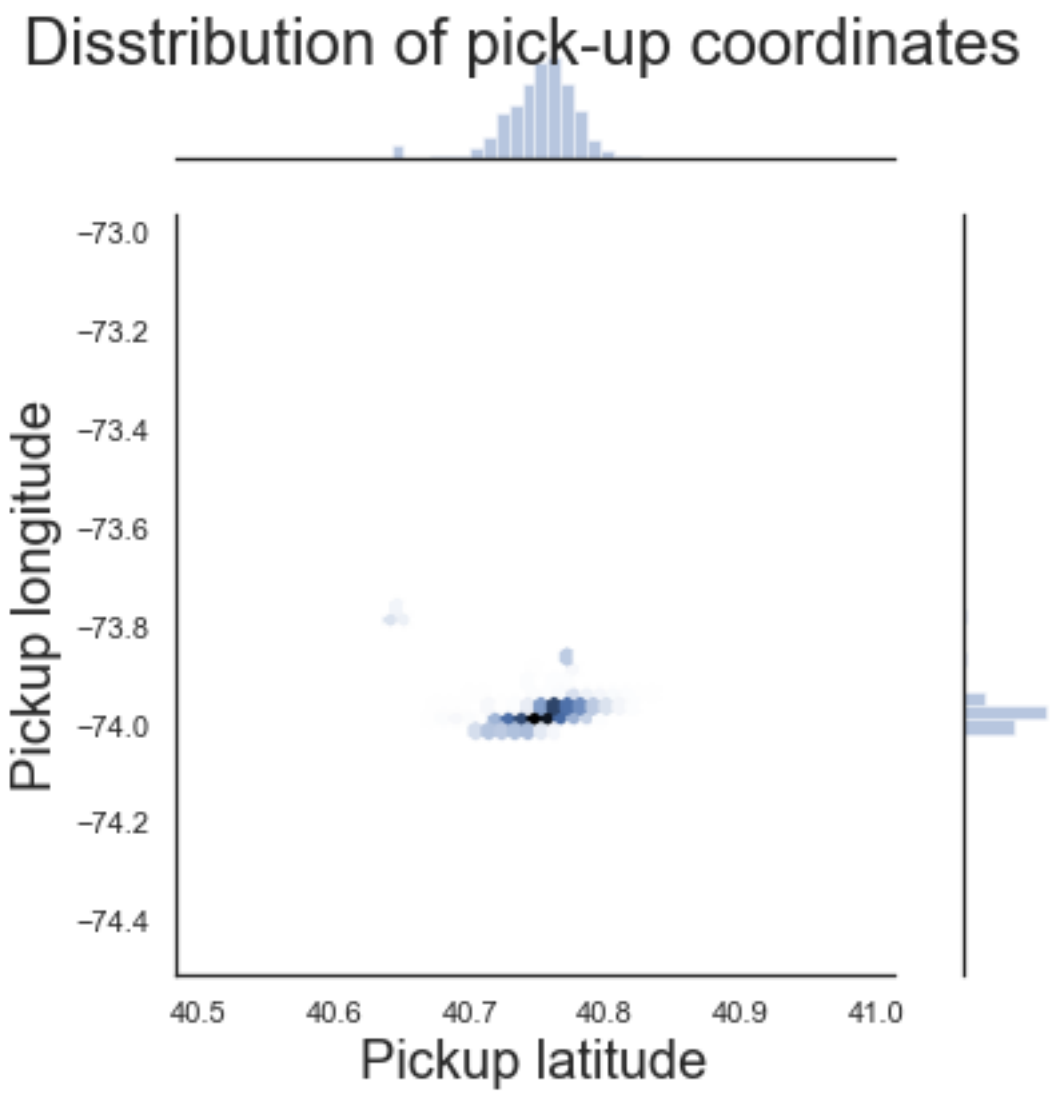
```
2                  0.0                    0.3         10.30  11.900000
3                  0.0                    0.3         19.30  11.200000
4                  0.0                    0.3         12.80  11.100000
…                  …                      …           …          …
10624517           0.0                    0.3         35.30  32.983333
10624518           0.0                    0.3         12.96   8.383333
10624519           0.0                    0.3          9.30   6.616667
10624520           0.0                    0.3         13.30  11.950000
10624521           0.0                    0.3          9.80   7.766667

          start_hour  start_date  weather  income  income/duration
0                  0  2016-01-01   remain   19.00         1.027027
1                  0  2016-01-01   remain   26.00         0.971963
2                  0  2016-01-01   remain    9.00         0.756303
3                  0  2016-01-01   remain   18.00         1.607143
4                  0  2016-01-01   remain   11.50         1.036036
…                  …           …       …       …              …
10624517          21  2016-01-31   remain   34.00         1.030824
10624518          22  2016-01-31   remain   11.66         1.390855
10624519          22  2016-01-31   remain    8.00         1.209068
10624520          23  2016-01-31   remain   12.00         1.004184
10624521          23  2016-01-31   remain    8.50         1.094421

[10624522 rows x 25 columns]
```

[21]:
```
df.describe()
```

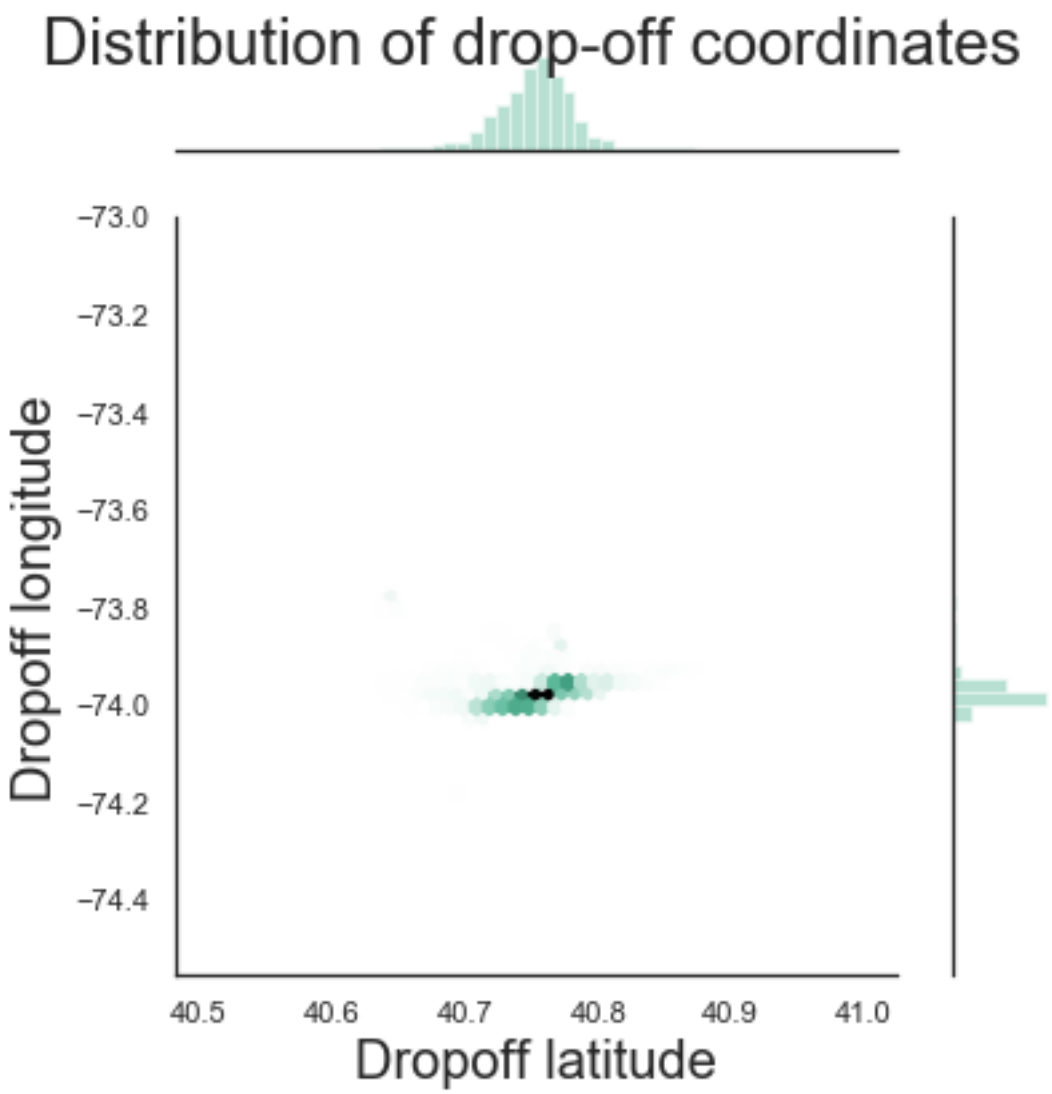
[21]:
```
           VendorID  passenger_count  trip_distance  pickup_longitude  \
count  1.062452e+07     1.062452e+07   1.062452e+07      1.062452e+07
mean   1.538963e+00     1.675594e+00   2.888937e+00     -7.397336e+01
std    4.984796e-01     1.329766e+00   3.503629e+00      3.796886e-02
min    1.000000e+00     0.000000e+00   1.000000e-02     -7.443886e+01
25%    1.000000e+00     1.000000e+00   1.000000e+00     -7.399164e+01
50%    2.000000e+00     1.000000e+00   1.690000e+00     -7.398169e+01
75%    2.000000e+00     2.000000e+00   3.100000e+00     -7.396725e+01
max    2.000000e+00     9.000000e+00   3.000000e+01     -7.303445e+01

       pickup_latitude    RatecodeID  dropoff_longitude  dropoff_latitude  \
count     1.062452e+07  1.062452e+07       1.062452e+07      1.062452e+07
mean      4.075104e+01  1.021407e+00      -7.397358e+01      4.075202e+01
std       2.779560e-02  1.447374e-01       3.365993e-02      3.144207e-02
min       4.050597e+01  1.000000e+00      -7.448333e+01      4.050733e+01
25%       4.073759e+01  1.000000e+00      -7.399119e+01      4.073634e+01
50%       4.075442e+01  1.000000e+00      -7.397976e+01      4.075478e+01
75%       4.076839e+01  1.000000e+00      -7.396313e+01      4.076998e+01
max       4.098892e+01  2.000000e+00      -7.306847e+01      4.099876e+01
```

```
       payment_type   fare_amount         extra       mta_tax    tip_amount  \
count  1.062452e+07  1.062452e+07  1.062452e+07  1.062452e+07  1.062452e+07
mean   1.339203e+00  1.229613e+01  3.143274e-01  4.991960e-01  1.723470e+00
std    4.734389e-01  9.823765e+00  3.656012e-01  2.003404e-02  2.243046e+00
min    1.000000e+00  1.000000e-02  0.000000e+00  0.000000e+00  0.000000e+00
25%    1.000000e+00  6.500000e+00  0.000000e+00  5.000000e-01  0.000000e+00
50%    1.000000e+00  9.000000e+00  0.000000e+00  5.000000e-01  1.260000e+00
75%    2.000000e+00  1.400000e+01  5.000000e-01  5.000000e-01  2.320000e+00
max    2.000000e+00  8.000000e+01  8.500000e+00  8.900000e-01  8.800000e+01

       tolls_amount  improvement_surcharge  total_amount      duration  \
count  1.062452e+07           1.062452e+07  1.062452e+07  1.062452e+07
mean   2.763625e-01           2.999957e-01  1.540948e+01  1.319822e+01
std    1.280491e+00           1.138437e-03  1.213060e+01  1.011057e+01
min    0.000000e+00           0.000000e+00  3.100000e-01  2.666667e-01
25%    0.000000e+00           3.000000e-01  8.300000e+00  6.416667e+00
50%    0.000000e+00           3.000000e-01  1.162000e+01  1.051667e+01
75%    0.000000e+00           3.000000e-01  1.716000e+01  1.688333e+01
max    9.782000e+01           3.000000e-01  1.000000e+02  1.497833e+02

         start_hour        income  income/duration
count  1.062452e+07  1.062452e+07     1.062452e+07
mean   1.355524e+01  1.401960e+01     1.148759e+00
std    6.386805e+00  1.131511e+01     3.862012e-01
min    0.000000e+00  1.000000e-02     8.424600e-05
25%    9.000000e+00  7.360000e+00     8.974359e-01
50%    1.400000e+01  1.046000e+01     1.063235e+00
75%    1.900000e+01  1.595000e+01     1.295681e+00
max    2.300000e+01  9.950000e+01     5.000000e+00
```

[22]:
```
p = sns.jointplot(x='pickup_latitude',y='pickup_longitude' , data=␣
 ↪df,kind="hex")
p.ax_joint.set_xlabel('Pickup latitude')
p.ax_joint.set_ylabel('Pickup longitude')
p.fig.suptitle("Disstribution of pick-up coordinates ")
p.fig.tight_layout()


p.fig.savefig('plots/disstribution of pick up coordinates.png')
```



[23]:
```
p = sns.jointplot(x='dropoff_latitude',y='dropoff_longitude' , data=␣
↪df,kind="hex",color="#4CB391")

p.ax_joint.set_xlabel('Dropoff latitude')
p.ax_joint.set_ylabel('Dropoff longitude')
p.fig.suptitle("Distribution of drop-off coordinates")
p.fig.tight_layout()
p.fig.savefig('plots/disstribution of drop off coordinates.png')
```



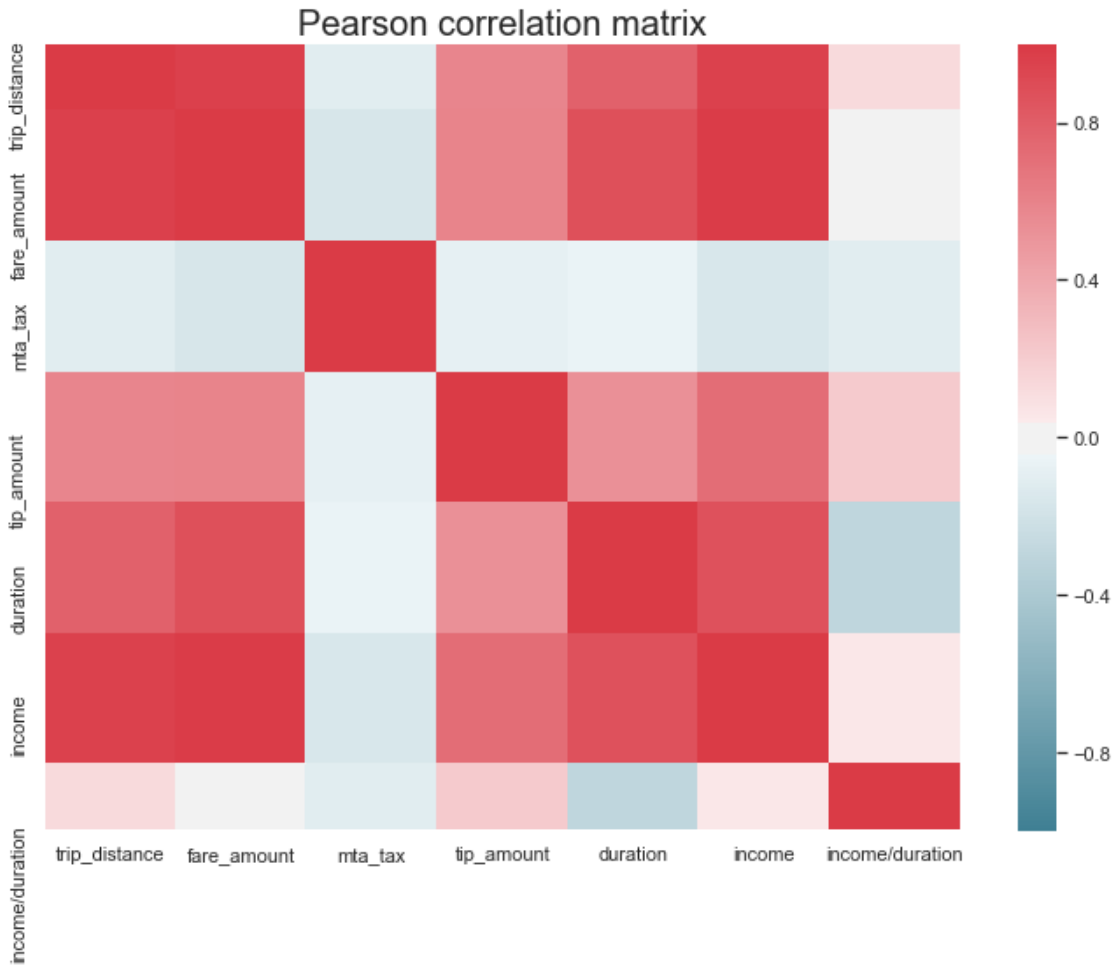
[24]:
```
df.drop(['VendorID','tpep_pickup_datetime',␣
 ↪'tpep_dropoff_datetime','store_and_fwd_flag', 'improvement_surcharge',
        'start_date'], axis=1, inplace = True)
```

[ ]:
```

```

2 Change data type

[25]:
```
df['start_hour'] = df['start_hour'].astype('category')
df['payment_type'] = df['payment_type'].astype('category')
df['RatecodeID'] = df['RatecodeID'].astype('category')
df['weather'] = df['weather'].astype('category')
```

[26]:
```
corr_attr =['trip_distance', 'payment_type', 'fare_amount', 'mta_tax',
 'tip_amount', 'duration', 'start_hour', 'weather','income','income/duration']
corr = df[corr_attr].corr()
sns.heatmap(corr,cmap = sns.diverging_palette(220, 10, as_cmap=True),␣
 ↪square=True, center=0, vmin=-1, vmax=1)
plt.title('Pearson correlation matrix')
plt.savefig('plots/correlation.png')
plt.show()
```



[ ]:

3 Sampling

[27]:
```
sub_df1 = df.sample(n=1000000, random_state=100)
sub_df2 = df.sample(n=1000000, random_state=50)
sub_df3 = df.sample(n=1000000, random_state=30)
```

[28]:
```
card_df = df.loc[(df["payment_type"] == 1)]
cash_df = df.loc[(df["payment_type"] == 2)]
preci_df =  df.loc[(df["weather"] != 'remain')]
remain_df = df.loc[(df["weather"] == 'remain')]
stand_df = df.loc[(df["RatecodeID"] == 1)]
other_df = df.loc[(df["RatecodeID"] == 2)]
```

[29]:
```
df.columns
```

[29]:
```
Index(['passenger_count', 'trip_distance', 'pickup_longitude',
       'pickup_latitude', 'RatecodeID', 'dropoff_longitude',
       'dropoff_latitude', 'payment_type', 'fare_amount', 'extra', 'mta_tax',
       'tip_amount', 'tolls_amount', 'total_amount', 'duration', 'start_hour',
       'weather', 'income', 'income/duration'],
      dtype='object')
```

[ ]:
```
```

4 What is related to tip amount

[30]:
```
fit = ols(formula="tip_amount ~ trip_distance + duration  +payment_type +␣
 ↪start_hour  + weather + duration * start_hour + duration * weather",
        data=sub_df1).fit()
print(fit.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:             tip_amount   R-squared:                       0.623
Model:                            OLS   Adj. R-squared:                  0.623
Method:                 Least Squares   F-statistic:                 3.235e+04
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:39:32   Log-Likelihood:            -1.7400e+06
No. Observations:             1000000   AIC:                         3.480e+06
Df Residuals:                  999948   BIC:                         3.481e+06
Df Model:                          51
Covariance Type:            nonrobust
==============================================================================
==============
                                 coef    std err          t      P>|t|
[0.025      0.975]
```

```
------------------------------------------------------------------------------
--------------
Intercept                      1.3750      0.017     82.495      0.000
1.342       1.408
payment_type[T.2]             -2.4419      0.003   -833.912      0.000
-2.448      -2.436
start_hour[T.1]                0.0979      0.020      4.944      0.000
0.059       0.137
start_hour[T.2]                0.1737      0.022      8.024      0.000
0.131       0.216
start_hour[T.3]                0.2309      0.024      9.812      0.000
0.185       0.277
start_hour[T.4]                0.3003      0.026     11.567      0.000
0.249       0.351
start_hour[T.5]               -0.0813      0.025     -3.211      0.001
-0.131      -0.032
start_hour[T.6]               -0.1434      0.019     -7.705      0.000
-0.180      -0.107
start_hour[T.7]               -0.0834      0.017     -4.960      0.000
-0.116      -0.050
start_hour[T.8]               -0.1438      0.017     -8.617      0.000
-0.177      -0.111
start_hour[T.9]               -0.1555      0.017     -9.215      0.000
-0.189      -0.122
start_hour[T.10]              -0.0996      0.017     -5.913      0.000
-0.133      -0.067
start_hour[T.11]              -0.0894      0.017     -5.317      0.000
-0.122      -0.056
start_hour[T.12]              -0.0435      0.017     -2.619      0.009
-0.076      -0.011
start_hour[T.13]               0.0180      0.017      1.084      0.278
-0.015       0.051
start_hour[T.14]               0.0095      0.016      0.583      0.560
-0.022       0.041
start_hour[T.15]               0.0570      0.016      3.569      0.000
0.026       0.088
start_hour[T.16]               0.0489      0.016      3.024      0.002
0.017       0.081
start_hour[T.17]               0.0359      0.016      2.263      0.024
0.005       0.067
start_hour[T.18]               0.0183      0.016      1.155      0.248
-0.013       0.049
start_hour[T.19]              -0.0120      0.016     -0.745      0.456
-0.044       0.020
start_hour[T.20]              -0.0189      0.016     -1.151      0.250
-0.051       0.013
start_hour[T.21]              -0.0351      0.017     -2.115      0.034
-0.068      -0.003
```

```
start_hour[T.22]              -0.0265      0.017     -1.571      0.116
-0.059       0.007
start_hour[T.23]               0.0038      0.018      0.215      0.830
-0.031       0.038
weather[T.remain]             -0.0365      0.011     -3.179      0.001
-0.059      -0.014
trip_distance                  0.2935      0.001    439.276      0.000
0.292       0.295
duration                       0.0196      0.001     17.933      0.000
0.017       0.022
duration:start_hour[T.1]      -0.0144      0.001    -10.871      0.000
-0.017      -0.012
duration:start_hour[T.2]      -0.0246      0.001    -16.615      0.000
-0.027      -0.022
duration:start_hour[T.3]      -0.0322      0.002    -20.246      0.000
-0.035      -0.029
duration:start_hour[T.4]      -0.0321      0.002    -18.811      0.000
-0.035      -0.029
duration:start_hour[T.5]       0.0112      0.002      6.833      0.000
0.008       0.014
duration:start_hour[T.6]       0.0089      0.001      7.399      0.000
0.007       0.011
duration:start_hour[T.7]       0.0026      0.001      2.455      0.014
0.001       0.005
duration:start_hour[T.8]       0.0113      0.001     10.770      0.000
0.009       0.013
duration:start_hour[T.9]       0.0151      0.001     14.149      0.000
0.013       0.017
duration:start_hour[T.10]      0.0133      0.001     12.498      0.000
0.011       0.015
duration:start_hour[T.11]      0.0141      0.001     13.256      0.000
0.012       0.016
duration:start_hour[T.12]      0.0102      0.001      9.654      0.000
0.008       0.012
duration:start_hour[T.13]      0.0046      0.001      4.395      0.000
0.003       0.007
duration:start_hour[T.14]      0.0052      0.001      5.181      0.000
0.003       0.007
duration:start_hour[T.15]      0.0013      0.001      1.301      0.193
-0.001       0.003
duration:start_hour[T.16]      0.0055      0.001      5.575      0.000
0.004       0.007
duration:start_hour[T.17]      0.0048      0.001      4.870      0.000
0.003       0.007
duration:start_hour[T.18]      0.0050      0.001      4.993      0.000
0.003       0.007
duration:start_hour[T.19]      0.0063      0.001      5.967      0.000
0.004       0.008
```

```
duration:start_hour[T.20]      0.0043      0.001      3.992      0.000
0.002       0.006
duration:start_hour[T.21]      0.0076      0.001      6.892      0.000
0.005       0.010
duration:start_hour[T.22]      0.0065      0.001      5.858      0.000
0.004       0.009
duration:start_hour[T.23]      0.0018      0.001      1.553      0.120
-0.000       0.004
duration:weather[T.remain]     0.0045      0.001      6.221      0.000
0.003       0.006
==============================================================================
Omnibus:                   622805.953   Durbin-Watson:                   2.000
Prob(Omnibus):                  0.000   Jarque-Bera (JB):        145312046.952
Skew:                           1.901   Prob(JB):                         0.00
Kurtosis:                      61.932   Cond. No.                     1.12e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.12e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[31]:
```
fit = ols(formula="tip_amount ~ trip_distance + duration  +payment_type +␣
 ↪start_hour  + weather + duration * start_hour + duration * weather",
          data=sub_df2).fit()
print(fit.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:             tip_amount   R-squared:                       0.626
Model:                            OLS   Adj. R-squared:                  0.626
Method:                 Least Squares   F-statistic:                 3.278e+04
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:39:39   Log-Likelihood:            -1.7348e+06
No. Observations:             1000000   AIC:                         3.470e+06
Df Residuals:                  999948   BIC:                         3.470e+06
Df Model:                          51
Covariance Type:            nonrobust
==============================================================================
==============
                                 coef    std err          t      P>|t|
[0.025      0.975]
------------------------------------------------------------------------------
--------------
Intercept                      1.3755      0.017     83.172      0.000
1.343       1.408
payment_type[T.2]             -2.4370      0.003   -836.442      0.000
```

```
-2.443      -2.431
start_hour[T.1]              0.0572      0.020      2.905      0.004
0.019       0.096
start_hour[T.2]              0.1291      0.021      6.033      0.000
0.087       0.171
start_hour[T.3]              0.1337      0.024      5.682      0.000
0.088       0.180
start_hour[T.4]              0.2179      0.026      8.423      0.000
0.167       0.269
start_hour[T.5]             -0.0485      0.025     -1.924      0.054
-0.098       0.001
start_hour[T.6]             -0.1698      0.019     -9.135      0.000
-0.206      -0.133
start_hour[T.7]             -0.1338      0.017     -8.040      0.000
-0.166      -0.101
start_hour[T.8]             -0.1768      0.017    -10.695      0.000
-0.209      -0.144
start_hour[T.9]             -0.1775      0.017    -10.589      0.000
-0.210      -0.145
start_hour[T.10]            -0.1067      0.017     -6.393      0.000
-0.139      -0.074
start_hour[T.11]            -0.0648      0.017     -3.872      0.000
-0.098      -0.032
start_hour[T.12]            -0.0270      0.017     -1.636      0.102
-0.059       0.005
start_hour[T.13]             0.0170      0.017      1.031      0.303
-0.015       0.049
start_hour[T.14]             0.0168      0.016      1.040      0.298
-0.015       0.049
start_hour[T.15]            -0.0011      0.016     -0.067      0.946
-0.032       0.030
start_hour[T.16]             0.0489      0.016      3.044      0.002
0.017       0.080
start_hour[T.17]             0.0255      0.016      1.612      0.107
-0.005       0.056
start_hour[T.18]             0.0106      0.016      0.676      0.499
-0.020       0.042
start_hour[T.19]            -0.0188      0.016     -1.165      0.244
-0.050       0.013
start_hour[T.20]            -0.0759      0.016     -4.630      0.000
-0.108      -0.044
start_hour[T.21]            -0.0774      0.016     -4.694      0.000
-0.110      -0.045
start_hour[T.22]            -0.0421      0.017     -2.512      0.012
-0.075      -0.009
start_hour[T.23]            -0.0274      0.017     -1.566      0.117
-0.062       0.007
weather[T.remain]           -0.0200      0.011     -1.757      0.079
```

```
-0.042       0.002
trip_distance                  0.2956      0.001    445.463      0.000
0.294       0.297
duration                       0.0197      0.001     18.115      0.000
0.018       0.022
duration:start_hour[T.1]      -0.0102      0.001     -7.689      0.000
-0.013      -0.008
duration:start_hour[T.2]      -0.0217      0.001    -14.757      0.000
-0.025      -0.019
duration:start_hour[T.3]      -0.0255      0.002    -15.906      0.000
-0.029      -0.022
duration:start_hour[T.4]      -0.0274      0.002    -16.282      0.000
-0.031      -0.024
duration:start_hour[T.5]       0.0064      0.002      3.872      0.000
0.003       0.010
duration:start_hour[T.6]       0.0119      0.001      9.932      0.000
0.010       0.014
duration:start_hour[T.7]       0.0070      0.001      6.612      0.000
0.005       0.009
duration:start_hour[T.8]       0.0144      0.001     13.846      0.000
0.012       0.016
duration:start_hour[T.9]       0.0177      0.001     16.667      0.000
0.016       0.020
duration:start_hour[T.10]      0.0150      0.001     14.281      0.000
0.013       0.017
duration:start_hour[T.11]      0.0114      0.001     10.755      0.000
0.009       0.013
duration:start_hour[T.12]      0.0087      0.001      8.266      0.000
0.007       0.011
duration:start_hour[T.13]      0.0040      0.001      3.822      0.000
0.002       0.006
duration:start_hour[T.14]      0.0045      0.001      4.487      0.000
0.003       0.006
duration:start_hour[T.15]      0.0065      0.001      6.677      0.000
0.005       0.008
duration:start_hour[T.16]      0.0058      0.001      5.844      0.000
0.004       0.008
duration:start_hour[T.17]      0.0063      0.001      6.468      0.000
0.004       0.008
duration:start_hour[T.18]      0.0058      0.001      5.729      0.000
0.004       0.008
duration:start_hour[T.19]      0.0073      0.001      6.866      0.000
0.005       0.009
duration:start_hour[T.20]      0.0097      0.001      8.989      0.000
0.008       0.012
duration:start_hour[T.21]      0.0116      0.001     10.576      0.000
0.009       0.014
duration:start_hour[T.22]      0.0073      0.001      6.651      0.000
```

```
0.005       0.009
duration:start_hour[T.23]      0.0044      0.001      3.892      0.000
0.002       0.007
duration:weather[T.remain]     0.0024      0.001      3.249      0.001
0.001       0.004
==============================================================================
Omnibus:                   530326.393   Durbin-Watson:                   1.997
Prob(Omnibus):                  0.000   Jarque-Bera (JB):         74084741.181
Skew:                           1.544   Prob(JB):                         0.00
Kurtosis:                      45.054   Cond. No.                     1.12e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.12e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[32]:
```
fit = ols(formula="tip_amount ~ trip_distance + duration  +payment_type +␣
 ↪start_hour  + weather + duration * start_hour + duration * weather",
        data=sub_df3).fit()
print(fit.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:             tip_amount   R-squared:                       0.622
Model:                            OLS   Adj. R-squared:                  0.622
Method:                 Least Squares   F-statistic:                 3.225e+04
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:39:46   Log-Likelihood:            -1.7395e+06
No. Observations:             1000000   AIC:                         3.479e+06
Df Residuals:                  999948   BIC:                         3.480e+06
Df Model:                          51
Covariance Type:            nonrobust
==============================================================================
==============
                                 coef    std err          t      P>|t|
[0.025      0.975]
------------------------------------------------------------------------------
--------------
Intercept                      1.3999      0.017     84.202      0.000
1.367       1.432
payment_type[T.2]             -2.4413      0.003   -833.862      0.000
-2.447      -2.436
start_hour[T.1]                0.0751      0.020      3.775      0.000
0.036       0.114
start_hour[T.2]                0.1229      0.022      5.697      0.000
0.081       0.165
```

```
start_hour[T.3]              0.1560      0.024      6.576      0.000
0.110       0.202
start_hour[T.4]              0.2289      0.026      8.871      0.000
0.178       0.279
start_hour[T.5]             -0.0020      0.025     -0.077      0.938
-0.051       0.048
start_hour[T.6]             -0.1406      0.019     -7.557      0.000
-0.177      -0.104
start_hour[T.7]             -0.1495      0.017     -8.895      0.000
-0.182      -0.117
start_hour[T.8]             -0.1527      0.017     -9.146      0.000
-0.185      -0.120
start_hour[T.9]             -0.1564      0.017     -9.292      0.000
-0.189      -0.123
start_hour[T.10]            -0.0727      0.017     -4.324      0.000
-0.106      -0.040
start_hour[T.11]            -0.0774      0.017     -4.611      0.000
-0.110      -0.044
start_hour[T.12]            -0.0186      0.017     -1.116      0.265
-0.051       0.014
start_hour[T.13]             0.0204      0.017      1.227      0.220
-0.012       0.053
start_hour[T.14]             0.0118      0.016      0.727      0.468
-0.020       0.044
start_hour[T.15]             0.0310      0.016      1.935      0.053
-0.000       0.062
start_hour[T.16]             0.0343      0.016      2.120      0.034
0.003       0.066
start_hour[T.17]             0.0325      0.016      2.036      0.042
0.001       0.064
start_hour[T.18]             0.0305      0.016      1.924      0.054
-0.001       0.061
start_hour[T.19]            -0.0596      0.016     -3.690      0.000
-0.091      -0.028
start_hour[T.20]            -0.0377      0.016     -2.292      0.022
-0.070      -0.005
start_hour[T.21]            -0.0947      0.017     -5.680      0.000
-0.127      -0.062
start_hour[T.22]            -0.0405      0.017     -2.405      0.016
-0.074      -0.008
start_hour[T.23]             0.0069      0.017      0.394      0.694
-0.027       0.041
weather[T.remain]           -0.0515      0.011     -4.507      0.000
-0.074      -0.029
trip_distance                0.2929      0.001    438.074      0.000
0.292       0.294
duration                     0.0158      0.001     14.499      0.000
0.014       0.018
```

```
duration:start_hour[T.1]      -0.0106      0.001     -7.872      0.000
-0.013      -0.008
duration:start_hour[T.2]      -0.0178      0.001    -12.055      0.000
-0.021      -0.015
duration:start_hour[T.3]      -0.0256      0.002    -15.903      0.000
-0.029      -0.022
duration:start_hour[T.4]      -0.0255      0.002    -15.149      0.000
-0.029      -0.022
duration:start_hour[T.5]       0.0039      0.002      2.387      0.017
0.001       0.007
duration:start_hour[T.6]       0.0104      0.001      8.741      0.000
0.008       0.013
duration:start_hour[T.7]       0.0105      0.001      9.789      0.000
0.008       0.013
duration:start_hour[T.8]       0.0135      0.001     12.823      0.000
0.011       0.016
duration:start_hour[T.9]       0.0171      0.001     15.960      0.000
0.015       0.019
duration:start_hour[T.10]      0.0125      0.001     11.780      0.000
0.010       0.015
duration:start_hour[T.11]      0.0132      0.001     12.381      0.000
0.011       0.015
duration:start_hour[T.12]      0.0093      0.001      8.817      0.000
0.007       0.011
duration:start_hour[T.13]      0.0055      0.001      5.224      0.000
0.003       0.008
duration:start_hour[T.14]      0.0060      0.001      5.991      0.000
0.004       0.008
duration:start_hour[T.15]      0.0043      0.001      4.330      0.000
0.002       0.006
duration:start_hour[T.16]      0.0082      0.001      8.283      0.000
0.006       0.010
duration:start_hour[T.17]      0.0064      0.001      6.535      0.000
0.005       0.008
duration:start_hour[T.18]      0.0060      0.001      5.934      0.000
0.004       0.008
duration:start_hour[T.19]      0.0121      0.001     11.424      0.000
0.010       0.014
duration:start_hour[T.20]      0.0082      0.001      7.533      0.000
0.006       0.010
duration:start_hour[T.21]      0.0146      0.001     13.182      0.000
0.012       0.017
duration:start_hour[T.22]      0.0089      0.001      8.074      0.000
0.007       0.011
duration:start_hour[T.23]      0.0022      0.001      1.909      0.056
-5.88e-05       0.004
duration:weather[T.remain]     0.0062      0.001      8.519      0.000
0.005       0.008
```

```
==============================================================================
Omnibus:                   639753.491   Durbin-Watson:                   2.000
Prob(Omnibus):                  0.000   Jarque-Bera (JB):        156474629.192
Skew:                           1.982   Prob(JB):                         0.00
Kurtosis:                      64.153   Cond. No.                     1.12e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.12e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

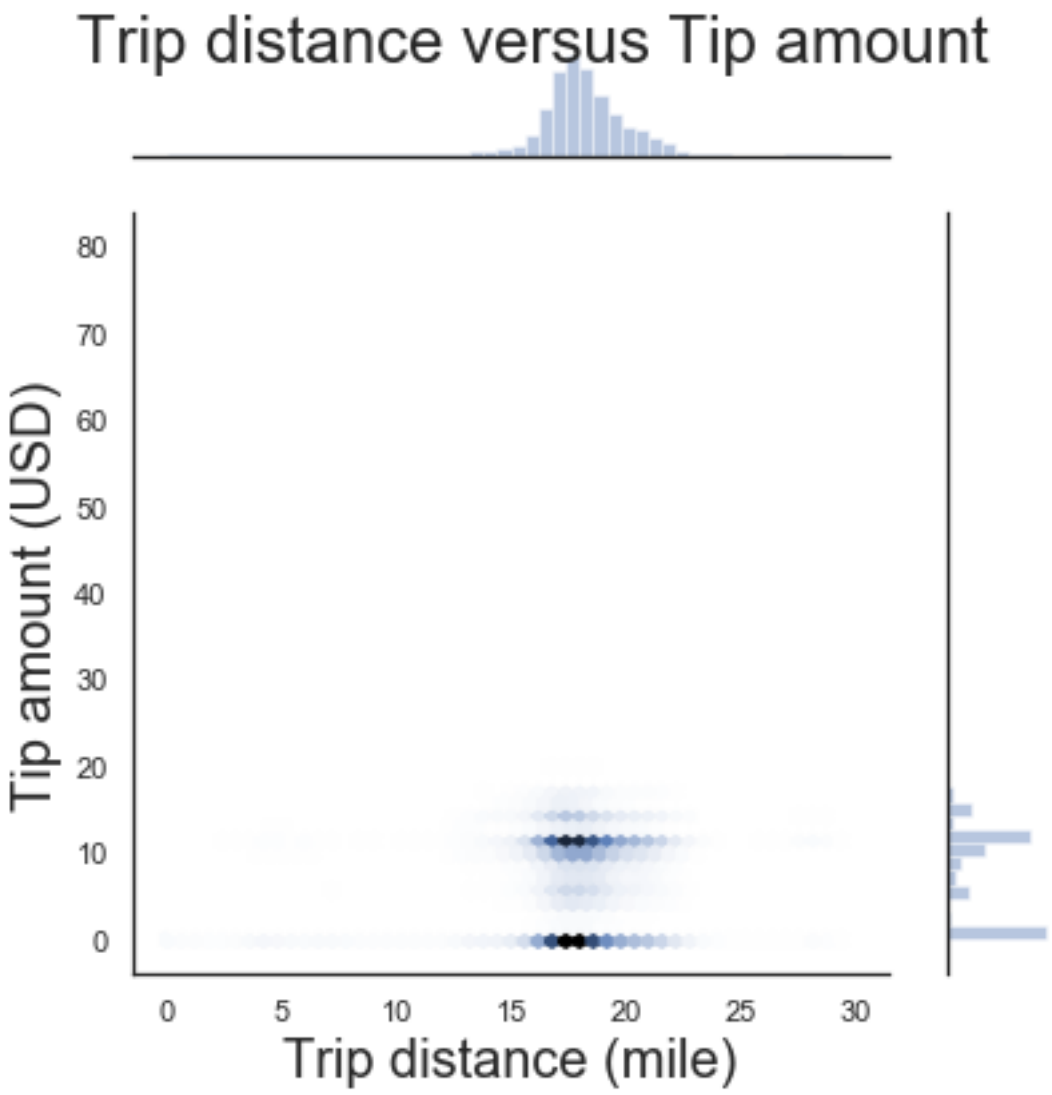
[33]:
```
fit = ols(formula="tip_amount ~ trip_distance +payment_type",
          data=df).fit()
print(fit.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:             tip_amount   R-squared:                       0.613
Model:                            OLS   Adj. R-squared:                  0.613
Method:                 Least Squares   F-statistic:                 8.406e+06
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:39:51   Log-Likelihood:            -1.8619e+07
No. Observations:            10624522   AIC:                         3.724e+07
Df Residuals:                10624519   BIC:                         3.724e+07
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
=====
                       coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
-----
Intercept              1.5257      0.001   2367.297      0.000       1.524
1.527
payment_type[T.2]     -2.4566      0.001  -2711.455      0.000      -2.458
-2.455
trip_distance          0.3569      0.000   2915.138      0.000       0.357
0.357
==============================================================================
Omnibus:                   6729583.760   Durbin-Watson:                   1.979
Prob(Omnibus):                  0.000   Jarque-Bera (JB):       1537681233.635
Skew:                           1.965   Prob(JB):                         0.00
Kurtosis:                      61.805   Cond. No.                         10.6
==============================================================================

Warnings:
```

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

[ ]:

[34]:
```
p = sns.jointplot(x='trip_distance',y= 'tip_amount',data= other_df, kind="hex",␣
↪color="b")
p.ax_joint.set_xlabel('Trip distance (mile)')
p.ax_joint.set_ylabel('Tip amount (USD)')
p.fig.suptitle("Trip distance versus Tip amount")
p.fig.tight_layout()
```



[ ]:

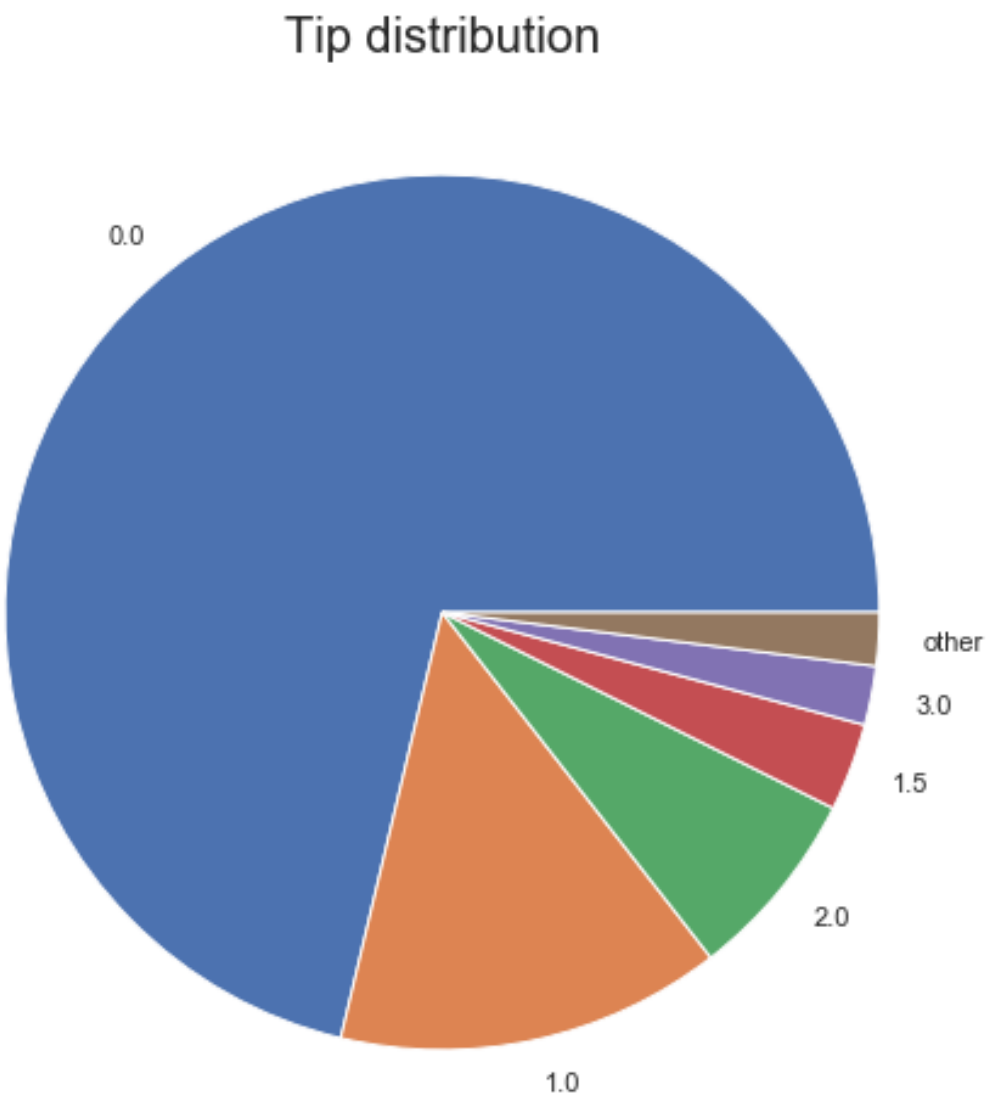
[35]:
```
tip_count = df['tip_amount'].value_counts()
tip_count
```

[35]:
```
0.00     3840212
1.00      768220
2.00      381510
1.50      174963
3.00      117458
          …
78.00          1
77.00          1
11.12          1
11.13          1
64.69          1
Name: tip_amount, Length: 2074, dtype: int64
```

[36]:
```
tip_count[5] = tip_count.iloc[5:].sum()
tip_count = tip_count.iloc[:6]
tip_count.index = tip_count.index.tolist()[:5] + ['other']
tip_count
```

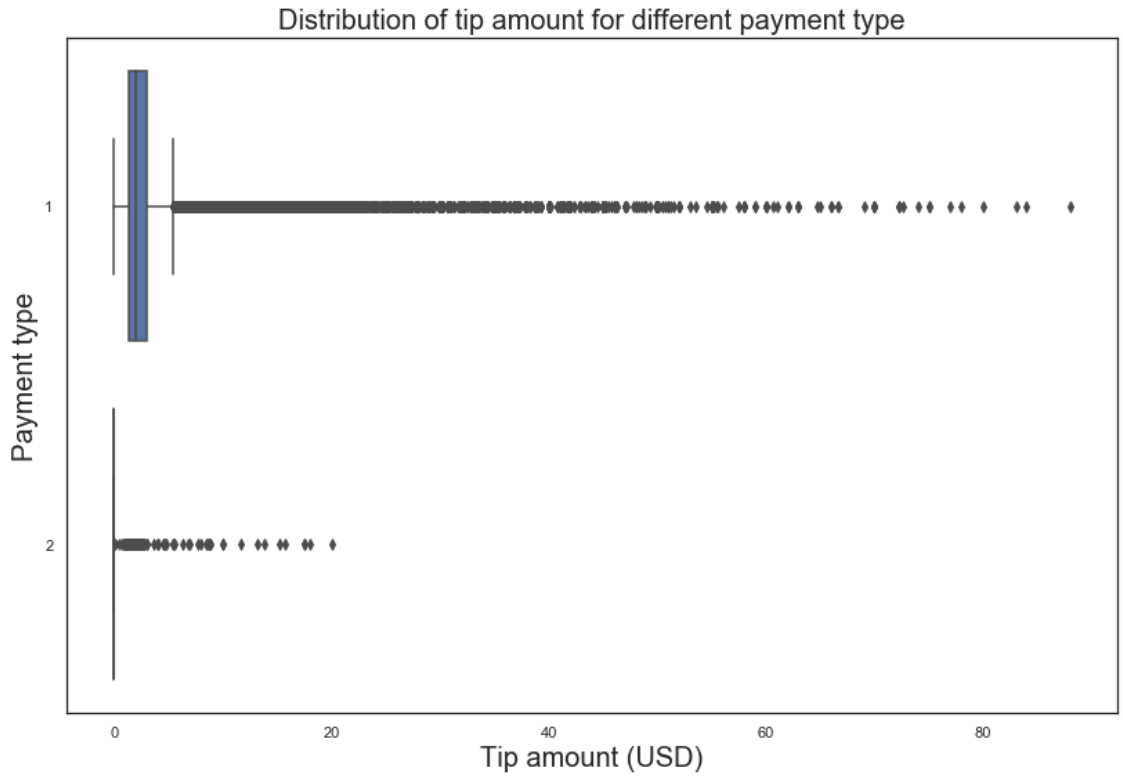
[36]:
```
0.0      3840212
1.0       768220
2.0       381510
1.5       174963
3.0       117458
other     105529
Name: tip_amount, dtype: int64
```

[37]:
```
plt.pie(tip_count.values,labels=tip_count.index)
plt.title("Tip distribution")
plt.show()
```



[ ]:

[38]:
```
sns.boxplot(x="tip_amount", y="payment_type", data=df)
plt.title("Distribution of tip amount for different payment type")
plt.xlabel('Tip amount (USD)')
plt.ylabel("Payment type")
plt.tight_layout()
```



[ ]:

5 What is related to fare amount

[39]:
```
fit = ols(formula="fare_amount ~ trip_distance + duration + start_hour +␣
 ↪weather + duration*start_hour + duration*weather",
          data=sub_df1).fit()
print(fit.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:            fare_amount   R-squared:                       0.974
Model:                            OLS   Adj. R-squared:                  0.974
Method:                 Least Squares   F-statistic:                 7.451e+05
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:40:04   Log-Likelihood:            -1.8819e+06
No. Observations:             1000000   AIC:                         3.764e+06
Df Residuals:                  999949   BIC:                         3.765e+06
Df Model:                          50
Covariance Type:            nonrobust
==============================================================================
==============
```

```
                                coef    std err          t      P>|t|
[0.025      0.975]
------------------------------------------------------------------------------
--------------
Intercept                      1.9486      0.019    101.664      0.000
1.911       1.986
start_hour[T.1]                0.0509      0.023      2.232      0.026
0.006       0.096
start_hour[T.2]                0.0606      0.025      2.430      0.015
0.012       0.110
start_hour[T.3]                0.0087      0.027      0.320      0.749
-0.044       0.062
start_hour[T.4]               -0.0441      0.030     -1.473      0.141
-0.103       0.015
start_hour[T.5]                0.0339      0.029      1.161      0.246
-0.023       0.091
start_hour[T.6]                0.5401      0.021     25.182      0.000
0.498       0.582
start_hour[T.7]                0.6817      0.019     35.166      0.000
0.644       0.720
start_hour[T.8]                0.5188      0.019     26.974      0.000
0.481       0.557
start_hour[T.9]                0.2486      0.019     12.784      0.000
0.210       0.287
start_hour[T.10]               0.2999      0.019     15.453      0.000
0.262       0.338
start_hour[T.11]               0.1468      0.019      7.581      0.000
0.109       0.185
start_hour[T.12]               0.2428      0.019     12.679      0.000
0.205       0.280
start_hour[T.13]               0.2887      0.019     15.077      0.000
0.251       0.326
start_hour[T.14]               0.6010      0.019     32.093      0.000
0.564       0.638
start_hour[T.15]               0.7723      0.018     41.934      0.000
0.736       0.808
start_hour[T.16]               0.7072      0.019     37.968      0.000
0.671       0.744
start_hour[T.17]               0.6678      0.018     36.521      0.000
0.632       0.704
start_hour[T.18]               0.4819      0.018     26.384      0.000
0.446       0.518
start_hour[T.19]               0.2590      0.019     13.957      0.000
0.223       0.295
start_hour[T.20]               0.0958      0.019      5.053      0.000
0.059       0.133
start_hour[T.21]               0.1093      0.019      5.711      0.000
0.072       0.147
```

```
start_hour[T.22]                0.0626      0.019      3.228      0.001
0.025       0.101
start_hour[T.23]               -0.0171      0.020     -0.847      0.397
-0.057       0.023
weather[T.remain]               0.0996      0.013      7.528      0.000
0.074       0.126
trip_distance                   2.0124      0.001   2613.856      0.000
2.011       2.014
duration                        0.3261      0.001    258.939      0.000
0.324       0.329
duration:start_hour[T.1]       -0.0073      0.002     -4.754      0.000
-0.010      -0.004
duration:start_hour[T.2]       -0.0099      0.002     -5.814      0.000
-0.013      -0.007
duration:start_hour[T.3]       -0.0026      0.002     -1.426      0.154
-0.006       0.001
duration:start_hour[T.4]        0.0147      0.002      7.472      0.000
0.011       0.019
duration:start_hour[T.5]        0.0196      0.002     10.324      0.000
0.016       0.023
duration:start_hour[T.6]       -0.0548      0.001    -39.698      0.000
-0.057      -0.052
duration:start_hour[T.7]       -0.0573      0.001    -46.421      0.000
-0.060      -0.055
duration:start_hour[T.8]       -0.0233      0.001    -19.245      0.000
-0.026      -0.021
duration:start_hour[T.9]        0.0023      0.001      1.868      0.062
-0.000       0.005
duration:start_hour[T.10]      -0.0034      0.001     -2.807      0.005
-0.006      -0.001
duration:start_hour[T.11]       0.0090      0.001      7.313      0.000
0.007       0.011
duration:start_hour[T.12]       0.0020      0.001      1.622      0.105
-0.000       0.004
duration:start_hour[T.13]      -0.0040      0.001     -3.299      0.001
-0.006      -0.002
duration:start_hour[T.14]      -0.0322      0.001    -27.775      0.000
-0.034      -0.030
duration:start_hour[T.15]      -0.0512      0.001    -45.212      0.000
-0.053      -0.049
duration:start_hour[T.16]      -0.0510      0.001    -44.767      0.000
-0.053      -0.049
duration:start_hour[T.17]      -0.0488      0.001    -43.103      0.000
-0.051      -0.047
duration:start_hour[T.18]      -0.0349      0.001    -30.004      0.000
-0.037      -0.033
duration:start_hour[T.19]      -0.0194      0.001    -15.978      0.000
-0.022      -0.017
```

```
duration:start_hour[T.20]     -0.0086      0.001     -6.836      0.000
-0.011      -0.006
duration:start_hour[T.21]     -0.0091      0.001     -7.179      0.000
-0.012      -0.007
duration:start_hour[T.22]     -0.0028      0.001     -2.205      0.027
-0.005      -0.000
duration:start_hour[T.23]      0.0033      0.001      2.515      0.012
0.001       0.006
duration:weather[T.remain]     0.0045      0.001      5.302      0.000
0.003       0.006
==============================================================================
Omnibus:                  1016425.708   Durbin-Watson:                   2.000
Prob(Omnibus):                  0.000   Jarque-Bera (JB):       2567932846.754
Skew:                           3.830   Prob(JB):                         0.00
Kurtosis:                     251.136   Cond. No.                     1.12e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.12e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[40]:
```
fit = ols(formula="fare_amount ~ trip_distance + duration + start_hour",
          data=df).fit()
print(fit.summary())
```

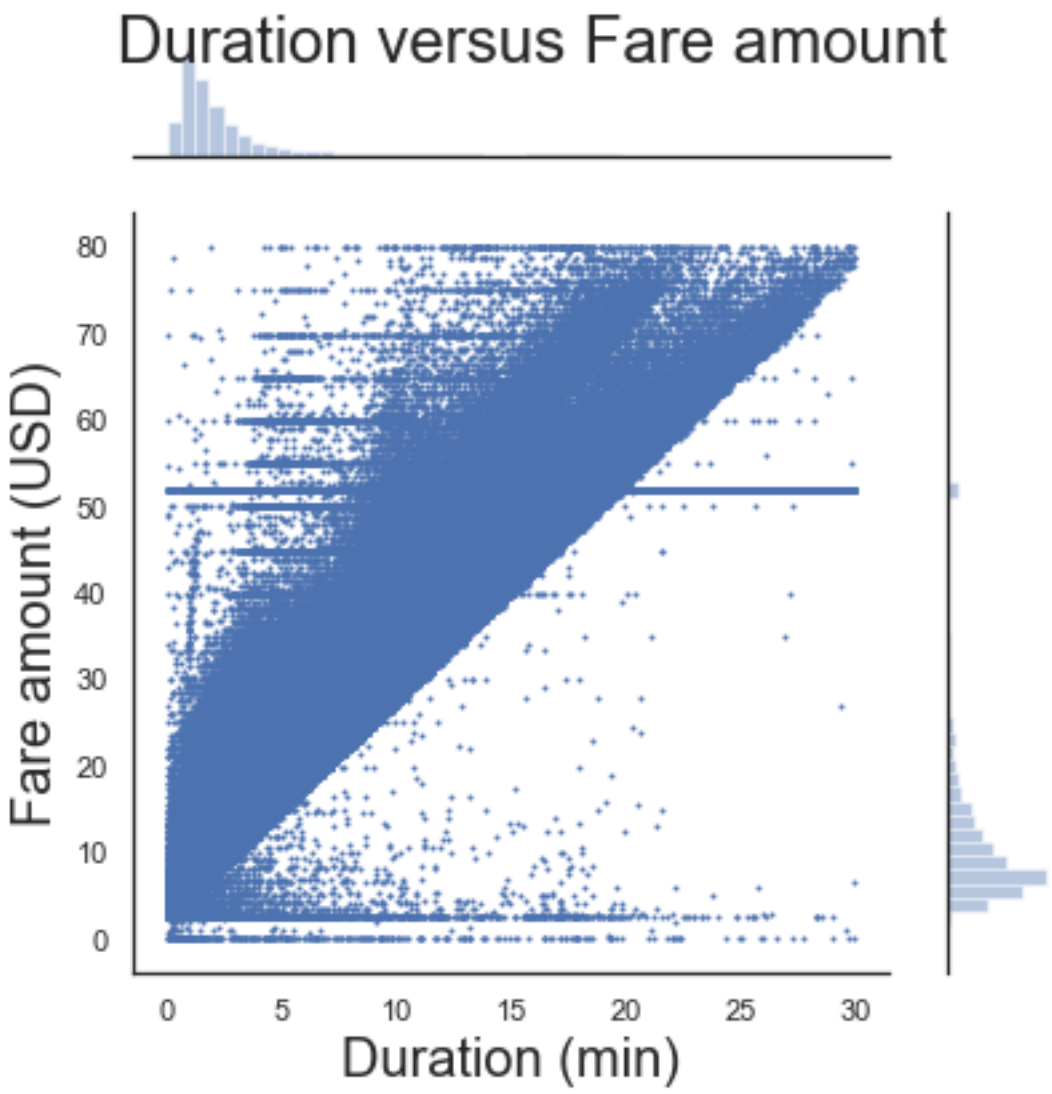
```
                            OLS Regression Results
==============================================================================
Dep. Variable:            fare_amount   R-squared:                       0.973
Model:                            OLS   Adj. R-squared:                  0.973
Method:                 Least Squares   F-statistic:                 1.532e+07
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:41:02   Log-Likelihood:            -2.0162e+07
No. Observations:            10624522   AIC:                         4.032e+07
Df Residuals:                10624496   BIC:                         4.032e+07
Df Model:                           25
Covariance Type:            nonrobust
==============================================================================
====
                       coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
----
Intercept            2.3201      0.003    867.692      0.000       2.315
2.325
start_hour[T.1]     -0.0492      0.004    -12.404      0.000      -0.057
-0.041
```

```
start_hour[T.2]     -0.0706      0.004    -16.410      0.000      -0.079
-0.062
start_hour[T.3]     -0.0396      0.005     -8.312      0.000      -0.049
-0.030
start_hour[T.4]      0.1059      0.005     19.868      0.000       0.095
0.116
start_hour[T.5]      0.2606      0.006     46.680      0.000       0.250
0.272
start_hour[T.6]     -0.0910      0.004    -21.361      0.000      -0.099
-0.083
start_hour[T.7]     -0.0289      0.004     -7.903      0.000      -0.036
-0.022
start_hour[T.8]      0.2317      0.004     66.160      0.000       0.225
0.239
start_hour[T.9]      0.3171      0.004     90.572      0.000       0.310
0.324
start_hour[T.10]     0.2916      0.004     82.908      0.000       0.285
0.299
start_hour[T.11]     0.3046      0.003     87.433      0.000       0.298
0.311
start_hour[T.12]     0.2999      0.003     87.276      0.000       0.293
0.307
start_hour[T.13]     0.2674      0.003     77.717      0.000       0.261
0.274
start_hour[T.14]     0.2011      0.003     59.117      0.000       0.194
0.208
start_hour[T.15]     0.1137      0.003     33.389      0.000       0.107
0.120
start_hour[T.16]     0.0058      0.003      1.662      0.097      -0.001
0.013
start_hour[T.17]     0.0148      0.003      4.392      0.000       0.008
0.021
start_hour[T.18]     0.0423      0.003     12.939      0.000       0.036
0.049
start_hour[T.19]     0.0288      0.003      8.803      0.000       0.022
0.035
start_hour[T.20]     0.0071      0.003      2.140      0.032       0.001
0.014
start_hour[T.21]     0.0093      0.003      2.769      0.006       0.003
0.016
start_hour[T.22]     0.0405      0.003     12.021      0.000       0.034
0.047
start_hour[T.23]     0.0334      0.004      9.507      0.000       0.026
0.040
trip_distance        2.0156      0.000   8559.985      0.000       2.015
2.016
duration             0.3068   8.14e-05   3767.531      0.000       0.307
0.307
```

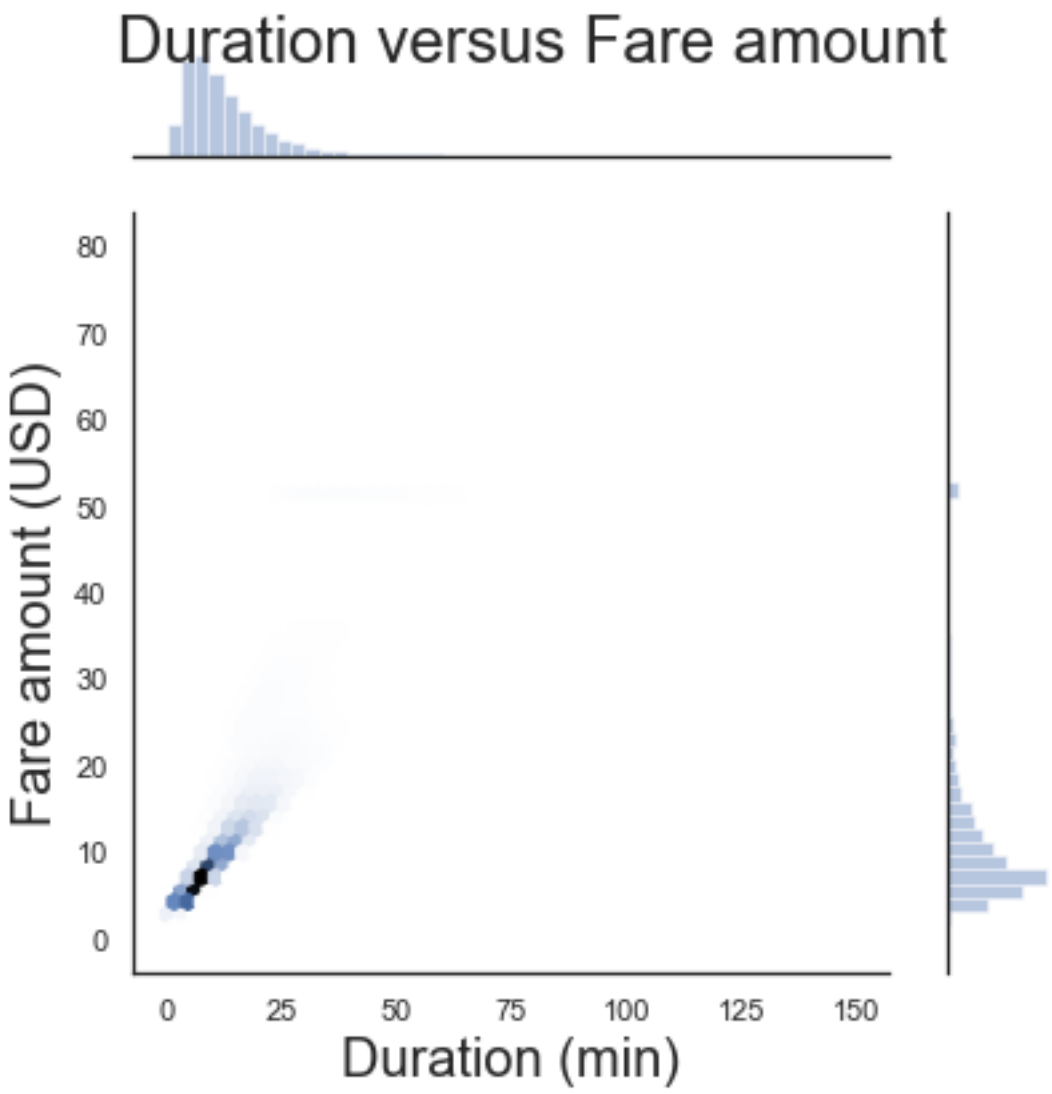
```
==============================================================================
Omnibus:                 10420296.736   Durbin-Watson:                   1.978
Prob(Omnibus):                 0.000   Jarque-Bera (JB):      24913210541.062
Skew:                          3.578   Prob(JB):                         0.00
Kurtosis:                    240.120   Cond. No.                         451.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[ ]:

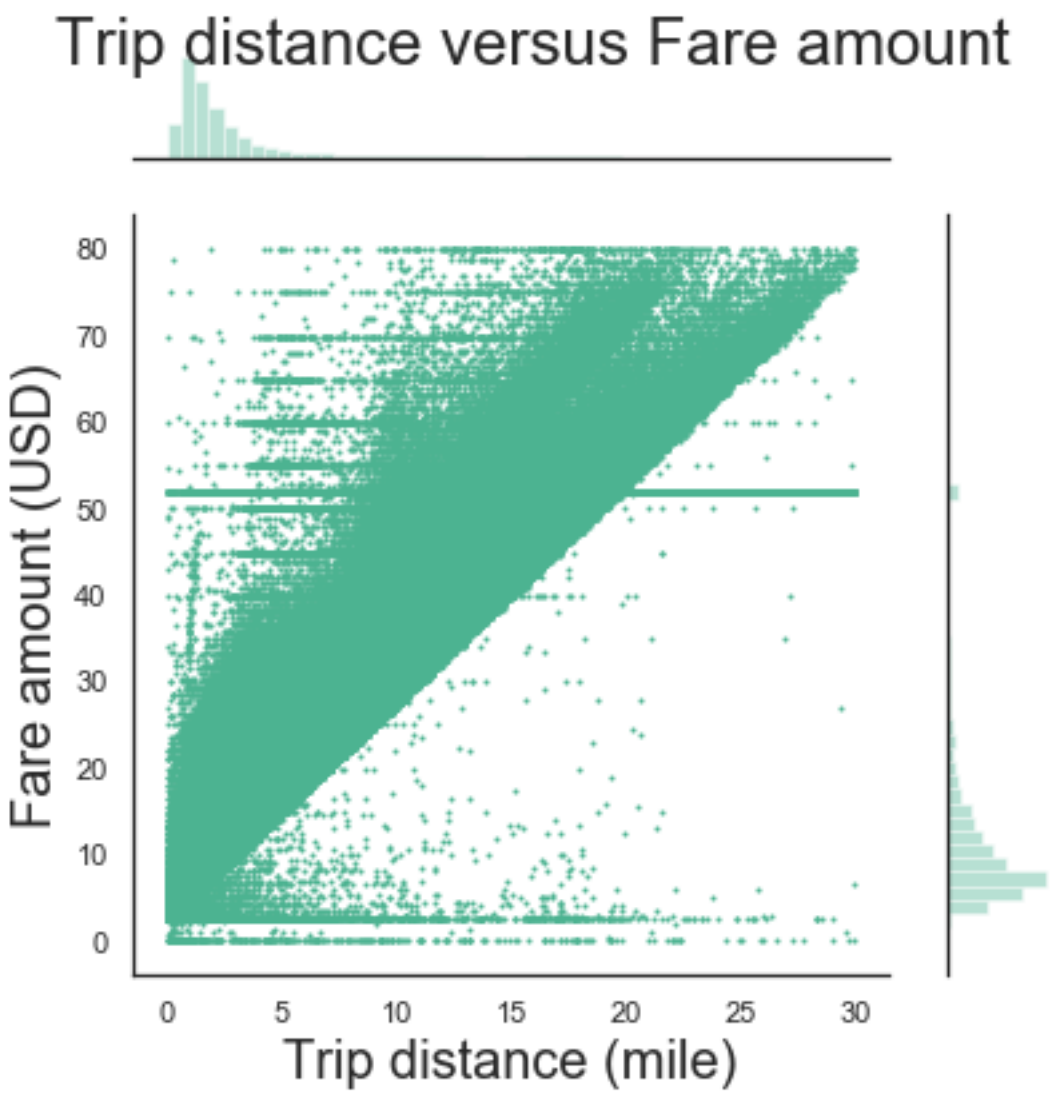
[41]:
```
p = sns.jointplot(x='trip_distance',y= 'fare_amount', data= df, s=1)
p.ax_joint.set_xlabel('Duration (min)')
p.ax_joint.set_ylabel('Fare amount (USD)')
p.fig.suptitle("Duration versus Fare amount")
p.fig.tight_layout()
```



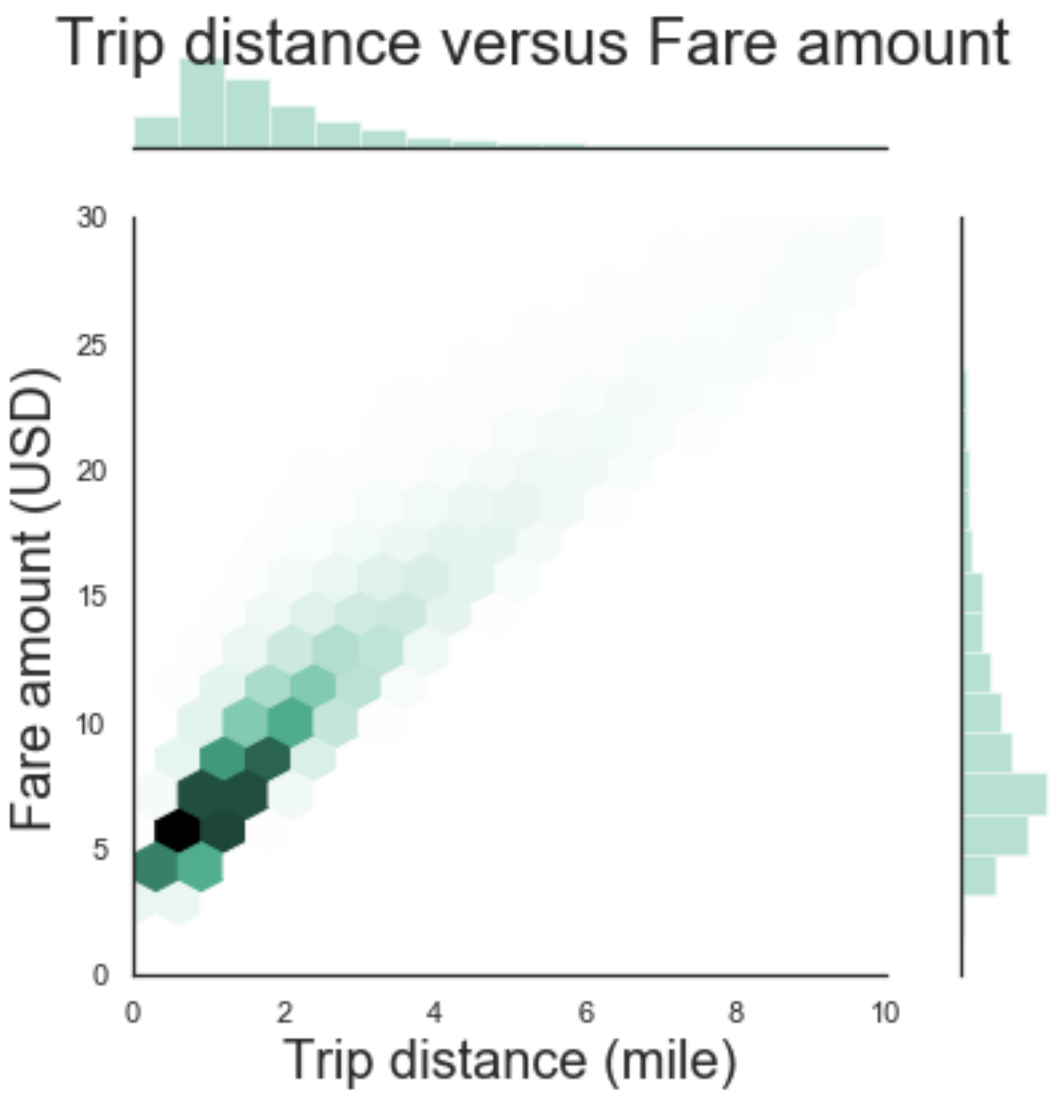
[42]:
```
p = sns.jointplot(x='duration',y= 'fare_amount',data= df, kind="hex")
p.ax_joint.set_xlabel('Duration (min)')
p.ax_joint.set_ylabel('Fare amount (USD)')
p.fig.suptitle("Duration versus Fare amount")
p.fig.tight_layout()
```



[43]:
```
p = sns.jointplot(x='trip_distance',y= 'fare_amount', data= df, s=1,␣
↪color="#4CB391")
p.ax_joint.set_xlabel('Trip distance (mile)')
p.ax_joint.set_ylabel('Fare amount (USD)')
p.fig.suptitle("Trip distance versus Fare amount")
p.fig.tight_layout()
```



[44]:
```
p = sns.jointplot(x='trip_distance',y= 'fare_amount',data= df, kind="hex",␣
↪color="#4CB391", xlim=(0,10), ylim=(0, 30))
p.ax_joint.set_xlabel('Trip distance (mile)')
p.ax_joint.set_ylabel('Fare amount (USD)')
p.fig.suptitle("Trip distance versus Fare amount")
p.fig.tight_layout()
```



[ ]:

6 What is related to trip distance

[45]:
```
fit = ols(formula="trip_distance ~ tip_amount + duration + start_hour + payment_type + weather + RatecodeID +\
                   duration* start_hour + duration* weather",
          data=sub_df1).fit()
print(fit.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          trip_distance   R-squared:                       0.780
```

```
Model:                            OLS   Adj. R-squared:                  0.780
Method:                 Least Squares   F-statistic:                 6.828e+04
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:44:11   Log-Likelihood:            -1.9156e+06
No. Observations:             1000000   AIC:                         3.831e+06
Df Residuals:                  999947   BIC:                         3.832e+06
Df Model:                          52
Covariance Type:            nonrobust
================================================================================
==============
                                 coef    std err          t      P>|t|
[0.025      0.975]
--------------------------------------------------------------------------------
--------------
Intercept                     -0.9023      0.020    -45.309      0.000
-0.941      -0.863
start_hour[T.1]               -0.0319      0.024     -1.353      0.176
-0.078       0.014
start_hour[T.2]               -0.0777      0.026     -3.010      0.003
-0.128      -0.027
start_hour[T.3]               -0.0639      0.028     -2.278      0.023
-0.119      -0.009
start_hour[T.4]            -6.041e-05      0.031     -0.002      0.998
-0.061       0.061
start_hour[T.5]                0.3590      0.030     11.883      0.000
0.300       0.418
start_hour[T.6]                0.6620      0.022     29.821      0.000
0.618       0.705
start_hour[T.7]                0.4677      0.020     23.324      0.000
0.428       0.507
start_hour[T.8]                0.2624      0.020     13.189      0.000
0.223       0.301
start_hour[T.9]                0.2310      0.020     11.486      0.000
0.192       0.270
start_hour[T.10]               0.3012      0.020     15.002      0.000
0.262       0.341
start_hour[T.11]               0.2251      0.020     11.234      0.000
0.186       0.264
start_hour[T.12]               0.1378      0.020      6.955      0.000
0.099       0.177
start_hour[T.13]              -0.0157      0.020     -0.792      0.428
-0.055       0.023
start_hour[T.14]               0.0112      0.019      0.580      0.562
-0.027       0.049
start_hour[T.15]               0.0917      0.019      4.811      0.000
0.054       0.129
start_hour[T.16]               0.1529      0.019      7.934      0.000
0.115       0.191
```

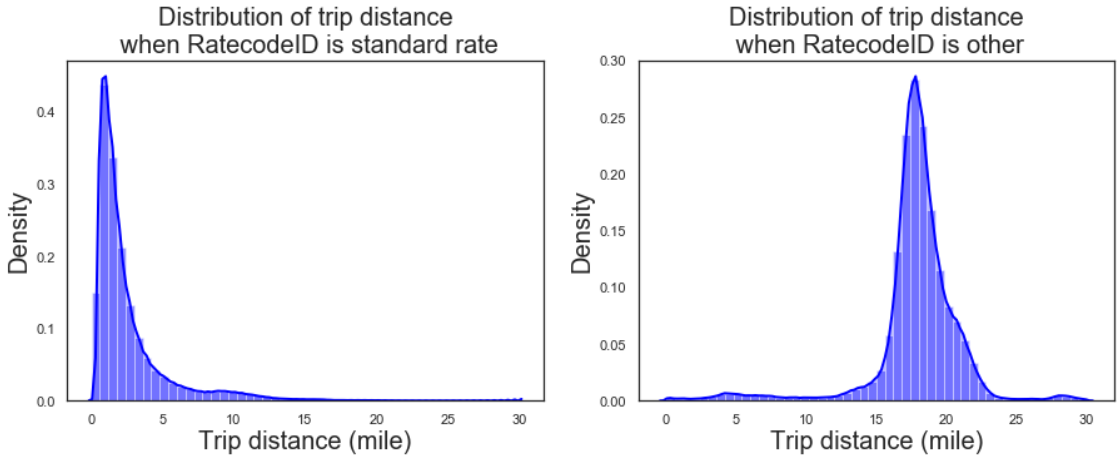
```
start_hour[T.17]               0.1084      0.019      5.730      0.000
0.071       0.146
start_hour[T.18]              -0.0506      0.019     -2.677      0.007
-0.088      -0.014
start_hour[T.19]              -0.1338      0.019     -6.969      0.000
-0.171      -0.096
start_hour[T.20]              -0.2008      0.020    -10.237      0.000
-0.239      -0.162
start_hour[T.21]              -0.1633      0.020     -8.249      0.000
-0.202      -0.125
start_hour[T.22]              -0.1494      0.020     -7.441      0.000
-0.189      -0.110
start_hour[T.23]              -0.1592      0.021     -7.610      0.000
-0.200      -0.118
payment_type[T.2]              0.9278      0.004    208.424      0.000
0.919       0.937
weather[T.remain]              0.0412      0.014      3.008      0.003
0.014       0.068
RatecodeID[T.2]                7.4829      0.013    567.486      0.000
7.457       7.509
tip_amount                     0.3994      0.001    355.463      0.000
0.397       0.402
duration                       0.2453      0.001    191.044      0.000
0.243       0.248
duration:start_hour[T.1]       0.0119      0.002      7.538      0.000
0.009       0.015
duration:start_hour[T.2]       0.0240      0.002     13.594      0.000
0.021       0.027
duration:start_hour[T.3]       0.0373      0.002     19.655      0.000
0.034       0.041
duration:start_hour[T.4]       0.0544      0.002     26.758      0.000
0.050       0.058
duration:start_hour[T.5]       0.0377      0.002     19.221      0.000
0.034       0.042
duration:start_hour[T.6]      -0.0391      0.001    -27.326      0.000
-0.042      -0.036
duration:start_hour[T.7]      -0.0723      0.001    -56.581      0.000
-0.075      -0.070
duration:start_hour[T.8]      -0.0911      0.001    -72.812      0.000
-0.094      -0.089
duration:start_hour[T.9]      -0.0877      0.001    -69.046      0.000
-0.090      -0.085
duration:start_hour[T.10]     -0.0897      0.001    -70.883      0.000
-0.092      -0.087
duration:start_hour[T.11]     -0.0881      0.001    -69.437      0.000
-0.091      -0.086
duration:start_hour[T.12]     -0.0807      0.001    -64.150      0.000
-0.083      -0.078
```

```
duration:start_hour[T.13]     -0.0647      0.001    -51.737      0.000
-0.067      -0.062
duration:start_hour[T.14]     -0.0704      0.001    -58.626      0.000
-0.073      -0.068
duration:start_hour[T.15]     -0.0810      0.001    -69.002      0.000
-0.083      -0.079
duration:start_hour[T.16]     -0.0846      0.001    -71.752      0.000
-0.087      -0.082
duration:start_hour[T.17]     -0.0840      0.001    -71.667      0.000
-0.086      -0.082
duration:start_hour[T.18]     -0.0680      0.001    -56.440      0.000
-0.070      -0.066
duration:start_hour[T.19]     -0.0413      0.001    -32.877      0.000
-0.044      -0.039
duration:start_hour[T.20]     -0.0141      0.001    -10.898      0.000
-0.017      -0.012
duration:start_hour[T.21]     -0.0066      0.001     -5.063      0.000
-0.009      -0.004
duration:start_hour[T.22]     -0.0046      0.001     -3.451      0.001
-0.007      -0.002
duration:start_hour[T.23]      0.0104      0.001      7.594      0.000
0.008       0.013
duration:weather[T.remain]    -0.0029      0.001     -3.306      0.001
-0.005      -0.001
==============================================================================
Omnibus:                   448238.632   Durbin-Watson:                   2.004
Prob(Omnibus):                  0.000   Jarque-Bera (JB):         14404965.415
Skew:                           1.536   Prob(JB):                         0.00
Kurtosis:                      21.338   Cond. No.                     1.11e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.11e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[ ]:

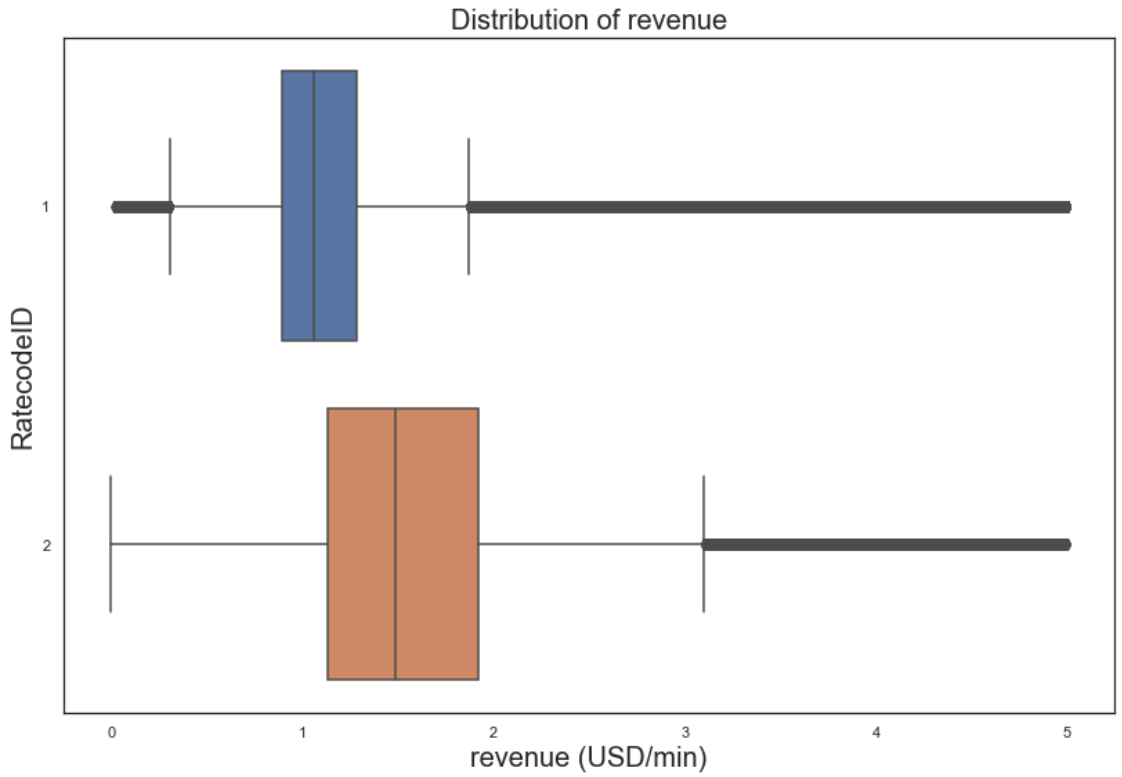
[46]:
```
plt.figure(figsize=(15, 5))
plt.subplot(121)
sns.distplot(stand_df ['trip_distance'], kde = True,
             kde_kws = {'shade': True, 'linewidth': 2}, color ="blue")
plt.title("Distribution of trip distance\n when RatecodeID is standard rate")
plt.xlabel('Trip distance (mile)')
plt.ylabel("Density")
```

```
plt.subplot(122)
sns.distplot(other_df['trip_distance'], kde = True,
             kde_kws = {'shade': True, 'linewidth': 2}, color ="blue")
plt.title("Distribution of trip distance\n when RatecodeID is other")
plt.xlabel('Trip distance (mile)')
plt.ylabel("Density")

fig.set_figheight(5)
fig.set_figwidth(15)
```



[ ]:

[47]:
```
sns.boxplot(x="income/duration", y="RatecodeID", data=df)
plt.title("Distribution of revenue")
plt.xlabel('revenue (USD/min)')
plt.tight_layout()
```



[ ]:

7 Delete ratecodeID = 2 from all dataset and resampling

[48]:
```
df = df.loc[(df["RatecodeID"] == 1)]
```

[49]:
```
df.shape
```

[49]: (10397081, 19)

[50]:
```
sub_df1 = sub_df1.loc[(sub_df1["RatecodeID"] == 1)]
sub_df2 = sub_df2.loc[(sub_df2["RatecodeID"] == 1)]
sub_df3 = sub_df3.loc[(sub_df3["RatecodeID"] == 1)]
```

[51]:
```
fit = ols(formula="trip_distance ~  duration + start_hour + payment_type +␣
 ↪weather +\
                    duration* start_hour + duration* weather",
          data=sub_df1).fit()
print(fit.summary())
```

```
                            OLS Regression Results
==============================================================================
```

```
Dep. Variable:          trip_distance   R-squared:                       0.616
Model:                            OLS   Adj. R-squared:                  0.616
Method:                 Least Squares   F-statistic:                 3.141e+04
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:44:26   Log-Likelihood:            -1.8964e+06
No. Observations:              978619   AIC:                         3.793e+06
Df Residuals:                  978568   BIC:                         3.794e+06
Df Model:                          50
Covariance Type:            nonrobust
==============================================================================
==============
                                 coef    std err          t      P>|t|
[0.025      0.975]
------------------------------------------------------------------------------
--------------
Intercept                     -0.2641      0.021    -12.674      0.000
-0.305      -0.223
start_hour[T.1]               -0.0232      0.024     -0.953      0.341
-0.071       0.025
start_hour[T.2]               -0.0621      0.027     -2.337      0.019
-0.114      -0.010
start_hour[T.3]               -0.0251      0.029     -0.868      0.385
-0.082       0.032
start_hour[T.4]                0.0572      0.032      1.780      0.075
-0.006       0.120
start_hour[T.5]               -0.0487      0.033     -1.495      0.135
-0.113       0.015
start_hour[T.6]                0.0312      0.024      1.285      0.199
-0.016       0.079
start_hour[T.7]                0.0735      0.022      3.417      0.001
0.031       0.116
start_hour[T.8]                0.1065      0.021      5.081      0.000
0.065       0.148
start_hour[T.9]                0.1482      0.021      7.058      0.000
0.107       0.189
start_hour[T.10]               0.2211      0.021     10.511      0.000
0.180       0.262
start_hour[T.11]               0.1996      0.021      9.527      0.000
0.159       0.241
start_hour[T.12]               0.1146      0.021      5.513      0.000
0.074       0.155
start_hour[T.13]              -0.0582      0.021     -2.785      0.005
-0.099      -0.017
start_hour[T.14]              -0.1435      0.021     -6.975      0.000
-0.184      -0.103
start_hour[T.15]              -0.1224      0.020     -6.038      0.000
-0.162      -0.083
start_hour[T.16]              -0.0595      0.020     -2.909      0.004
```

```
-0.100      -0.019
start_hour[T.17]              -0.0660      0.020     -3.293      0.001
-0.105      -0.027
start_hour[T.18]              -0.1711      0.020     -8.590      0.000
-0.210      -0.132
start_hour[T.19]              -0.1985      0.020     -9.862      0.000
-0.238      -0.159
start_hour[T.20]              -0.2477      0.021    -12.068      0.000
-0.288      -0.207
start_hour[T.21]              -0.2165      0.021    -10.494      0.000
-0.257      -0.176
start_hour[T.22]              -0.1700      0.021     -8.145      0.000
-0.211      -0.129
start_hour[T.23]              -0.1840      0.022     -8.476      0.000
-0.227      -0.141
payment_type[T.2]             -0.0411      0.004    -11.409      0.000
-0.048      -0.034
weather[T.remain]             -0.0828      0.015     -5.616      0.000
-0.112      -0.054
duration                       0.2732      0.001    195.946      0.000
0.271       0.276
duration:start_hour[T.1]       0.0105      0.002      6.316      0.000
0.007       0.014
duration:start_hour[T.2]       0.0224      0.002     12.172      0.000
0.019       0.026
duration:start_hour[T.3]       0.0343      0.002     17.326      0.000
0.030       0.038
duration:start_hour[T.4]       0.0557      0.002     25.492      0.000
0.051       0.060
duration:start_hour[T.5]       0.0969      0.002     40.489      0.000
0.092       0.102
duration:start_hour[T.6]       0.0321      0.002     17.880      0.000
0.029       0.036
duration:start_hour[T.7]      -0.0421      0.001    -28.743      0.000
-0.045      -0.039
duration:start_hour[T.8]      -0.0881      0.001    -64.460      0.000
-0.091      -0.085
duration:start_hour[T.9]      -0.0900      0.001    -65.911      0.000
-0.093      -0.087
duration:start_hour[T.10]     -0.0901      0.001    -65.809      0.000
-0.093      -0.087
duration:start_hour[T.11]     -0.0933      0.001    -68.174      0.000
-0.096      -0.091
duration:start_hour[T.12]     -0.0862      0.001    -62.963      0.000
-0.089      -0.084
duration:start_hour[T.13]     -0.0677      0.001    -49.210      0.000
-0.070      -0.065
duration:start_hour[T.14]     -0.0642      0.001    -48.065      0.000
```

```
-0.067      -0.062
duration:start_hour[T.15]     -0.0696      0.001    -53.217      0.000
-0.072      -0.067
duration:start_hour[T.16]     -0.0708      0.001    -53.906      0.000
-0.073      -0.068
duration:start_hour[T.17]     -0.0746      0.001    -57.583      0.000
-0.077      -0.072
duration:start_hour[T.18]     -0.0634      0.001    -48.105      0.000
-0.066      -0.061
duration:start_hour[T.19]     -0.0398      0.001    -29.163      0.000
-0.042      -0.037
duration:start_hour[T.20]     -0.0128      0.001     -9.145      0.000
-0.016      -0.010
duration:start_hour[T.21]     -0.0024      0.001     -1.728      0.084
-0.005       0.000
duration:start_hour[T.22]     -0.0029      0.001     -2.047      0.041
-0.006      -0.000
duration:start_hour[T.23]      0.0134      0.001      9.185      0.000
0.011       0.016
duration:weather[T.remain]     0.0091      0.001      9.010      0.000
0.007       0.011
==============================================================================
Omnibus:                   479239.040   Durbin-Watson:                   2.003
Prob(Omnibus):                  0.000   Jarque-Bera (JB):         12934893.544
Skew:                           1.801   Prob(JB):                         0.00
Kurtosis:                      20.443   Cond. No.                     1.02e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
[2] The condition number is large, 1.02e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

[ ]:

[52]:
```
fit = ols(formula="trip_distance ~  duration + start_hour + payment_type +␣
 ↪weather",
          data=sub_df1).fit()
print(fit.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:          trip_distance   R-squared:                       0.598
Model:                            OLS   Adj. R-squared:                  0.598
Method:                 Least Squares   F-statistic:                 5.602e+04
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:44:28   Log-Likelihood:           -1.9188e+06
```

```
No. Observations:              978619   AIC:                          3.838e+06
Df Residuals:                  978592   BIC:                          3.838e+06
Df Model:                          26
Covariance Type:            nonrobust
==============================================================================
=====
                         coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
-----
Intercept              0.2814      0.012     22.661      0.000       0.257
0.306
start_hour[T.1]        0.0862      0.014      6.204      0.000       0.059
0.113
start_hour[T.2]        0.1784      0.015     11.865      0.000       0.149
0.208
start_hour[T.3]        0.3641      0.017     21.893      0.000       0.332
0.397
start_hour[T.4]        0.7026      0.019     37.372      0.000       0.666
0.739
start_hour[T.5]        0.8762      0.020     43.714      0.000       0.837
0.915
start_hour[T.6]        0.2237      0.015     14.859      0.000       0.194
0.253
start_hour[T.7]       -0.4487      0.013    -35.005      0.000      -0.474
-0.424
start_hour[T.8]       -1.0021      0.012    -81.852      0.000      -1.026
-0.978
start_hour[T.9]       -0.9907      0.012    -80.976      0.000      -1.015
-0.967
start_hour[T.10]      -0.9136      0.012    -74.194      0.000      -0.938
-0.889
start_hour[T.11]      -0.9772      0.012    -80.174      0.000      -1.001
-0.953
start_hour[T.12]      -0.9621      0.012    -79.917      0.000      -0.986
-0.939
start_hour[T.13]      -0.9005      0.012    -74.763      0.000      -0.924
-0.877
start_hour[T.14]      -0.9453      0.012    -79.053      0.000      -0.969
-0.922
start_hour[T.15]      -0.9996      0.012    -83.880      0.000      -1.023
-0.976
start_hour[T.16]      -0.9531      0.012    -78.304      0.000      -0.977
-0.929
start_hour[T.17]      -1.0099      0.012    -85.745      0.000      -1.033
-0.987
start_hour[T.18]      -0.9570      0.011    -83.659      0.000      -0.979
-0.935
```

```
start_hour[T.19]     -0.6886      0.011    -60.096      0.000      -0.711
-0.666
start_hour[T.20]     -0.4191      0.012    -35.972      0.000      -0.442
-0.396
start_hour[T.21]     -0.2589      0.012    -22.118      0.000      -0.282
-0.236
start_hour[T.22]     -0.2031      0.012    -17.163      0.000      -0.226
-0.180
start_hour[T.23]     -0.0070      0.012     -0.569      0.569      -0.031
0.017
payment_type[T.2]    -0.0385      0.004    -10.447      0.000      -0.046
-0.031
weather[T.remain]    -0.0264      0.009     -3.033      0.002      -0.044
-0.009
duration              0.2331      0.000   1185.661      0.000       0.233
0.233
==============================================================================
Omnibus:                   468487.939   Durbin-Watson:                   2.003
Prob(Omnibus):                  0.000   Jarque-Bera (JB):          9516502.815
Skew:                           1.832   Prob(JB):                         0.00
Kurtosis:                      17.831   Cond. No.                         406.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[53]:
```
fit = ols(formula="trip_distance ~ duration + start_hour + payment_type",
          data=df).fit()
print(fit.summary())
```

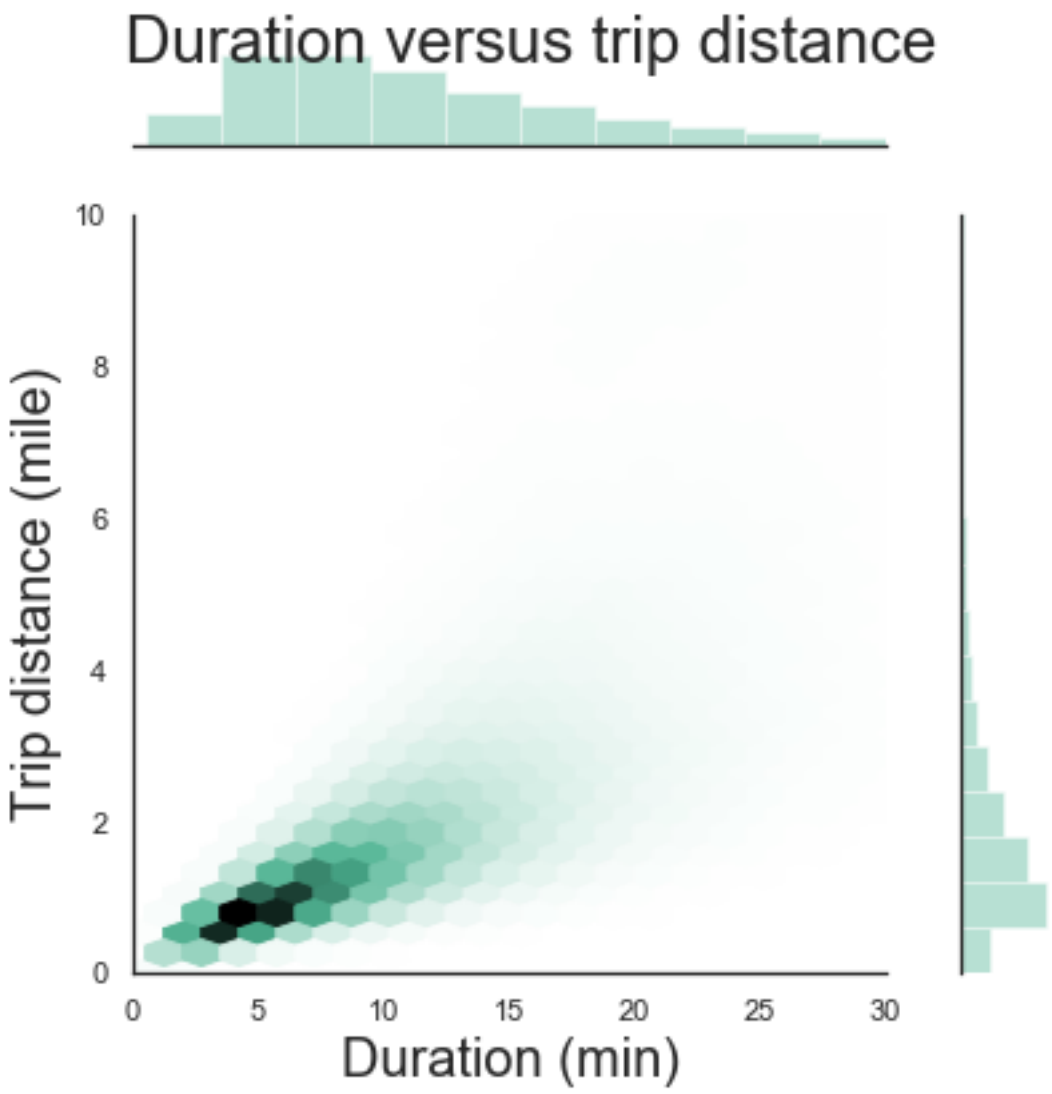
```
                            OLS Regression Results
==============================================================================
Dep. Variable:          trip_distance   R-squared:                       0.598
Model:                            OLS   Adj. R-squared:                  0.598
Method:                 Least Squares   F-statistic:                 6.189e+05
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:45:03   Log-Likelihood:            -2.0368e+07
No. Observations:            10397081   AIC:                         4.074e+07
Df Residuals:                10397055   BIC:                         4.074e+07
Df Model:                          25
Covariance Type:            nonrobust
==============================================================================
=====
                         coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
-----
```

```
Intercept             0.2651      0.003     90.971      0.000        0.259
0.271
start_hour[T.1]       0.0749      0.004     17.670      0.000        0.067
0.083
start_hour[T.2]       0.1835      0.005     39.971      0.000        0.175
0.193
start_hour[T.3]       0.3630      0.005     71.304      0.000        0.353
0.373
start_hour[T.4]       0.6985      0.006    121.783      0.000        0.687
0.710
start_hour[T.5]       0.8469      0.006    138.262      0.000        0.835
0.859
start_hour[T.6]       0.2392      0.005     51.817      0.000        0.230
0.248
start_hour[T.7]      -0.4673      0.004   -118.987      0.000       -0.475
-0.460
start_hour[T.8]      -1.0053      0.004   -268.657      0.000       -1.013
-0.998
start_hour[T.9]      -1.0082      0.004   -269.610      0.000       -1.016
-1.001
start_hour[T.10]     -0.9097      0.004   -241.856      0.000       -0.917
-0.902
start_hour[T.11]     -0.9729      0.004   -261.153      0.000       -0.980
-0.966
start_hour[T.12]     -0.9663      0.004   -262.822      0.000       -0.974
-0.959
start_hour[T.13]     -0.9143      0.004   -247.929      0.000       -0.921
-0.907
start_hour[T.14]     -0.9579      0.004   -262.449      0.000       -0.965
-0.951
start_hour[T.15]     -1.0181      0.004   -279.000      0.000       -1.025
-1.011
start_hour[T.16]     -0.9476      0.004   -254.267      0.000       -0.955
-0.940
start_hour[T.17]     -1.0236      0.004   -283.774      0.000       -1.031
-1.016
start_hour[T.18]     -0.9577      0.003   -274.151      0.000       -0.965
-0.951
start_hour[T.19]     -0.7014      0.004   -200.385      0.000       -0.708
-0.695
start_hour[T.20]     -0.4229      0.004   -118.682      0.000       -0.430
-0.416
start_hour[T.21]     -0.2713      0.004    -75.786      0.000       -0.278
-0.264
start_hour[T.22]     -0.2045      0.004    -56.614      0.000       -0.212
-0.197
start_hour[T.23]     -0.0228      0.004     -6.060      0.000       -0.030
-0.015
```

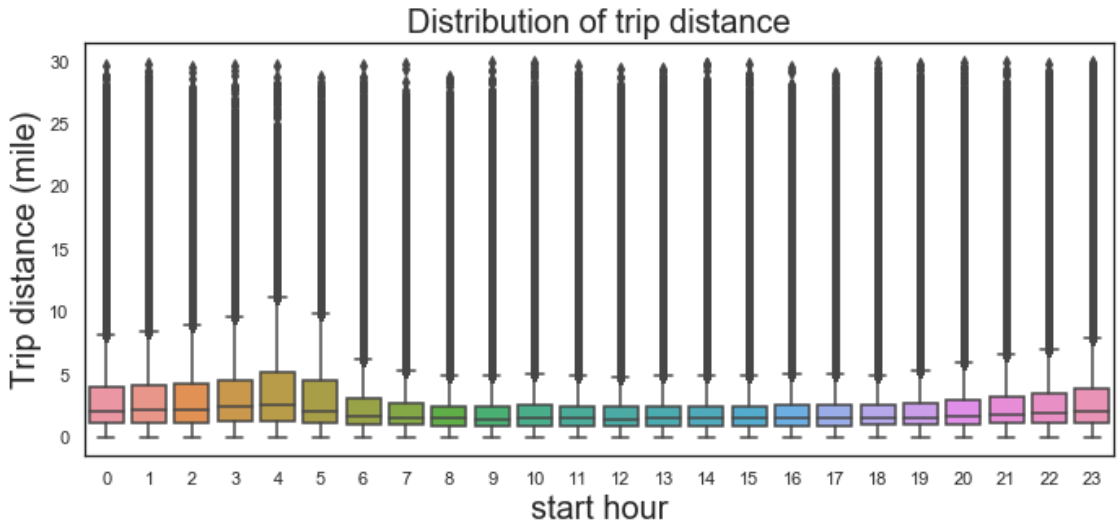
```
payment_type[T.2]     -0.0320      0.001    -28.313      0.000      -0.034
-0.030
duration               0.2326   6.02e-05   3865.297      0.000       0.232
0.233
==============================================================================
Omnibus:                  4920433.098   Durbin-Watson:                   1.839
Prob(Omnibus):                  0.000   Jarque-Bera (JB):         97517120.372
Skew:                           1.811   Prob(JB):                         0.00
Kurtosis:                      17.560   Cond. No.                         404.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[ ]:

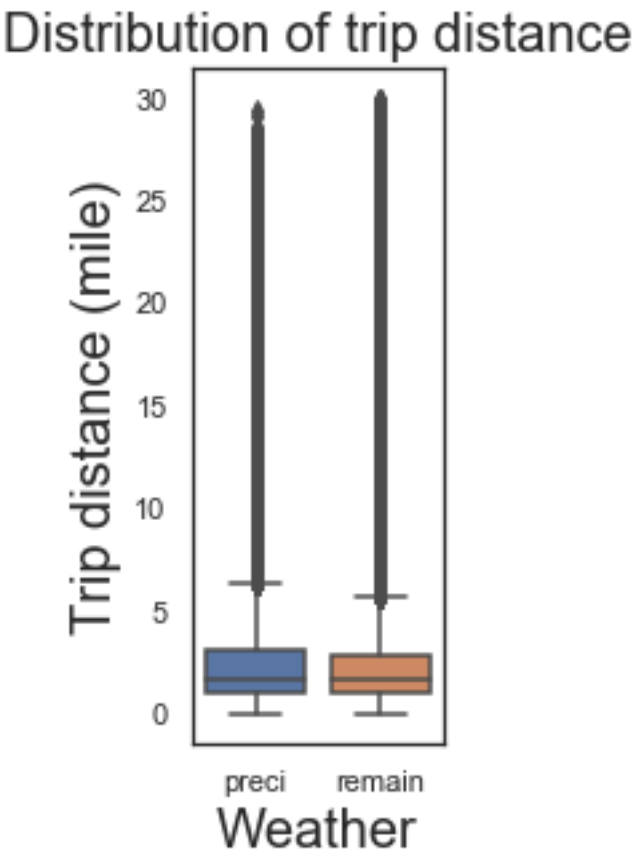
[54]:
```
p = sns.jointplot(x='duration',y= 'trip_distance',data= df, kind="hex",␣
 ↪color="#4CB391", xlim=(0,30), ylim=(0,10), gridsize=100)
p.ax_joint.set_xlabel('Duration (min)')
p.ax_joint.set_ylabel('Trip distance (mile)')
p.fig.suptitle("Duration versus trip distance")
p.fig.tight_layout()
```



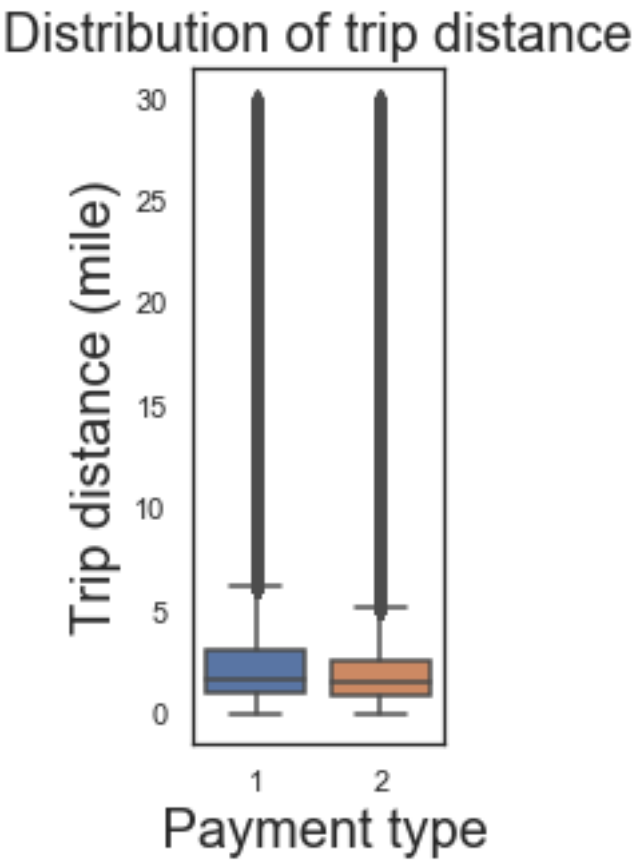
[55]:
```
plt.figure(figsize=(10, 5))
sns.boxplot(x="start_hour", y="trip_distance", data=df)
plt.title("Distribution of trip distance")
plt.ylabel('Trip distance (mile)')
plt.xlabel('start hour')
plt.tight_layout()
```



[56]:
```
plt.figure(figsize=(3, 5))
sns.boxplot(x="weather", y="trip_distance", data=df)
plt.title("Distribution of trip distance")
plt.ylabel('Trip distance (mile)')
plt.xlabel('Weather')
plt.tight_layout()
```



[57]:
```
plt.figure(figsize=(3, 5))
sns.boxplot(x="payment_type", y="trip_distance", data=df)
plt.title("Distribution of trip distance")
plt.ylabel('Trip distance (mile)')
plt.xlabel(' Payment type')
plt.tight_layout()
```



[ ]:

[ ]:

8 what related to income

[58]:
```
fit = ols(formula="income ~ duration + payment_type  +start_hour + duration * ␣
 ↪payment_type + duration * start_hour",data=sub_df1).fit()
print(fit.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                 income   R-squared:                       0.812
Model:                            OLS   Adj. R-squared:                  0.812
Method:                 Least Squares   F-statistic:                 8.606e+04
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:45:42   Log-Likelihood:            -2.7340e+06
No. Observations:              978619   AIC:                         5.468e+06
Df Residuals:                  978569   BIC:                         5.469e+06
```

```
Df Model:                           49
Covariance Type:            nonrobust
==============================================================================
==============
                                 coef    std err          t      P>|t|
[0.025      0.975]
------------------------------------------------------------------------------
--------------
Intercept                      1.8370      0.038     48.529      0.000
1.763       1.911
payment_type[T.2]             -0.2886      0.014    -19.991      0.000
-0.317      -0.260
start_hour[T.1]                0.1167      0.057      2.034      0.042
0.004       0.229
start_hour[T.2]                0.0243      0.063      0.389      0.697
-0.098       0.147
start_hour[T.3]                0.0637      0.068      0.937      0.349
-0.070       0.197
start_hour[T.4]                0.2699      0.076      3.570      0.000
0.122       0.418
start_hour[T.5]               -0.0248      0.077     -0.323      0.747
-0.175       0.126
start_hour[T.6]                0.0018      0.057      0.031      0.975
-0.110       0.114
start_hour[T.7]                0.0725      0.051      1.434      0.152
-0.027       0.172
start_hour[T.8]                0.2776      0.049      5.632      0.000
0.181       0.374
start_hour[T.9]                0.2367      0.049      4.793      0.000
0.140       0.333
start_hour[T.10]               0.3729      0.049      7.548      0.000
0.276       0.470
start_hour[T.11]               0.2180      0.049      4.426      0.000
0.121       0.315
start_hour[T.12]               0.0616      0.049      1.260      0.208
-0.034       0.157
start_hour[T.13]              -0.3020      0.049     -6.148      0.000
-0.398      -0.206
start_hour[T.14]              -0.3351      0.048     -6.935      0.000
-0.430      -0.240
start_hour[T.15]              -0.1915      0.048     -4.019      0.000
-0.285      -0.098
start_hour[T.16]              -0.0129      0.048     -0.268      0.789
-0.107       0.081
start_hour[T.17]              -0.0552      0.047     -1.171      0.242
-0.148       0.037
start_hour[T.18]              -0.2565      0.047     -5.480      0.000
-0.348      -0.165
```

```
start_hour[T.19]              -0.3286      0.047     -6.944      0.000
-0.421      -0.236
start_hour[T.20]              -0.5343      0.048    -11.075      0.000
-0.629      -0.440
start_hour[T.21]              -0.4027      0.049     -8.301      0.000
-0.498      -0.308
start_hour[T.22]              -0.3164      0.049     -6.455      0.000
-0.412      -0.220
start_hour[T.23]              -0.4277      0.051     -8.377      0.000
-0.528      -0.328
duration                       1.0509      0.003    414.220      0.000
1.046       1.056
duration:payment_type[T.2]    -0.1738      0.001   -179.995      0.000
-0.176      -0.172
duration:start_hour[T.1]       0.0015      0.004      0.385      0.701
-0.006       0.009
duration:start_hour[T.2]       0.0262      0.004      6.043      0.000
0.018       0.035
duration:start_hour[T.3]       0.0552      0.005     11.853      0.000
0.046       0.064
duration:start_hour[T.4]       0.1040      0.005     20.237      0.000
0.094       0.114
duration:start_hour[T.5]       0.2084      0.006     36.990      0.000
0.197       0.219
duration:start_hour[T.6]       0.0673      0.004     15.914      0.000
0.059       0.076
duration:start_hour[T.7]      -0.0849      0.003    -24.682      0.000
-0.092      -0.078
duration:start_hour[T.8]      -0.1818      0.003    -56.633      0.000
-0.188      -0.176
duration:start_hour[T.9]      -0.1695      0.003    -52.874      0.000
-0.176      -0.163
duration:start_hour[T.10]     -0.1655      0.003    -51.481      0.000
-0.172      -0.159
duration:start_hour[T.11]     -0.1631      0.003    -50.726      0.000
-0.169      -0.157
duration:start_hour[T.12]     -0.1487      0.003    -46.301      0.000
-0.155      -0.142
duration:start_hour[T.13]     -0.1105      0.003    -34.218      0.000
-0.117      -0.104
duration:start_hour[T.14]     -0.1194      0.003    -38.116      0.000
-0.126      -0.113
duration:start_hour[T.15]     -0.1443      0.003    -46.944      0.000
-0.150      -0.138
duration:start_hour[T.16]     -0.1509      0.003    -48.848      0.000
-0.157      -0.145
duration:start_hour[T.17]     -0.1592      0.003    -52.251      0.000
-0.165      -0.153
```

```
duration:start_hour[T.18]     -0.1377      0.003    -44.496      0.000
-0.144      -0.132
duration:start_hour[T.19]     -0.0875      0.003    -27.299      0.000
-0.094      -0.081
duration:start_hour[T.20]     -0.0243      0.003     -7.357      0.000
-0.031      -0.018
duration:start_hour[T.21]     -0.0050      0.003     -1.509      0.131
-0.011       0.001
duration:start_hour[T.22]     -0.0039      0.003     -1.166      0.243
-0.010       0.003
duration:start_hour[T.23]      0.0360      0.003     10.525      0.000
0.029       0.043
==============================================================================
Omnibus:                   472872.262   Durbin-Watson:                   2.001
Prob(Omnibus):                  0.000   Jarque-Bera (JB):         55605092.808
Skew:                           1.350   Prob(JB):                         0.00
Kurtosis:                      39.829   Cond. No.                         780.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[59]:
```
fit = ols(formula="income ~ duration + payment_type  +start_hour",data=df).fit()
print(fit.summary())
```

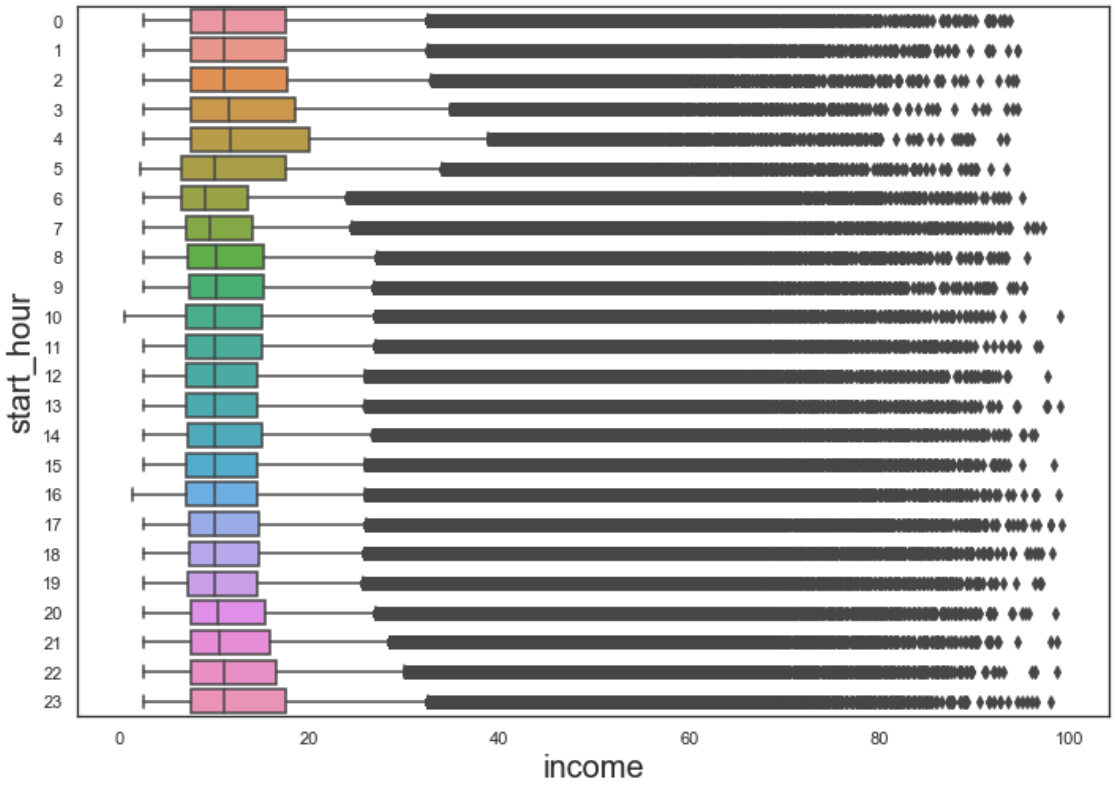
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                 income   R-squared:                       0.800
Model:                            OLS   Adj. R-squared:                  0.800
Method:                 Least Squares   F-statistic:                 1.664e+06
Date:                Fri, 04 Sep 2020   Prob (F-statistic):               0.00
Time:                        20:46:16   Log-Likelihood:            -2.9344e+07
No. Observations:            10397081   AIC:                         5.869e+07
Df Residuals:                10397055   BIC:                         5.869e+07
Df Model:                          25
Covariance Type:            nonrobust
==============================================================================
=====
                         coef    std err          t      P>|t|      [0.025
0.975]
------------------------------------------------------------------------------
-----
Intercept              3.7478      0.007    542.448      0.000       3.734
3.761
payment_type[T.2]     -2.3755      0.003   -887.310      0.000      -2.381
-2.370
start_hour[T.1]        0.0956      0.010      9.517      0.000       0.076
```

```
0.115
start_hour[T.2]       0.2958      0.011     27.172      0.000       0.275
0.317
start_hour[T.3]       0.6549      0.012     54.249      0.000       0.631
0.679
start_hour[T.4]       1.4539      0.014    106.900      0.000       1.427
1.481
start_hour[T.5]       1.9355      0.015    133.275      0.000       1.907
1.964
start_hour[T.6]       0.4873      0.011     44.514      0.000       0.466
0.509
start_hour[T.7]      -0.9951      0.009   -106.861      0.000      -1.013
-0.977
start_hour[T.8]      -1.9803      0.009   -223.193      0.000      -1.998
-1.963
start_hour[T.9]      -1.8977      0.009   -214.025      0.000      -1.915
-1.880
start_hour[T.10]     -1.6679      0.009   -187.026      0.000      -1.685
-1.650
start_hour[T.11]     -1.7957      0.009   -203.303      0.000      -1.813
-1.778
start_hour[T.12]     -1.7816      0.009   -204.361      0.000      -1.799
-1.764
start_hour[T.13]     -1.6951      0.009   -193.869      0.000      -1.712
-1.678
start_hour[T.14]     -1.8381      0.009   -212.389      0.000      -1.855
-1.821
start_hour[T.15]     -2.0287      0.009   -234.465      0.000      -2.046
-2.012
start_hour[T.16]     -1.8938      0.009   -214.319      0.000      -1.911
-1.876
start_hour[T.17]     -2.0793      0.009   -243.129      0.000      -2.096
-2.063
start_hour[T.18]     -1.9590      0.008   -236.508      0.000      -1.975
-1.943
start_hour[T.19]     -1.4165      0.008   -170.673      0.000      -1.433
-1.400
start_hour[T.20]     -0.8467      0.008   -100.230      0.000      -0.863
-0.830
start_hour[T.21]     -0.4974      0.008    -58.603      0.000      -0.514
-0.481
start_hour[T.22]     -0.3422      0.009    -39.944      0.000      -0.359
-0.325
start_hour[T.23]      0.0212      0.009      2.382      0.017       0.004
0.039
duration              0.8976      0.000   6291.336      0.000       0.897
0.898
==============================================================================
```

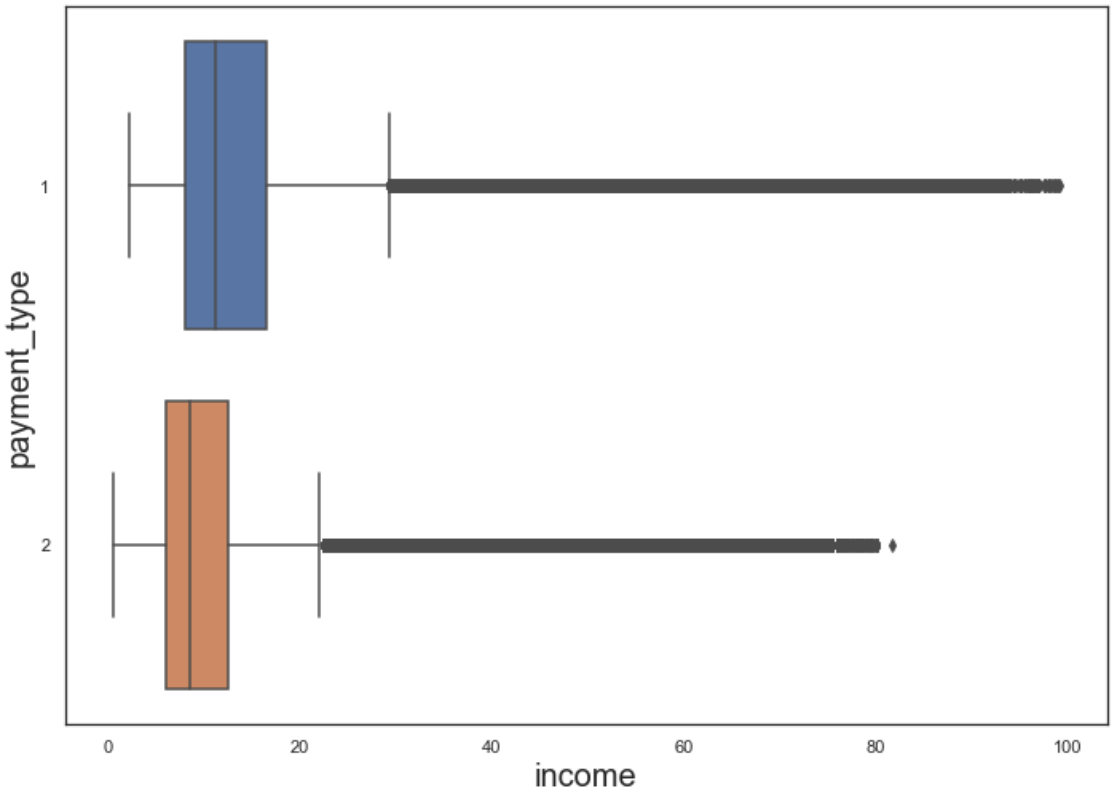
```
Omnibus:                  5137951.303   Durbin-Watson:                   1.883
Prob(Omnibus):                  0.000   Jarque-Bera (JB):        414165231.594
Skew:                           1.507   Prob(JB):                         0.00
Kurtosis:                      33.773   Cond. No.                         404.
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
```

[ ]:

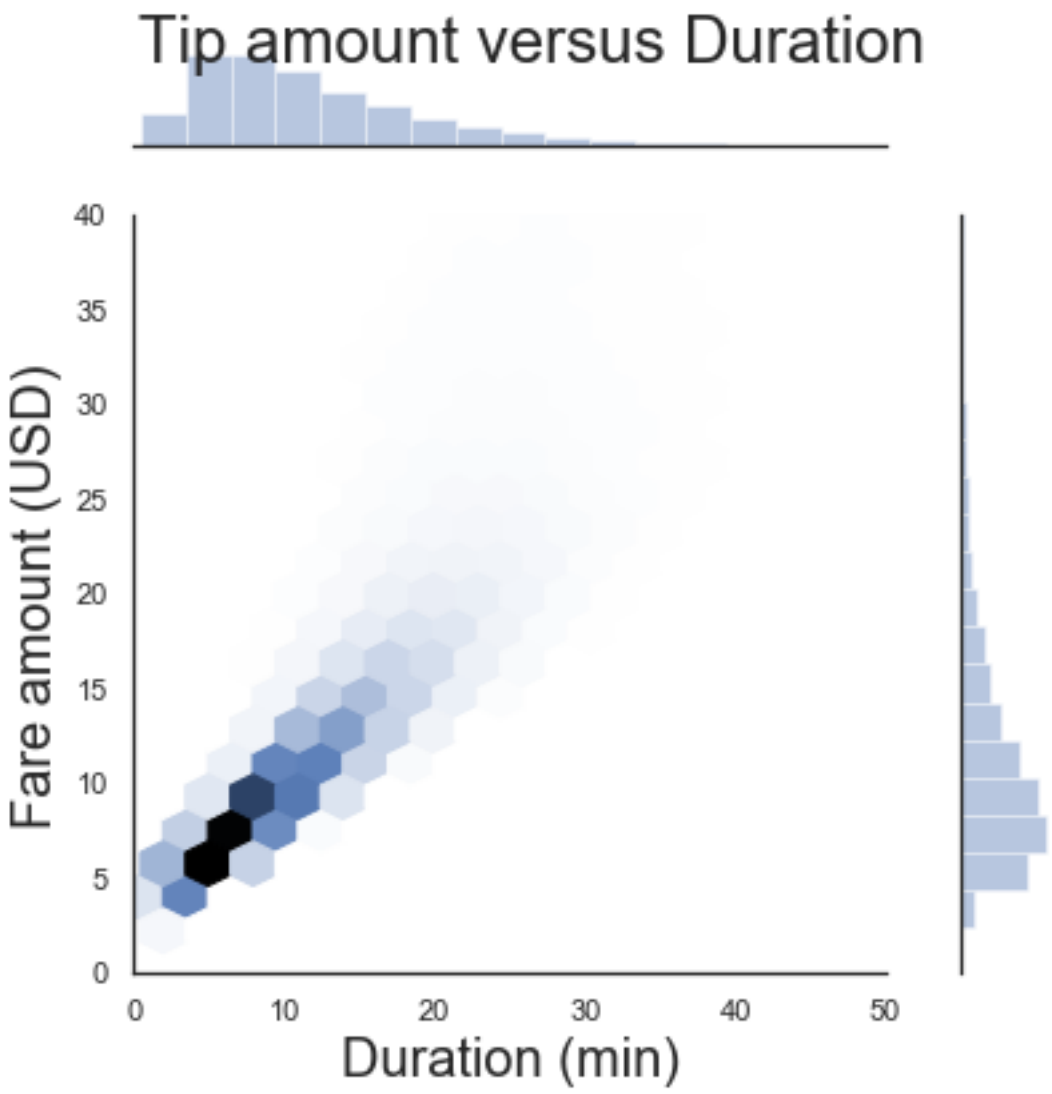
[60]:
```
ax = sns.boxplot(x="income", y="start_hour", data=df)
```



[61]:
```
ax = sns.boxplot(x="income", y="payment_type", data=df)
```

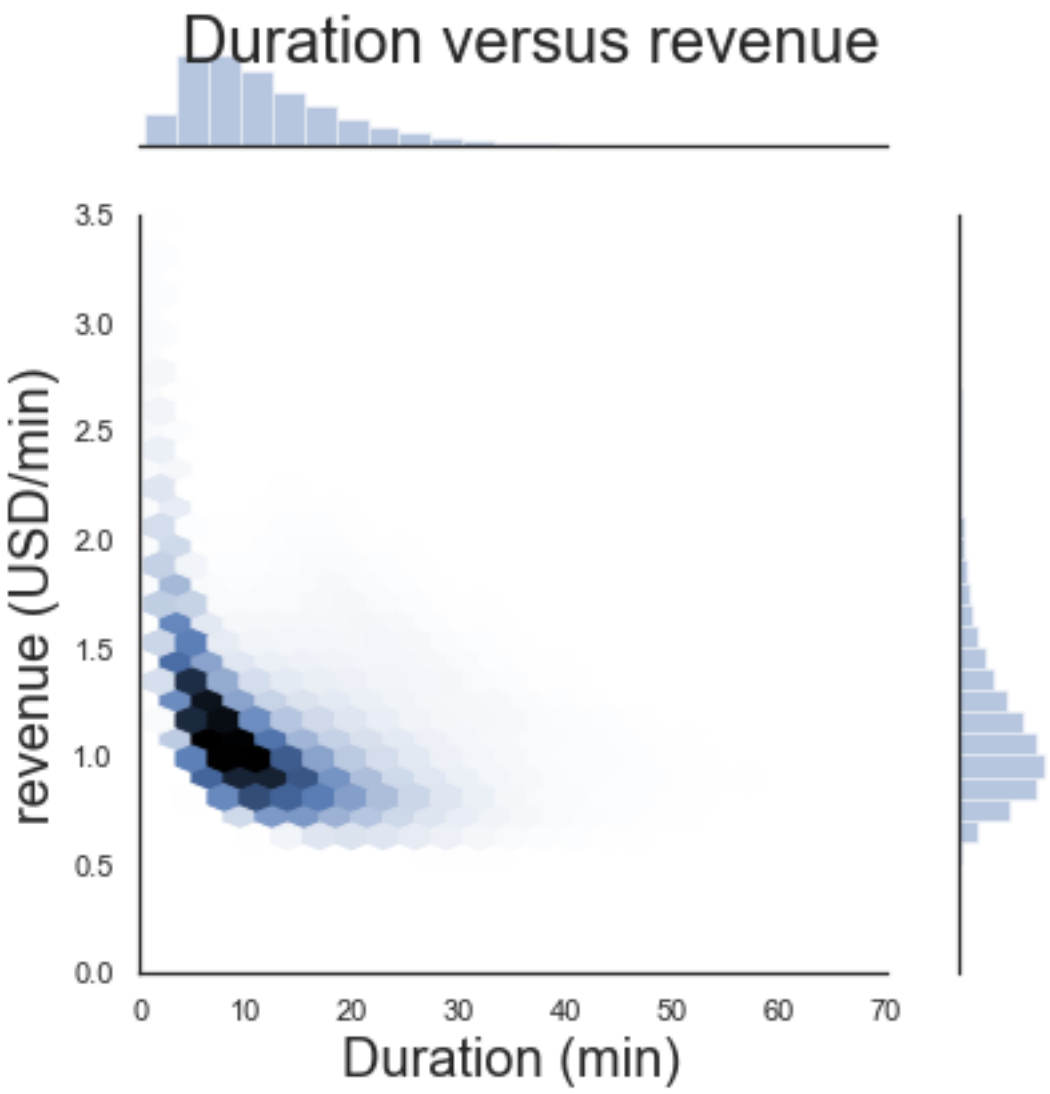


[62]:
```
p = sns.jointplot(x='duration',y= 'income',data= stand_df, kind="hex",␣
↪color="b", xlim=(0,50), ylim=(0,40))
p.ax_joint.set_xlabel('Duration (min)')
p.ax_joint.set_ylabel('Fare amount (USD)')
p.fig.suptitle("Tip amount versus Duration")
p.fig.tight_layout()
```



[ ]:

[63]:
```
p = sns.jointplot(x='duration',y= 'income/duration',data= stand_df, kind="hex",␣
↪color="b", xlim=(0,70), ylim=(0,3.5))
p.ax_joint.set_xlabel('Duration (min)')
p.ax_joint.set_ylabel('revenue (USD/min)')
p.fig.suptitle("Duration versus revenue")
p.fig.tight_layout()
```



[ ]:

[64]:
```
for i in range(24):
    curr_data = stand_df[start_coords].loc[(df['start_hour'] == i) &␣
↪(df['duration'] <= 10)]
    curr = folium.Map(location=[40.75, -73.9], tiles="Stamen Terrain",␣
↪zoom_start=12)
    curr.add_child(HeatMap(curr_data[start_coords].values, radius=10))
    curr.save('plots/start_Heatmap_high_revenue_in' + str(i) + '.html')
```

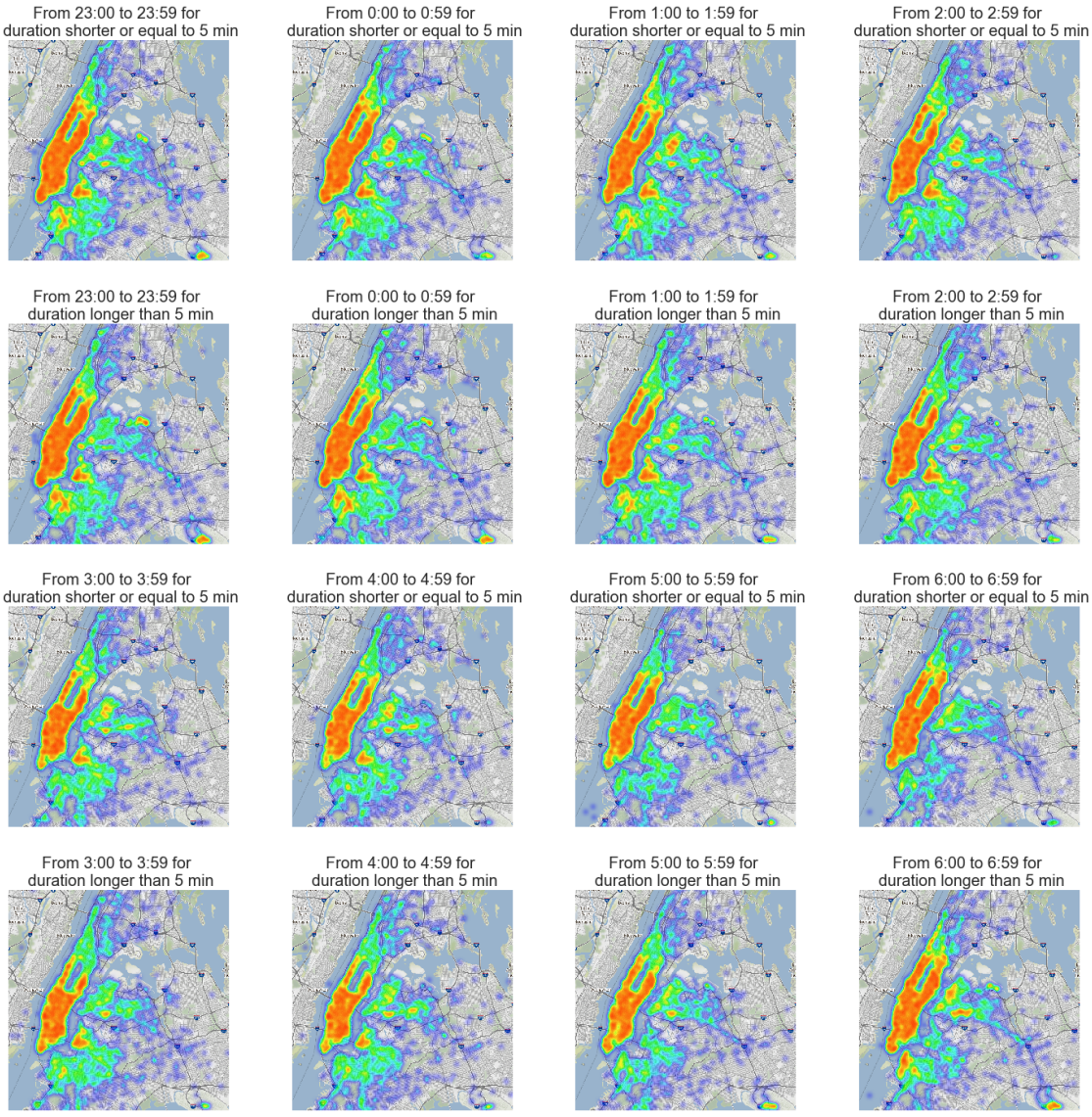
[65]:
```
for i in range(24):
```

```
    curr_data = stand_df[start_coords].loc[(df['start_hour'] == i) &␣
↪(df['duration'] > 10)]
    curr = folium.Map(location=[40.75, -73.9], tiles="Stamen Terrain",␣
↪zoom_start=12)
    curr.add_child(HeatMap(curr_data[start_coords].values, radius=10))
    curr.save('plots/start_Heatmap_low_revenue_in' + str(i) + '.html')
```

[ ]:

[66]:
```
time = [0,1,2,3,4,5,6,23]
time = [str(i) for i in time]
posi = [i for i in range(1,5)] + [i for i in range(9,13)]
```

[67]:
```
plt.figure(figsize=(20, 20))
for i in range(8):
    plt.subplot(4,4,posi[i])
    plt.title("From " + time[i-1] + ":00 to " + time[i-1] + ":59"\
              + " for \n duration shorter or equal to 5 min" )
    img = mpimg.imread("plots/heatmap/high " + time[i-1] +'.png')
    plt.imshow(img)
    plt.axis('off')
    plt.subplot(4,4, posi[i]+4)
    plt.title("From " + time[i-1] + ":00 to " + time[i-1] + ":59"\
              + " for \n duration longer than 5 min" )
    img = mpimg.imread("plots/heatmap/low " + time[i-1] +'.png')
    plt.imshow(img)
    plt.axis('off')
plt.tight_layout()
plt.show()
```


From 23:00 to 23:59 for duration shorter or equal to 5 min
From 0:00 to 0:59 for duration shorter or equal to 5 min
From 1:00 to 1:59 for duration shorter or equal to 5 min
From 2:00 to 2:59 for duration shorter or equal to 5 min
From 23:00 to 23:59 for duration longer than 5 min
From 0:00 to 0:59 for duration longer than 5 min
From 1:00 to 1:59 for duration longer than 5 min
From 2:00 to 2:59 for duration longer than 5 min
From 3:00 to 3:59 for duration shorter or equal to 5 min
From 4:00 to 4:59 for duration shorter or equal to 5 min
From 5:00 to 5:59 for duration shorter or equal to 5 min
From 6:00 to 6:59 for duration shorter or equal to 5 min
From 3:00 to 3:59 for duration longer than 5 min
From 4:00 to 4:59 for duration longer than 5 min
From 5:00 to 5:59 for duration longer than 5 min
From 6:00 to 6:59 for duration longer than 5 min

[ ]:

[ ]: