Appendix A

Jupyter Notebook part 1 (the page number is only for this Notebook)

[1]:
```python
import pandas as pd
import numpy as np
```

[2]:
```python
weather = pd.read_csv('data/2016_01_weather.CSV')
weather
```

[2]:
```
         time                 12:51 AM             1:51 AM  \
0    2016/1/1                     Fair              Cloudy
1    2016/1/2                     Fair                Fair
2    2016/1/3                     Fair                Fair
3    2016/1/4  Partly Cloudy / Windy                  Fair
4    2016/1/5                     Fair         Fair / Windy
5    2016/1/6                     Fair                Fair
6    2016/1/7                     Fair                Fair
7    2016/1/8                   Cloudy                Fair
8    2016/1/9                   Cloudy              Cloudy
9   2016/1/10            Mostly Cloudy          Light Rain
10  2016/1/11                     Fair       Mostly Cloudy
11  2016/1/12  Partly Cloudy / Windy                  Fair
12  2016/1/13                   Cloudy         Fair / Windy
13  2016/1/14                   Cloudy       Mostly Cloudy
14  2016/1/15                   Cloudy              Cloudy
15  2016/1/16            Mostly Cloudy              Cloudy
16  2016/1/17                   Cloudy       Mostly Cloudy
17  2016/1/18                     Fair                Fair
18  2016/1/19  Partly Cloudy / Windy                  Fair
19  2016/1/20                   Cloudy         Fair / Windy
20  2016/1/21             Fair / Windy                 NaN
21  2016/1/22               Light Snow                Fair
22  2016/1/23               Light Snow          Light Snow
23  2016/1/24                   Cloudy  Light Snow / Windy
24  2016/1/25                   Cloudy       Partly Cloudy
25  2016/1/26                   Cloudy              Cloudy
26  2016/1/27                   Cloudy              Cloudy
27  2016/1/28                   Cloudy                Fair
28  2016/1/29                     Fair              Cloudy
29  2016/1/30            Partly Cloudy       Partly Cloudy
```

30	2016/1/31	Cloudy	Cloudy

	2:51 AM	3:51 AM	4:51 AM	\
0	Cloudy	Cloudy	Cloudy	
1	Fair	Mostly Cloudy	Mostly Cloudy	
2	Fair	Fair	Fair	
3	Mostly Cloudy	Mostly Cloudy / Windy	Mostly Cloudy	
4	Fair	Fair	Fair	
5	Fair	Cloudy	Fair	
6	Fair	Fair	Fair	
7	Fair	Partly Cloudy	Fair	
8	Mostly Cloudy	Mostly Cloudy	Cloudy	
9	Cloudy	Cloudy	Rain	
10	Mostly Cloudy / Windy	Partly Cloudy / Windy	Partly Cloudy / Windy	
11	Partly Cloudy	Partly Cloudy	Mostly Cloudy	
12	Partly Cloudy / Windy	Fair / Windy	Partly Cloudy	
13	Cloudy	Cloudy	Cloudy	
14	Partly Cloudy	Partly Cloudy	Partly Cloudy	
15	Rain	Light Rain	Light Rain	
16	Cloudy	Cloudy	Mostly Cloudy	
17	Fair	Fair	Fair	
18	Fair / Windy	Fair	Fair	
19	Fair	Fair	Fair	
20	Cloudy	Cloudy	Cloudy	
21	Fair	Fair	Fair	
22	Light Snow / Windy	Light Snow / Windy	Light Snow / Windy	
23	Light Snow / Windy	Cloudy / Windy	Cloudy	
24	Partly Cloudy	Fair	Fair	
25	Mostly Cloudy	Cloudy	Cloudy	
26	Mostly Cloudy	Cloudy	Cloudy	
27	Partly Cloudy	Partly Cloudy	Fair	
28	Cloudy	Cloudy	Cloudy	
29	Fair	Partly Cloudy	Partly Cloudy	
30	Partly Cloudy	Partly Cloudy	Cloudy	

	5:51 AM	6:51 AM	7:51 AM	8:51 AM	…	\
0	Cloudy	Cloudy	Mostly Cloudy	Cloudy	…	
1	Partly Cloudy	Fair	Partly Cloudy	Mostly Cloudy	…	
2	Fair	Fair	Fair	Fair	…	
3	Mostly Cloudy	Partly Cloudy	Mostly Cloudy	Mostly Cloudy	…	
4	Fair	Fair	Fair	Fair	…	
5	Cloudy	Cloudy	Cloudy	Cloudy	…	
6	Fair	Partly Cloudy	Partly Cloudy	Mostly Cloudy	…	
7	Fair	Fair	Fair	Partly Cloudy	…	
8	Cloudy	Cloudy	Cloudy	Mostly Cloudy	…	
9	Heavy Rain	Rain	Rain	Heavy Rain	…	
10	Fair	Fair	Fair	Fair	…	

11	Mostly Cloudy	Partly Cloudy	Mostly Cloudy	Mostly Cloudy	…
12	Fair / Windy	Fair / Windy	Fair / Windy	Fair	…
13	Cloudy	Light Snow	Cloudy	Cloudy	…
14	Partly Cloudy	Cloudy	Cloudy	Cloudy	…
15	Light Rain	Cloudy	Light Rain	Light Rain	…
16	Fair	Fair	Mostly Cloudy	Cloudy	…
17	Fair / Windy	Partly Cloudy	Light Snow	Mostly Cloudy / Windy	…
18	Fair	Fair / Windy	Fair	Fair / Windy	…
19	Fair	Partly Cloudy	Fair	Partly Cloudy	…
20	Cloudy	Partly Cloudy	Fair	Fair	…
21	Fair	Fair	Fair	Mostly Cloudy	…
22	Snow / Windy	Snow	Snow / Windy	Heavy Snow / Windy	…
23	Fair / Windy	Fair	Fair	Fair	…
24	Mostly Cloudy	Cloudy	Cloudy	Cloudy	…
25	Cloudy	Cloudy	Cloudy	Cloudy	…
26	Cloudy	Cloudy	Cloudy	Cloudy	…
27	Fair	Fair	Fair	Fair	…
28	Cloudy	Mostly Cloudy	Partly Cloudy	Partly Cloudy	…
29	Fair	Fair	Fair	Fair	…
30	Cloudy	Cloudy	Mostly Cloudy	Mostly Cloudy	…

	2:51 PM	3:51 PM	4:51 PM	\
0	Cloudy	Mostly Cloudy	Mostly Cloudy	
1	Mostly Cloudy	Mostly Cloudy	Mostly Cloudy	
2	Partly Cloudy	Partly Cloudy	Partly Cloudy	
3	Fair / Windy	Fair	Fair	
4	Fair	Fair	Fair	
5	Fair	Fair	Fair	
6	Mostly Cloudy	Mostly Cloudy	Mostly Cloudy	
7	Cloudy	Mostly Cloudy	Cloudy	
8	Cloudy	Cloudy	Cloudy	
9	Fog	Fog	Light Rain	
10	Fair	Fair	Fair / Windy	
11	Cloudy	Cloudy	Cloudy / Windy	
12	Fair / Windy	Fair	Partly Cloudy	
13	Mostly Cloudy	Mostly Cloudy	Cloudy	
14	Cloudy	Cloudy	Cloudy	
15	Mostly Cloudy	Mostly Cloudy	Mostly Cloudy	
16	Cloudy	Light Snow	Light Snow	
17	Fair / Windy	Partly Cloudy / Windy	Mostly Cloudy / Windy	
18	Fair / Windy	Fair / Windy	Partly Cloudy / Windy	
19	Mostly Cloudy	Cloudy	Cloudy	
20	Partly Cloudy	Partly Cloudy	Partly Cloudy / Windy	
21	Cloudy	Cloudy	Cloudy	
22	Heavy Snow / Windy	Heavy Snow / Windy	Heavy Snow	
23	Partly Cloudy	Partly Cloudy	Partly Cloudy	
24	Mostly Cloudy	Cloudy	Cloudy	

25	Cloudy	Cloudy	Fair
26	Cloudy	Cloudy	Fair
27	Fair	Mostly Cloudy	Cloudy
28	Cloudy	Cloudy	Cloudy
29	Mostly Cloudy	Mostly Cloudy	Mostly Cloudy
30	Mostly Cloudy	Cloudy	Mostly Cloudy

	5:51 PM	6:51 PM	7:51 PM \
0	Partly Cloudy	Partly Cloudy	Partly Cloudy
1	Mostly Cloudy	Partly Cloudy	Fair
2	Mostly Cloudy	Partly Cloudy	Partly Cloudy
3	Fair / Windy	Fair / Windy	Fair
4	Fair	Fair	Fair
5	Fair	Fair	Fair
6	Mostly Cloudy	Mostly Cloudy	Mostly Cloudy
7	Cloudy	Cloudy	Cloudy
8	Cloudy	Cloudy	Cloudy
9	Mostly Cloudy	Partly Cloudy	Fair
10	Fair	Fair	Fair
11	Light Rain	Cloudy	Mostly Cloudy
12	Partly Cloudy	Mostly Cloudy	Partly Cloudy
13	Cloudy	Cloudy	Cloudy
14	Cloudy	Cloudy	Cloudy
15	Cloudy	Cloudy	Mostly Cloudy
16	Light Snow	Light Snow	Light Snow
17	Partly Cloudy	Partly Cloudy / Windy	Partly Cloudy / Windy
18	Partly Cloudy / Windy	Fair	Fair / Windy
19	Cloudy	Mostly Cloudy	Mostly Cloudy
20	Partly Cloudy	Mostly Cloudy	Partly Cloudy
21	Cloudy	Cloudy	Cloudy
22	Heavy Snow / Windy	Heavy Snow / Windy	Heavy Snow
23	Mostly Cloudy	Mostly Cloudy	Partly Cloudy
24	Cloudy	Cloudy	Mostly Cloudy
25	Cloudy	Cloudy	Cloudy
26	Cloudy	Cloudy	Cloudy
27	Mostly Cloudy	Partly Cloudy	Cloudy
28	Mostly Cloudy / Windy	Mostly Cloudy / Windy	Mostly Cloudy / Windy
29	Mostly Cloudy	Partly Cloudy	Partly Cloudy
30	Cloudy	Mostly Cloudy	Cloudy

	8:51 PM	9:51 PM	10:51 PM \
0	Fair	Fair	Fair
1	Fair	Fair	Fair
2	Partly Cloudy	Fair	Fair
3	Partly Cloudy / Windy	Mostly Cloudy / Windy	Mostly Cloudy / Windy
4	Fair	Fair	Fair
5	Fair	Fair	Fair

6	Fair	Fair	Fair
7	Cloudy	Cloudy	Cloudy
8	Cloudy	Light Drizzle	Cloudy
9	Mostly Cloudy	Fair / Windy	Fair / Windy
10	Fair	Fair	Fair
11	Mostly Cloudy	Cloudy / Windy	Mostly Cloudy / Windy
12	Cloudy	Cloudy	Cloudy
13	Cloudy	Partly Cloudy	Mostly Cloudy
14	Cloudy	Cloudy	Cloudy
15	Cloudy	Cloudy	Cloudy
16	Light Snow	Mostly Cloudy	Partly Cloudy
17	Fair / Windy	Fair	Fair / Windy
18	Fair	Fair	Mostly Cloudy / Windy
19	Cloudy	Cloudy	Cloudy
20	Partly Cloudy	Fair	Fair
21	Cloudy	Cloudy	Cloudy
22	Heavy Snow / Windy	Snow / Windy	Light Snow
23	Partly Cloudy	Mostly Cloudy	Mostly Cloudy
24	Fair	Fair	Fair
25	Cloudy	Cloudy	Cloudy
26	Cloudy	Cloudy	Cloudy
27	Cloudy	Cloudy	Cloudy
28	Partly Cloudy / Windy	Fair	Fair
29	Partly Cloudy	Cloudy	Mostly Cloudy
30	Cloudy	Cloudy	Cloudy

	11:51 PM
0	Fair
1	Fair
2	Fair
3	Fair / Windy
4	Fair
5	Fair
6	Fair
7	Cloudy
8	Cloudy
9	Fair
10	Fair
11	Partly Cloudy
12	Cloudy
13	Cloudy
14	Cloudy
15	Mostly Cloudy
16	Partly Cloudy
17	Fair / Windy
18	Mostly Cloudy
19	Cloudy

```
20       Partly Cloudy
21          Light Snow
22  Light Snow / Windy
23              Cloudy
24       Mostly Cloudy
25              Cloudy
26              Cloudy
27              Cloudy
28                Fair
29       Mostly Cloudy
30              Cloudy

[31 rows x 25 columns]
```

[3]:
```
weather.columns = ['time'] + [i for i in range(24)]
weather_list = weather.iloc[:,1:].values.tolist()
weather
```

[3]:
```
         time                      0                   1  \
0    2016/1/1                   Fair              Cloudy
1    2016/1/2                   Fair                Fair
2    2016/1/3                   Fair                Fair
3    2016/1/4  Partly Cloudy / Windy                Fair
4    2016/1/5                   Fair         Fair / Windy
5    2016/1/6                   Fair                Fair
6    2016/1/7                   Fair                Fair
7    2016/1/8                 Cloudy                Fair
8    2016/1/9                 Cloudy              Cloudy
9   2016/1/10          Mostly Cloudy          Light Rain
10  2016/1/11                   Fair       Mostly Cloudy
11  2016/1/12  Partly Cloudy / Windy                Fair
12  2016/1/13                 Cloudy         Fair / Windy
13  2016/1/14                 Cloudy       Mostly Cloudy
14  2016/1/15                 Cloudy              Cloudy
15  2016/1/16          Mostly Cloudy              Cloudy
16  2016/1/17                 Cloudy       Mostly Cloudy
17  2016/1/18                   Fair                Fair
18  2016/1/19  Partly Cloudy / Windy                Fair
19  2016/1/20                 Cloudy         Fair / Windy
20  2016/1/21           Fair / Windy                 NaN
21  2016/1/22             Light Snow                Fair
22  2016/1/23             Light Snow          Light Snow
23  2016/1/24                 Cloudy  Light Snow / Windy
24  2016/1/25                 Cloudy       Partly Cloudy
25  2016/1/26                 Cloudy              Cloudy
26  2016/1/27                 Cloudy              Cloudy
27  2016/1/28                 Cloudy                Fair
```

```
28  2016/1/29                  Fair             Cloudy
29  2016/1/30         Partly Cloudy      Partly Cloudy
30  2016/1/31                Cloudy             Cloudy

                        2                       3                       4  \
0                  Cloudy                  Cloudy                  Cloudy
1                    Fair           Mostly Cloudy           Mostly Cloudy
2                    Fair                    Fair                    Fair
3           Mostly Cloudy   Mostly Cloudy / Windy           Mostly Cloudy
4                    Fair                    Fair                    Fair
5                    Fair                  Cloudy                    Fair
6                    Fair                    Fair                    Fair
7                    Fair           Partly Cloudy                    Fair
8           Mostly Cloudy           Mostly Cloudy                  Cloudy
9                  Cloudy                  Cloudy                    Rain
10  Mostly Cloudy / Windy   Partly Cloudy / Windy   Partly Cloudy / Windy
11          Partly Cloudy           Partly Cloudy           Mostly Cloudy
12  Partly Cloudy / Windy            Fair / Windy           Partly Cloudy
13                 Cloudy                  Cloudy                  Cloudy
14          Partly Cloudy           Partly Cloudy           Partly Cloudy
15                   Rain              Light Rain              Light Rain
16                 Cloudy                  Cloudy           Mostly Cloudy
17                   Fair                    Fair                    Fair
18           Fair / Windy                    Fair                    Fair
19                   Fair                    Fair                    Fair
20                 Cloudy                  Cloudy                  Cloudy
21                   Fair                    Fair                    Fair
22     Light Snow / Windy      Light Snow / Windy      Light Snow / Windy
23     Light Snow / Windy          Cloudy / Windy                  Cloudy
24          Partly Cloudy                    Fair                    Fair
25          Mostly Cloudy                  Cloudy                  Cloudy
26          Mostly Cloudy                  Cloudy                  Cloudy
27          Partly Cloudy           Partly Cloudy                    Fair
28                 Cloudy                  Cloudy                  Cloudy
29                   Fair           Partly Cloudy           Partly Cloudy
30          Partly Cloudy           Partly Cloudy                  Cloudy

                5               6               7                      8  …  \
0          Cloudy          Cloudy   Mostly Cloudy                 Cloudy  …
1   Partly Cloudy            Fair   Partly Cloudy          Mostly Cloudy  …
2            Fair            Fair            Fair                   Fair  …
3   Mostly Cloudy   Partly Cloudy   Mostly Cloudy          Mostly Cloudy  …
4            Fair            Fair            Fair                   Fair  …
5          Cloudy          Cloudy          Cloudy                 Cloudy  …
6            Fair   Partly Cloudy   Partly Cloudy          Mostly Cloudy  …
7            Fair            Fair            Fair          Partly Cloudy  …
8          Cloudy          Cloudy          Cloudy          Mostly Cloudy  …
```

9	Heavy Rain	Rain	Rain	Heavy Rain	…
10	Fair	Fair	Fair	Fair	…
11	Mostly Cloudy	Partly Cloudy	Mostly Cloudy	Mostly Cloudy	…
12	Fair / Windy	Fair / Windy	Fair / Windy	Fair	…
13	Cloudy	Light Snow	Cloudy	Cloudy	…
14	Partly Cloudy	Cloudy	Cloudy	Cloudy	…
15	Light Rain	Cloudy	Light Rain	Light Rain	…
16	Fair	Fair	Mostly Cloudy	Cloudy	…
17	Fair / Windy	Partly Cloudy	Light Snow	Mostly Cloudy / Windy	…
18	Fair	Fair / Windy	Fair	Fair / Windy	…
19	Fair	Partly Cloudy	Fair	Partly Cloudy	…
20	Cloudy	Partly Cloudy	Fair	Fair	…
21	Fair	Fair	Fair	Mostly Cloudy	…
22	Snow / Windy	Snow	Snow / Windy	Heavy Snow / Windy	…
23	Fair / Windy	Fair	Fair	Fair	…
24	Mostly Cloudy	Cloudy	Cloudy	Cloudy	…
25	Cloudy	Cloudy	Cloudy	Cloudy	…
26	Cloudy	Cloudy	Cloudy	Cloudy	…
27	Fair	Fair	Fair	Fair	…
28	Cloudy	Mostly Cloudy	Partly Cloudy	Partly Cloudy	…
29	Fair	Fair	Fair	Fair	…
30	Cloudy	Cloudy	Mostly Cloudy	Mostly Cloudy	…

	14	15	16 \
0	Cloudy	Mostly Cloudy	Mostly Cloudy
1	Mostly Cloudy	Mostly Cloudy	Mostly Cloudy
2	Partly Cloudy	Partly Cloudy	Partly Cloudy
3	Fair / Windy	Fair	Fair
4	Fair	Fair	Fair
5	Fair	Fair	Fair
6	Mostly Cloudy	Mostly Cloudy	Mostly Cloudy
7	Cloudy	Mostly Cloudy	Cloudy
8	Cloudy	Cloudy	Cloudy
9	Fog	Fog	Light Rain
10	Fair	Fair	Fair / Windy
11	Cloudy	Cloudy	Cloudy / Windy
12	Fair / Windy	Fair	Partly Cloudy
13	Mostly Cloudy	Mostly Cloudy	Cloudy
14	Cloudy	Cloudy	Cloudy
15	Mostly Cloudy	Mostly Cloudy	Mostly Cloudy
16	Cloudy	Light Snow	Light Snow
17	Fair / Windy	Partly Cloudy / Windy	Mostly Cloudy / Windy
18	Fair / Windy	Fair / Windy	Partly Cloudy / Windy
19	Mostly Cloudy	Cloudy	Cloudy
20	Partly Cloudy	Partly Cloudy	Partly Cloudy / Windy
21	Cloudy	Cloudy	Cloudy
22	Heavy Snow / Windy	Heavy Snow / Windy	Heavy Snow

```
23       Partly Cloudy         Partly Cloudy         Partly Cloudy
24       Mostly Cloudy                Cloudy                Cloudy
25              Cloudy                Cloudy                  Fair
26              Cloudy                Cloudy                  Fair
27                Fair         Mostly Cloudy                Cloudy
28              Cloudy                Cloudy                Cloudy
29       Mostly Cloudy         Mostly Cloudy         Mostly Cloudy
30       Mostly Cloudy                Cloudy         Mostly Cloudy

                       17                    18                    19  \
0           Partly Cloudy         Partly Cloudy         Partly Cloudy
1           Mostly Cloudy         Partly Cloudy                  Fair
2           Mostly Cloudy         Partly Cloudy         Partly Cloudy
3             Fair / Windy          Fair / Windy                  Fair
4                    Fair                  Fair                  Fair
5                    Fair                  Fair                  Fair
6           Mostly Cloudy         Mostly Cloudy         Mostly Cloudy
7                  Cloudy                Cloudy                Cloudy
8                  Cloudy                Cloudy                Cloudy
9           Mostly Cloudy         Partly Cloudy                  Fair
10                   Fair                  Fair                  Fair
11             Light Rain                Cloudy         Mostly Cloudy
12          Partly Cloudy         Mostly Cloudy         Partly Cloudy
13                 Cloudy                Cloudy                Cloudy
14                 Cloudy                Cloudy                Cloudy
15                 Cloudy                Cloudy         Mostly Cloudy
16             Light Snow            Light Snow            Light Snow
17          Partly Cloudy  Partly Cloudy / Windy  Partly Cloudy / Windy
18  Partly Cloudy / Windy                  Fair          Fair / Windy
19                 Cloudy         Mostly Cloudy         Mostly Cloudy
20          Partly Cloudy         Mostly Cloudy         Partly Cloudy
21                 Cloudy                Cloudy                Cloudy
22      Heavy Snow / Windy    Heavy Snow / Windy            Heavy Snow
23          Mostly Cloudy         Mostly Cloudy         Partly Cloudy
24                 Cloudy                Cloudy         Mostly Cloudy
25                 Cloudy                Cloudy                Cloudy
26                 Cloudy                Cloudy                Cloudy
27          Mostly Cloudy         Partly Cloudy                Cloudy
28  Mostly Cloudy / Windy  Mostly Cloudy / Windy  Mostly Cloudy / Windy
29          Mostly Cloudy         Partly Cloudy         Partly Cloudy
30                 Cloudy         Mostly Cloudy                Cloudy

                       20                    21                    22  \
0                    Fair                  Fair                  Fair
1                    Fair                  Fair                  Fair
2           Partly Cloudy                  Fair                  Fair
3   Partly Cloudy / Windy  Mostly Cloudy / Windy  Mostly Cloudy / Windy
```

4	Fair	Fair	Fair
5	Fair	Fair	Fair
6	Fair	Fair	Fair
7	Cloudy	Cloudy	Cloudy
8	Cloudy	Light Drizzle	Cloudy
9	Mostly Cloudy	Fair / Windy	Fair / Windy
10	Fair	Fair	Fair
11	Mostly Cloudy	Cloudy / Windy	Mostly Cloudy / Windy
12	Cloudy	Cloudy	Cloudy
13	Cloudy	Partly Cloudy	Mostly Cloudy
14	Cloudy	Cloudy	Cloudy
15	Cloudy	Cloudy	Cloudy
16	Light Snow	Mostly Cloudy	Partly Cloudy
17	Fair / Windy	Fair	Fair / Windy
18	Fair	Fair	Mostly Cloudy / Windy
19	Cloudy	Cloudy	Cloudy
20	Partly Cloudy	Fair	Fair
21	Cloudy	Cloudy	Cloudy
22	Heavy Snow / Windy	Snow / Windy	Light Snow
23	Partly Cloudy	Mostly Cloudy	Mostly Cloudy
24	Fair	Fair	Fair
25	Cloudy	Cloudy	Cloudy
26	Cloudy	Cloudy	Cloudy
27	Cloudy	Cloudy	Cloudy
28	Partly Cloudy / Windy	Fair	Fair
29	Partly Cloudy	Cloudy	Mostly Cloudy
30	Cloudy	Cloudy	Cloudy

	23
0	Fair
1	Fair
2	Fair
3	Fair / Windy
4	Fair
5	Fair
6	Fair
7	Cloudy
8	Cloudy
9	Fair
10	Fair
11	Partly Cloudy
12	Cloudy
13	Cloudy
14	Cloudy
15	Mostly Cloudy
16	Partly Cloudy
17	Fair / Windy

```
18       Mostly Cloudy
19              Cloudy
20       Partly Cloudy
21          Light Snow
22  Light Snow / Windy
23              Cloudy
24       Mostly Cloudy
25              Cloudy
26              Cloudy
27              Cloudy
28                Fair
29       Mostly Cloudy
30              Cloudy

[31 rows x 25 columns]
```

[4]:
```
possible = []
for i in weather_list:
    possible = possible + i

possible = list(set(possible))
possible
len(possible)
```

[4]:
```
21
```

[5]:
```
preci = ['Heavy Rain','Light Drizzle', 'Light Snow', 'Rain',
         'Light Rain / Windy', 'Heavy Snow', 'Snow', 'Light Snow / Windy',
         'Snow / Windy', 'Light Rain', 'Heavy Snow / Windy']

remain = ['Partly Cloudy', 'Cloudy / Windy', 'Partly Cloudy / Windy',
          'Fair / Windy', 'Fair', 'Mostly Cloudy',
          'Mostly Cloudy / Windy', 'Fog', 'Cloudy']
```

[ ]:
```

```

[6]:
```
def precipitation_or_not(condition):
    if condition in preci:
        return 'preci'
    elif condition in remain:
        return 'remain'
    else:
        return 'unknown'
```

[7]:
```
for i in range(24):
    weather.loc[:,i] = weather.loc[:,i].apply(precipitation_or_not)
```

[8]:
```python
weather.iloc[20,2] = 'remain'
```

[ ]:

[9]:
```python
weather['time'] = pd.to_datetime(weather['time'], format='%Y/%m/%d')
weather
```

[9]:
```
         time       0       1       2       3       4       5       6       7  \
0  2016-01-01  remain  remain  remain  remain  remain  remain  remain  remain
1  2016-01-02  remain  remain  remain  remain  remain  remain  remain  remain
2  2016-01-03  remain  remain  remain  remain  remain  remain  remain  remain
3  2016-01-04  remain  remain  remain  remain  remain  remain  remain  remain
4  2016-01-05  remain  remain  remain  remain  remain  remain  remain  remain
5  2016-01-06  remain  remain  remain  remain  remain  remain  remain  remain
6  2016-01-07  remain  remain  remain  remain  remain  remain  remain  remain
7  2016-01-08  remain  remain  remain  remain  remain  remain  remain  remain
8  2016-01-09  remain  remain  remain  remain  remain  remain  remain  remain
9  2016-01-10  remain   preci  remain  remain   preci   preci   preci   preci
10 2016-01-11  remain  remain  remain  remain  remain  remain  remain  remain
11 2016-01-12  remain  remain  remain  remain  remain  remain  remain  remain
12 2016-01-13  remain  remain  remain  remain  remain  remain  remain  remain
13 2016-01-14  remain  remain  remain  remain  remain  remain   preci  remain
14 2016-01-15  remain  remain  remain  remain  remain  remain  remain  remain
15 2016-01-16  remain  remain   preci   preci   preci   preci  remain   preci
16 2016-01-17  remain  remain  remain  remain  remain  remain  remain  remain
17 2016-01-18  remain  remain  remain  remain  remain  remain  remain   preci
18 2016-01-19  remain  remain  remain  remain  remain  remain  remain  remain
19 2016-01-20  remain  remain  remain  remain  remain  remain  remain  remain
20 2016-01-21  remain  remain  remain  remain  remain  remain  remain  remain
21 2016-01-22   preci  remain  remain  remain  remain  remain  remain  remain
22 2016-01-23   preci   preci   preci   preci   preci   preci   preci   preci
23 2016-01-24  remain   preci   preci  remain  remain  remain  remain  remain
24 2016-01-25  remain  remain  remain  remain  remain  remain  remain  remain
25 2016-01-26  remain  remain  remain  remain  remain  remain  remain  remain
26 2016-01-27  remain  remain  remain  remain  remain  remain  remain  remain
27 2016-01-28  remain  remain  remain  remain  remain  remain  remain  remain
28 2016-01-29  remain  remain  remain  remain  remain  remain  remain  remain
29 2016-01-30  remain  remain  remain  remain  remain  remain  remain  remain
30 2016-01-31  remain  remain  remain  remain  remain  remain  remain  remain

         8  …      14      15      16      17      18      19      20  \
0   remain  …  remain  remain  remain  remain  remain  remain  remain
1   remain  …  remain  remain  remain  remain  remain  remain  remain
2   remain  …  remain  remain  remain  remain  remain  remain  remain
3   remain  …  remain  remain  remain  remain  remain  remain  remain
4   remain  …  remain  remain  remain  remain  remain  remain  remain
5   remain  …  remain  remain  remain  remain  remain  remain  remain
```

6	remain	…	remain	remain	remain	remain	remain	remain	remain
7	remain	…	remain	remain	remain	remain	remain	remain	remain
8	remain	…	remain	remain	remain	remain	remain	remain	remain
9	preci	…	remain	remain	preci	remain	remain	remain	remain
10	remain	…	remain	remain	remain	remain	remain	remain	remain
11	remain	…	remain	remain	remain	preci	remain	remain	remain
12	remain	…	remain	remain	remain	remain	remain	remain	remain
13	remain	…	remain	remain	remain	remain	remain	remain	remain
14	remain	…	remain	remain	remain	remain	remain	remain	remain
15	preci	…	remain	remain	remain	remain	remain	remain	remain
16	remain	…	remain	preci	preci	preci	preci	preci	preci
17	remain	…	remain	remain	remain	remain	remain	remain	remain
18	remain	…	remain	remain	remain	remain	remain	remain	remain
19	remain	…	remain	remain	remain	remain	remain	remain	remain
20	remain	…	remain	remain	remain	remain	remain	remain	remain
21	remain	…	remain	remain	remain	remain	remain	remain	remain
22	preci	…	preci	preci	preci	preci	preci	preci	preci
23	remain	…	remain	remain	remain	remain	remain	remain	remain
24	remain	…	remain	remain	remain	remain	remain	remain	remain
25	remain	…	remain	remain	remain	remain	remain	remain	remain
26	remain	…	remain	remain	remain	remain	remain	remain	remain
27	remain	…	remain	remain	remain	remain	remain	remain	remain
28	remain	…	remain	remain	remain	remain	remain	remain	remain
29	remain	…	remain	remain	remain	remain	remain	remain	remain
30	remain	…	remain	remain	remain	remain	remain	remain	remain

	21	22	23
0	remain	remain	remain
1	remain	remain	remain
2	remain	remain	remain
3	remain	remain	remain
4	remain	remain	remain
5	remain	remain	remain
6	remain	remain	remain
7	remain	remain	remain
8	preci	remain	remain
9	remain	remain	remain
10	remain	remain	remain
11	remain	remain	remain
12	remain	remain	remain
13	remain	remain	remain
14	remain	remain	remain
15	remain	remain	remain
16	remain	remain	remain
17	remain	remain	remain
18	remain	remain	remain
19	remain	remain	remain

```
20  remain  remain  remain
21  remain  remain   preci
22   preci   preci   preci
23  remain  remain  remain
24  remain  remain  remain
25  remain  remain  remain
26  remain  remain  remain
27  remain  remain  remain
28  remain  remain  remain
29  remain  remain  remain
30  remain  remain  remain

[31 rows x 25 columns]
```

[10]:
```python
weather.to_csv('data/weather_preprocessed.csv', index=False)
```

[ ]:
```python

```

Appendix B

Jupyter Notebook part 2 (the page number is only for this Notebook)

[1]:
```
import pandas as pd
import numpy as np
from numpy import log, sqrt
import matplotlib.pyplot as plt
import seaborn as sns
from scipy import stats
```

[2]:
```
df = pd.read_csv('data/yellow_tripdata_2016-01.csv',error_bad_lines=False)
df
```

[2]:
```
          VendorID tpep_pickup_datetime tpep_dropoff_datetime  \
0                2  2016-01-01 00:00:00   2016-01-01 00:00:00
1                2  2016-01-01 00:00:00   2016-01-01 00:00:00
2                2  2016-01-01 00:00:00   2016-01-01 00:00:00
3                2  2016-01-01 00:00:00   2016-01-01 00:00:00
4                2  2016-01-01 00:00:00   2016-01-01 00:00:00
…             …                  …                   …
10906853         2  2016-01-31 23:30:32   2016-01-31 23:38:18
10906854         1  2016-01-05 00:15:55   2016-01-05 00:16:06
10906855         1  2016-01-05 06:12:46   2016-03-19 20:45:50
10906856         1  2016-01-05 06:21:44   2016-03-28 12:54:26
10906857         1  2016-01-05 06:15:21   2016-01-05 06:15:36

          passenger_count  trip_distance  pickup_longitude  pickup_latitude  \
0                       2           1.10        -73.990372        40.734695
1                       5           4.90        -73.980782        40.729912
2                       1          10.54        -73.984550        40.679565
3                       1           4.75        -73.993469        40.718990
4                       3           1.76        -73.960625        40.781330
…                     …              …                 …                …
10906853                1           2.20        -74.003578        40.751011
10906854                1           0.00        -73.945488        40.751530
10906855                3           1.40        -73.994240        40.766586
10906856                1           2.10        -73.948067        40.776531
10906857                3           0.00        -73.960938        40.758595

          RatecodeID store_and_fwd_flag  dropoff_longitude  dropoff_latitude  \
```

```
0                 1                 N         -73.981842         40.732407
1                 1                 N         -73.944473         40.716679
2                 1                 N         -73.950272         40.788925
3                 1                 N         -73.962242         40.657333
4                 1                 N         -73.977264         40.758514
…              …                 …                 …                 …
10906853          1                 N         -73.982651         40.767509
10906854          1                 N         -73.945457         40.751530
10906855          1                 N         -73.984428         40.753922
10906856          1                 N         -73.978188         40.777435
10906857          2                 N         -73.961006         40.758583

          payment_type  fare_amount  extra  mta_tax  tip_amount  tolls_amount  \
0                    2          7.5    0.5      0.5        0.00          0.00
1                    1         18.0    0.5      0.5        0.00          0.00
2                    1         33.0    0.5      0.5        0.00          0.00
3                    2         16.5    0.0      0.5        0.00          0.00
4                    2          8.0    0.0      0.5        0.00          0.00
…                  …          …      …        …          …             …
10906853             2          8.5    0.5      0.5        0.00          0.00
10906854             2          2.5    0.5      0.5        0.00          0.00
10906855             2          7.5    0.5      0.5        0.00          0.00
10906856             1         11.5    0.0      0.5        2.45          0.00
10906857             2         52.0    0.0      0.5        0.00          5.54

          improvement_surcharge  total_amount
0                           0.3          8.80
1                           0.3         19.30
2                           0.3         34.30
3                           0.3         17.30
4                           0.3          8.80
…                         …             …
10906853                    0.3          9.80
10906854                    0.3          3.80
10906855                    0.3          8.80
10906856                    0.3         14.75
10906857                    0.3         58.34

[10906858 rows x 19 columns]
```

[3]:
```
df.columns
```

[3]:
```
Index(['VendorID', 'tpep_pickup_datetime', 'tpep_dropoff_datetime',
       'passenger_count', 'trip_distance', 'pickup_longitude',
       'pickup_latitude', 'RatecodeID', 'store_and_fwd_flag',
       'dropoff_longitude', 'dropoff_latitude', 'payment_type', 'fare_amount',
       'extra', 'mta_tax', 'tip_amount', 'tolls_amount',
```

```
             'improvement_surcharge', 'total_amount'],
            dtype='object')
```

[ ]:

[4]:
```
df.dropna(inplace=True)
df['tpep_pickup_datetime'] = pd.to_datetime(df['tpep_pickup_datetime'],
                             format='%Y/%m/%d %H:%M', errors='coerce')
df['tpep_dropoff_datetime'] = pd.to_datetime(df['tpep_dropoff_datetime'],
                             format='%Y/%m/%d %H:%M', errors='coerce')

df['duration'] = (df['tpep_dropoff_datetime'] -
                  df['tpep_pickup_datetime']).dt.seconds.astype(int) /60
```

[5]:
```
df['start_hour'] =  df['tpep_pickup_datetime'].dt.hour
df['start_date'] = df['tpep_pickup_datetime'].dt.strftime('%Y-%m-%d')
```

[ ]:

[ ]:

[6]:
```
weather = pd.read_csv('data/weather_preprocessed.csv', index_col= 'time')
weather
```

[6]:
```
                 0       1       2       3       4       5       6       7  \
time
2016-01-01  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-02  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-03  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-04  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-05  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-06  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-07  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-08  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-09  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-10  remain   preci  remain  remain   preci   preci   preci   preci
2016-01-11  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-12  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-13  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-14  remain  remain  remain  remain  remain  remain   preci  remain
2016-01-15  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-16  remain  remain   preci   preci   preci   preci  remain   preci
2016-01-17  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-18  remain  remain  remain  remain  remain  remain  remain   preci
2016-01-19  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-20  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-21  remain  remain  remain  remain  remain  remain  remain  remain
```

```
2016-01-22   preci  remain  remain  remain  remain  remain  remain  remain
2016-01-23   preci   preci   preci   preci   preci   preci   preci   preci
2016-01-24  remain   preci   preci  remain  remain  remain  remain  remain
2016-01-25  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-26  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-27  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-28  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-29  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-30  remain  remain  remain  remain  remain  remain  remain  remain
2016-01-31  remain  remain  remain  remain  remain  remain  remain  remain

                 8       9  …      14      15      16      17      18  \
time                        …
2016-01-01  remain  remain  …  remain  remain  remain  remain  remain
2016-01-02  remain  remain  …  remain  remain  remain  remain  remain
2016-01-03  remain  remain  …  remain  remain  remain  remain  remain
2016-01-04  remain  remain  …  remain  remain  remain  remain  remain
2016-01-05  remain  remain  …  remain  remain  remain  remain  remain
2016-01-06  remain  remain  …  remain  remain  remain  remain  remain
2016-01-07  remain  remain  …  remain  remain  remain  remain  remain
2016-01-08  remain  remain  …  remain  remain  remain  remain  remain
2016-01-09  remain  remain  …  remain  remain  remain  remain  remain
2016-01-10   preci   preci  …  remain  remain   preci  remain  remain
2016-01-11  remain  remain  …  remain  remain  remain  remain  remain
2016-01-12  remain  remain  …  remain  remain  remain   preci  remain
2016-01-13  remain  remain  …  remain  remain  remain  remain  remain
2016-01-14  remain  remain  …  remain  remain  remain  remain  remain
2016-01-15  remain  remain  …  remain  remain  remain  remain  remain
2016-01-16   preci  remain  …  remain  remain  remain  remain  remain
2016-01-17  remain  remain  …  remain   preci   preci   preci   preci
2016-01-18  remain  remain  …  remain  remain  remain  remain  remain
2016-01-19  remain  remain  …  remain  remain  remain  remain  remain
2016-01-20  remain  remain  …  remain  remain  remain  remain  remain
2016-01-21  remain  remain  …  remain  remain  remain  remain  remain
2016-01-22  remain  remain  …  remain  remain  remain  remain  remain
2016-01-23   preci   preci  …   preci   preci   preci   preci   preci
2016-01-24  remain  remain  …  remain  remain  remain  remain  remain
2016-01-25  remain  remain  …  remain  remain  remain  remain  remain
2016-01-26  remain  remain  …  remain  remain  remain  remain  remain
2016-01-27  remain  remain  …  remain  remain  remain  remain  remain
2016-01-28  remain  remain  …  remain  remain  remain  remain  remain
2016-01-29  remain  remain  …  remain  remain  remain  remain  remain
2016-01-30  remain  remain  …  remain  remain  remain  remain  remain
2016-01-31  remain  remain  …  remain  remain  remain  remain  remain

                19      20      21      22      23
time
```

```
2016-01-01  remain  remain  remain  remain  remain
2016-01-02  remain  remain  remain  remain  remain
2016-01-03  remain  remain  remain  remain  remain
2016-01-04  remain  remain  remain  remain  remain
2016-01-05  remain  remain  remain  remain  remain
2016-01-06  remain  remain  remain  remain  remain
2016-01-07  remain  remain  remain  remain  remain
2016-01-08  remain  remain  remain  remain  remain
2016-01-09  remain  remain   preci  remain  remain
2016-01-10  remain  remain  remain  remain  remain
2016-01-11  remain  remain  remain  remain  remain
2016-01-12  remain  remain  remain  remain  remain
2016-01-13  remain  remain  remain  remain  remain
2016-01-14  remain  remain  remain  remain  remain
2016-01-15  remain  remain  remain  remain  remain
2016-01-16  remain  remain  remain  remain  remain
2016-01-17   preci   preci  remain  remain  remain
2016-01-18  remain  remain  remain  remain  remain
2016-01-19  remain  remain  remain  remain  remain
2016-01-20  remain  remain  remain  remain  remain
2016-01-21  remain  remain  remain  remain  remain
2016-01-22  remain  remain  remain  remain   preci
2016-01-23   preci   preci   preci   preci   preci
2016-01-24  remain  remain  remain  remain  remain
2016-01-25  remain  remain  remain  remain  remain
2016-01-26  remain  remain  remain  remain  remain
2016-01-27  remain  remain  remain  remain  remain
2016-01-28  remain  remain  remain  remain  remain
2016-01-29  remain  remain  remain  remain  remain
2016-01-30  remain  remain  remain  remain  remain
2016-01-31  remain  remain  remain  remain  remain

[31 rows x 24 columns]
```

[ ]:

```

```

[7]:

```python
def fill_weather(weather, date, time):
    return weather.loc[date][time]


df['weather'] = df[['start_date','start_hour']].apply(
    lambda x: fill_weather(weather,x.iloc[0],x.iloc[1]), axis=1)
```

[8]:

```python
df.to_feather('data/yellow_tripdata_01_weather.feather')
```

[9]:

```python
df
```

[9]:

```
          VendorID tpep_pickup_datetime tpep_dropoff_datetime  \
0                2  2016-01-01 00:00:00   2016-01-01 00:00:00
1                2  2016-01-01 00:00:00   2016-01-01 00:00:00
2                2  2016-01-01 00:00:00   2016-01-01 00:00:00
3                2  2016-01-01 00:00:00   2016-01-01 00:00:00
4                2  2016-01-01 00:00:00   2016-01-01 00:00:00
…              …                  …                   …
10906853         2  2016-01-31 23:30:32   2016-01-31 23:38:18
10906854         1  2016-01-05 00:15:55   2016-01-05 00:16:06
10906855         1  2016-01-05 06:12:46   2016-03-19 20:45:50
10906856         1  2016-01-05 06:21:44   2016-03-28 12:54:26
10906857         1  2016-01-05 06:15:21   2016-01-05 06:15:36

          passenger_count  trip_distance  pickup_longitude  pickup_latitude  \
0                       2           1.10        -73.990372        40.734695
1                       5           4.90        -73.980782        40.729912
2                       1          10.54        -73.984550        40.679565
3                       1           4.75        -73.993469        40.718990
4                       3           1.76        -73.960625        40.781330
…                     …            …               …              …
10906853                1           2.20        -74.003578        40.751011
10906854                1           0.00        -73.945488        40.751530
10906855                3           1.40        -73.994240        40.766586
10906856                1           2.10        -73.948067        40.776531
10906857                3           0.00        -73.960938        40.758595

          RatecodeID store_and_fwd_flag  dropoff_longitude  …  extra  \
0                  1                  N         -73.981842  …    0.5
1                  1                  N         -73.944473  …    0.5
2                  1                  N         -73.950272  …    0.5
3                  1                  N         -73.962242  …    0.0
4                  1                  N         -73.977264  …    0.0
…                …                …                …  …    …
10906853           1                  N         -73.982651  …    0.5
10906854           1                  N         -73.945457  …    0.5
10906855           1                  N         -73.984428  …    0.5
10906856           1                  N         -73.978188  …    0.0
10906857           2                  N         -73.961006  …    0.0

          mta_tax  tip_amount  tolls_amount  improvement_surcharge  \
0             0.5        0.00          0.00                    0.3
1             0.5        0.00          0.00                    0.3
2             0.5        0.00          0.00                    0.3
3             0.5        0.00          0.00                    0.3
4             0.5        0.00          0.00                    0.3
…           …         …           …                    …
10906853      0.5        0.00          0.00                    0.3
```

```
10906854      0.5        0.00          0.00                       0.3
10906855      0.5        0.00          0.00                       0.3
10906856      0.5        2.45          0.00                       0.3
10906857      0.5        0.00          5.54                       0.3

          total_amount    duration  start_hour  start_date  weather
0                 8.80    0.000000           0  2016-01-01   remain
1                19.30    0.000000           0  2016-01-01   remain
2                34.30    0.000000           0  2016-01-01   remain
3                17.30    0.000000           0  2016-01-01   remain
4                 8.80    0.000000           0  2016-01-01   remain
…                 …        …          …          …      …
10906853          9.80    7.766667          23  2016-01-31   remain
10906854          3.80    0.183333           0  2016-01-05   remain
10906855          8.80  873.066667           6  2016-01-05   remain
10906856         14.75  392.700000           6  2016-01-05   remain
10906857         58.34    0.250000           6  2016-01-05   remain

[10906858 rows x 23 columns]
```

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]:
```python
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]:
```python
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)]
```

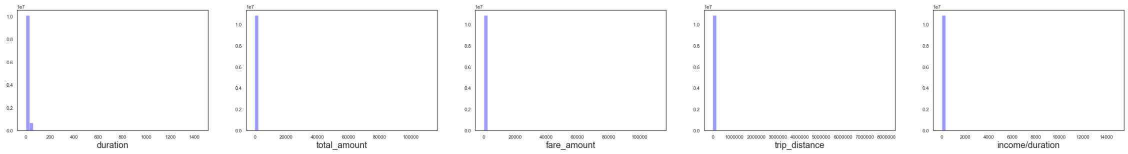
[12]:
```
# lat, long
start_coords = ['pickup_latitude', 'pickup_longitude']
end_coords = ['dropoff_latitude', 'dropoff_longitude']
df[start_coords+ end_coords].describe()
```

[12]:

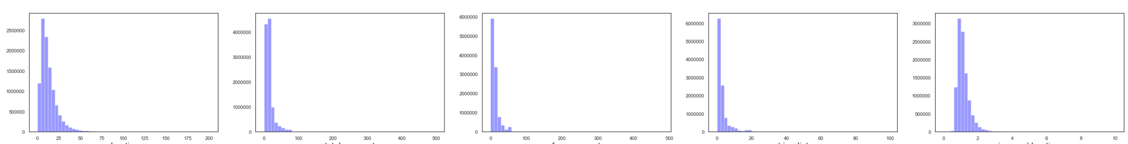
	pickup_latitude	pickup_longitude	dropoff_latitude	dropoff_longitude
count	1.082888e+07	1.082888e+07	1.082888e+07	1.082888e+07
mean	4.016214e+01	-7.290432e+01	4.022927e+01	-7.302472e+01
std	4.863079e+00	8.827634e+00	4.585772e+00	8.323998e+00
min	0.000000e+00	-1.008229e+02	0.000000e+00	-1.008229e+02
25%	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)
```

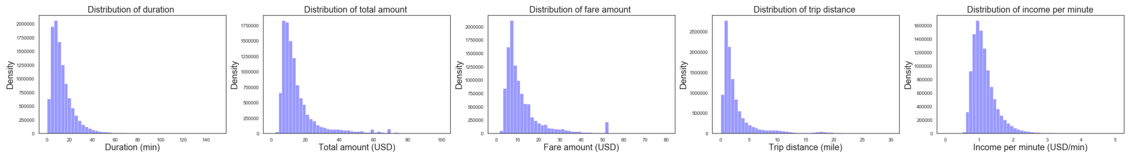


[15]:
```
df = df.loc[(df["duration"] <= 200) & (df["total_amount"]<= 500)
            & (df['fare_amount'] <= 500) & (df['trip_distance'] <= 100) & (df["income/duration"] <= 10)]

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)
```



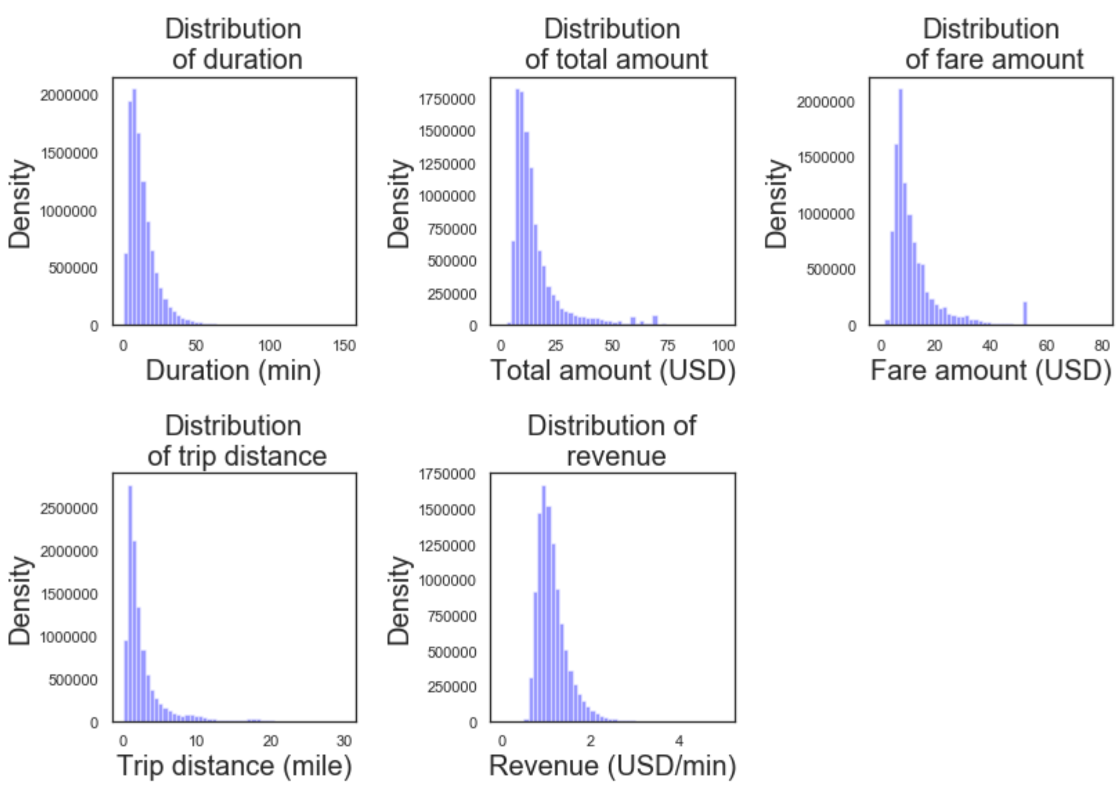
[16]:
```
df = df.loc[(df["duration"] <= 150) & (df["total_amount"]<=100) & (df['fare_amount'] <=80) & (df['trip_distance'] <= 30) & (df["income/duration"] <= 5)]

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')
```



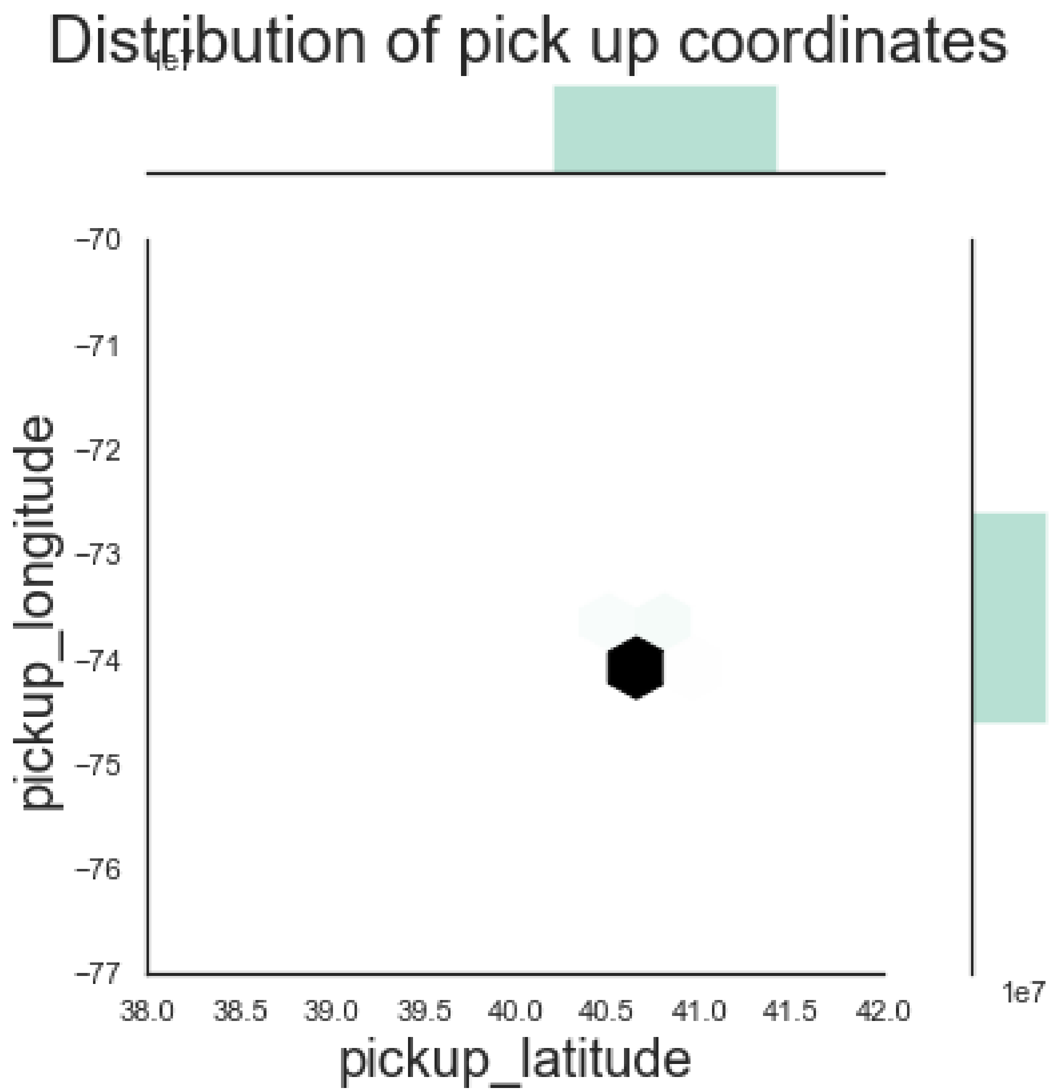
[17]:
```
plt.subplot(231)
sns.distplot(df['duration'], kde = False, label = "duration", color ="blue")
plt.title("Distribution\n of duration")
plt.xlabel('Duration (min)')
plt.ylabel("Density")

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]
```

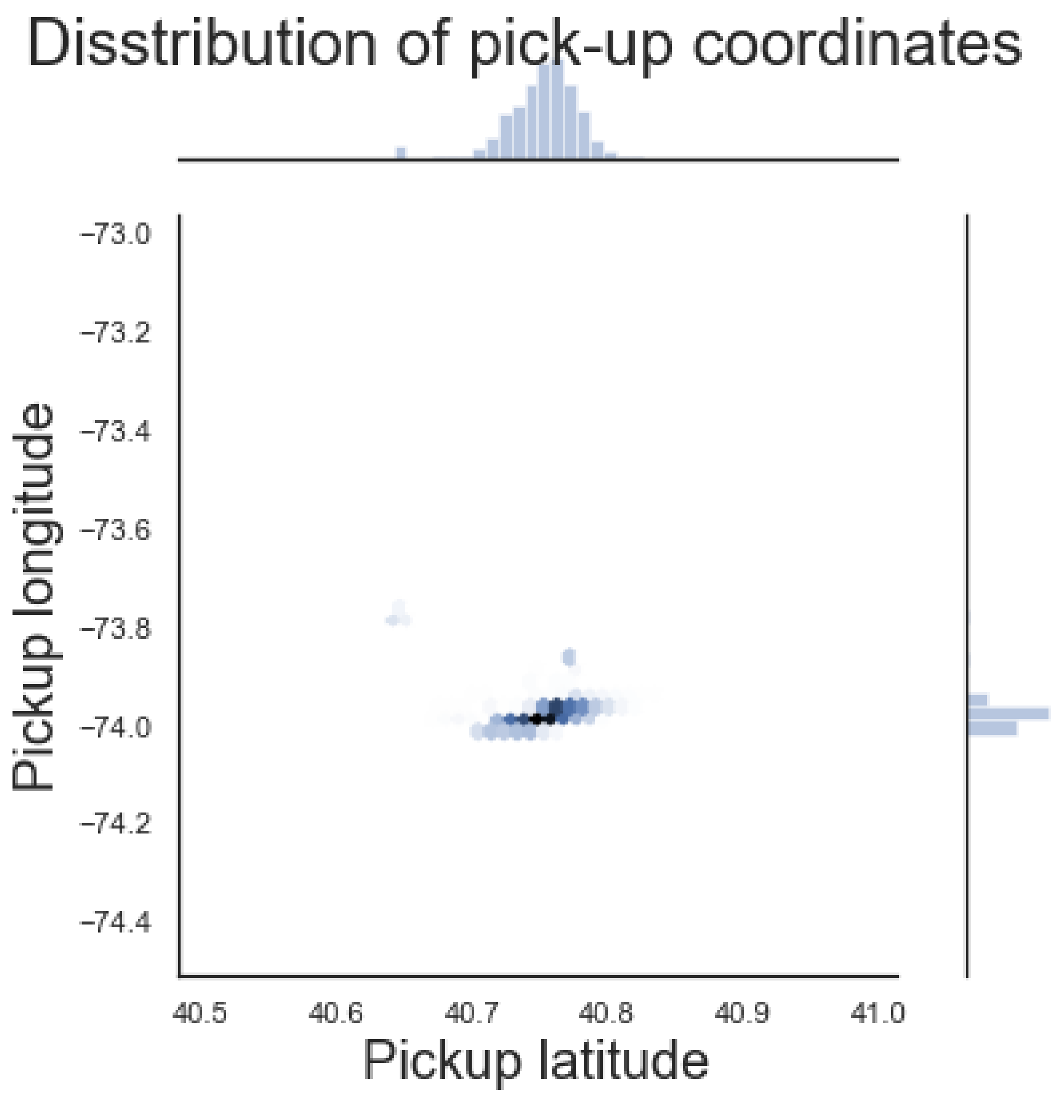
[21]:
```
df.describe()
```

[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
```

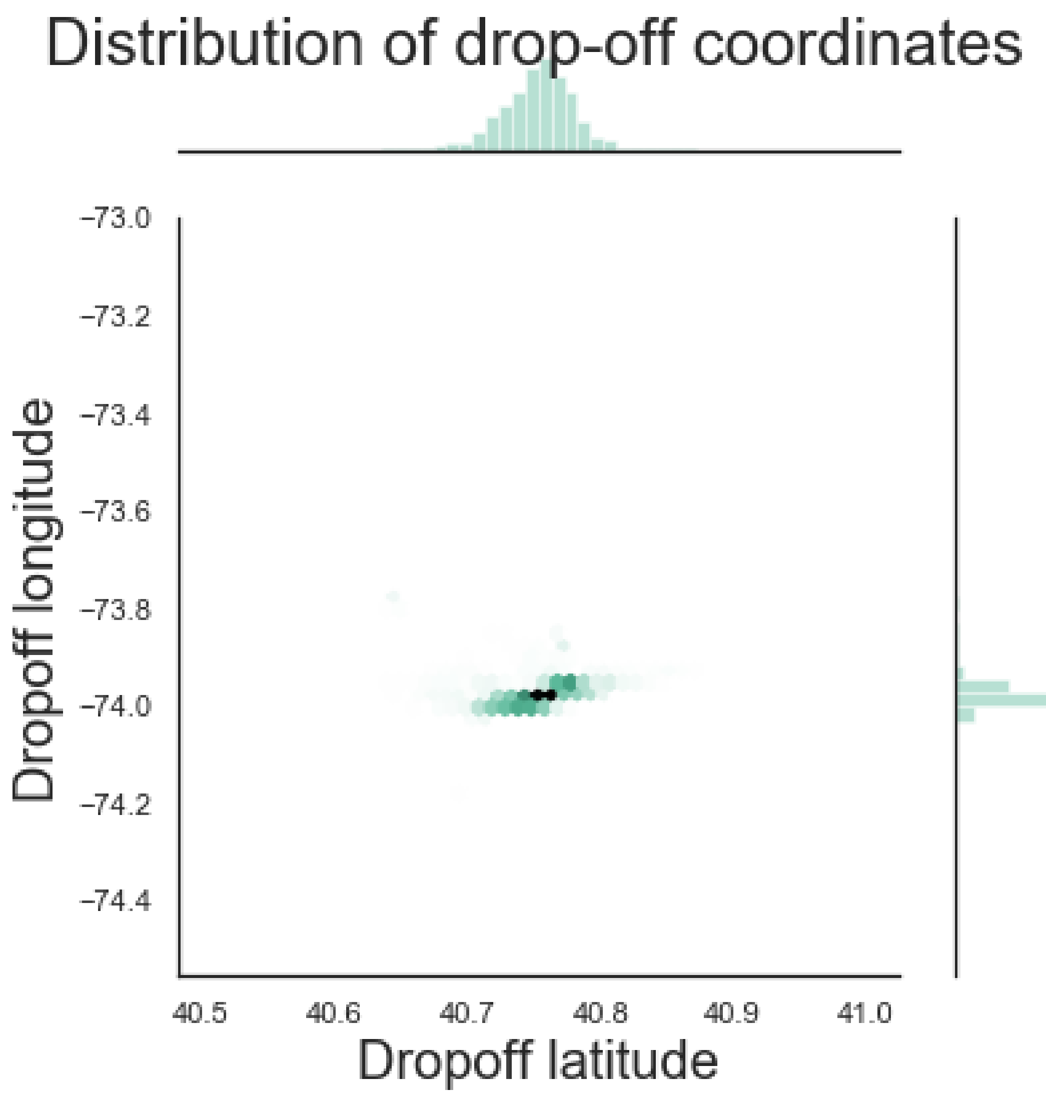
[22]:

```python
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')
```



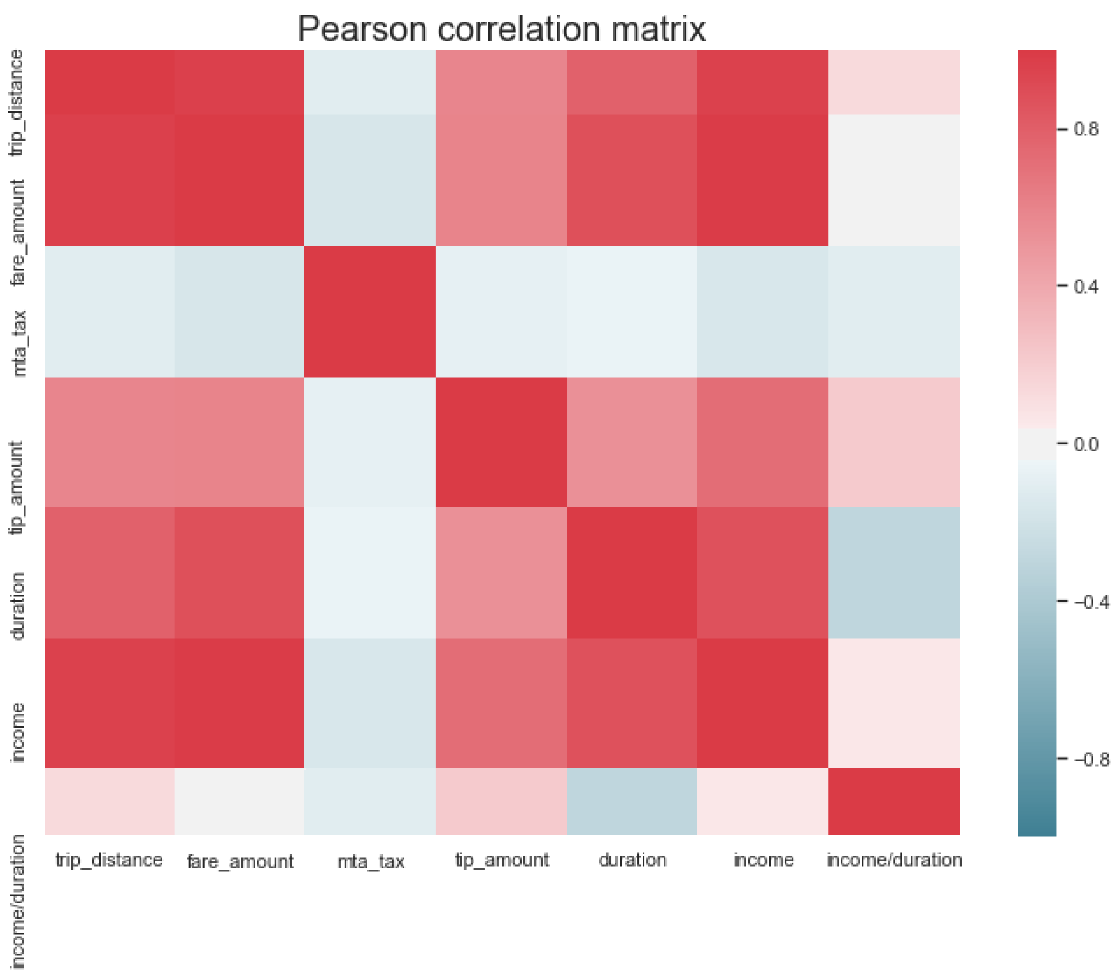
[24]:
```
df.drop(['VendorID','tpep_pickup_datetime',␣
↪'tpep_dropoff_datetime','store_and_fwd_flag', 'improvement_surcharge',
        'start_date'], axis=1, inplace = True)
```

[ ]:

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]:

```python
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.
```

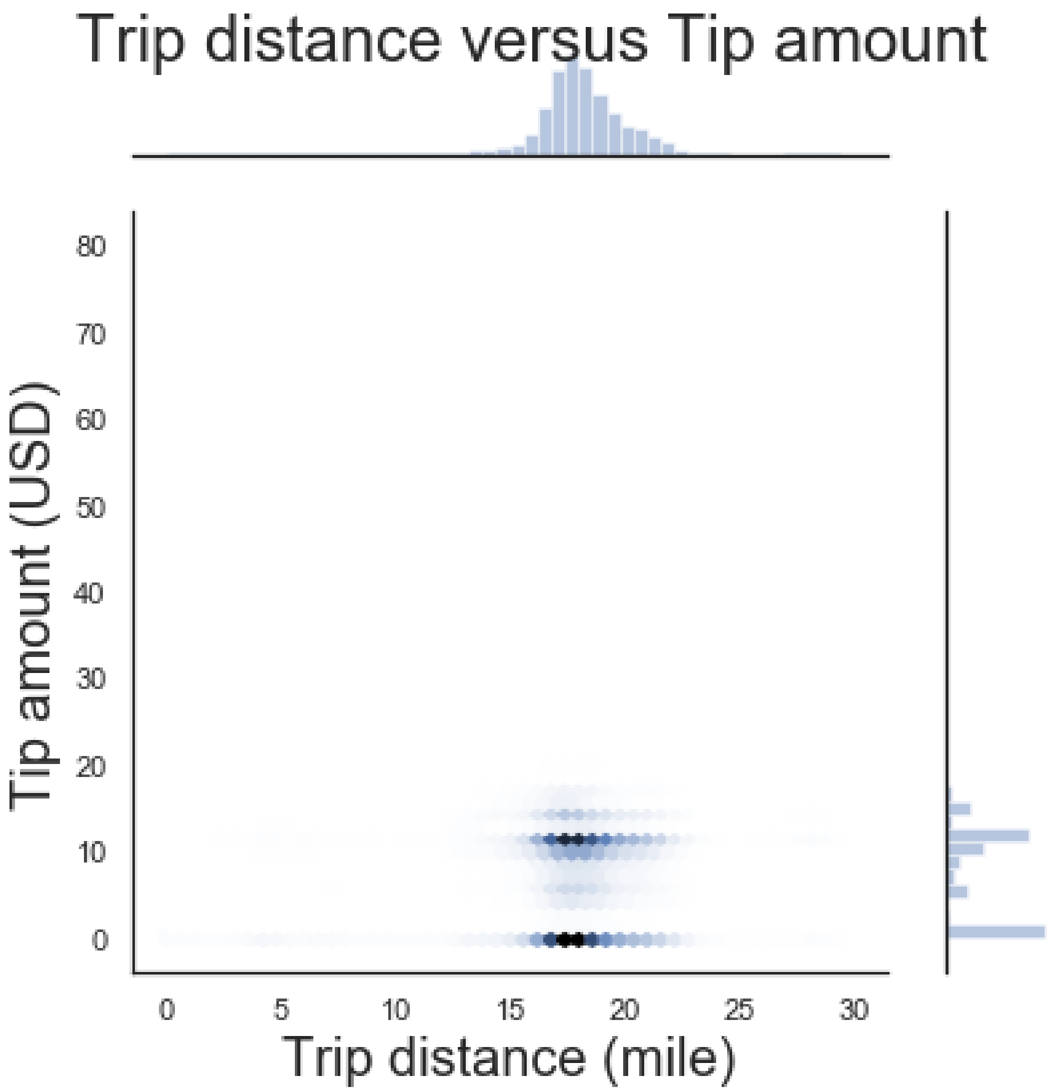
[33]:
```
fit = ols(formula="tip_amount ~ trip_distance +payment_type",
         data=df).fit()
print(fit.summary())
```

```
                            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()
```



[ ]:

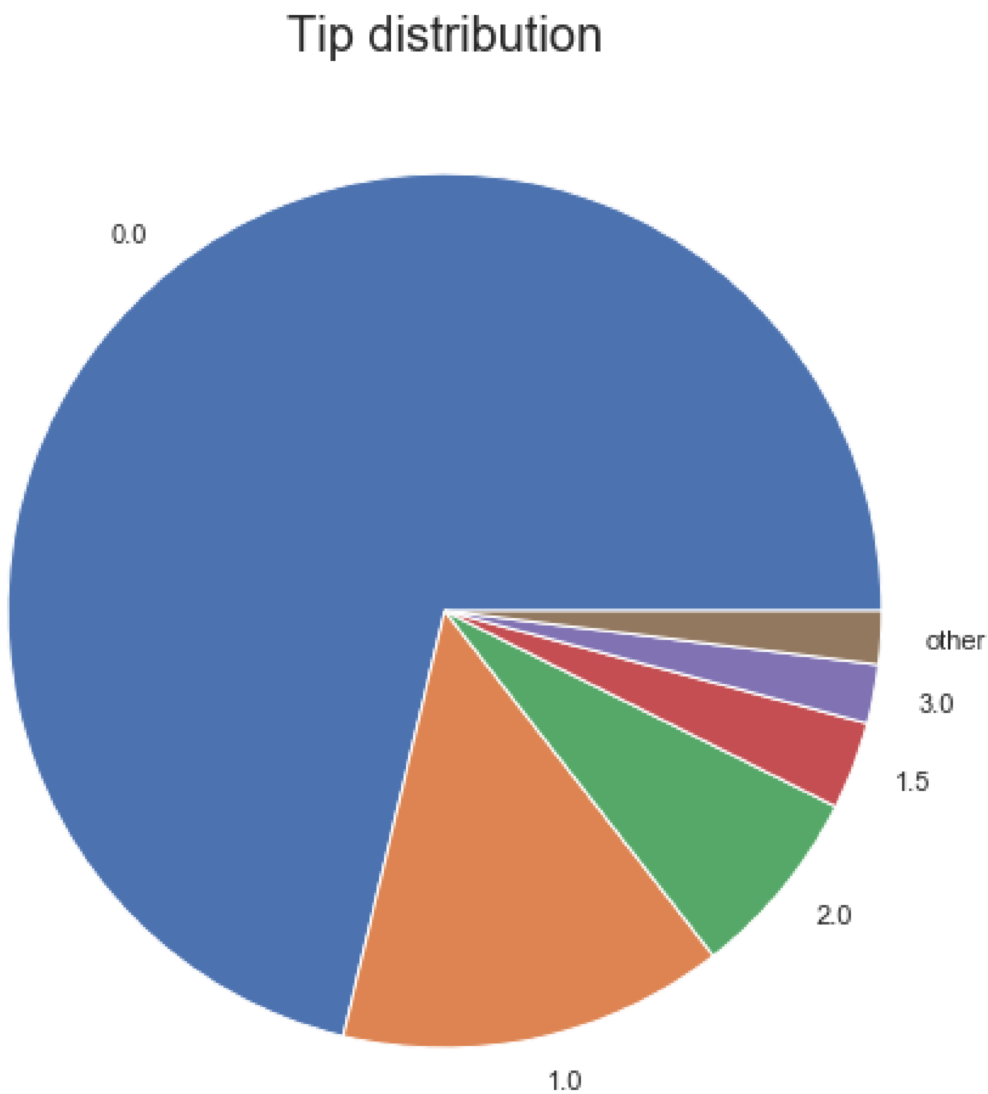
[35]:
```
tip_count = df['tip_amount'].value_counts()
tip_count
```

[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
```

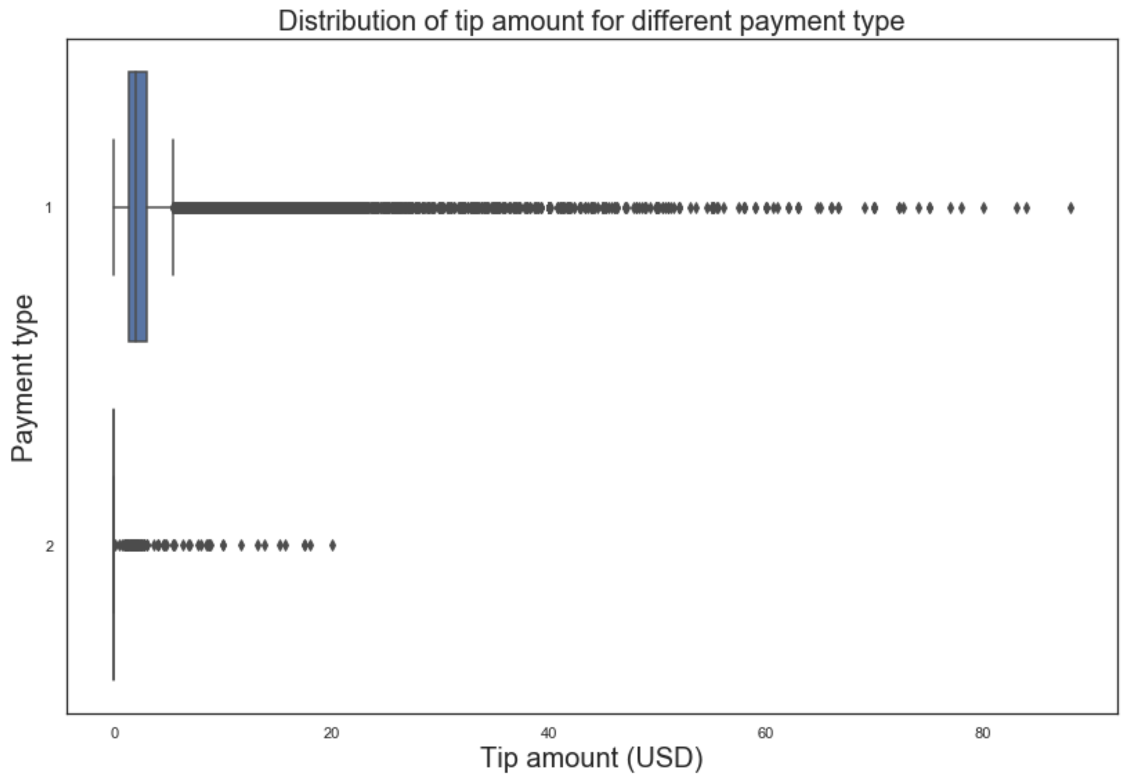
[36]:
```
0.0      3840212
1.0       768220
2.0       381510
1.5       174963
3.0       117458
other     105529
Name: tip_amount, dtype: int64
```

[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]:
```python
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

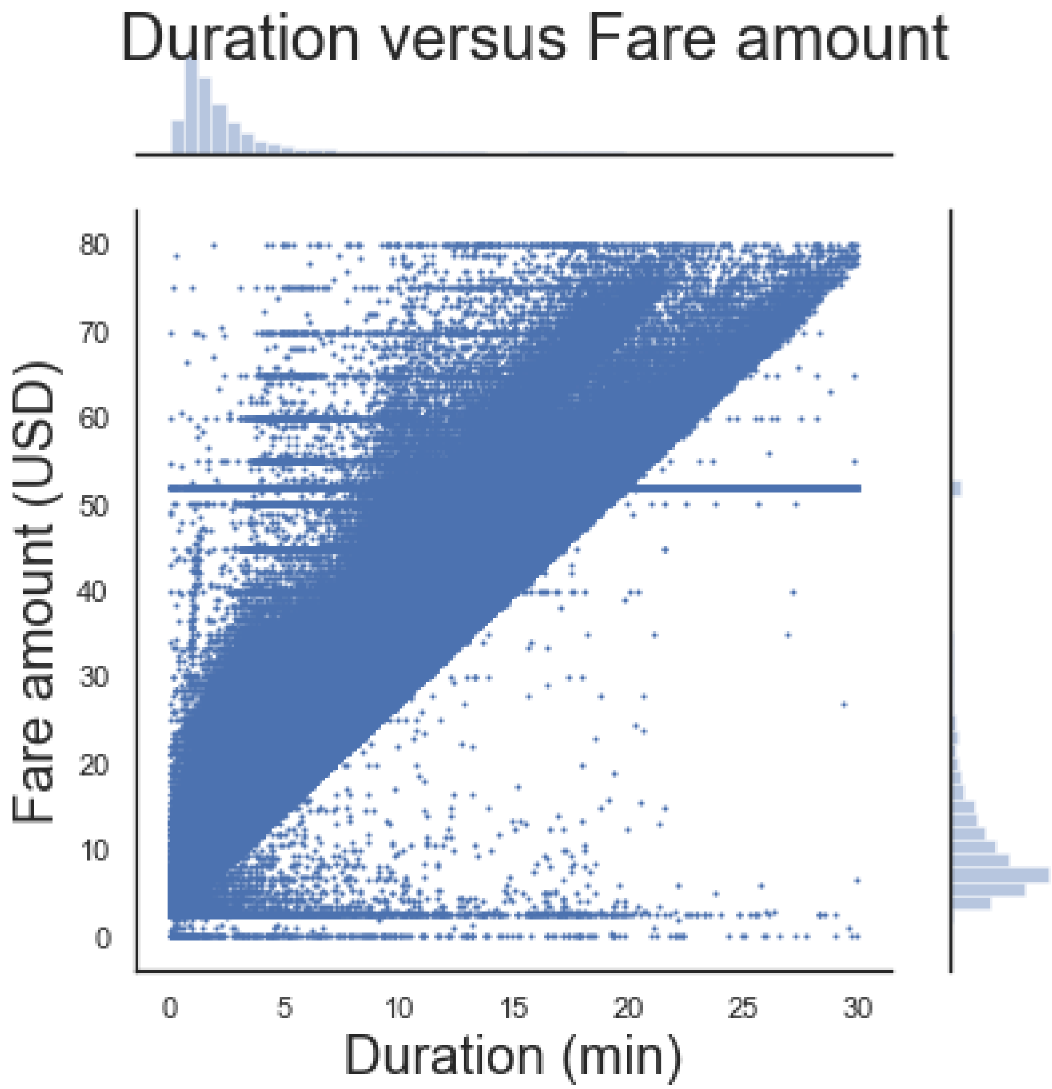
```
==============================================================================
Omnibus:                 10420296.736   Durbin-Watson:                   1.978
Prob(Omnibus):                  0.000   Jarque-Bera (JB):      24913210541.062
Skew:                           3.578   Prob(JB):          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

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

[ ]:

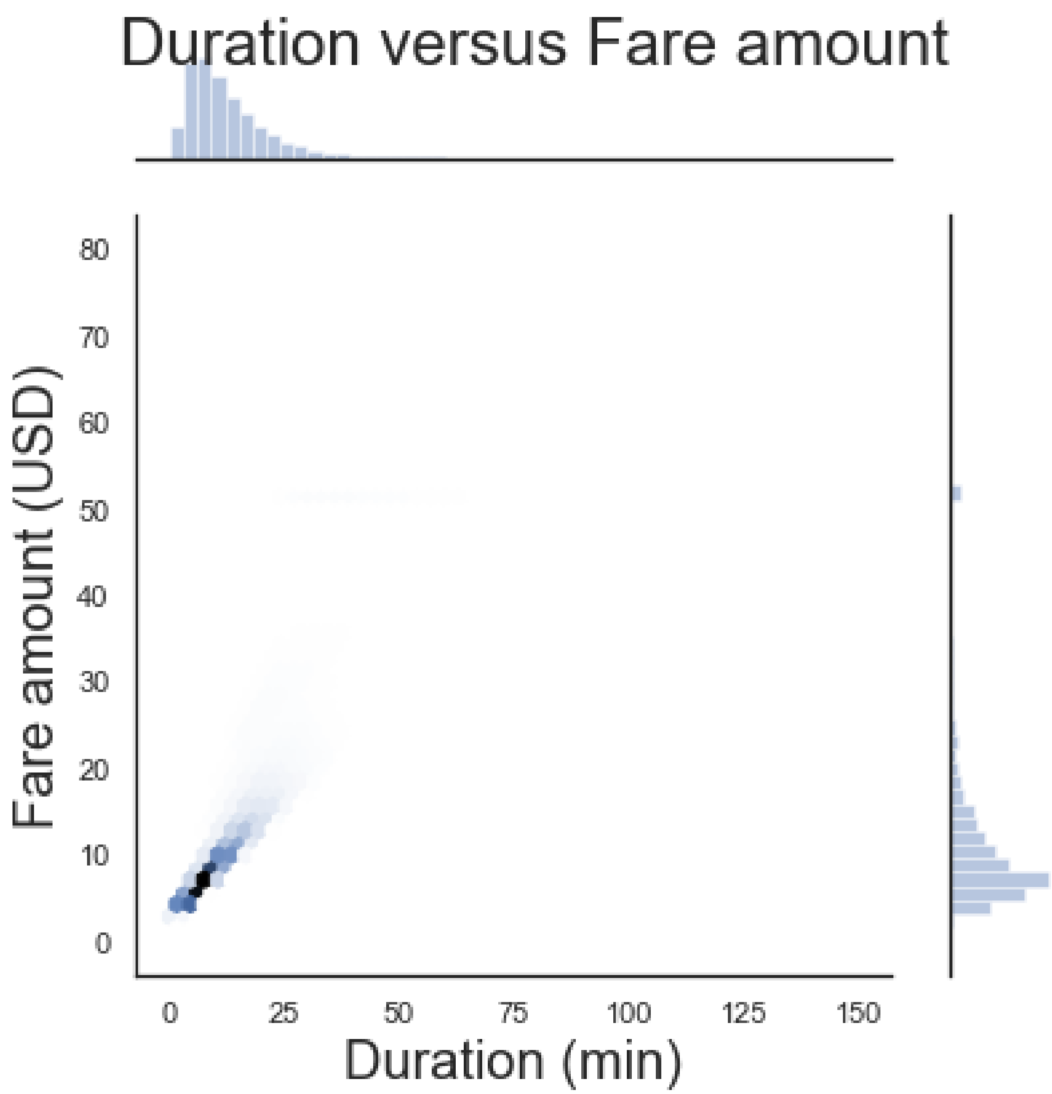
```

```

[41]:

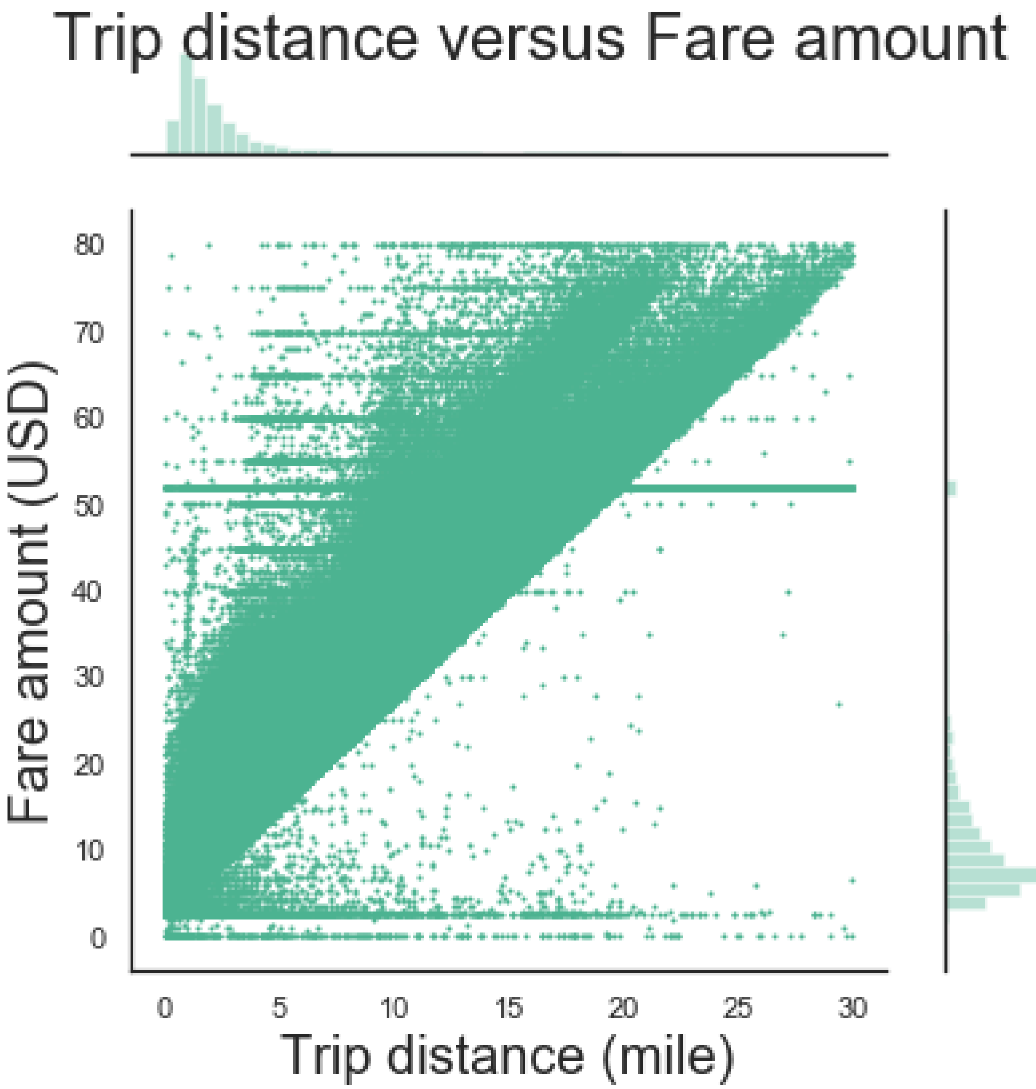
```
p = sns.jointplot(x='trip_distance',y= 'fare_amount', data= df, s=1)
p.ax_joint.set_xlabel('Duration (min)')
p.ax_joint.set_ylabel('Fare amount (USD)')
p.fig.suptitle("Duration versus Fare amount")
p.fig.tight_layout()
```



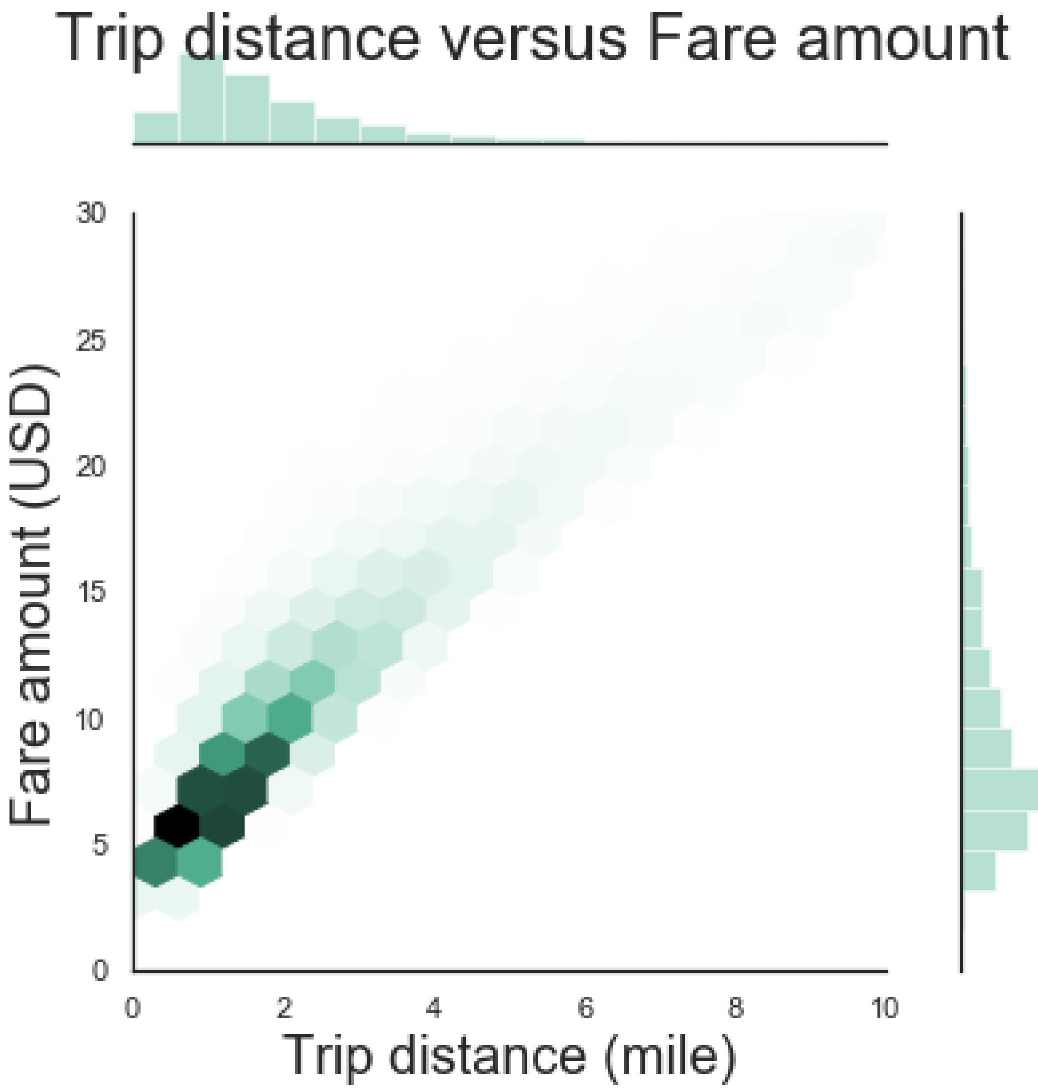
[42]:
```
p = sns.jointplot(x='duration',y= 'fare_amount',data= df, kind="hex")
p.ax_joint.set_xlabel('Duration (min)')
p.ax_joint.set_ylabel('Fare amount (USD)')
p.fig.suptitle("Duration versus Fare amount")
p.fig.tight_layout()
```



[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.
```

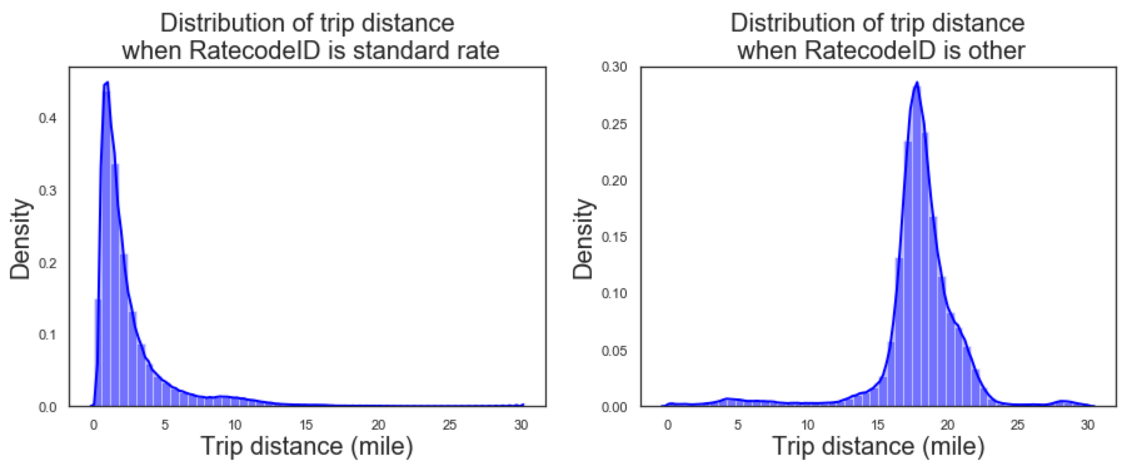
[ ]:

```

```

[46]:

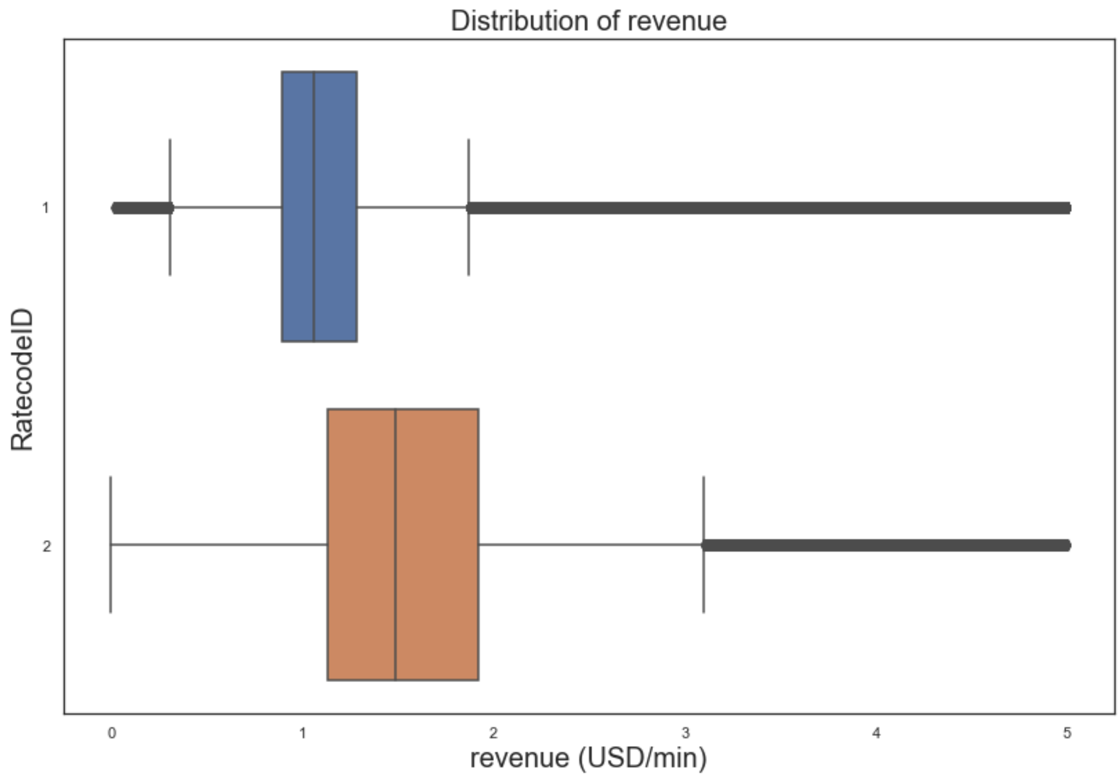
```
plt.figure(figsize=(15, 5))
plt.subplot(121)
sns.distplot(stand_df ['trip_distance'], kde = True,
             kde_kws = {'shade': True, 'linewidth': 2}, color ="blue")
plt.title("Distribution of trip distance\n when RatecodeID is standard rate")
plt.xlabel('Trip distance (mile)')
plt.ylabel("Density")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

```
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]:

```python
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

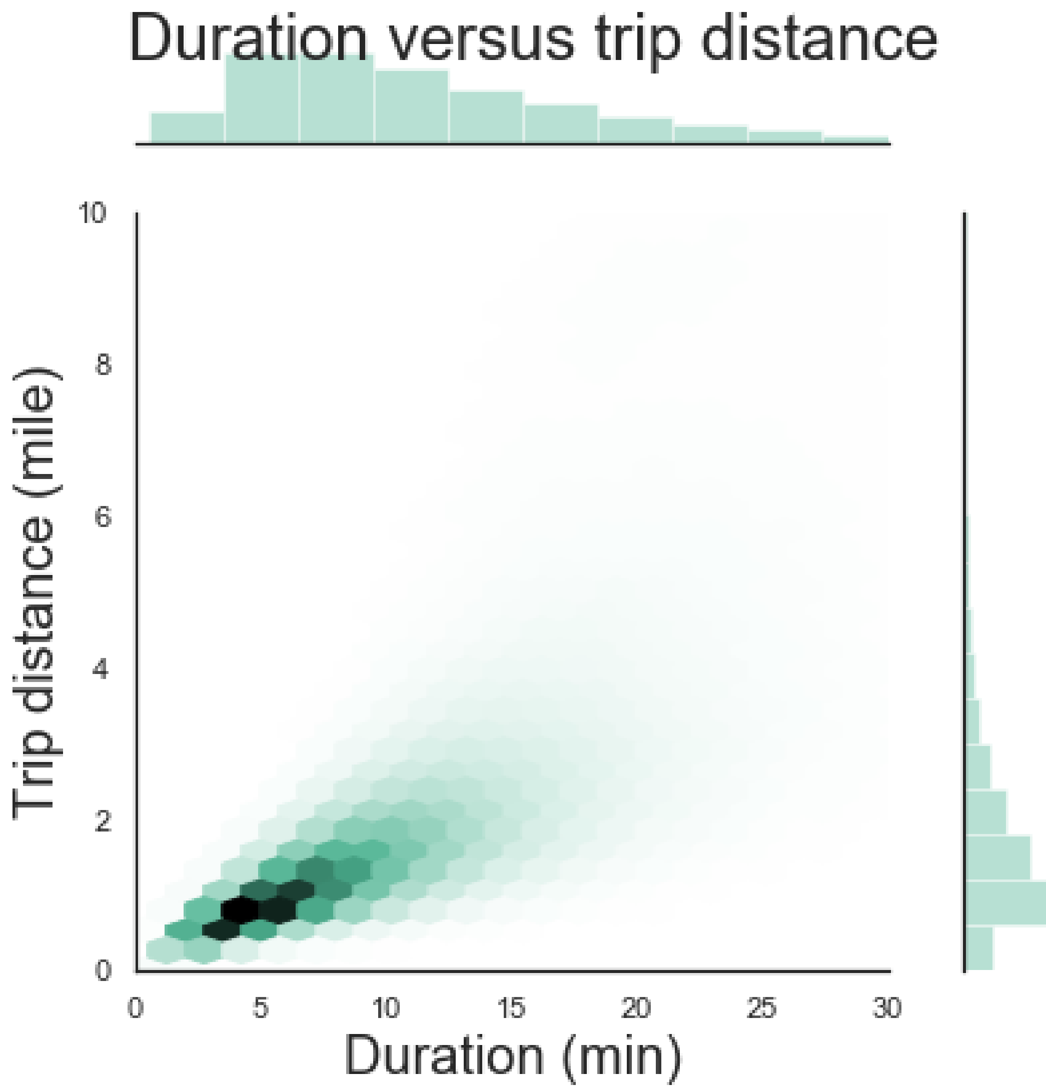
```
payment_type[T.2]    -0.0320      0.001    -28.313      0.000      -0.034
-0.030
duration              0.2326   6.02e-05   3865.297      0.000       0.232
0.233
==============================================================================
Omnibus:                  4920433.098   Durbin-Watson:                   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.
```

[ ]:

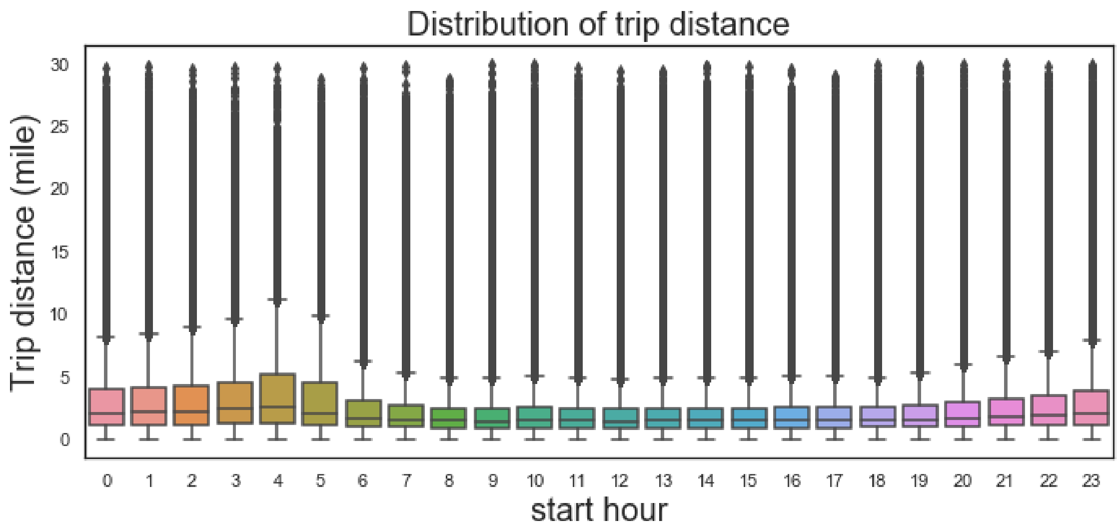
```

```

[54]:

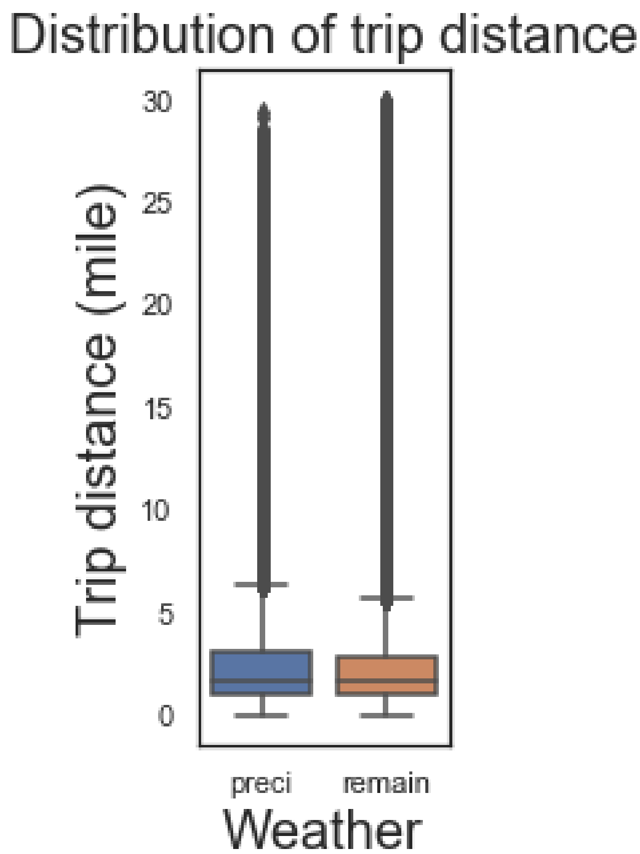
```
p = sns.jointplot(x='duration',y= 'trip_distance',data= df, kind="hex",␣
 ↪color="#4CB391", xlim=(0,30), ylim=(0,10), gridsize=100)
p.ax_joint.set_xlabel('Duration (min)')
p.ax_joint.set_ylabel('Trip distance (mile)')
p.fig.suptitle("Duration versus trip distance")
p.fig.tight_layout()
```



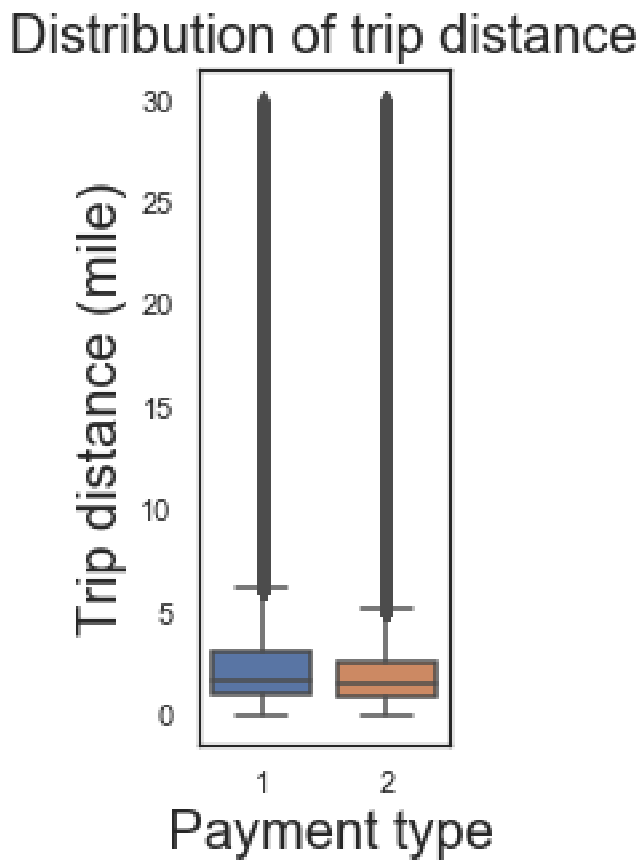
[55]:
```
plt.figure(figsize=(10, 5))
sns.boxplot(x="start_hour", y="trip_distance", data=df)
plt.title("Distribution of trip distance")
plt.ylabel('Trip distance (mile)')
plt.xlabel('start hour')
plt.tight_layout()
```



[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())
```

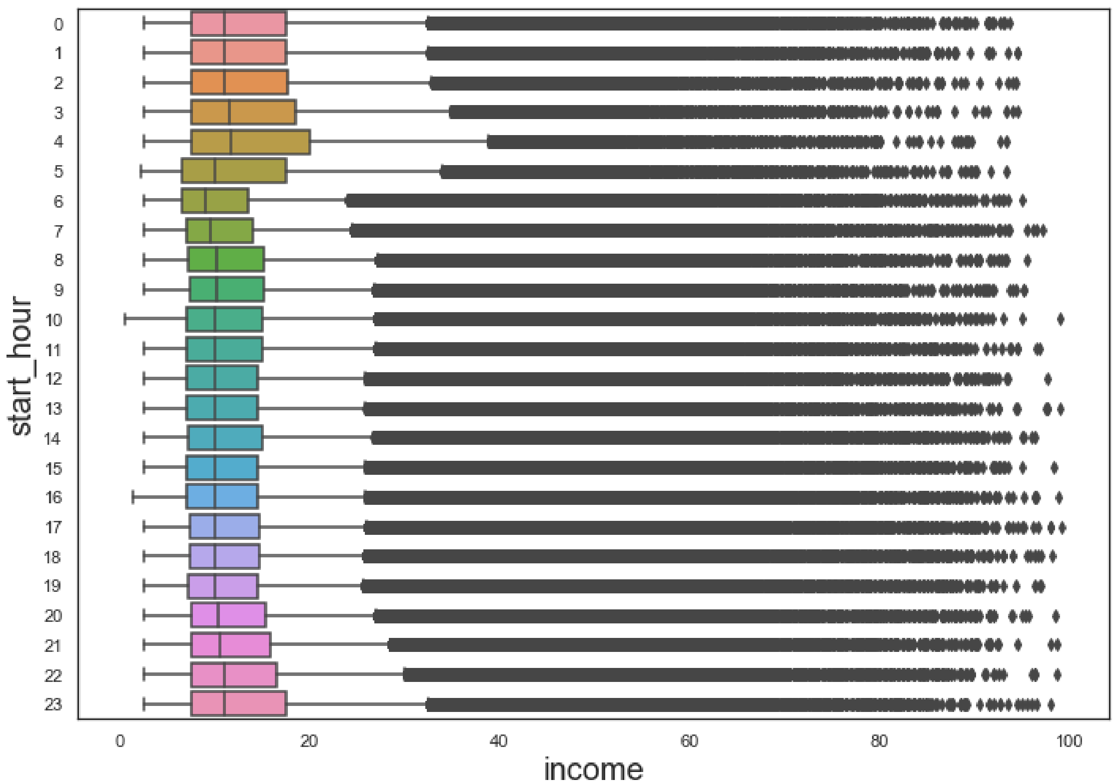
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                 income   R-squared:                       0.800
Model:                            OLS   Adj. R-squared:                  0.800
Method:                 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
==============================================================================
```

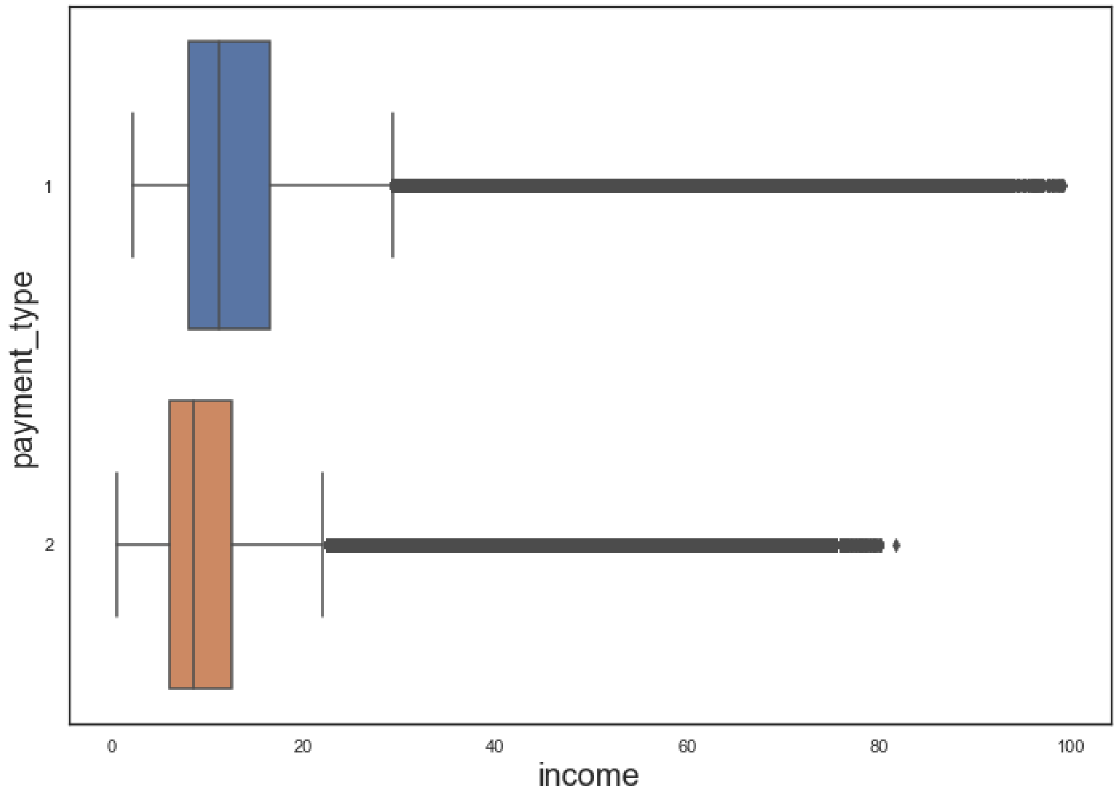
```
Omnibus:                  5137951.303   Durbin-Watson:                   1.883
Prob(Omnibus):                  0.000   Jarque-Bera (JB):        414165231.594
Skew:                           1.507   Prob(JB):                         0.00
Kurtosis:                      33.773   Cond. No.          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

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

[ ]:

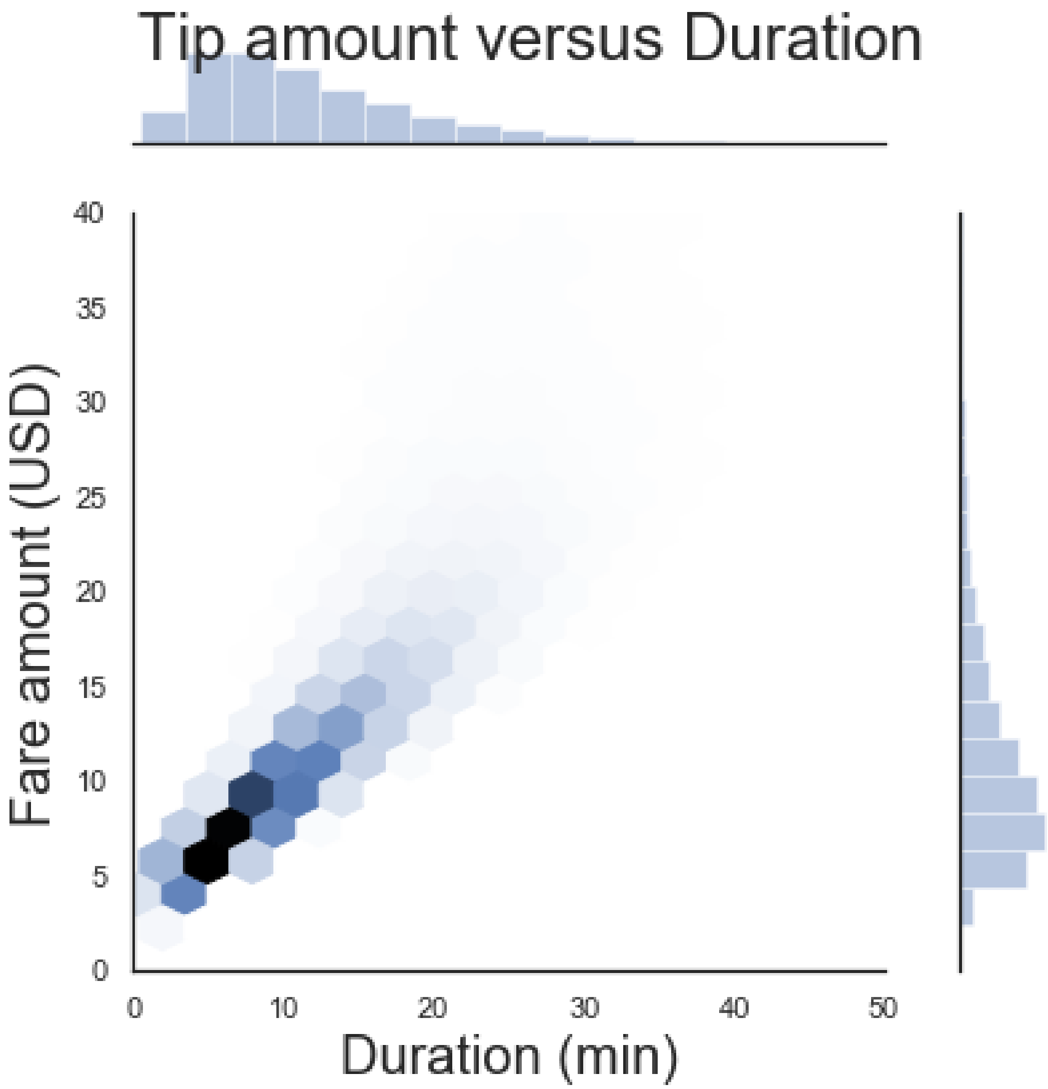
[60]:
```python
ax = sns.boxplot(x="income", y="start_hour", data=df)
```



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

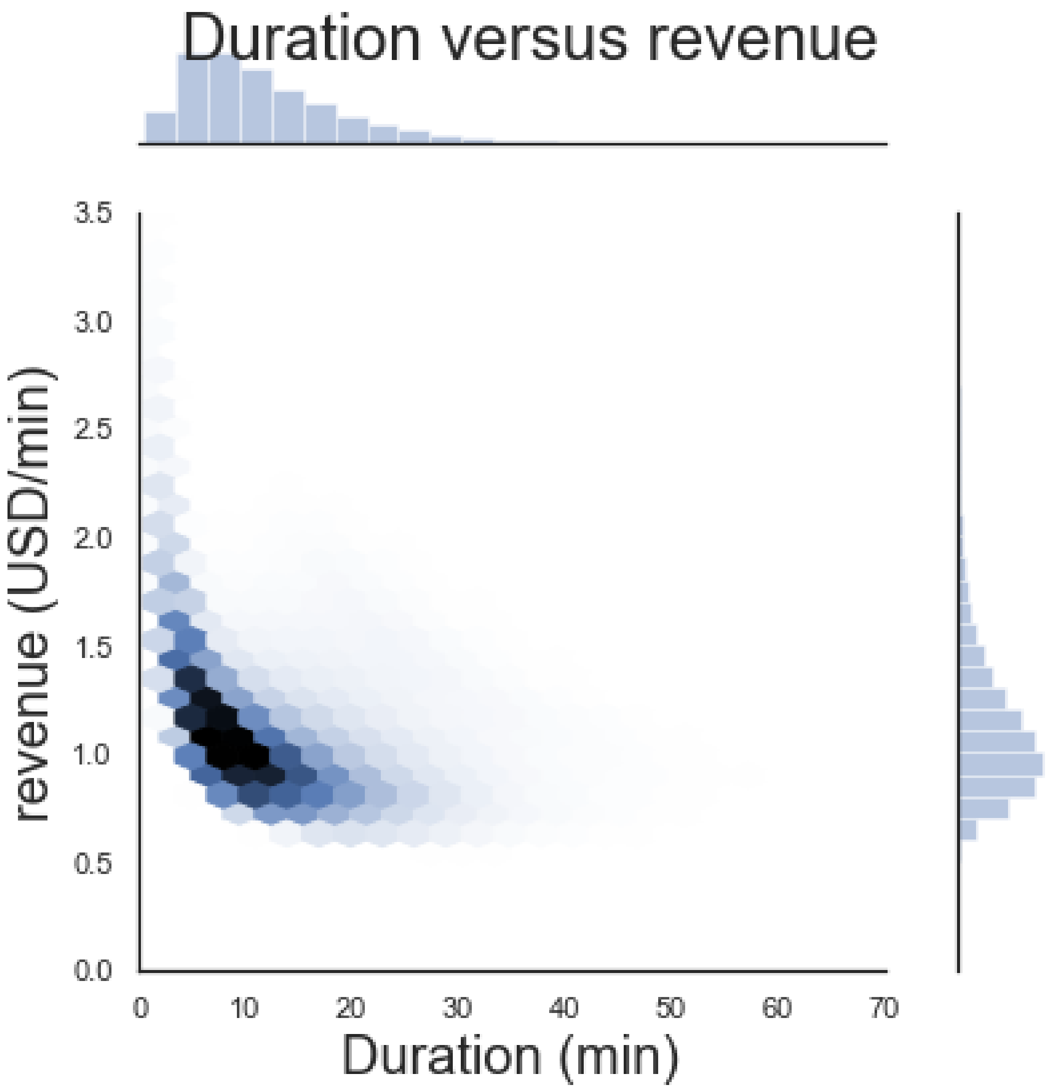


[62]:
```
p = sns.jointplot(x='duration',y= 'income',data= stand_df, kind="hex",␣
 ↪color="b", xlim=(0,50), ylim=(0,40))
p.ax_joint.set_xlabel('Duration (min)')
p.ax_joint.set_ylabel('Fare amount (USD)')
p.fig.suptitle("Tip amount versus Duration")
p.fig.tight_layout()
```



[ ]:

[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')
```

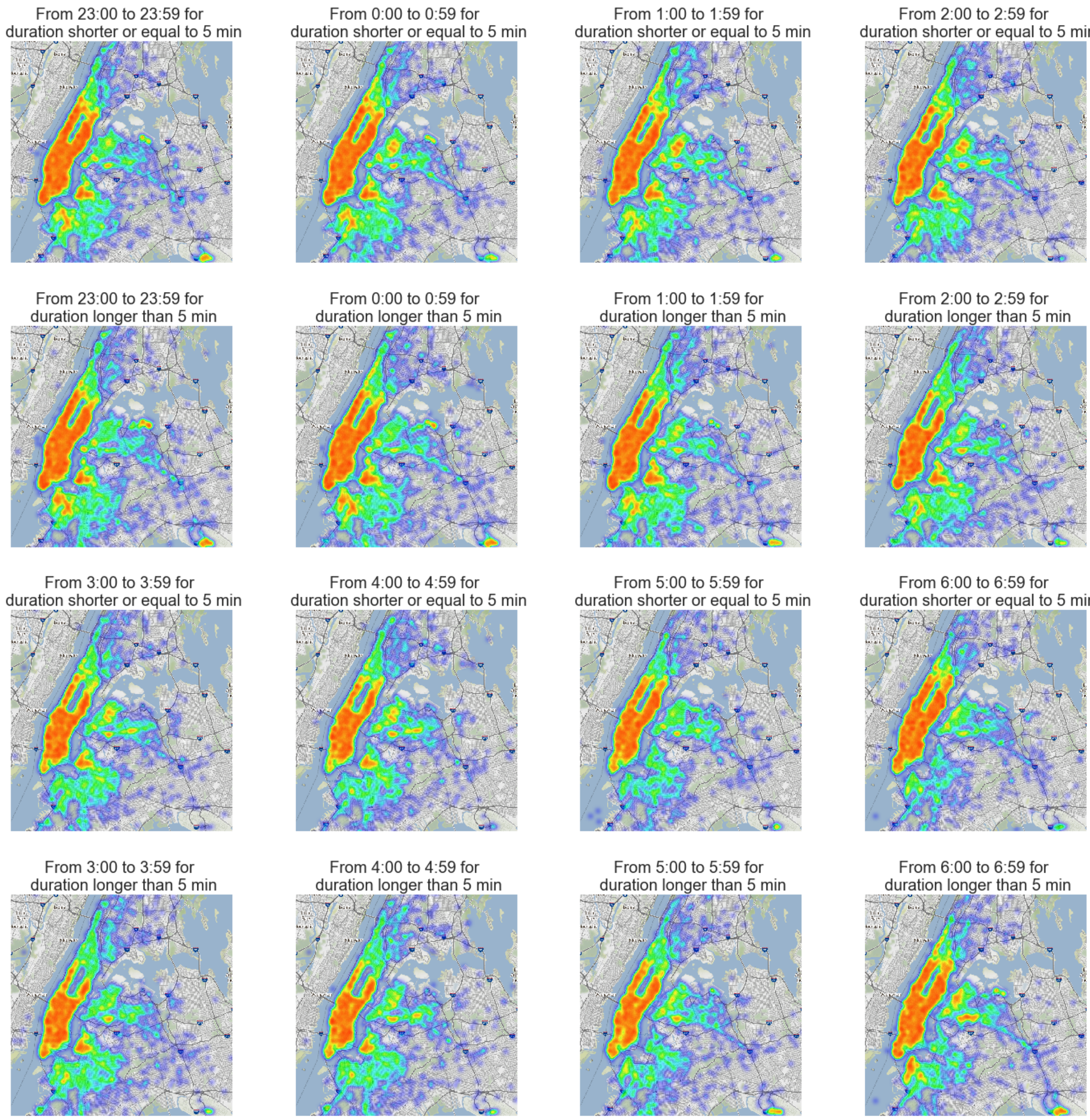
[65]:
```
for i in range(24):
```

```
    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

[ ]:

[ ]: