

```
In [4]:  
import pandas as pd  
import seaborn as sns  
%matplotlib inline  
from matplotlib import pyplot as plt
```

```
In [5]:  
import numpy as np
```

```
In [6]:  
import pandas as pd  
import numpy as np  
import scipy.stats as st  
import matplotlib.pyplot as plt  
import seaborn as sns  
%config InlineBackend.figure_formats = ['svg']  
%matplotlib inline  
  
plt.rcParams['figure.figsize'] = (9, 6)  
sns.set(context='notebook', style='whitegrid', font_scale=1.2)
```

```
In [7]:  
from sklearn.preprocessing import OneHotEncoder
```

```
In [8]:  
from sklearn.model_selection import train_test_split
```

```
In [9]:  
import statsmodels.api as sm
```

```
In [10]:  
# Make better use of Jupyter Notebook cell width  
from IPython.core.display import display, HTML  
display(HTML("<style>.container { width:95% !important; }</style>"))
```

```
In [27]:  
pd.set_option('display.max_rows', 500)  
pd.set_option('display.max_columns', 500)
```

```
In [11]:  
train_identity = pd.read_csv('/Users/arcarter/Git_Repos/project_03/data/ieee-fra
```

```
In [8]:  
train_identity.info()
```

```
<class 'pandas.core.frame.DataFrame'>  
RangeIndex: 144233 entries, 0 to 144232  
Data columns (total 41 columns):  
 #   Column           Non-Null Count  Dtype     
---  --  
 0   TransactionID  144233 non-null  int64    
 1   id_01          144233 non-null  float64  
 2   id_02          140872 non-null  float64  
 3   id_03          66324 non-null   float64  
 4   id_04          66324 non-null   float64  
 5   id_05          136865 non-null  float64
```

```

6    id_06           136865 non-null  float64
7    id_07           5155 non-null   float64
8    id_08           5155 non-null   float64
9    id_09           74926 non-null  float64
10   id_10           74926 non-null  float64
11   id_11          140978 non-null  float64
12   id_12          144233 non-null  object
13   id_13          127320 non-null  float64
14   id_14          80044 non-null  float64
15   id_15          140985 non-null  object
16   id_16          129340 non-null  object
17   id_17          139369 non-null  float64
18   id_18          45113 non-null  float64
19   id_19          139318 non-null  float64
20   id_20          139261 non-null  float64
21   id_21          5159 non-null  float64
22   id_22          5169 non-null  float64
23   id_23          5169 non-null  object
24   id_24          4747 non-null  float64
25   id_25          5132 non-null  float64
26   id_26          5163 non-null  float64
27   id_27          5169 non-null  object
28   id_28          140978 non-null  object
29   id_29          140978 non-null  object
30   id_30          77565 non-null  object
31   id_31          140282 non-null  object
32   id_32          77586 non-null  float64
33   id_33          73289 non-null  object
34   id_34          77805 non-null  object
35   id_35          140985 non-null  object
36   id_36          140985 non-null  object
37   id_37          140985 non-null  object
38   id_38          140985 non-null  object
39 DeviceType       140810 non-null  object
40 DeviceInfo       118666 non-null  object
dtypes: float64(23), int64(1), object(17)
memory usage: 45.1+ MB

```

In [8]: `#train_identity.sample(15)`

In [12]: `train_transaction = pd.read_csv('/Users/arcarter/Git_Repos/project_03/data/ieee-`

In [13]: `train_transaction.info()`

```

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 590540 entries, 0 to 590539
Columns: 394 entries, TransactionID to V339
dtypes: float64(376), int64(4), object(14)
memory usage: 1.7+ GB

```

In [11]: `#train_transaction.head(25)`

In [14]: `train_transaction_identity = train_transaction.merge(train_identity, on='Transac`

In [10]: `train_transaction_identity.shape`

Out[10]: (590540, 434)

In [13]: train_transaction_identity.info()

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 590540 entries, 0 to 590539
Columns: 434 entries, TransactionID to DeviceInfo
dtypes: float64(399), int64(4), object(31)
memory usage: 1.9+ GB
```

In [348...]

```
def df_column_unique_values(df, top_n = 5):
    for col_name, values in df.iteritems():
        col_value_counts = values.value_counts()
        print(f"{col_name} : {len(col_value_counts)}")
        col_value_count_list = [
            "" + str(c) + ":" + str(n) for c, n in sorted(
                col_value_counts.items(),
                key=lambda kv: kv[1],
                reverse=True
            )
        ]
        print(", ".join(col_value_count_list[:min(len(col_value_count_list), top_n)]))
        # print ('\n')
```

In [349...]

df_column_unique_values(train_transaction_identity)

```
TransactionID : 590540
'3147775':1, '3089230':1, '3189951':1, '3187902':1, '3194045':1
isFraud : 2
'0':569877, '1':20663
TransactionDT : 573349
'9474817':8, '11576951':5, '7236588':5, '4397066':5, '8468062':4
TransactionAmt : 20902
'59.0':30582, '117.0':28933, '107.95':23954, '57.95':23600, '100.0':20362
ProductCD : 5
'W':439670, 'C':68519, 'R':37699, 'H':33024, 'S':11628
card1 : 13553
'7919':14932, '9500':14162, '15885':10361, '17188':10344, '15066':7945
card2 : 500
'321.0':48935, '111.0':45191, '555.0':41995, '490.0':38145, '583.0':21803
card3 : 114
'150.0':521287, '185.0':56346, '106.0':1571, '146.0':1252, '144.0':1252
card4 : 4
'veisa':384767, 'mastercard':189217, 'american express':8328, 'discover':6651
card5 : 119
'226.0':296546, '224.0':81513, '166.0':57140, '102.0':29105, '117.0':25941
card6 : 4
'debit':439938, 'credit':148986, 'debit or credit':30, 'charge card':15
addr1 : 332
'299.0':46335, '325.0':42751, '204.0':42020, '264.0':39870, '330.0':26287
addr2 : 74
'87.0':520481, '60.0':3084, '96.0':638, '32.0':91, '65.0':82
dist1 : 2651
'0.0':19824, '1.0':18330, '2.0':17028, '4.0':13067, '3.0':12808
dist2 : 1751
'7.0':5687, '0.0':3519, '1.0':1374, '9.0':742, '4.0':659
P_emaildomain : 59
'gmail.com':228355, 'yahoo.com':100934, 'hotmail.com':45250, 'anonymous.com':369
98, 'aol.com':28289
R_emaildomain : 60
```

```

'gmail.com':57147, 'hotmail.com':27509, 'anonymous.com':20529, 'yahoo.com':1184
2, 'aol.com':3701
C1 : 1657
'1.0':316791, '2.0':105071, '3.0':51315, '4.0':28845, '5.0':17922
C2 : 1216
'1.0':316261, '2.0':103948, '3.0':51770, '4.0':28251, '5.0':16971
C3 : 27
'0.0':588111, '1.0':2137, '2.0':180, '3.0':58, '4.0':7
C4 : 1260
'0.0':451883, '1.0':111817, '2.0':12994, '3.0':4949, '4.0':1902
C5 : 319
'0.0':372435, '1.0':122883, '2.0':34776, '3.0':13189, '4.0':6828
C6 : 1328
'1.0':341552, '2.0':86103, '0.0':49066, '3.0':35490, '4.0':17805
C7 : 1103
'0.0':523142, '1.0':51966, '2.0':7314, '3.0':2033, '4.0':1109
C8 : 1253
'0.0':447667, '1.0':104994, '2.0':15927, '3.0':5493, '4.0':2817
C9 : 205
'1.0':228938, '0.0':183795, '2.0':77829, '3.0':32505, '4.0':16196
C10 : 1231
'0.0':453442, '1.0':100231, '2.0':14938, '3.0':6417, '4.0':2836
C11 : 1476
'1.0':389692, '2.0':89677, '3.0':34463, '4.0':16051, '5.0':9972
C12 : 1199
'0.0':489199, '1.0':76661, '2.0':12242, '3.0':4185, '4.0':1716
C13 : 1597
'1.0':199337, '2.0':57616, '0.0':35460, '3.0':33033, '4.0':23704
C14 : 1108
'1.0':320189, '2.0':93843, '3.0':44471, '0.0':35947, '4.0':25390
D1 : 641
'0.0':280130, '1.0':8634, '2.0':4969, '3.0':3954, '4.0':3570
D2 : 641
'0.0':15124, '1.0':6654, '2.0':4454, '3.0':3677, '4.0':3344
D3 : 649
'0.0':73094, '1.0':21258, '2.0':13789, '7.0':13320, '3.0':10786
D4 : 808
'0.0':166571, '1.0':5315, '2.0':3385, '3.0':2572, '4.0':2354
D5 : 688
'0.0':65377, '1.0':15282, '2.0':10244, '7.0':9734, '3.0':7987
D6 : 829
'0.0':45782, '1.0':1588, '256.0':895, '2.0':855, '3.0':642
D7 : 597
'0.0':21135, '1.0':1717, '2.0':998, '3.0':791, '7.0':606
D8 : 12353
'0.7916659712791443':1351, '0.8333330154418945':1327, '0.875':1304, '0.958333015
4418944':1300, '0.9166659712791444':1259
D9 : 24
'0.7916659712791443':5388, '0.8333330154418945':5273, '0.75':5147, '0.7083330154
418945':5132, '0.6666659712791443':5069
D10 : 818
'0.0':221930, '1.0':5186, '2.0':3482, '3.0':2756, '7.0':2740
D11 : 676
'0.0':112281, '1.0':3165, '2.0':2020, '3.0':1642, '7.0':1639
D12 : 635
'0.0':42756, '1.0':1526, '2.0':818, '3.0':634, '4.0':564
D13 : 577
'0.0':48840, '1.0':1097, '26.0':891, '2.0':623, '3.0':476
D14 : 802
'0.0':45266, '1.0':1105, '256.0':658, '2.0':495, '3.0':307
D15 : 859
'0.0':174246, '1.0':5936, '2.0':3691, '3.0':2878, '7.0':2577
M1 : 2
'T':319415, 'F':25
M2 : 2

```

```
'T':285468, 'F':33972
M3 : 2
'T':251731, 'F':67709
M4 : 3
'M0':196405, 'M2':59865, 'M1':52826
M5 : 2
'F':132491, 'T':107567
M6 : 2
'F':227856, 'T':193324
M7 : 2
'F':211374, 'T':32901
M8 : 2
'F':155251, 'T':89037
M9 : 2
'T':205656, 'F':38632
V1 : 2
'1.0':311236, '0.0':17
V2 : 9
'1.0':298894, '2.0':10926, '3.0':1181, '4.0':163, '5.0':36
V3 : 10
'1.0':290583, '2.0':17763, '3.0':2335, '4.0':403, '5.0':93
V4 : 7
'1.0':246500, '0.0':56687, '2.0':7385, '3.0':564, '4.0':88
V5 : 7
'1.0':242883, '0.0':54276, '2.0':12610, '3.0':1200, '4.0':193
V6 : 10
'1.0':298627, '2.0':11319, '3.0':1044, '4.0':180, '5.0':46
V7 : 10
'1.0':291485, '2.0':17464, '3.0':1823, '4.0':337, '5.0':83
V8 : 9
'1.0':303466, '2.0':7076, '3.0':553, '4.0':95, '0.0':24
V9 : 9
'1.0':299625, '2.0':10544, '3.0':848, '4.0':172, '0.0':24
V10 : 5
'0.0':170281, '1.0':137743, '2.0':3042, '3.0':180, '4.0':7
V11 : 6
'0.0':169633, '1.0':135148, '2.0':5672, '3.0':608, '4.0':190
V12 : 4
'1.0':281003, '0.0':230049, '2.0':3295, '3.0':120
V13 : 7
'1.0':287644, '0.0':216752, '2.0':9661, '3.0':371, '4.0':26
V14 : 2
'1.0':514210, '0.0':257
V15 : 8
'0.0':452075, '1.0':61974, '2.0':346, '3.0':48, '7.0':10
V16 : 15
'0.0':452052, '1.0':61749, '2.0':481, '3.0':101, '4.0':42
V17 : 16
'0.0':447823, '1.0':65244, '2.0':927, '3.0':274, '4.0':104
V18 : 16
'0.0':447792, '1.0':64889, '2.0':1155, '3.0':388, '4.0':120
V19 : 8
'1.0':405665, '0.0':101871, '2.0':6540, '3.0':348, '4.0':29
V20 : 15
'1.0':401929, '0.0':96318, '2.0':14902, '3.0':1070, '4.0':161
V21 : 6
'0.0':448220, '1.0':65837, '2.0':354, '3.0':53, '5.0':2
V22 : 9
'0.0':448185, '1.0':65334, '2.0':604, '3.0':169, '7.0':94
V23 : 14
'1.0':498764, '2.0':13197, '3.0':1244, '0.0':588, '4.0':337
V24 : 14
'1.0':488478, '2.0':22289, '3.0':2241, '0.0':578, '4.0':431
V25 : 7
'1.0':497241, '0.0':14465, '2.0':2569, '3.0':177, '4.0':13
```

```

V26 : 13
'1.0':495119, '0.0':13068, '2.0':5906, '3.0':271, '4.0':50
V27 : 4
'0.0':514076, '1.0':385, '2.0':5, '4.0':1
V28 : 4
'0.0':514073, '1.0':363, '2.0':30, '4.0':1
V29 : 6
'0.0':320407, '1.0':189060, '2.0':4590, '3.0':351, '4.0':57
V30 : 8
'0.0':319017, '1.0':184133, '2.0':9685, '3.0':1160, '4.0':279
V31 : 8
'0.0':443045, '1.0':70729, '2.0':477, '3.0':167, '4.0':33
V32 : 15
'0.0':443018, '1.0':70307, '2.0':790, '3.0':226, '4.0':51
V33 : 7
'0.0':447769, '1.0':66267, '2.0':338, '3.0':82, '4.0':9
V34 : 13
'0.0':443989, '1.0':69776, '2.0':496, '3.0':129, '4.0':34
V35 : 4
'1.0':221387, '0.0':196551, '2.0':3544, '3.0':89
V36 : 6
'1.0':226024, '0.0':186733, '2.0':8307, '3.0':495, '4.0':10
V37 : 55
'1.0':395228, '2.0':18453, '3.0':3801, '4.0':1474, '5.0':796
V38 : 55
'1.0':382093, '2.0':28073, '3.0':5616, '4.0':2208, '5.0':1129
V39 : 16
'0.0':357994, '1.0':59921, '2.0':2497, '3.0':566, '4.0':253
V40 : 18
'0.0':357837, '1.0':57473, '2.0':4230, '3.0':1046, '4.0':400
V41 : 2
'1.0':421263, '0.0':308
V42 : 9
'0.0':358439, '1.0':60801, '2.0':2037, '3.0':256, '4.0':30
V43 : 9
'0.0':358261, '1.0':56929, '2.0':5234, '3.0':885, '4.0':174
V44 : 49
'1.0':397653, '2.0':19434, '3.0':2242, '4.0':615, '0.0':441
V45 : 49
'1.0':387027, '2.0':28125, '3.0':3472, '4.0':906, '5.0':438
V46 : 7
'1.0':412247, '2.0':8340, '3.0':521, '0.0':348, '4.0':103
V47 : 9
'1.0':406519, '2.0':13389, '3.0':1018, '0.0':347, '4.0':189
V48 : 6
'0.0':264325, '1.0':153267, '2.0':3685, '3.0':280, '4.0':12
V49 : 6
'0.0':263761, '1.0':149250, '2.0':7604, '3.0':691, '4.0':187
V50 : 6
'0.0':352482, '1.0':68817, '2.0':202, '3.0':52, '4.0':15
V51 : 7
'0.0':353522, '1.0':64775, '2.0':2780, '3.0':416, '4.0':66
V52 : 9
'0.0':351237, '1.0':65030, '2.0':4362, '3.0':705, '4.0':161
V53 : 6
'1.0':288055, '0.0':221227, '2.0':4006, '3.0':140, '4.0':9
V54 : 7
'1.0':295235, '0.0':207068, '2.0':10445, '3.0':603, '4.0':76
V55 : 18
'1.0':489239, '2.0':18464, '3.0':3100, '4.0':1233, '5.0':530
V56 : 52
'1.0':472700, '2.0':30886, '3.0':5610, '4.0':1881, '5.0':952
V57 : 7
'0.0':449807, '1.0':61670, '2.0':1731, '3.0':203, '4.0':27
V58 : 11

```

```
'0.0':449600, '1.0':60662, '2.0':2675, '3.0':300, '4.0':105  
V59 : 17  
'0.0':448636, '1.0':61876, '2.0':2264, '3.0':388, '4.0':148  
V60 : 17  
'0.0':448369, '1.0':59589, '2.0':4065, '3.0':854, '4.0':296  
V61 : 7  
'1.0':404182, '0.0':98827, '2.0':9620, '3.0':702, '5.0':60  
V62 : 11  
'1.0':398513, '0.0':93177, '2.0':19368, '3.0':1860, '4.0':287  
V63 : 8  
'0.0':448961, '1.0':62231, '2.0':1969, '3.0':221, '4.0':32  
V64 : 8  
'0.0':448662, '1.0':58547, '2.0':5145, '3.0':757, '6.0':144  
V65 : 2  
'1.0':513271, '0.0':173  
V66 : 8  
'1.0':490779, '0.0':16418, '2.0':5897, '3.0':285, '4.0':50  
V67 : 9  
'1.0':486457, '0.0':14565, '2.0':11435, '3.0':844, '4.0':112  
V68 : 3  
'0.0':513178, '1.0':258, '2.0':8  
V69 : 6  
'0.0':319136, '1.0':188826, '2.0':4989, '3.0':432, '4.0':59  
V70 : 7  
'0.0':317801, '1.0':184177, '2.0':9739, '3.0':1296, '4.0':253  
V71 : 7  
'0.0':443821, '1.0':67435, '2.0':1837, '3.0':311, '4.0':34  
V72 : 11  
'0.0':443611, '1.0':66364, '2.0':2802, '3.0':413, '4.0':129  
V73 : 8  
'0.0':444786, '1.0':65814, '2.0':2551, '3.0':235, '4.0':43  
V74 : 9  
'0.0':440878, '1.0':67816, '2.0':4109, '3.0':525, '4.0':86  
V75 : 5  
'1.0':265082, '0.0':232467, '2.0':3676, '3.0':150, '4.0':1  
V76 : 7  
'1.0':273293, '0.0':217817, '2.0':9571, '3.0':641, '4.0':43  
V77 : 31  
'1.0':474434, '2.0':18955, '3.0':3695, '4.0':1623, '5.0':742  
V78 : 32  
'1.0':457915, '2.0':31364, '3.0':6135, '4.0':2261, '5.0':1125  
V79 : 8  
'0.0':436802, '1.0':61751, '2.0':2179, '3.0':435, '7.0':109  
V80 : 20  
'0.0':434732, '1.0':63368, '2.0':2283, '3.0':475, '4.0':245  
V81 : 20  
'0.0':434653, '1.0':60829, '2.0':4033, '3.0':902, '4.0':509  
V82 : 8  
'1.0':402612, '0.0':88757, '2.0':9288, '3.0':626, '4.0':76  
V83 : 8  
'1.0':396619, '0.0':83605, '2.0':18834, '3.0':1816, '4.0':292  
V84 : 8  
'0.0':435246, '1.0':63848, '2.0':2035, '3.0':191, '4.0':35  
V85 : 8  
'0.0':435103, '1.0':59565, '2.0':5322, '3.0':987, '4.0':216  
V86 : 31  
'1.0':476911, '2.0':19527, '3.0':2428, '4.0':743, '0.0':727  
V87 : 31  
'1.0':463708, '2.0':30832, '3.0':3761, '4.0':1033, '0.0':694  
V88 : 2  
'1.0':500998, '0.0':378  
V89 : 3  
'0.0':500954, '1.0':392, '2.0':30  
V90 : 6  
'0.0':305817, '1.0':190162, '2.0':4941, '3.0':388, '4.0':64
```

V91 : 7
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V268 : 2756
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V269 : 151
'0.0':128257, '100.0':212, '106.0':165, '181.0':146, '50.0':138
V270 : 2340
'0.0':128634, '50.0':674, '100.0':660, '25.0':351, '150.0':272
V271 : 2787
'0.0':128066, '100.0':642, '50.0':639, '25.0':323, '150.0':273
V272 : 2507
'0.0':128436, '100.0':711, '50.0':653, '25.0':344, '150.0':265
V273 : 7177
'0.0':112885, '100.0':976, '200.0':650, '150.0':642, '50.0':637
V274 : 8315
'0.0':110617, '100.0':974, '200.0':698, '150.0':684, '50.0':653
V275 : 7776
'0.0':111756, '100.0':964, '200.0':684, '150.0':663, '50.0':639
V276 : 2263
'0.0':117724, '100.0':1265, '200.0':919, '150.0':681, '50.0':650
V277 : 2540
'0.0':115566, '100.0':1339, '200.0':969, '50.0':729, '150.0':710
V278 : 2398
'0.0':116709, '100.0':1295, '200.0':949, '150.0':694, '50.0':687
V279 : 881
'0.0':492169, '1.0':60474, '2.0':18826, '3.0':8016, '4.0':4030
V280 : 975
'0.0':422464, '1.0':90882, '2.0':32870, '3.0':15309, '4.0':8340
V281 : 23
'0.0':561201, '1.0':16896, '2.0':5694, '3.0':2484, '4.0':1469
V282 : 33
'1.0':316455, '0.0':212812, '2.0':37537, '3.0':12243, '4.0':4976
V283 : 62
'1.0':284599, '0.0':211499, '2.0':51773, '3.0':18984, '4.0':8912
V284 : 13

```

```
'0.0':545552, '1.0':39347, '2.0':4481, '3.0':846, '4.0':190
V285 : 96
'0.0':354815, '1.0':106275, '2.0':50008, '3.0':26969, '4.0':17739
V286 : 9
'0.0':573290, '1.0':16122, '2.0':949, '3.0':136, '4.0':11
V287 : 32
'0.0':466863, '1.0':83560, '2.0':22186, '3.0':8784, '4.0':4863
V288 : 11
'0.0':489641, '1.0':91654, '2.0':7133, '3.0':761, '4.0':33
V289 : 13
'0.0':487073, '1.0':75947, '2.0':18920, '3.0':5076, '4.0':1736
V290 : 58
'1.0':551866, '2.0':30249, '3.0':4936, '4.0':1672, '5.0':681
V291 : 219
'1.0':462929, '2.0':92440, '3.0':21378, '4.0':7251, '5.0':2884
V292 : 173
'1.0':522151, '2.0':52574, '3.0':9605, '4.0':3145, '5.0':1221
V293 : 870
'0.0':546442, '1.0':24280, '2.0':8882, '3.0':4188, '4.0':2103
V294 : 1286
'0.0':519413, '1.0':29582, '2.0':13719, '3.0':7490, '4.0':4576
V295 : 928
'0.0':535074, '1.0':25973, '2.0':11104, '3.0':5694, '4.0':3182
V296 : 94
'0.0':536687, '1.0':32376, '2.0':10099, '3.0':3586, '4.0':1620
V297 : 13
'0.0':562740, '1.0':19398, '2.0':4605, '3.0':1435, '11.0':1299
V298 : 94
'0.0':542892, '1.0':29739, '2.0':9068, '3.0':3101, '4.0':1410
V299 : 50
'0.0':555629, '1.0':23124, '2.0':6255, '3.0':2066, '4.0':858
V300 : 12
'0.0':569522, '1.0':15133, '2.0':3183, '3.0':938, '4.0':285
V301 : 14
'0.0':567409, '1.0':16292, '2.0':3778, '3.0':1141, '4.0':324
V302 : 17
'0.0':450191, '1.0':134072, '2.0':5155, '3.0':683, '4.0':219
V303 : 21
'0.0':449499, '1.0':126757, '2.0':9113, '3.0':2332, '5.0':1375
V304 : 17
'0.0':449830, '1.0':130542, '2.0':7212, '3.0':1601, '4.0':962
V305 : 2
'1.0':590524, '2.0':4
V306 : 16210
'0.0':492169, '117.0':3838, '59.0':3768, '100.0':2194, '49.0':1996
V307 : 37367
'0.0':316650, '107.9499969482422':6360, '57.95000076293945':5672, '59.0':5418,
'117.0':5247
V308 : 23064
'0.0':422464, '59.0':5724, '117.0':5723, '57.95000076293945':3809, '107.94999694
82422':3232
V309 : 4236
'0.0':545552, '59.0':3160, '117.0':2903, '49.0':1625, '39.0':1187
V310 : 19136
'0.0':354815, '107.9499969482422':6520, '59.0':6245, '117.0':5804, '57.950000762
93945':5757
V311 : 3098
'0.0':573290, '59.0':823, '117.0':805, '107.9499969482422':611, '57.950000762939
45':585
V312 : 8068
'0.0':466863, '59.0':6301, '117.0':6102, '57.95000076293945':3472, '49.0':3085
V313 : 5529
'0.0':489641, '59.0':6654, '117.0':5319, '57.95000076293945':3608, '107.94999694
82422':3472
V314 : 11377
```

```
'0.0':473273, '59.0':4262, '117.0':3839, '107.9499969482422':2671, '57.95000076293945':2567
V315 : 6973
'0.0':487073, '59.0':5114, '117.0':4360, '107.9499969482422':3048, '57.95000076293945':3012
V316 : 9814
'0.0':546442, '117.0':1727, '59.0':1504, '100.0':949, '49.0':878
V317 : 15184
'0.0':519413, '117.0':2224, '59.0':1827, '226.0':1045, '100.0':1039
V318 : 12309
'0.0':535074, '117.0':1937, '59.0':1586, '100.0':991, '226.0':873
V319 : 4799
'0.0':562740, '100.0':1040, '1165.0':870, '117.0':778, '200.0':747
V320 : 6439
'0.0':542892, '117.0':1298, '59.0':1256, '100.0':1172, '57.95000076293945':978
V321 : 5560
'0.0':555629, '100.0':1104, '117.0':981, '59.0':881, '200.0':769
V322 : 881
'0.0':65970, '1.0':8562, '2.0':3226, '3.0':1502, '4.0':777
V323 : 1411
'0.0':60806, '1.0':9407, '2.0':3857, '3.0':2027, '4.0':1235
V324 : 976
'0.0':62945, '1.0':9152, '2.0':3782, '3.0':1931, '4.0':1133
V325 : 13
'0.0':78588, '1.0':2948, '2.0':686, '3.0':74, '4.0':33
V326 : 45
'0.0':72668, '1.0':4231, '2.0':1097, '27.0':954, '3.0':524
V327 : 19
'0.0':75098, '1.0':3630, '2.0':945, '10.0':692, '3.0':423
V328 : 16
'0.0':73464, '1.0':4947, '2.0':1574, '11.0':1005, '3.0':587
V329 : 100
'0.0':72114, '1.0':5428, '2.0':1796, '77.0':871, '3.0':725
V330 : 56
'0.0':72799, '1.0':5199, '2.0':1739, '3.0':648, '35.0':419
V331 : 1758
'0.0':65970, '100.0':2158, '200.0':1462, '50.0':1375, '150.0':1222
V332 : 2453
'0.0':60806, '100.0':2546, '50.0':1653, '200.0':1642, '150.0':1418
V333 : 1971
'0.0':62945, '100.0':2378, '200.0':1576, '50.0':1560, '150.0':1327
V334 : 143
'0.0':78588, '100.0':590, '50.0':385, '25.0':228, '265.0':193
V335 : 672
'0.0':72668, '2301.0':925, '100.0':835, '50.0':809, '150.0':426
V336 : 356
'0.0':75098, '50.0':645, '1052.0':645, '100.0':604, '25.0':381
V337 : 254
'0.0':73464, '100.0':1243, '1165.0':870, '200.0':861, '150.0':661
V338 : 380
'0.0':72114, '100.0':1370, '200.0':929, '7709.0':871, '50.0':729
V339 : 334
'0.0':72799, '100.0':1319, '200.0':896, '150.0':702, '50.0':663
id_01 : 77
'-5.0':82170, '0.0':19555, '-10.0':11257, '-20.0':11211, '-15.0':5674
id_02 : 115655
'1102.0':11, '696.0':10, '1141.0':9, '1083.0':9, '1116.0':9
id_03 : 24
'0.0':63903, '1.0':863, '3.0':668, '2.0':421, '5.0':109
id_04 : 15
'0.0':65739, '-5.0':132, '-6.0':98, '-8.0':64, '-4.0':51
id_05 : 93
'0.0':92743, '1.0':8293, '2.0':4937, '3.0':3854, '4.0':2941
id_06 : 101
'0.0':91325, '-1.0':4687, '-5.0':3849, '-6.0':3257, '-9.0':2634
```

```
id_07 : 84
'0.0':409, '16.0':245, '14.0':228, '12.0':208, '15.0':186
id_08 : 94
'-100.0':500, '0.0':261, '-34.0':257, '-33.0':209, '-32.0':185
id_09 : 46
'0.0':70378, '1.0':1616, '3.0':966, '2.0':773, '4.0':270
id_10 : 62
'0.0':72879, '-6.0':295, '-5.0':247, '-1.0':200, '-8.0':147
id_11 : 365
'100.0':133162, '95.08000183105469':1231, '95.16000366210938':754, '97.120002746
58205':440, '96.66999816894531':333
id_12 : 2
'NotFound':123025, 'Found':21208
id_13 : 54
'52.0':58099, '49.0':26365, '64.0':14429, '33.0':10048, '27.0':3666
id_14 : 25
'-300.0':44121, '-360.0':16661, '-480.0':12891, '-420.0':4542, '-600.0':498
id_15 : 3
'Found':67728, 'New':61612, 'Unknown':11645
id_16 : 2
'Found':66324, 'NotFound':63016
id_17 : 104
'166.0':78631, '225.0':56968, '102.0':689, '159.0':352, '100.0':336
id_18 : 18
'15.0':25489, '13.0':13439, '12.0':4656, '18.0':650, '20.0':339
id_19 : 522
'266.0':19849, '410.0':11318, '427.0':8808, '529.0':8122, '312.0':6227
id_20 : 394
'507.0':22311, '222.0':11065, '325.0':8133, '533.0':6611, '214.0':5664
id_21 : 490
'252.0':2542, '228.0':239, '255.0':109, '596.0':103, '576.0':101
id_22 : 25
'14.0':4736, '41.0':321, '33.0':38, '17.0':7, '21.0':7
id_23 : 3
'IP_PROXY:TRANSPARENT':3489, 'IP_PROXY:ANONYMOUS':1071, 'IP_PROXY:HIDDEN':609
id_24 : 12
'11.0':2817, '15.0':1594, '16.0':220, '18.0':37, '21.0':33
id_25 : 341
'321.0':2494, '205.0':301, '426.0':236, '501.0':103, '371.0':83
id_26 : 95
'161.0':824, '184.0':582, '142.0':528, '102.0':451, '100.0':433
id_27 : 2
'Found':5155, 'NotFound':14
id_28 : 2
'Found':76232, 'New':64746
id_29 : 2
'Found':74926, 'NotFound':66052
id_30 : 75
'Windows 10':21155, 'Windows 7':13110, 'iOS 11.2.1':3722, 'iOS 11.1.2':3699, 'An
droid 7.0':2871
id_31 : 130
'chrome 63.0':22000, 'mobile safari 11.0':13423, 'mobile safari generic':11474,
'ie 11.0 for desktop':9030, 'safari generic':8195
id_32 : 4
'24.0':53071, '32.0':24428, '16.0':81, '0.0':6
id_33 : 260
'1920x1080':16874, '1366x768':8605, '1334x750':6447, '2208x1242':4900, '1440x90
0':4384
id_34 : 4
'match_status:2':60011, 'match_status:1':17376, 'match_status:0':415, 'match_st
atus:-1':3
id_35 : 2
'T':77814, 'F':63171
id_36 : 2
'F':134066, 'T':6919
```

```

id_37 : 2
'T':110452, 'F':30533
id_38 : 2
'F':73922, 'T':67063
DeviceType : 2
'desktop':85165, 'mobile':55645
DeviceInfo : 1786
'Windows':47722, 'iOS Device':19782, 'MacOS':12573, 'Trident/7.0':7440, 'rv:11.0':1901

```

In [16]:

```
dataframe_dtypes_orig = pd.DataFrame(train_transaction_identity.dtypes)
dataframe_dtypes_orig.head(200)
```

Out[16]:

	0
TransactionID	int64
isFraud	int64
TransactionDT	int64
TransactionAmt	float64
ProductCD	object
...	...
V141	float64
V142	float64
V143	float64
V144	float64
V145	float64

200 rows × 1 columns

In [55]:

```
#test_identity = pd.read_csv('/Users/arcarter/Git_Repos/project_03/data/ieee-fra
```

In [56]:

```
#test_transaction = pd.read_csv('/Users/arcarter/Git_Repos/project_03/data/ieee-
```

In [57]:

```
#test_transaction_identity = test_transaction.merge(test_identity, on='Transacti
```

In [250...]:

```

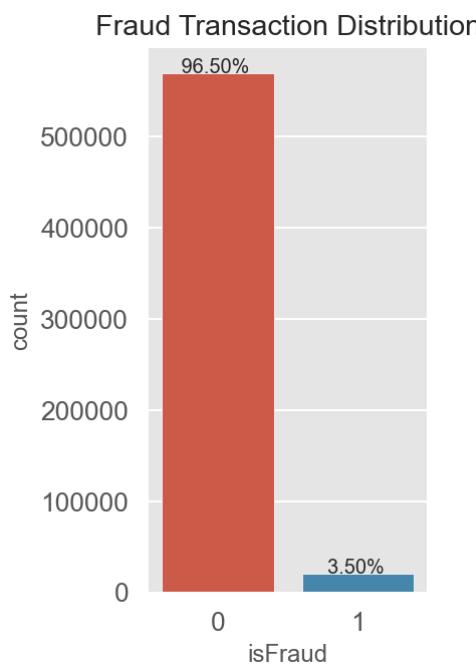
plt.figure(figsize=(2.5,5))
plt.title("Fraud Transaction Distribution")
p1 = sns.countplot(train_transaction_identity['isFraud'])
for p in p1.patches: p1.annotate('{:.2f}%'.format(p.get_height()/len(train_transac
plt.show()

```

```

/Users/arcarter/opt/anaconda3/lib/python3.8/site-packages/seaborn/_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.
warnings.warn(

```



In [15]:

```
plt.figure(figsize=(2.5,5))
plt.title("Fraud Transaction Distribution")
p1 = sns.countplot(train_transaction_identity['isFraud'])
for p in p1.patches: p1.annotate('{:6.2f}%'.format(p.get_height()/len(train_transac
plt.bar(labels, values, color=['blue', 'orange']))
plt.show()
```

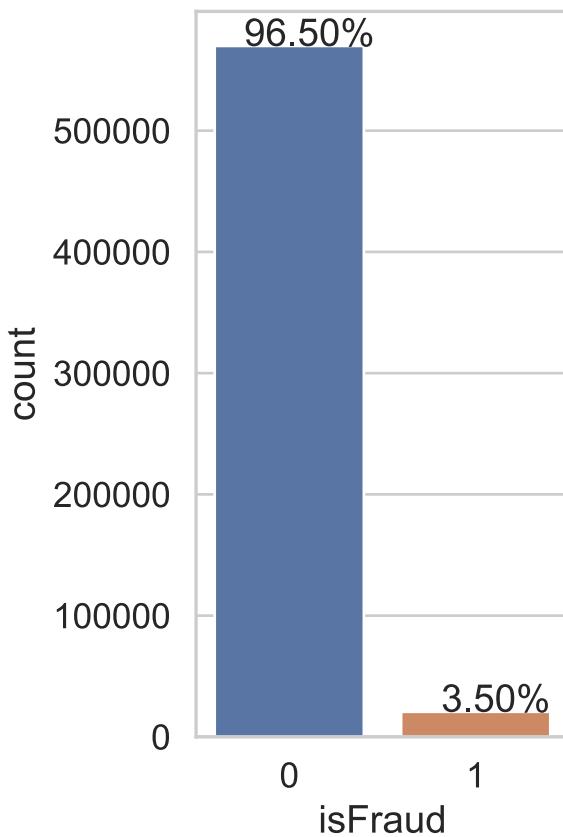
```
/Users/arcarter/opt/anaconda3/lib/python3.8/site-packages/seaborn/_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.
```

```
    warnings.warn(
```

```
NameError                                                 Traceback (most recent call last)
<ipython-input-15-d90a35809e36> in <module>
      3 p1 = sns.countplot(train_transaction_identity['isFraud'])
      4 for p in p1.patches: p1.annotate('{:6.2f}%'.format(p.get_height()/len(tr
----> 5     ain_transaction_identity)*100), (p.get_x()+0.1, p.get_height()+50))
      6 plt.show()

NameError: name 'labels' is not defined
```

Fraud Transaction Distribution



```
In [350]: target_count = train_transaction_identity['isFraud'].value_counts()
```

```
In [351]: target_count
```

```
Out[351]: 0    569877  
1     20663  
Name: isFraud, dtype: int64
```

```
In [ ]:  
#####  
#####  
#  
# Remove outlier Transaction Amounts  
#  
#####  
#####
```

```
In [ ]: train_transaction_identity_noOutlier = train_transaction_identity[train_transact
```

```
In [18]: train_transaction_identity_noOutlier.info()
```

```
<class 'pandas.core.frame.DataFrame'>  
Int64Index: 590538 entries, 0 to 590539  
Columns: 434 entries, TransactionID to DeviceInfo  
dtypes: float64(399), int64(4), object(31)  
memory usage: 1.9+ GB
```

```
In [ ]: ### Remove high NAN columns
df_column_completion = pd.DataFrame((np.sum(pd.isnull(train_transaction_identity_n)
                                             sort_values(ascending=False))/len(train_transaction_identity_n)

df_column_completion.rename(columns = {0:'% Null'}, inplace = True)
```

```
In [251... df_column_completion.head(20)
```

	% Null
id_24	99.196157
id_25	99.130962
id_07	99.127067
id_08	99.127067
id_21	99.126390
id_26	99.125712
id_22	99.124696
id_23	99.124696
id_27	99.124696
dist2	93.628352
D7	93.409908
id_18	92.360695
D13	89.509227
D14	89.469433
D12	89.041010
id_04	88.768885
id_03	88.768885
D6	87.606725
id_33	87.589452
id_10	87.312247

```
In [34]: train_transaction_identity_noOutlier_limNAN = train_transaction_identity_noOutli
```

```
In [35]: #Remove variables with missing values more than 30 percent
```

```
A = (np.sum(pd.isnull(train_transaction_identity_noOutlier_limNAN)).sort_values()
Removed_col = A[A>30].index
print(Removed_col)

Index(['id_24', 'id_25', 'id_07', 'id_08', 'id_21', 'id_26', 'id_22', 'id_23',
       'id_27', 'dist2',
       ...]
```

```
'D11', 'V7', 'V8', 'V9', 'V10', 'V11', 'M3', 'M2', 'M1', 'D3'],
dtype='object', length=232)
```

In [36]: `train_transaction_identity_noOutlier_limNAN.drop(columns=Removed_col, inplace=True)`

In [37]: `train_transaction_identity_noOutlier_limNAN.head()`

Out[37]:

	TransactionID	isFraud	TransactionDT	TransactionAmt	ProductCD	card1	card2	card3
0	2987000	0	86400	68.5	W	13926	NaN	150.0
1	2987001	0	86401	29.0	W	2755	404.0	150.0
2	2987002	0	86469	59.0	W	4663	490.0	150.0
3	2987003	0	86499	50.0	W	18132	567.0	150.0
4	2987004	0	86506	50.0	H	4497	514.0	150.0

In []:

```
#####
# One Hot Encode
#####
```

In [42]: `train_transaction_identity_noOutlier_limNAN["card6"].fillna('None', inplace=True)`

In [43]: `cat_X = train_transaction_identity_noOutlier_limNAN.loc[:, ['card6']]`

In [44]:

```
ohe = OneHotEncoder(sparse=False)

ohe.fit(cat_X)

ohe_X = ohe.transform(cat_X)

columns = ohe.get_feature_names(['card6'])

ohe_X_df = pd.DataFrame(ohe_X, columns=columns, index=cat_X.index)

ohe_X_df.head()
```

Out[44]:

	card6_None	card6_charge card	card6_credit	card6_debit	card6_debit or credit
0	0.0	0.0	1.0	0.0	0.0
1	0.0	0.0	1.0	0.0	0.0
2	0.0	0.0	0.0	1.0	0.0
3	0.0	0.0	0.0	1.0	0.0
4	0.0	0.0	1.0	0.0	0.0

In [46]: `train_transaction_identity_noOutlier_limNAN["card4"].fillna('None', inplace=True)`

```
In [47]: cat_X2 = train_transaction_identity_noOutlier_limNAN.loc[:, ['card4']]
```

```
In [48]: ohe = OneHotEncoder(sparse=False)

ohe.fit(cat_X2)

ohe_X2 = ohe.transform(cat_X2)

columns = ohe.get_feature_names(['card4'])

ohe_X2_df = pd.DataFrame(ohe_X2, columns=columns, index=cat_X2.index)

ohe_X2_df.head()
```

```
Out[48]:   card4_None  card4_americ express  card4_discover  card4_mastercard  card4_visa
0           0.0            0.0          1.0            0.0            0.0
1           0.0            0.0          0.0            1.0            0.0
2           0.0            0.0          0.0            0.0            1.0
3           0.0            0.0          0.0            1.0            0.0
4           0.0            0.0          0.0            1.0            0.0
```

```
In [49]: combined_df = pd.concat([ohe_X_df, ohe_X2_df, train_transaction_identity_noOutlie
combined_df.head()
```

```
Out[49]:   card6_None  card6_charge card  card6_credit  card6_debit  card6_debit or credit  card4_None  card4_ameri expr
0           0.0            0.0          1.0            0.0            0.0            0.0
1           0.0            0.0          1.0            0.0            0.0            0.0
2           0.0            0.0          0.0            1.0            0.0            0.0
3           0.0            0.0          0.0            1.0            0.0            0.0
4           0.0            0.0          1.0            0.0            0.0            0.0
```

```
In [370...]: train_transaction_identity_noOutlier_limNAN["P_emaildomain"].dtype
```

```
Out[370...]: dtype('O')
```

```
In [57]: train_transaction_identity_noOutlier_limNAN["P_emaildomain"].fillna('None', inpl
```

```
In [58]: train_transaction_identity_noOutlier_limNAN['P_emaildomain'].value_counts()
```

```
Out[58]: gmail.com      228355
yahoo.com       100932
None           94456
```

hotmail.com	45250
anonymous.com	36998
aol.com	28289
comcast.net	7888
icloud.com	6267
outlook.com	5096
msn.com	4092
att.net	4033
live.com	3041
sbcglobal.net	2970
verizon.net	2705
ymail.com	2396
bellsouth.net	1909
yahoo.com.mx	1543
me.com	1522
cox.net	1393
optonline.net	1011
charter.net	816
live.com.mx	749
rocketmail.com	664
mail.com	559
earthlink.net	514
gmail	496
outlook.es	438
mac.com	436
juno.com	322
aim.com	315
windstream.net	305
hotmail.es	305
roadrunner.com	305
hotmail.fr	295
frontier.com	280
embarqmail.com	260
web.de	240
twc.com	230
netzero.com	230
prodigy.net.mx	207
centurylink.net	205
netzero.net	196
frontiernet.net	195
q.com	189
suddenlink.net	175
cfl.rr.com	172
sc.rr.com	164
cableone.net	159
gmx.de	149
yahoo.fr	143
yahoo.es	134
hotmail.co.uk	112
protonmail.com	76
yahoo.de	74
ptd.net	68
live.fr	56
yahoo.co.uk	49
hotmail.de	43
servicios-ta.com	35
yahoo.co.jp	32

Name: P_emaildomain, dtype: int64

```
In [60]: train_transaction_identity_noOutlier_limNAN['P_emaildomain_gmail'] = np.where(tr
```

```
In [61]: train_transaction_identity_noOutlier_limNAN['P_emaildomain_yahoo'] = np.where(tr
```

```
In [62]: train_transaction_identity_noOutlier_limNAN[ 'P_emaildomain_none' ] = np.where(trai
```

```
In [65]: #train_transaction_identity_noOutlier_limNAN[ 'P_emaildomain_small' ] = np.where(t  
#result = result[(result[ 'var' ]>0.25) | (result[ 'var' ]<-0.25)]
```

```
In [67]: del train_transaction_identity_noOutlier_limNAN[ 'P_emaildomain_MainEmails' ]
```

```
In [69]: train_transaction_identity_noOutlier_limNAN[ 'ProductCD' ].value_counts()
```

```
Out[69]: W      439668  
C      68519  
R      37699  
H      33024  
S      11628  
Name: ProductCD, dtype: int64
```

```
In [70]: train_transaction_identity_noOutlier_limNAN[ "ProductCD" ].fillna( 'None' , inplace=
```

```
In [74]: cat_X3 = train_transaction_identity_noOutlier_limNAN.loc[:, [ 'ProductCD' ]]
```

```
In [75]: ohe = OneHotEncoder(sparse=False)  
  
ohe.fit(cat_X3)  
  
ohe_X3 = ohe.transform(cat_X3)  
  
columns = ohe.get_feature_names([ 'ProductCD' ])  
  
ohe_X3_df = pd.DataFrame(ohe_X3, columns=columns, index=cat_X3.index)  
  
ohe_X3_df.head()
```

	ProductCD_C	ProductCD_H	ProductCD_R	ProductCD_S	ProductCD_W
0	0.0	0.0	0.0	0.0	1.0
1	0.0	0.0	0.0	0.0	1.0
2	0.0	0.0	0.0	0.0	1.0
3	0.0	0.0	0.0	0.0	1.0
4	0.0	1.0	0.0	0.0	0.0

```
In [102... combined_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>  
Int64Index: 590538 entries, 0 to 590539  
Columns: 220 entries, card6_None to P_emaildomain_none  
dtypes: float64(208), int64(7), object(5)  
memory usage: 995.7+ MB
```

```
In [76]: combined_df = pd.concat([ohe_X_df, ohe_X2_df, ohe_X3_df, train_transaction_idenit
combined_df.head()
```

```
Out[76]:
```

	card6_None	card6_charge card	card6_credit	card6_debit	card6_debit or credit	card4_None	card4_ameri expr
0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
1	0.0	0.0	1.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	1.0	0.0	0.0	0.0
3	0.0	0.0	0.0	1.0	0.0	0.0	0.0
4	0.0	0.0	1.0	0.0	0.0	0.0	0.0

```
In [77]: combined_df_final = combined_df.copy()
```

```
In [79]: del combined_df_final['card6']
```

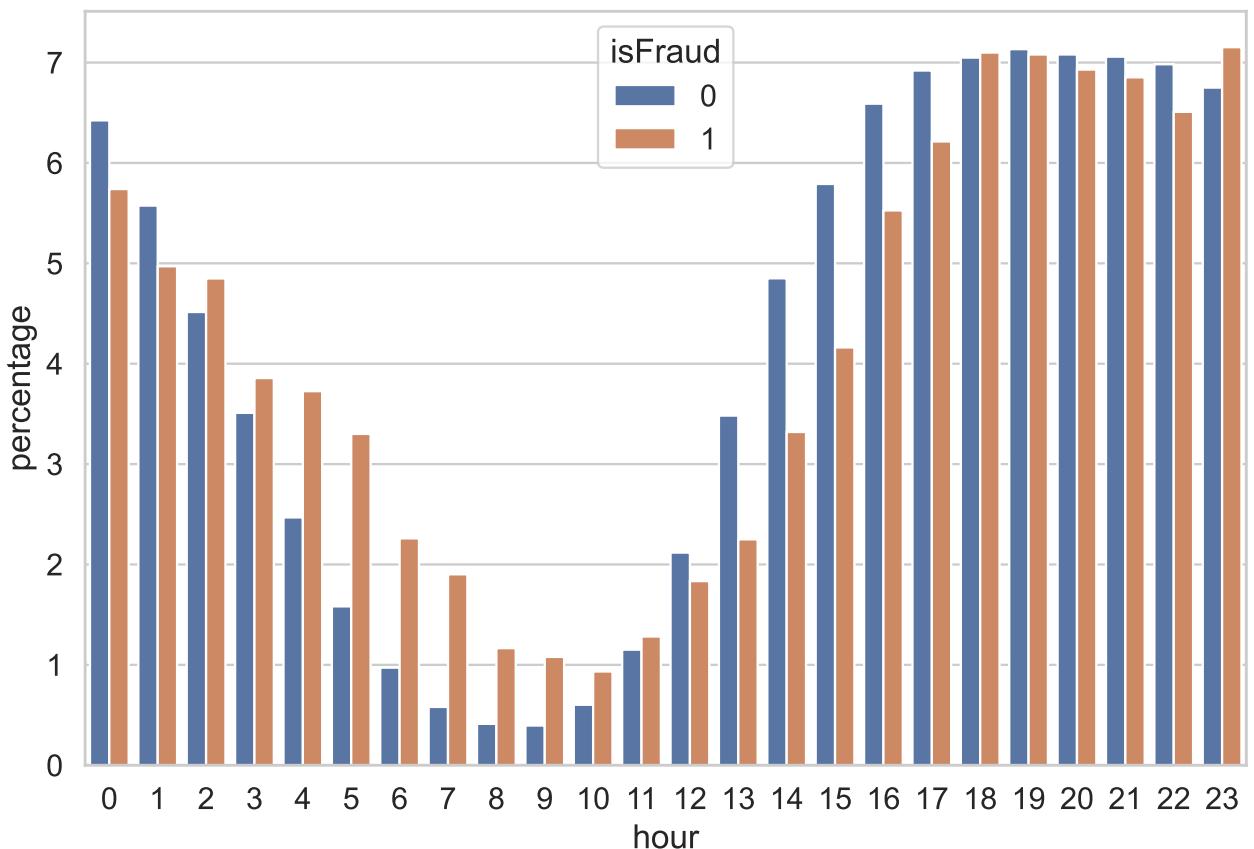
```
In [80]: del combined_df_final['card4']
del combined_df_final['P_emaildomain']
del combined_df_final['ProductCD']
```

```
In [93]: combined_df_final['hour'] = (combined_df_final['TransactionDT']//(3600))%24
```

```
In [96]: train_hour = (combined_df_final.groupby(['isFraud'])['hour']
.value_counts(normalize=True)
.rename('percentage')
.mul(100)
.reset_index()
.sort_values('hour'))
```

```
In [97]: sns.barplot(x="hour", y="percentage", hue="isFraud", data=train_hour)
```

```
Out[97]: <AxesSubplot:xlabel='hour', ylabel='percentage'>
```



In [95]: `combined_df_final.tail()`

Out[95]:

	card6_None	card6_charge_card	card6_credit	card6_debit	card6_debit or credit	card4_None	card4...
590535	0.0	0.0	0.0	1.0	0.0	0.0	0.0
590536	0.0	0.0	0.0	1.0	0.0	0.0	0.0
590537	0.0	0.0	0.0	1.0	0.0	0.0	0.0
590538	0.0	0.0	0.0	1.0	0.0	0.0	0.0
590539	0.0	0.0	1.0	0.0	0.0	0.0	0.0

In [98]: `combined_df_final.isFraud.dtype`

Out[98]: `CategoricalDtype(categories=[0, 1], ordered=False)`

In []:

```
#####
#####
#
# Final prep of data and Train Validate Split
#
#####
#####
```

In [87]:

```
combined_df_final.loc[:, 'isFraud'] = combined_df_final['isFraud'].astype('categ
```

In [99]:

```
df_train, df_test = train_test_split(combined_df_final,
                                      test_size=0.2,
                                      random_state=42)
```

In [100...:

```
print(df_train.shape)
print(df_test.shape)
```

```
(472430, 217)
(118108, 217)
```

In []:

```
#sns.pairplot(df_train.sample(10000), corner=True, height=3, plot_kws={'size': 5}
```

In []:

In []:

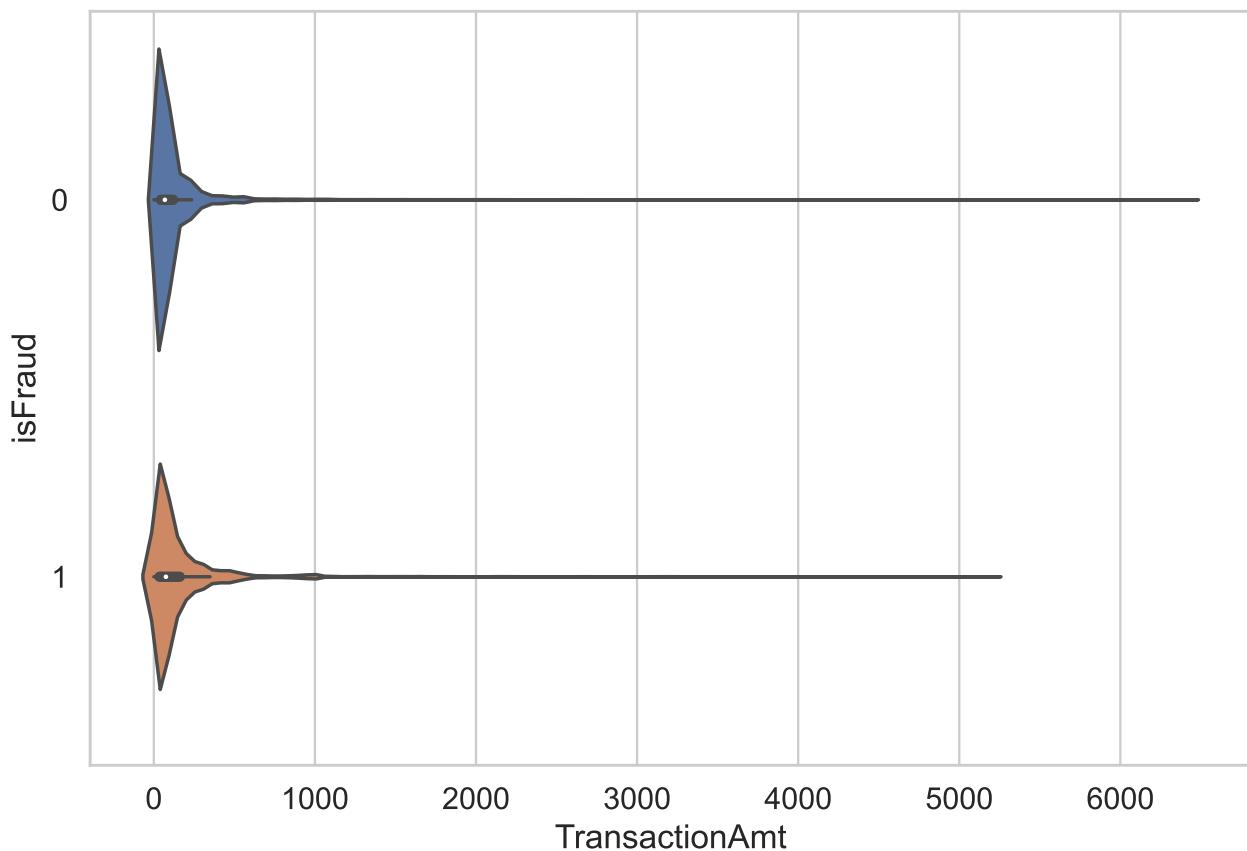
```
sns.violinplot(x='price_per_sqft',
                 y='in_sf',
                 data=df_train);
```

In []:

```
#####
#####
#
# Separability
#
#####
#####
```

In [101...:

```
# `price_per_sqft` should work for our purposes
sns.violinplot(x='TransactionAmt',
                 y='isFraud',
                 data=df_train);
```



```
In [103...]: import statsmodels.api as sm
```

```
In [104...]: # For this first example, we'll employ statsmodels
lm_1 = sm.Logit(df_train['isFraud'], # with statsmodels, `y` comes first
                 sm.add_constant(df_train[['TransactionAmt']]))) # and then `x`
lm_1 = lm_1.fit()
```

Optimization terminated successfully.
 Current function value: 0.150807
 Iterations 7

```
In [105...]: lm_1.summary()
```

Logit Regression Results					
Dep. Variable:	isFraud	No. Observations:	472430		
Model:	Logit	Df Residuals:	472428		
Method:	MLE	Df Model:	1		
Date:	Thu, 04 Feb 2021	Pseudo R-squ.:	0.0004674		
Time:	01:07:52	Log-Likelihood:	-71246.		
converged:	True	LL-Null:	-71279.		
Covariance Type:	nonrobust	LLR p-value:	3.265e-16		
	coef	std err	z	P> z	[0.025 0.975]
const	-3.3591	0.009	-373.446	0.000	-3.377 -3.341

```
TransactionAmt 0.0002 2.82e-05      8.709 0.000 0.000 0.000
```

```
In [106... # Let's go down the sklearn path, since this is better used in model pipelines
from sklearn.linear_model import LogisticRegression
```

```
In [107... # By default, LogisticRegression will fit an intercept, as we did with statsmodel
lm_1 = LogisticRegression(solver='newton-cg', # For comparison, use the same so
                           C=100000) # No regularization

lm_1.fit(df_train[['TransactionAmt']], df_train['isFraud'])
```

```
Out[107... LogisticRegression(C=100000, solver='newton-cg')
```

```
In [108... print('intercept: ', round(lm_1.intercept_[0], 4))
print('TransactionAmt coef: ', round(lm_1.coef_[0][0], 4))
```

```
intercept: -3.3591
TransactionAmt coef: 0.0002
```

```
In [115... df_eval = df_test.copy()
df_eval['pred'] = lm_1.predict(df_test[['TransactionAmt']])
df_eval.loc[:, 'pred'] = df_eval['pred'].astype('category')
```

```
In [120... df_eval.loc[:, 'pred'] = df_eval['pred'].astype('int')
```

```
In [121... df_eval.loc[:, 'isFraud'] = df_eval['isFraud'].astype('int')
```

```
In [123... df_eval.isFraud.dtype
```

```
Out[123... dtype('int64')
```

```
In [124... df_eval.pred.dtype
```

```
Out[124... dtype('int64')
```

```
In [122... df_eval['correct_pred'] = df_eval['pred'] == df_eval['isFraud']
```

```
In [125... df_eval.correct_pred.dtype
```

```
Out[125... dtype('bool')
```

```
In [ ]: sns.stripplot(data=df_eval.sample(20000),
                     x='TransactionAmt',
                     y='pred',
                     hue='correct_pred',
                     palette={False: '#f03b20', True: '#3182bd'});
```

In [128...]

```

import pandas as pd
import numpy as np
import scipy.stats as st
import matplotlib.pyplot as plt
import seaborn as sns
%config InlineBackend.figure_formats = ['retina'] # or svg
%matplotlib inline

plt.rcParams['figure.figsize'] = (9, 6)
sns.set(context='notebook', style='whitegrid', font_scale=1.2)

from sklearn.datasets import fetch_california_housing
from sklearn.datasets import load_breast_cancer
from sklearn.metrics import accuracy_score
import xgboost as xgb

```

In [210...]

```
combined_df_final_xg = combined_df_final.copy()
```

In [220...]

```
#y = combined_df_final_xg['isFraud']
pd.to_numeric(y)
```

Out[220...]

```

0      0
1      0
2      0
3      0
4      0
 ..
590535  0
590536  0
590537  0
590538  0
590539  0
Name: isFraud, Length: 590538, dtype: int64

```

In [213...]

```
combined_df_final_xg.shape
```

Out[213...]

```
(590538, 217)
```

In [170...]

```
combined_df_final_xg = combined_df_final_xg[combined_df_final_xg.columns.difference(['isFraud'])]
```

In [214...]

```
X = combined_df_final_xg[cols]
```

In [215...]

```
X.head()
```

Out[215...]

	P_emaildomain_gmail	P_emaildomain_none	P_emaildomain_yahoo	ProductCD_C	ProductCD_H
0	0	0	0	0.0	0.0
1	1	0	0	0.0	0.0
2	0	0	0	0.0	0.0

P_emaildomain_gmail	P_emaildomain_none	P_emaildomain_yahoo	ProductCD_C	ProductCD_H
---------------------	--------------------	---------------------	-------------	-------------

3	0	0	1	0.0	0.0
4	1	0	0	0.0	1.0

```
In [216...]: X.shape
```

```
Out[216...]: (590538, 22)
```

```
In [217...]: y.shape
```

```
Out[217...]: (590538,)
```

```
In [195...]: cols = ['P_emaildomain_gmail', 'P_emaildomain_none', 'P_emaildomain_yahoo', 'ProductCD_C', 'ProductCD_H', 'ProductCD_R', 'ProductCD_S', 'ProductCD_W', 'TransactionAmt', 'TransactionDT', 'card1', 'card4_None', 'card4_americane_express', 'card4_discover', 'card4_mastercard', 'card4_visa', 'card6_None', 'card6_charge_card', 'card6_credit', 'card6_debit', 'card6_debit or credit', 'hour', 'dtype: object']
```

```
In [218...]: X.dtypes
```

```
Out[218...]: P_emaildomain_gmail      int64
P_emaildomain_none       int64
P_emaildomain_yahoo      int64
ProductCD_C              float64
ProductCD_H              float64
ProductCD_R              float64
ProductCD_S              float64
ProductCD_W              float64
TransactionAmt           float64
TransactionDT             int64
card1                     int64
card4_None                float64
card4_americane_express  float64
card4_discover            float64
card4_mastercard          float64
card4_visa                 float64
card6_None                float64
card6_charge_card         float64
card6_credit               float64
card6_debit                float64
card6_debit or credit     float64
hour                      int64
dtype: object
```

```
In [223...]: y = pd.to_numeric(y)
```

```
In [224...]: y.dtype
```

```
Out[224...]: dtype('int64')
```

```
In [199...]: X.isnull().sum()
```

```
Out[199... P_emaildomain_gmail      0
P_emaildomain_none      0
P_emaildomain_yahoo      0
ProductCD_C      0
ProductCD_H      0
ProductCD_R      0
ProductCD_S      0
ProductCD_W      0
TransactionAmt      0
TransactionDT      0
card1      0
card4_None      0
card4_amERICAN express      0
card4_Discover      0
card4_maSTERCard      0
card4_vISA      0
card6_None      0
card6_charge card      0
card6_credit      0
card6_debit      0
card6_debit or credit      0
hour      0
dtype: int64
```

```
In [188... X["addr1"].fillna('None', inplace=True)
X["addr2"].fillna('None', inplace=True)
X["card2"].fillna('None', inplace=True)
X["card3"].fillna('None', inplace=True)
X["card5"].fillna('None', inplace=True)
```

```
/Users/arcarter/opt/anaconda3/lib/python3.8/site-packages/pandas/core/series.py:4530: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
    return super().fillna()
```

```
In [ ]:
```

```
In [152... from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestRegressor
from sklearn.linear_model import LinearRegression
```

```
In [257... X.shape
```

```
Out[257... (590538, 22)
```

```
In [261... #Split data into 3: 60% train, 20% validation, 20% test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_
X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.

#Evaluate models with Root Mean Squared Error
def rmse(actuals, preds):
    return np.sqrt(((actuals - preds) ** 2).mean())
```

In [262...]: `x_train.head()`

Out[262...]:

	P_emaildomain_gmail	P_emaildomain_none	P_emaildomain_yahoo	ProductCD_C	ProductCD_I
355475	1	0	0	0.0	0.0
361077	1	0	0	0.0	0.0
505847	1	0	0	0.0	0.0
215651	0	0	0	0.0	0.0
323833	0	0	1	0.0	0.0

In [322...]: `import pickle`

In []: `filename`

In [323...]: `pickle.dump(x, open("save.p", "wb"))`

In [324...]: `pickle.dump(y, open("save2.p", "wb"))`

In [264...]:
`lr = LinearRegression()
lr.fit(X_train, y_train)
rmse(lr.predict(X_test), y_test)`

Out[264...]: 0.17897426807171246

In []:

In [265...]:
`rf = RandomForestRegressor(n_estimators = 100, max_features = 3, n_jobs=-1)
rf.fit(X_train, y_train)
rmse(rf.predict(X_test), y_test)`

Out[265...]: 0.14743695961204123

In [267...]: `rf_preds = rf.predict(X_test)`

In [269...]: `rf_preds[:10]`

Out[269...]: `array([0. , 0.03, 0.01, 0.01, 0.02, 0. , 0.03, 0. , 0. , 0.15])`

In [270...]: `y_test[:10]`

Out[270...]: 458896 0

```
535881      0
353211      0
502338      0
425874      0
528002      0
37984       0
169741      0
255541      0
172731      1
Name: isFraud, dtype: int64
```

```
In [266... rf.fit(X_train,y_train)
```

```
Out[266... RandomForestRegressor(max_features=3, n_jobs=-1)
```

```
In [376... 97/3
```

```
Out[376... 32.333333333333336
```

```
In [229... gbm = xgb.XGBRegressor(
                    n_estimators=30000, #arbitrary large number
                    max_depth=3,
                    objective="reg:squarederror",
                    learning_rate=.1,
                    subsample=1,
                    min_child_weight=1,
                    colsample_bytree=.8
                )

eval_set=[(X_train,y_train),(X_val,y_val)] #tracking train/validation error as we
fit_model = gbm.fit(
                    X_train, y_train,
                    eval_set=eval_set,
                    eval_metric='rmse',
                    early_stopping_rounds=20,
                    verbose=True #gives output log as below
                )
```

[0]	validation_0-rmse:0.45677	validation_1-rmse:0.45685
[1]	validation_0-rmse:0.41870	validation_1-rmse:0.41871
[2]	validation_0-rmse:0.38488	validation_1-rmse:0.38484
[3]	validation_0-rmse:0.35514	validation_1-rmse:0.35507
[4]	validation_0-rmse:0.32914	validation_1-rmse:0.32899
[5]	validation_0-rmse:0.30638	validation_1-rmse:0.30618
[6]	validation_0-rmse:0.28669	validation_1-rmse:0.28640
[7]	validation_0-rmse:0.26959	validation_1-rmse:0.26930
[8]	validation_0-rmse:0.25487	validation_1-rmse:0.25460
[9]	validation_0-rmse:0.24244	validation_1-rmse:0.24202
[10]	validation_0-rmse:0.23174	validation_1-rmse:0.23133
[11]	validation_0-rmse:0.22270	validation_1-rmse:0.22224
[12]	validation_0-rmse:0.21508	validation_1-rmse:0.21456
[13]	validation_0-rmse:0.20869	validation_1-rmse:0.20813
[14]	validation_0-rmse:0.20331	validation_1-rmse:0.20275
[15]	validation_0-rmse:0.19893	validation_1-rmse:0.19830
[16]	validation_0-rmse:0.19523	validation_1-rmse:0.19458
[17]	validation_0-rmse:0.19214	validation_1-rmse:0.19146
[18]	validation_0-rmse:0.18966	validation_1-rmse:0.18896
[19]	validation_0-rmse:0.18759	validation_1-rmse:0.18687
[20]	validation_0-rmse:0.18589	validation_1-rmse:0.18515

```

[21] validation_0-rmse:0.18451
[22] validation_0-rmse:0.18338
[23] validation_0-rmse:0.18238
[24] validation_0-rmse:0.18162
[25] validation_0-rmse:0.18098
[26] validation_0-rmse:0.18042
[27] validation_0-rmse:0.17997
[28] validation_0-rmse:0.17962
[29] validation_0-rmse:0.17930
[30] validation_0-rmse:0.17905
[31] validation_0-rmse:0.17880
[32] validation_0-rmse:0.17863
[33] validation_0-rmse:0.17846
[34] validation_0-rmse:0.17835
[35] validation_0-rmse:0.17822
[36] validation_0-rmse:0.17813
[37] validation_0-rmse:0.17801
[38] validation_0-rmse:0.17792
[39] validation_0-rmse:0.17787
[40] validation_0-rmse:0.17781
[41] validation_0-rmse:0.17776
[42] validation_0-rmse:0.17773
[43] validation_0-rmse:0.17768
[44] validation_0-rmse:0.17761
[45] validation_0-rmse:0.17758
[46] validation_0-rmse:0.17752
[47] validation_0-rmse:0.17750
[48] validation_0-rmse:0.17748
[49] validation_0-rmse:0.17742
[50] validation_0-rmse:0.17737
[51] validation_0-rmse:0.17734
[52] validation_0-rmse:0.17733
[53] validation_0-rmse:0.17729
[54] validation_0-rmse:0.17727
[55] validation_0-rmse:0.17722
[56] validation_0-rmse:0.17719
[57] validation_0-rmse:0.17717
[58] validation_0-rmse:0.17714
[59] validation_0-rmse:0.17713
[60] validation_0-rmse:0.17712
[61] validation_0-rmse:0.17710
[62] validation_0-rmse:0.17709
[63] validation_0-rmse:0.17702
[64] validation_0-rmse:0.17700
[65] validation_0-rmse:0.17696
[66] validation_0-rmse:0.17692
[67] validation_0-rmse:0.17690
[68] validation_0-rmse:0.17687
[69] validation_0-rmse:0.17683
[70] validation_0-rmse:0.17682
[71] validation_0-rmse:0.17680
[72] validation_0-rmse:0.17678
[73] validation_0-rmse:0.17674
[74] validation_0-rmse:0.17669
[75] validation_0-rmse:0.17668
[76] validation_0-rmse:0.17665
[77] validation_0-rmse:0.17660
[78] validation_0-rmse:0.17658
[79] validation_0-rmse:0.17654
[80] validation_0-rmse:0.17651
[81] validation_0-rmse:0.17647
[82] validation_0-rmse:0.17646
[83] validation_0-rmse:0.17645
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project_03

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project_03

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project_03

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project_03


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project_03

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project_03


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project_03

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project_03

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project_03

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project_03

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project_03

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project_03

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[5238] validation_0-rmse:0.15469
[5239] validation_0-rmse:0.15469
validation_1-rmse:0.16315
```

In [230...]: `rmse(gbm.predict(X_test, ntree_limit=gbm.best_ntree_limit), y_test)`

Out[230...]: 0.1627314249284993

In [272...]: `preds = gbm.predict(X_test, ntree_limit=gbm.best_ntree_limit)`

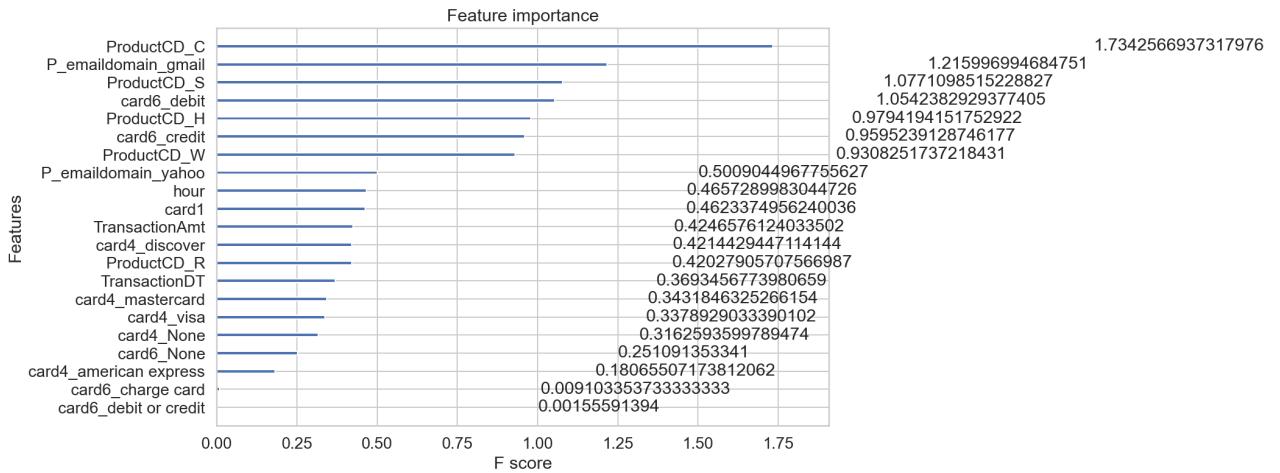
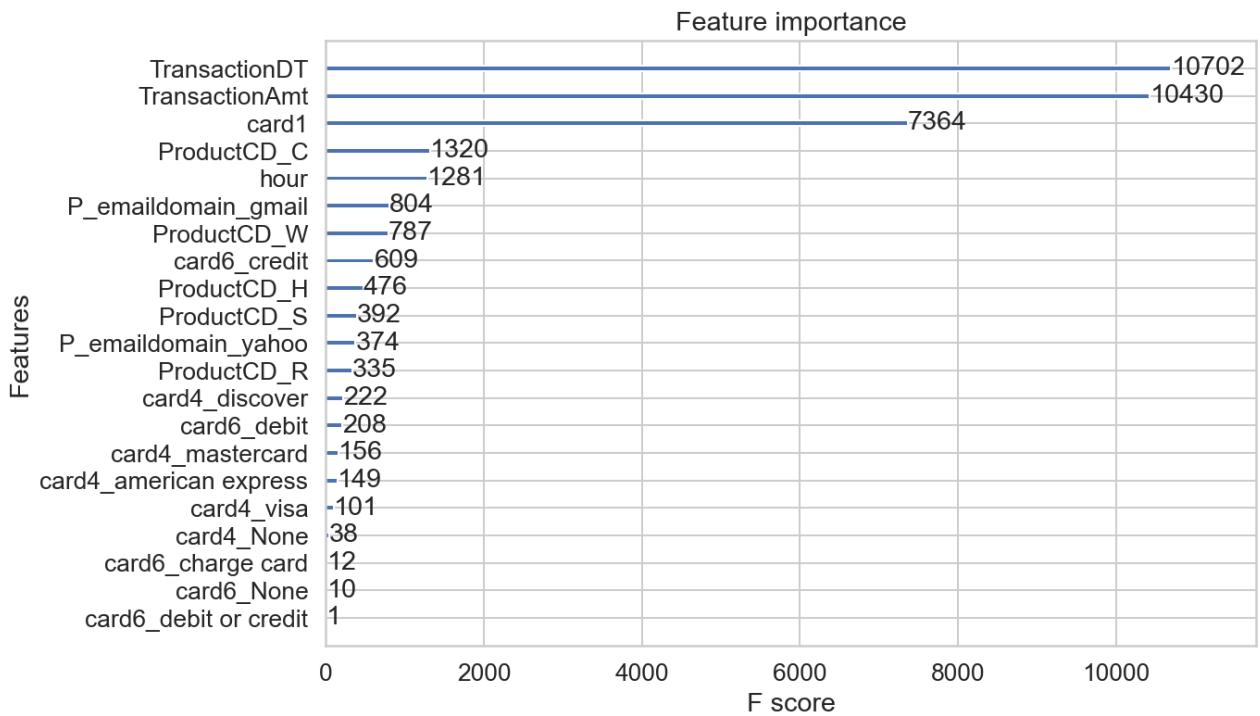
In []: `# Print confusion matrix for kNN`
`RF_matrix = confusion_matrix(rf.predict(X_test), y_test)`
`plt.figure(dpi=150)`
`values_format = '.5f'`
`sns.heatmap(log_confusion, cmap=plt.cm.Blues, fmt = ".1f", annot=True, square=True)`
`xticklabels=[0,1],`
`yticklabels=[0,1])`
`plt.xlabel('Prediction Fraud vs. Not Fraud')`
`plt.ylabel('Actual Fraud vs. Not Fraud')`
`plt.title('Logistic Regression Confusion Matrix');`

In [231...]: `rmse(gbm.predict(X_val, ntree_limit=gbm.best_ntree_limit), y_val)`

Out[231...]: 0.16313787878103742

In [233...]: `xgb.plot_importance(gbm)`
`xgb.plot_importance(gbm, importance_type='gain')`

Out[233...]: <AxesSubplot:title={'center':'Feature importance'}, xlabel='F score', ylabel='Features'>



```
In [234]: gbm.get_booster().get_score(importance_type='weight') #extract raw frequency sco
```

```
Out[234]: {'ProductCD_C': 1320,
 'ProductCD_W': 787,
 'TransactionDT': 10702,
 'card4_discover': 222,
 'hour': 1281,
 'card6_credit': 609,
 'TransactionAmt': 10430,
 'P_emaildomain_gmail': 804,
 'ProductCD_S': 392,
 'ProductCD_H': 476,
 'card6_debit': 208,
 'card1': 7364,
 'card4_visa': 101,
 'ProductCD_R': 335,
 'card6_None': 10,
 'card4_americane express': 149,
 'card4_mastercard': 156,
 'card4_None': 38,
 'P_emaildomain_yahoo': 374,
```

```
'card6_charge card': 12,  
'card6_debit or credit': 1}
```

```
In [ ]: def make_confusion_matrix(model, threshold=0.5):  
    # Predict class 1 if probability of being in class 1 is greater than threshold  
    # (model.predict(X_test) does this automatically with a threshold of 0.5)  
    y_predict = (model.predict_proba(X_test)[:, 1] >= threshold)  
    fraud_confusion = confusion_matrix(y_test, y_predict)  
    plt.figure(dpi=80)  
    sns.heatmap(fraud_confusion, cmap=plt.cm.Blues, annot=True, square=True, fmt='d',  
                xticklabels=['legit', 'fraud'],  
                yticklabels=['legit', 'fraud']);  
    plt.xlabel('prediction')  
    plt.ylabel('actual')
```

```
In [ ]: make_confusion_matrix(gbm)
```

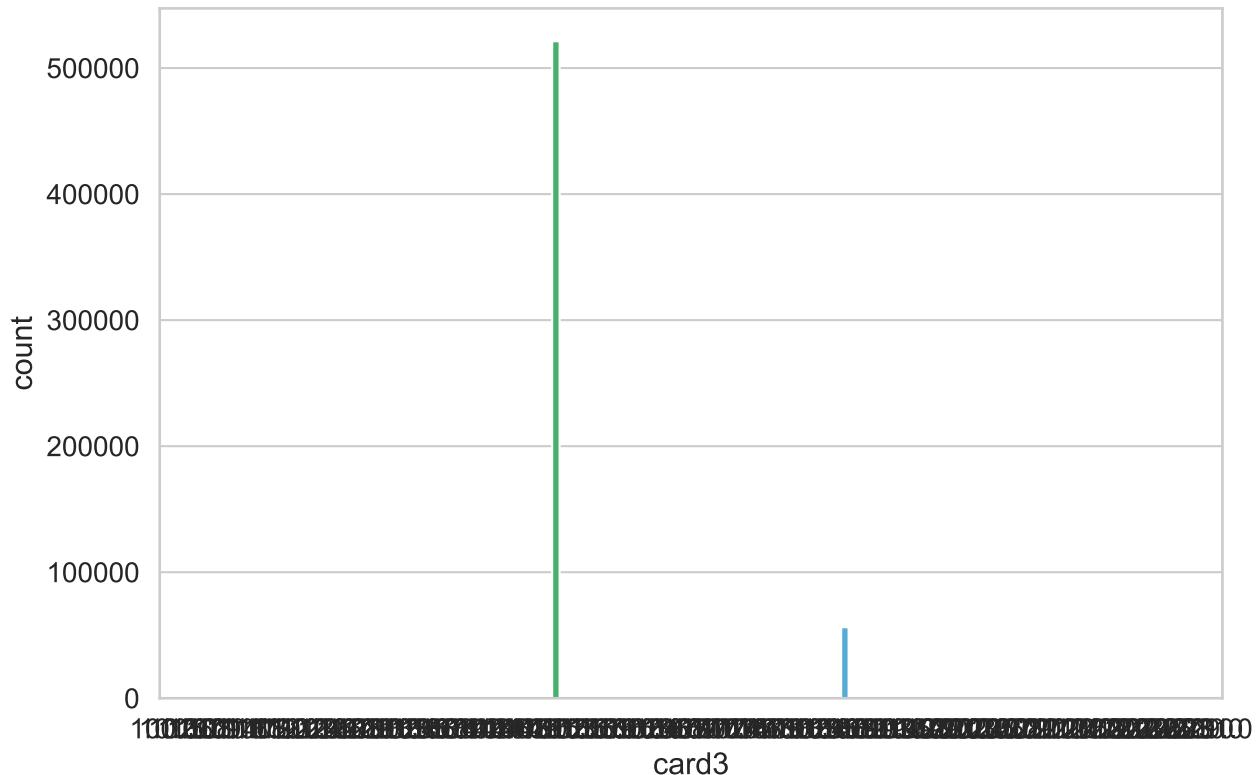
```
In [ ]:
```

```
In [ ]:
```

```
In [18]: plt.title("Card3")  
p1 = sns.countplot(train_transaction_identity['card3'])
```

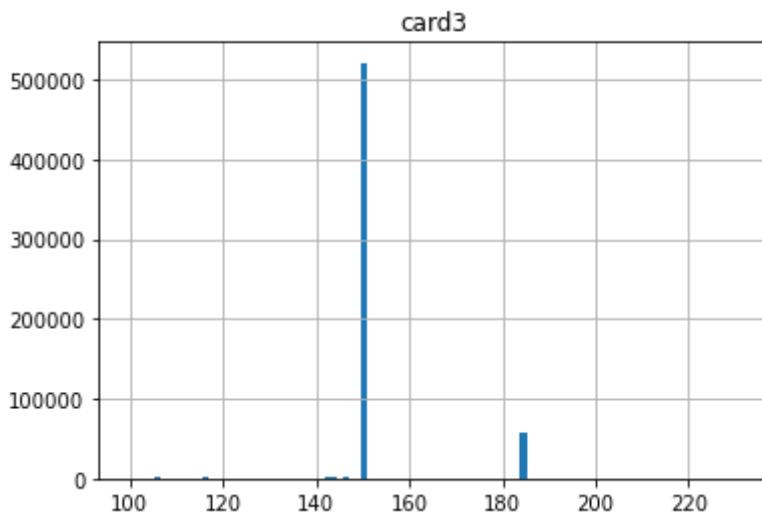
```
/Users/arcarter/opt/anaconda3/lib/python3.8/site-packages/seaborn/_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation.  
    warnings.warn(
```

Card3



```
In [93]: df.hist(column='card3', bins=100)
```

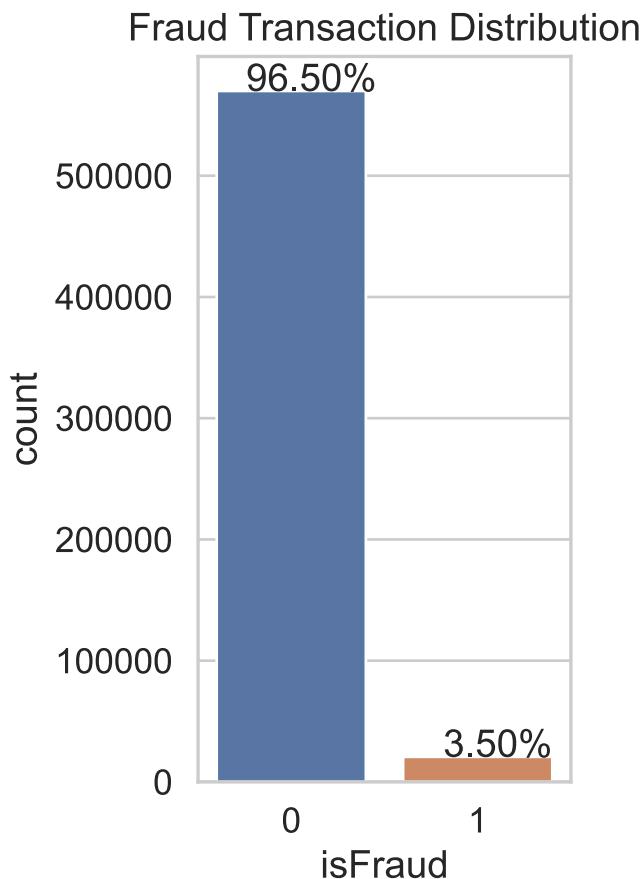
```
Out[93]: array([ [] ], dtype=object)
```



```
In [11]: plt.figure(figsize=(2.5,5))
plt.title("Fraud Transaction Distribution")
p1 = sns.countplot(train_transaction_identity['isFraud'])
for p in p1.patches: p1.annotate('{:6.2f}%'.format(p.get_height()/len(train_trans)))
plt.show()
```

```
/Users/arcarter/opt/anaconda3/lib/python3.8/site-packages/seaborn/_decorators.py:36: FutureWarning: Pass the following variable as a keyword arg: x. From version 0.12, the only valid positional argument will be `data`, and passing other arguments without an explicit keyword will result in an error or misinterpretation
```

```
n.  
warnings.warn(
```

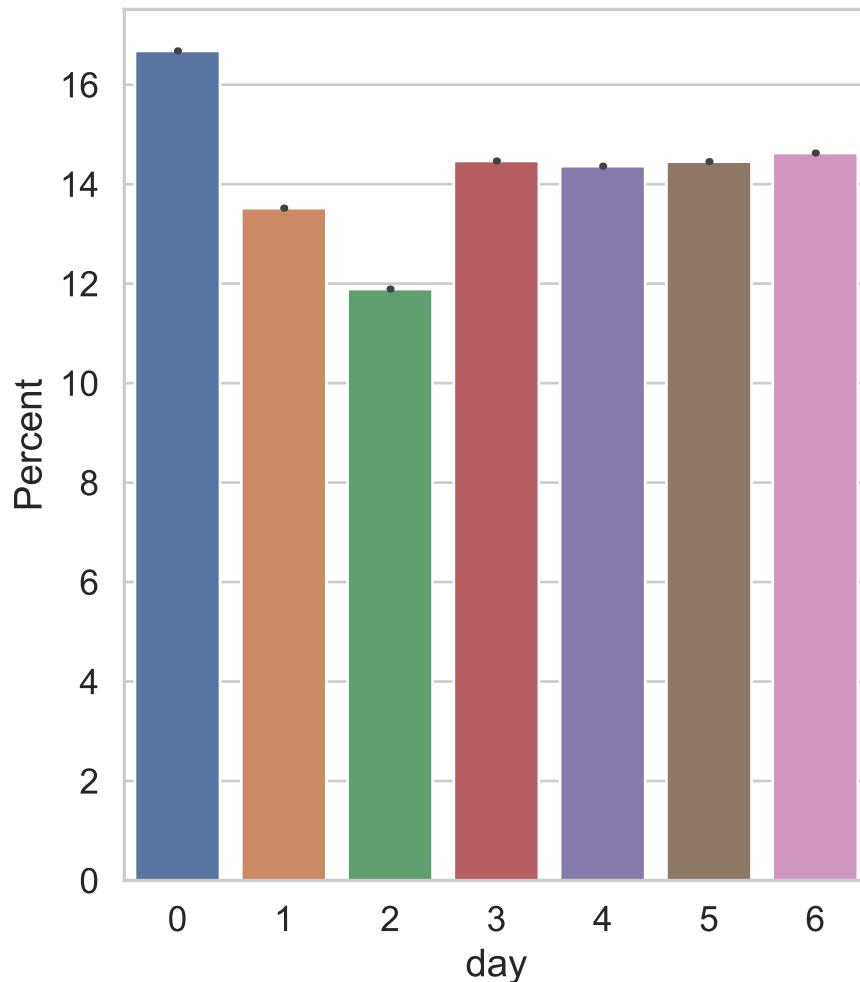


```
In [12]: train_transaction_identity['day'] = (train_transaction_identity['TransactionDT']
```

```
In [13]: plt.figure(figsize=(11,6))  
plt.subplot(1,2,1)  
percentage = lambda i: len(i) / float(len(train_transaction_identity['day'])) *  
ax = sns.barplot(x=train_transaction_identity['day'], y=train_transaction_identity)  
ax.set(ylabel="Percent")  
plt.title('Train')
```

```
Out[13]: Text(0.5, 1.0, 'Train')
```

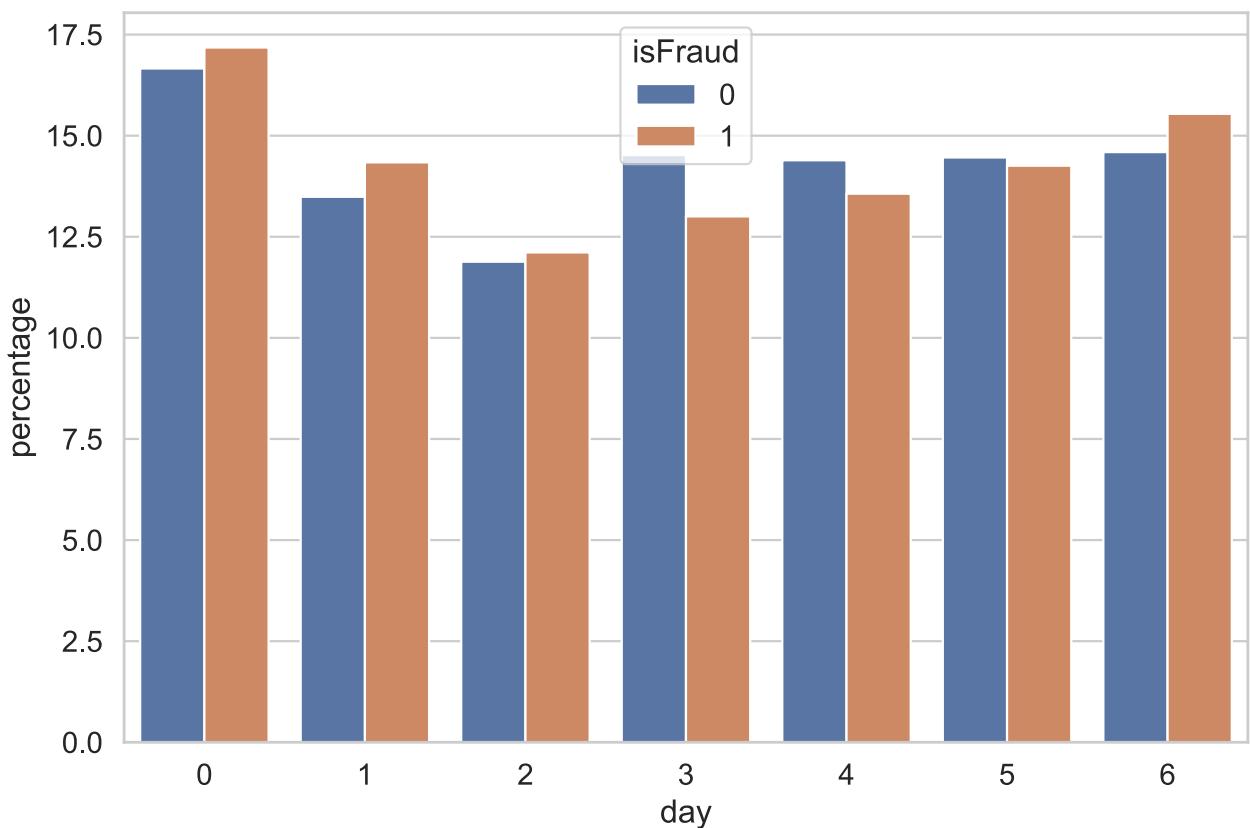
Train



```
In [14]: train_day = (train_transaction_identity.groupby(['isFraud'])['day']
                  .value_counts(normalize=True)
                  .rename('percentage')
                  .mul(100)
                  .reset_index()
                  .sort_values('day'))
```

```
In [15]: sns.barplot(x="day", y="percentage", hue="isFraud", data=train_day)
```

```
Out[15]: <AxesSubplot:xlabel='day', ylabel='percentage'>
```

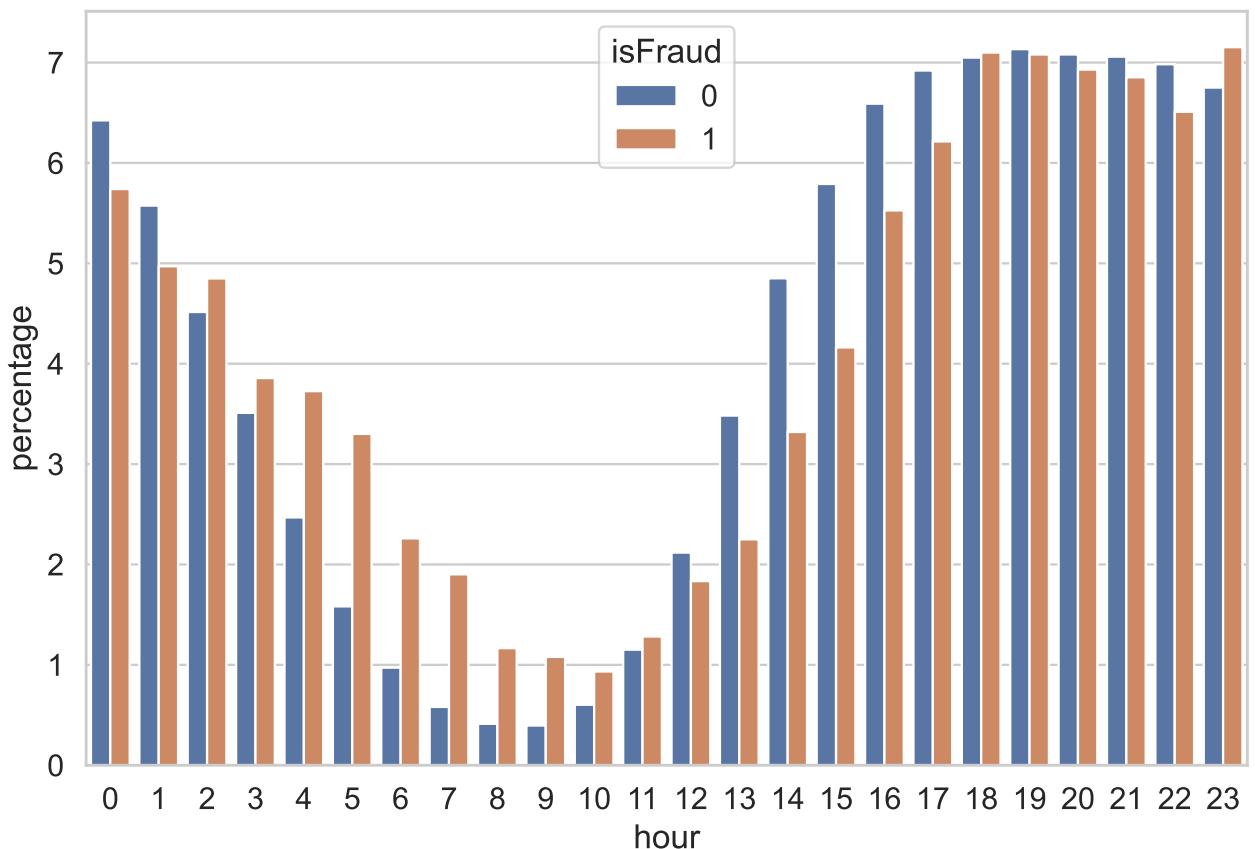


```
In [16]: train_transaction_identity['hour'] = (train_transaction_identity['TransactionDT']
```

```
In [17]: train_hour = (train_transaction_identity.groupby(['isFraud'])['hour']
                  .value_counts(normalize=True)
                  .rename('percentage')
                  .mul(100)
                  .reset_index()
                  .sort_values('hour'))
```

```
In [18]: sns.barplot(x="hour", y="percentage", hue="isFraud", data=train_hour)
```

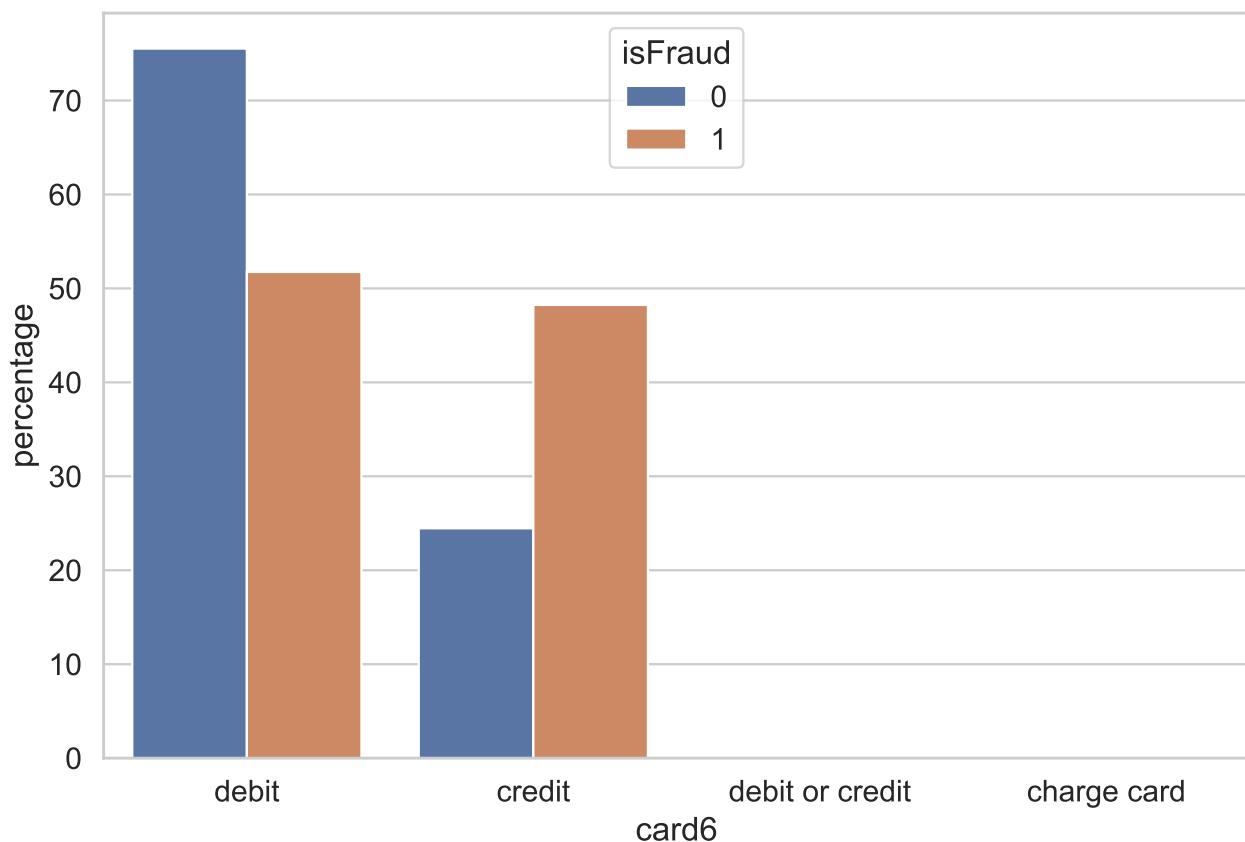
```
Out[18]: <AxesSubplot:xlabel='hour', ylabel='percentage'>
```



```
In [19]: train_card_type = (train_transaction_identity.groupby(['isFraud'])['card6']
                        .value_counts(normalize=True)
                        .rename('percentage')
                        .mul(100)
                        .reset_index())
```

```
In [20]: sns.barplot(x="card6", y="percentage", hue="isFraud", data=train_card_type)
```

```
Out[20]: <AxesSubplot:xlabel='card6', ylabel='percentage'>
```



```
In [21]: logistic_test = train_transaction_identity[["isFraud", "hour", "TransactionAmt", "card6"]]
```

```
In [22]: logistic_test = logistic_test[logistic_test['TransactionAmt'] < 10000]
```

```
In [24]: logistic_test.shape
```

```
Out[24]: (590538, 4)
```

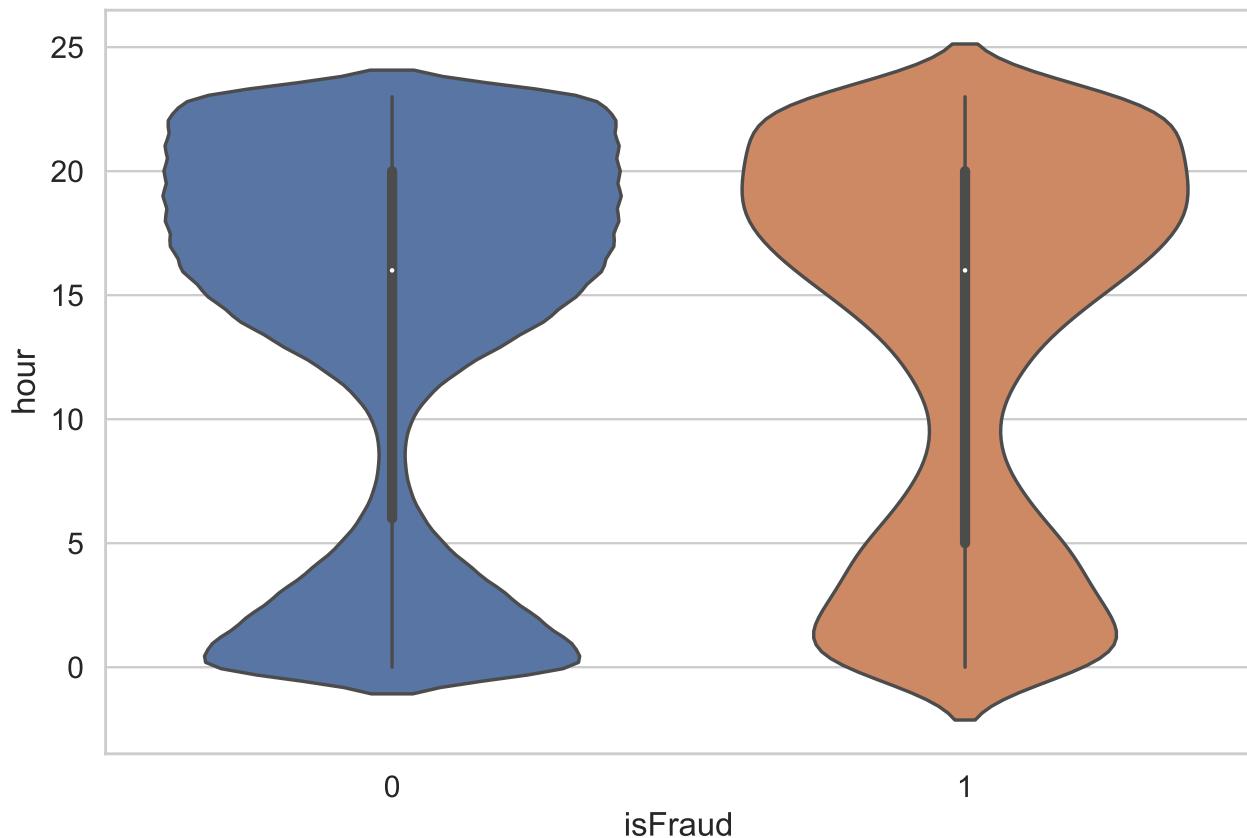
```
In [47]: logistic_test.info
```

```
Out[47]: <bound method DataFrame.info of
   isFraud    hour  TransactionAmt    card6
0          0      0        68.50  credit
1          0      0        29.00  credit
2          0      0        59.00  debit
3          0      0        50.00  debit
4          0      0        50.00  credit
...
590535      0     23        49.00  debit
590536      0     23        39.50  debit
590537      0     23        30.95  debit
590538      0     23       117.00  debit
590539      0     23       279.95  credit
```

```
[590538 rows x 4 columns]>
```

```
In [33]: sns.pairplot(logistic_test, corner=True, height=5, plot_kws={'size': 3}, hue='isFraud')
```

```
In [23]: sns.violinplot(y='hour',
                      x='isFraud',
                      data=logistic_test);
```



```
In [28]: df_train, df_validate = train_test_split(logistic_test,
                                              test_size=0.2,
                                              random_state=42)
```

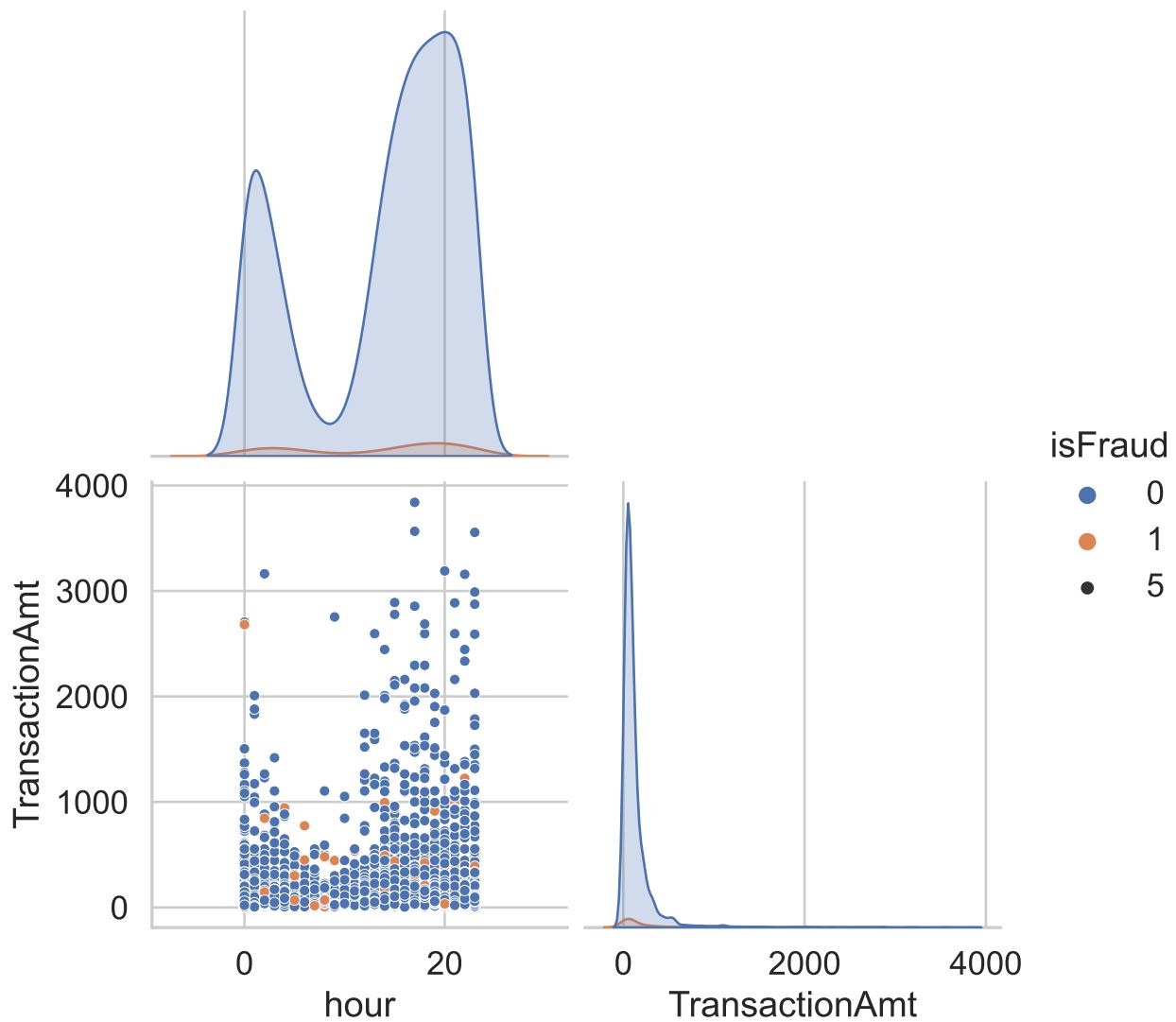
```
In [29]: df_train.shape
```

```
Out[29]: (472430, 4)
```

```
In [30]: df_validate.shape
```

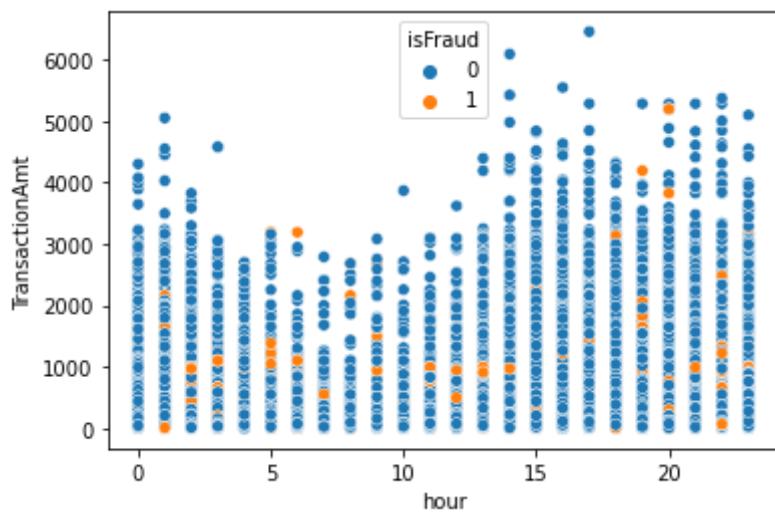
```
Out[30]: (118108, 4)
```

```
In [36]: sns.pairplot(df_train.sample(10000), corner=True, height=3, plot_kws={'size': 5})
```



In [123...]

```
sns.scatterplot(data=logistic_test,
                 x='hour',
                 y='TransactionAmt',
                 hue='isFraud');
```



In [236...]

```
from sklearn.linear_model import LogisticRegression
```

```
In [237...]: from sklearn.metrics import roc_auc_score, confusion_matrix, roc_curve
from sklearn.preprocessing import StandardScaler
```

```
In [238...]: features = ['hour', 'TransactionAmt']

# Since we're using more than one feature, let's scale our features
scaler = StandardScaler()
X_train = scaler.fit_transform(df_train[features])
y_train = df_train['isFraud']
```

```
In [239...]: lm_2 = LogisticRegression() # We'll also regularize our features
```

```
In [240...]: lm_2.fit(X_train, y_train)
```

```
Out[240...]: LogisticRegression()
```

```
In [242...]: X_validate = scaler.transform(df_test[features])
preds = lm_2.predict(X_validate)
```

```
In [243...]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

plt.style.use('ggplot')
%matplotlib inline
np.set_printoptions(suppress=True)
```

```
In [245...]: confusion_matrix(df_test['isFraud'],
                           preds)
```

```
Out[245...]: array([[113861,      0],
                     [   4247,      0]])
```

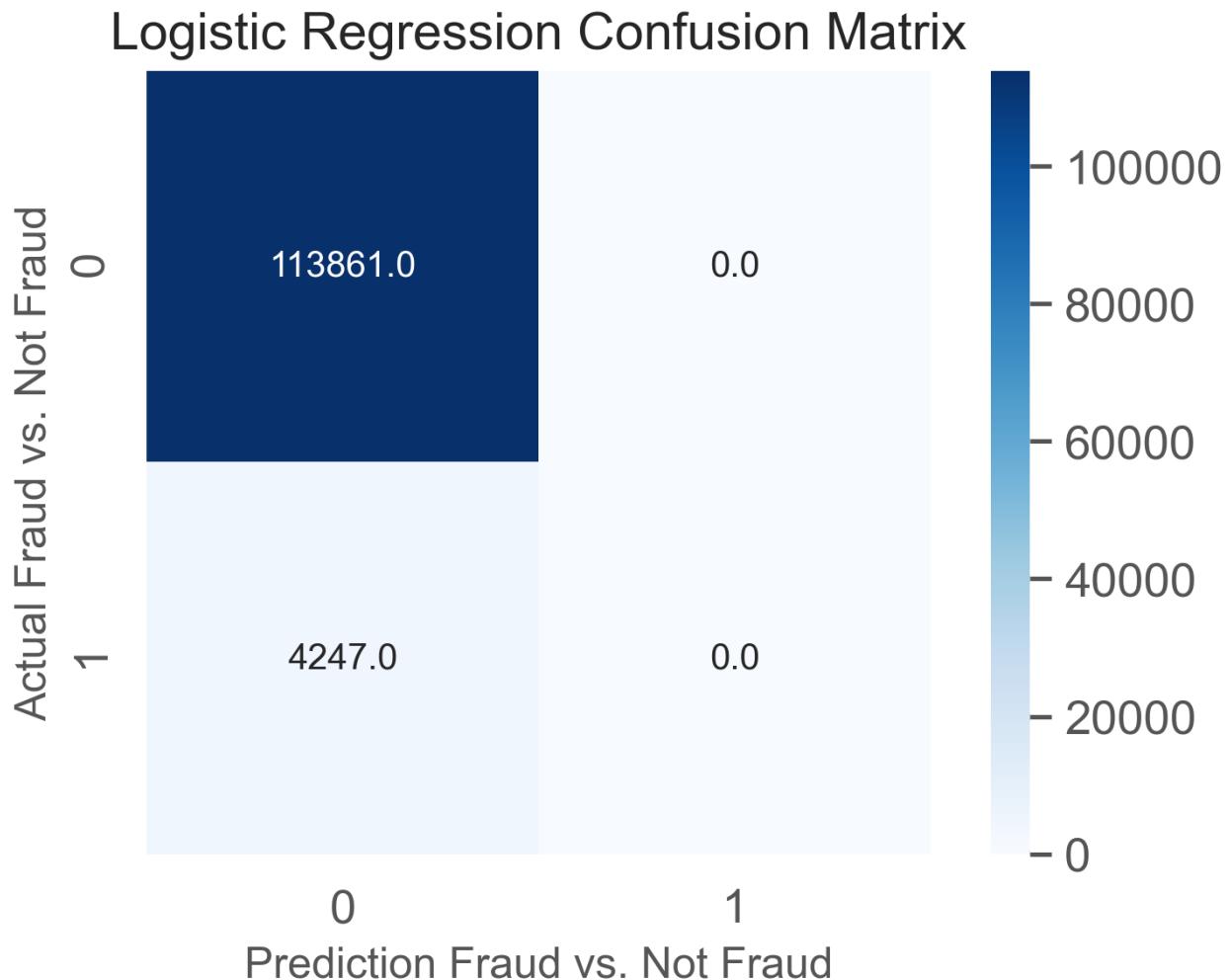
```
In [35]: confusion_matrix(df_validate['isFraud'],
                           preds)
```

```
Out[35]: array([[113861,      0],
                     [   4247,      0]])
```

```
In [246...]: # Print confusion matrix for kNN
log_confusion = confusion_matrix(df_test['isFraud'], preds)
plt.figure(dpi=150)
values_format = '.5f'
sns.heatmap(log_confusion, cmap=plt.cm.Blues, fmt = ".1f", annot=True, square=True,
            xticklabels=[0,1],
            yticklabels=[0,1])

plt.xlabel('Prediction Fraud vs. Not Fraud')
```

```
plt.ylabel('Actual Fraud vs. Not Fraud')
plt.title('Logistic Regression Confusion Matrix');
```



In [42]: `confusion_matrix(df_validate['isFraud'],
preds)`

Out[42]: `array([[113861, 0],
[4247, 0]])`

In []:

In [252...]: `def make_confusion_matrix(model, threshold=0.5):
 # Predict class 1 if probability of being in class 1 is greater than threshold
 # (model.predict(X_test) does this automatically with a threshold of 0.5)
 y_predict = (model.predict_proba(X_test)[:, 1] >= threshold)
 fraud_confusion = confusion_matrix(y_test, y_predict)
 plt.figure(dpi=80)
 sns.heatmap(fraud_confusion, cmap=plt.cm.Blues, annot=True, square=True, fmt='d',
 xticklabels=['legit', 'fraud'],
 yticklabels=['legit', 'fraud']);
 plt.xlabel('prediction')
 plt.ylabel('actual')`

```
In [ ]: xgb.plot_importance(gbm)
xgb.plot_importance(gbm, importance_type='gain')
```

```
In [274...]: from xgboost import XGBClassifier
from sklearn.datasets import load_iris
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score, KFold
```

```
In [275...]: xgbc = XGBClassifier()
print(xgbc)
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, gamma=0, learning_rate=0.1,
              max_delta_step=0, max_depth=3, min_child_weight=1, missing=None,
              n_estimators=100, n_jobs=1, nthread=None,
              objective='multi:softprob', random_state=0, reg_alpha=0,
              reg_lambda=1, scale_pos_weight=1, seed=None, silent=None,
              subsample=1, verbosity=1)
```

```
XGBClassifier(base_score=None, booster=None, colsample_bylevel=None,
              colsample_bynode=None, colsample_bytree=None, gamma=None,
              gpu_id=None, importance_type='gain', interaction_constraints=None,
              learning_rate=None, max_delta_step=None, max_depth=None,
              min_child_weight=None, missing=nan, monotone_constraints=None,
              n_estimators=100, n_jobs=None, num_parallel_tree=None,
              random_state=None, reg_alpha=None, reg_lambda=None,
              scale_pos_weight=None, subsample=None, tree_method=None,
              validate_parameters=None, verbosity=None)
```

```
Out[275...]: XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
                           colsample_bynode=1, colsample_bytree=1, gamma=0, gpu_id=None,
                           importance_type='gain', interaction_constraints=None,
                           learning_rate=0.1, max_delta_step=0, max_depth=3,
                           min_child_weight=1, missing=None, monotone_constraints=None,
                           n_estimators=100, n_jobs=1, nthread=None, num_parallel_tree=None,
                           objective='multi:softprob', random_state=0, reg_alpha=0,
                           reg_lambda=1, scale_pos_weight=1, seed=None, silent=None,
                           subsample=1, tree_method=None, validate_parameters=None,
                           verbosity=1)
```

```
In [ ]: #Split data into 3: 60% train, 20% validation, 20% test
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_
X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.

#Evaluate models with Root Mean Squared Error
def rmse(actuals, preds):
    return np.sqrt(((actuals - preds) ** 2).mean())
```

```
In [371...]: pickle.dump( X_train, open( "X_train.p", "wb" ) )
```

```
In [372...]: pickle.dump( X_test, open( "X_test.p", "wb" ) )
```

```
In [373...]: pickle.dump( y_train, open( "y_train.p", "wb" ) )
```

```
In [375... pickle.dump( y_test, open( "y_test.p", "wb" ) )
```

```
In [329... pickle.dump( X_val, open( "X_val", "wb" ) )
```

```
In [330... pickle.dump( y_val, open( "y_val", "wb" ) )
```

```
In [344... y_val[5]
```

```
Out[344... 0
```

```
In [347... y_val[57034]
```

```
Out[347... 1
```

```
In [346... y_val.loc[y_val== 1]
```

```
Out[346... 57034      1  
578730      1  
159217      1  
507147      1  
316467      1  
..  
501392      1  
386601      1  
248871      1  
122093      1  
409689      1  
Name: isFraud, Length: 4131, dtype: int64
```

```
In [338... y_val[23578]
```

```
Out[338... 0
```

```
In [340... y_val.sample(25)
```

```
Out[340... 590130      0  
520194      0  
388532      0  
187664      0  
159899      0  
143177      0  
441615      0  
494263      0  
494554      0  
385560      0  
552232      0  
385019      0  
418947      0  
507372      0  
97906       0  
111662      0  
83600       0  
325607      0
```

```
476478    0
53519     0
196466    0
519531    0
239072    0
422980    0
340644    0
Name: isFraud, dtype: int64
```

In [358...]

```
xgbc.fit(X_resampled, y_resampled)
```

```
/Users/arcarter/opt/anaconda3/lib/python3.8/site-packages/xgboost/sklearn.py:88
8: UserWarning: The use of label encoder in XGBClassifier is deprecated and will
be removed in a future release. To remove this warning, do the following: 1) Pas
s option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_clas
s - 1].
    warnings.warn(label_encoder_deprecation_msg, UserWarning)
[14:45:10] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starti
ng in XGBoost 1.3.0, the default evaluation metric used with the objective 'bina
ry:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric i
f you'd like to restore the old behavior.
```

Out[358...]

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, gamma=0, gpu_id=-1,
              importance_type='gain', interaction_constraints='',
              learning_rate=0.300000012, max_delta_step=0, max_depth=6,
              min_child_weight=1, missing=nan, monotone_constraints='()',
              n_estimators=100, n_jobs=6, num_parallel_tree=1, random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, subsample=1,
              tree_method='exact', validate_parameters=1, verbosity=None)
```

In [359...]

```
scores = cross_val_score(xgbc, X_resampled, y_resampled, cv=5)
print("Mean cross-validation score: %.2f" % scores.mean())
```

```
kfold = KFold(n_splits=10, shuffle=True)
kf_cv_scores = cross_val_score(xgbc, X_resampled, y_resampled, cv=kfold, scoring='accuracy')
print("K-fold CV average score: %.2f" % kf_cv_scores.mean())
```

```
/Users/arcarter/opt/anaconda3/lib/python3.8/site-packages/xgboost/sklearn.py:88
8: UserWarning: The use of label encoder in XGBClassifier is deprecated and will
be removed in a future release. To remove this warning, do the following: 1) Pas
s option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_clas
s - 1].
    warnings.warn(label_encoder_deprecation_msg, UserWarning)
[14:48:36] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starti
ng in XGBoost 1.3.0, the default evaluation metric used with the objective 'bina
ry:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric i
f you'd like to restore the old behavior.
[14:48:54] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starti
ng in XGBoost 1.3.0, the default evaluation metric used with the objective 'bina
ry:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric i
f you'd like to restore the old behavior.
[14:49:11] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starti
ng in XGBoost 1.3.0, the default evaluation metric used with the objective 'bina
ry:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric i
f you'd like to restore the old behavior.
[14:49:28] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starti
ng in XGBoost 1.3.0, the default evaluation metric used with the objective 'bina
ry:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric i
f you'd like to restore the old behavior.
```

```
[14:49:45] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
Mean cross-validation score: 0.83
[14:50:04] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[14:50:24] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[14:50:44] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[14:51:05] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[14:51:25] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[14:51:48] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[14:52:10] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[14:52:30] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[14:52:49] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
[14:53:10] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
K-fold CV average score: 0.83
```

In [279...]

```
scores = cross_val_score(xgbc, X_train, y_train, cv=5)
print("Mean cross-validation score: %.2f" % scores.mean())

kfold = KFold(n_splits=10, shuffle=True)
kf_cv_scores = cross_val_score(xgbc, X_train, y_train, cv=kfold )
print("K-fold CV average score: %.2f" % kf_cv_scores.mean())
```

```
/Users/arcarter/opt/anaconda3/lib/python3.8/site-packages/xgboost/sklearn.py:88
8: UserWarning: The use of label encoder in XGBClassifier is deprecated and will
be removed in a future release. To remove this warning, do the following: 1) Pas
s option use_label_encoder=False when constructing XGBClassifier object; and 2)
Encode your labels (y) as integers starting with 0, i.e. 0, 1, 2, ..., [num_clas
s - 1].
    warnings.warn(label_encoder_deprecation_msg, UserWarning)
[21:44:18] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starti
```

ng in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:44:26] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:44:34] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:44:42] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:44:50] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

Mean cross-validation score: 0.97

[21:44:59] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:45:08] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:45:17] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:45:27] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:45:36] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:45:45] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:45:54] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:46:03] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:46:12] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

[21:46:21] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

K-fold CV average score: 0.97

In [280...]

```
ypred = xgbc.predict(X_val)
cm = confusion_matrix(y_val, ypred)
```

```
print(cm)
```

```
[[113825    152]
 [ 3605    526]]
```

```
In [281... ypred = xgbc.predict(X_test)
cm = confusion_matrix(y_test,ypred)
print(cm)
```

```
[[113902    142]
 [ 3555    509]]
```

```
In [365... ypred = xgbc.predict(X_test)
```

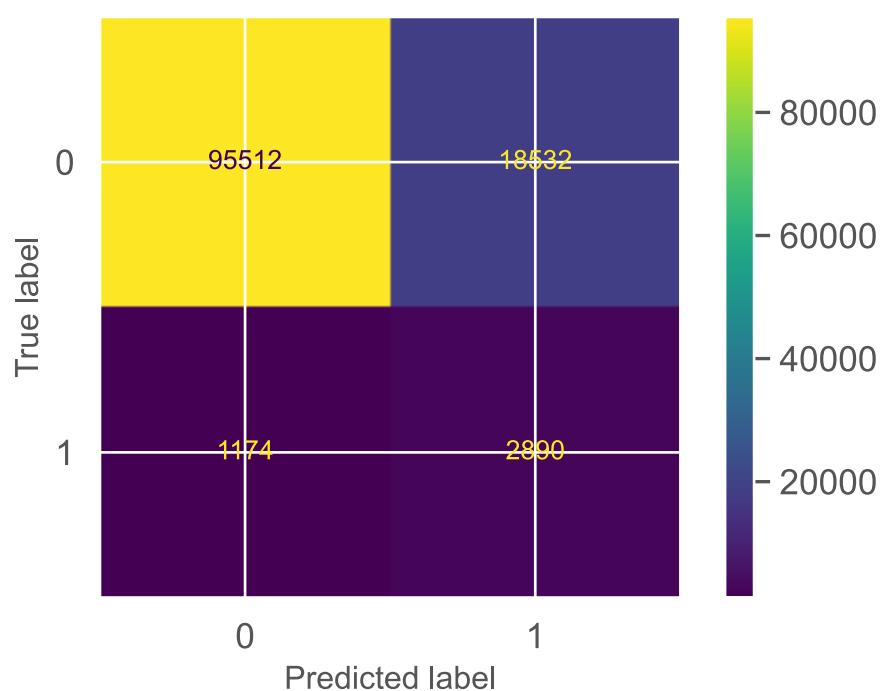
```
In [ ]: X_resampled, y_resampled
```

```
In [366... cm = confusion_matrix(y_test,ypred)
print(cm)
```

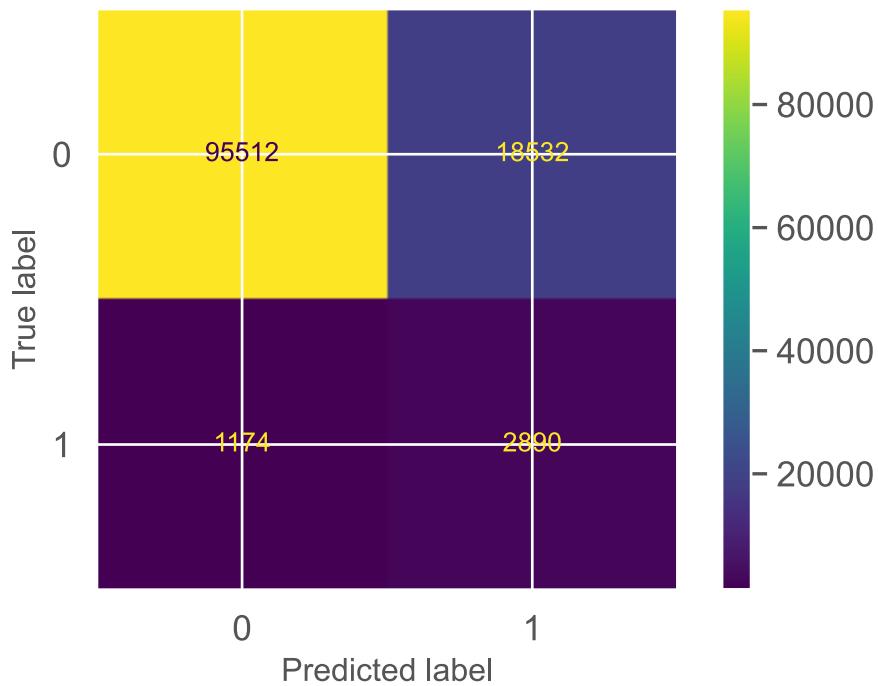
```
[[95512 18532]
 [ 1174  2890]]
```

```
In [362... from sklearn.metrics import confusion_matrix
from sklearn.metrics import ConfusionMatrixDisplay
```

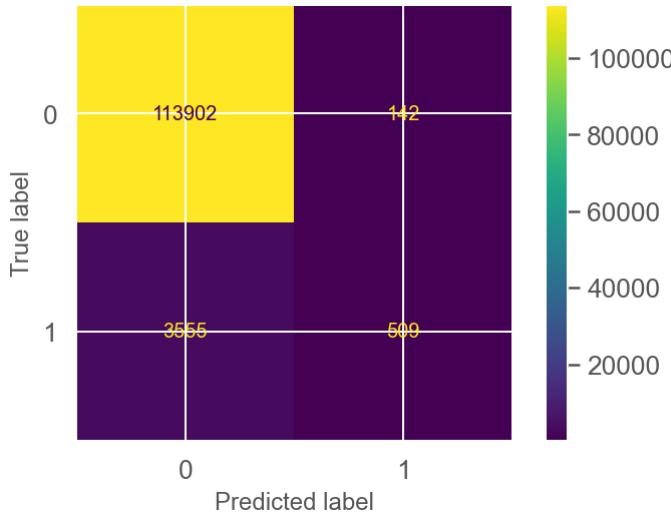
```
In [367... y_pred = xgbc.predict(X_test)
#plt.grid(False)
cm = confusion_matrix(y_test, y_pred)
#plt.grid(False)
cm_display = ConfusionMatrixDisplay(cm).plot()
```



```
In [368...]  
y_pred = xgbc.predict(X_test)  
#plt.grid(False)  
cm = confusion_matrix(y_test, y_pred)  
#plt.grid(False)  
cm_display = ConfusionMatrixDisplay(cm).plot()
```



```
In [305...]  
y_pred = xgbc.predict(X_test)  
#plt.grid(False)  
cm = confusion_matrix(y_test, y_pred)  
#plt.grid(False)  
cm_display = ConfusionMatrixDisplay(cm).plot()
```



```
In [291...]  
from sklearn.metrics import roc_curve  
from sklearn.metrics import RocCurveDisplay
```

```
In [352...]  
# Import the usual suspects. Any new functions will be introduced individually f
```

```

import pandas as pd
import numpy as np

from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score, confusion_matrix
from sklearn.datasets import make_classification
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import LinearSVC, SVC
from xgboost import XGBClassifier
from collections import Counter

import matplotlib.pyplot as plt
import seaborn as sns
from mlxtend.plotting import plot_decision_regions
%matplotlib inline

# make prettier plots
%config InlineBackend.figure_format = 'svg'

```

In [353...]

```

from imblearn.over_sampling import RandomOverSampler
ros = RandomOverSampler(random_state=0)
X_resampled, y_resampled = ros.fit_sample(X_train,y_train)

```

In [356...]

```
X_resampled.shape
```

Out[356...](683708, 22)

In [357...]

```
y_resampled.shape
```

Out[357...](683708,)

In [354...]

```
Counter(y_resampled)
```

Out[354...]: Counter({0: 341854, 1: 341854})

In []:

```
cm = print_confusion_matrix(confusion_matrix(y_test, clf_ros.predict(X)), ['Clas
```

In [292...]

```

y_score = xgbc.decision_function(X_test)

fpr, tpr, _ = roc_curve(y_test, y_score, pos_label=xgbc.classes_[1])
roc_display = RocCurveDisplay(fpr=fpr, tpr=tpr).plot()

```

```

AttributeError                                     Traceback (most recent call last)
<ipython-input-292-b7e6f762483b> in <module>
----> 1 y_score = xgbc.decision_function(X_test)
      2
      3 fpr, tpr, _ = roc_curve(y_test, y_score, pos_label=xgbc.classes_[1])
      4 roc_display = RocCurveDisplay(fpr=fpr, tpr=tpr).plot()

AttributeError: 'XGBClassifier' object has no attribute 'decision_function'

```

```
In [293...]: import matplotlib.pyplot as plt
from sklearn import metrics
from sklearn.linear_model import LogisticRegression
```

```
In [308...]: y_train[:10:-1]
```

```
Out[308...]:
```

390043	0
9940	0
458491	0
55520	0
548788	0
..	
13064	0
576572	0
153504	0
562402	0
189703	0

Name: isFraud, Length: 354311, dtype: int64

```
In [294...]: xgbc.fit(X_train, y_train)
```

```
y_preds = xgbc.predict_proba(X_test)
```

```
[22:12:12] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.
```

```
In [295...]: preds = y_preds[:, 1]
```

```
In [301...]: preds[:10]
```

```
Out[301...]: array([0.00373403, 0.00474583, 0.04345177, 0.0235094 , 0.02487361,
       0.0443178 , 0.00464996, 0.00962159, 0.05723713, 0.22898142],
      dtype=float32)
```

```
In [302...]: y_test[:10]
```

```
Out[302...]:
```

458896	0
535881	0
353211	0
502338	0
425874	0
528002	0
37984	0
169741	0
255541	0
172731	1

Name: isFraud, dtype: int64

```
In [296...]: fpr, tpr, _ = metrics.roc_curve(y_test, preds)
```

```
auc_score = metrics.auc(fpr, tpr)
```

```
In [303...]: print(fpr)
```

```
[0.          0.          0.          ... 0.99928098 0.99929852 1.         ]
```

```
In [304... fpr
```

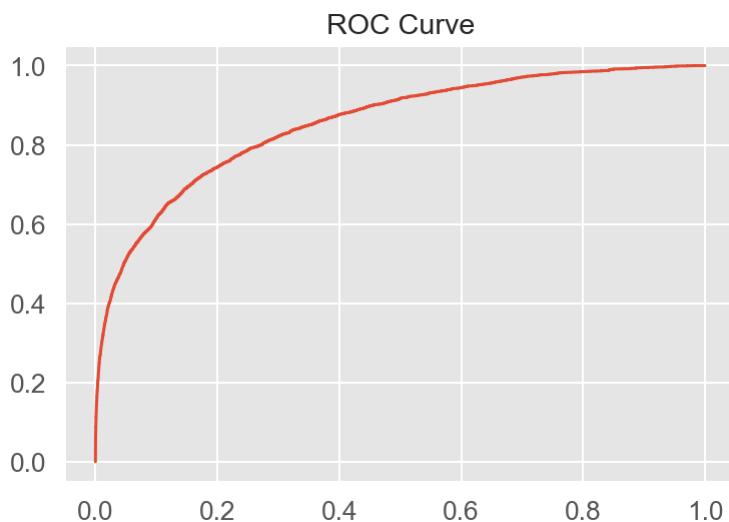
```
Out[304... array([0.          , 0.          , 0.          , ..., 0.99928098, 0.99929852, 1.        ])
```

```
In [297... plt.clf()
```

```
<Figure size 432x288 with 0 Axes>
```

```
In [298... plt.title('ROC Curve')
plt.plot(fpr, tpr, label='AUC = {:.2f}'.format(auc_score))
```

```
Out[298... <matplotlib.lines.Line2D at 0x7f93640c2310>]
```



```
In [300... plt.clf()

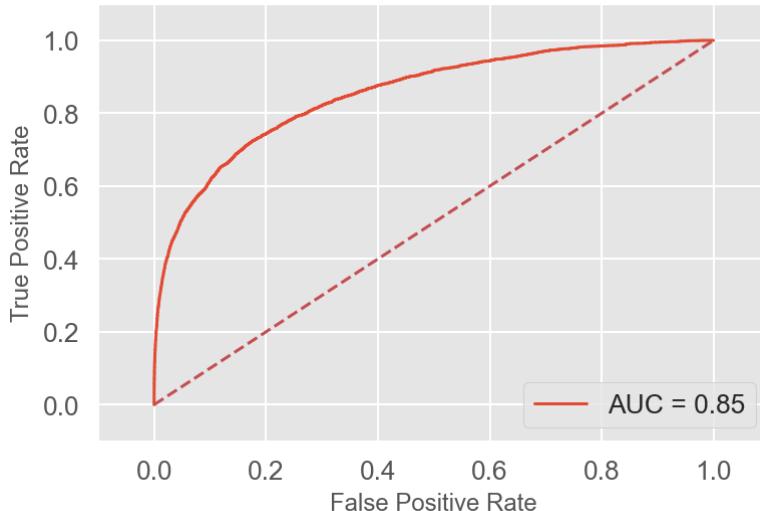
plt.title('ROC Curve')
plt.plot(fpr, tpr, label='AUC = {:.2f}'.format(auc_score))

# it's helpful to add a diagonal to indicate where chance
# scores lie (i.e. just flipping a coin)
plt.plot([0,1],[0,1], 'r--')

plt.xlim([-0.1,1.1])
plt.ylim([-0.1,1.1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')

plt.legend(loc='lower right')
plt.show()
```

ROC Curve



In []:

```
# load data
#X_train, X_test, y_train, y_test = load_my_data()

# model can be any trained classifier that supports predict_proba()
#clf = LogisticRegression()
#xgbc.fit(X_train, y_train)

#y_preds = xgbc.predict_proba(X_test)

# take the second column because the classifier outputs scores for
# the 0 class as well
#preds = y_preds[:,1]

# fpr means false-positive-rate
# tpr means true-positive-rate
#fpr, tpr, _ = metrics.roc_curve(y_test, preds)

#auc_score = metrics.auc(fpr, tpr)

# clear current figure
plt.clf()

plt.title('ROC Curve')
plt.plot(fpr, tpr, label='AUC = {:.2f}'.format(auc_score))

# it's helpful to add a diagonal to indicate where chance
# scores lie (i.e. just flipping a coin)
plt.plot([0,1],[0,1], 'r--')

plt.xlim([-0.1,1.1])
plt.ylim([-0.1,1.1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')

plt.legend(loc='lower right')
plt.show()
```

In [306...]

```
# precision-recall curve and f1 for an imbalanced dataset
from sklearn.datasets import make_classification
from sklearn.linear_model import LogisticRegression
```

```
from sklearn.model_selection import train_test_split
from sklearn.metrics import precision_recall_curve
from sklearn.metrics import f1_score
from sklearn.metrics import auc
from matplotlib import pyplot
```

In []:

In [309...]: model = xgbc

```
model.fit(X_train, y_train)
# predict probabilities
xgb_probs = model.predict_proba(X_test)
# keep probabilities for the positive outcome only
xgb_probs = xgb_probs[:, 1]
```

[22:45:20] WARNING: /Users/travis/build/dmlc/xgboost/src/learner.cc:1061: Starting in XGBoost 1.3.0, the default evaluation metric used with the objective 'binary:logistic' was changed from 'error' to 'logloss'. Explicitly set eval_metric if you'd like to restore the old behavior.

In [312...]: xgb_probs[:10]

```
Out[312...]: array([0.00373403, 0.00474583, 0.04345177, 0.0235094 , 0.02487361,
       0.0443178 , 0.00464996, 0.00962159, 0.05723713, 0.22898142],
      dtype=float32)
```

In [313...]: yhat = model.predict(X_test)

In [314...]: xgb_precision, xgb_recall, _ = precision_recall_curve(y_test, xgb_probs)

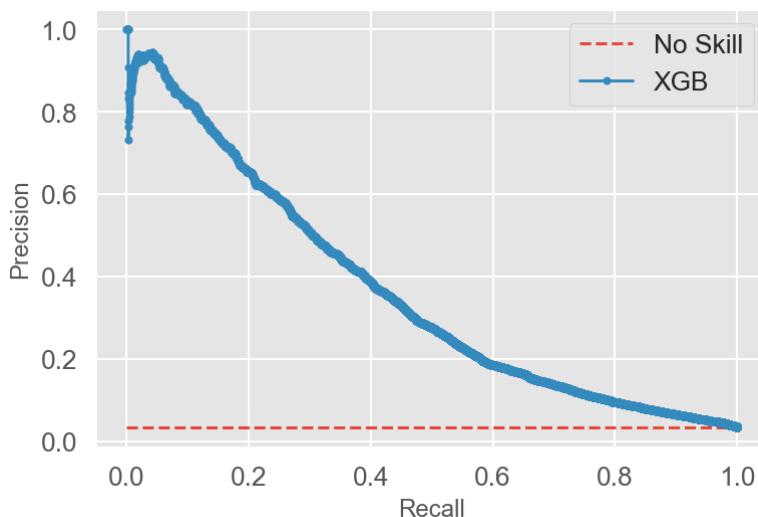
In [316...]: xgb_f1, xgb_auc = f1_score(y_test, yhat), auc(xgb_recall, xgb_precision)

In [318...]: print('XGB: f1=% .3f auc=% .3f' % (xgb_f1, xgb_auc))

```
XGB: f1=0.216 auc=0.363
```

In [319...]: no_skill = len(y_test[y_test==1]) / len(y_test)

```
pyplot.plot([0, 1], [no_skill, no_skill], linestyle='--', label='No Skill')
pyplot.plot(xgb_recall, xgb_precision, marker='.', label='XGB')
# axis labels
pyplot.xlabel('Recall')
pyplot.ylabel('Precision')
# show the legend
pyplot.legend()
# show the plot
pyplot.show()
```



In []:

In []:

In []:

```
# generate 2 class dataset
#X, y = make_classification(n_samples=1000, n_classes=2, weights=[0.99,0.01], ra
# split into train/test sets
#trainX, testX, trainy, testy = train_test_split(X, y, test_size=0.5, random_st
# fit a model
#model = LogisticRegression(solver='lbfgs')
model.fit(trainX, trainy)
# predict probabilities
lr_probs = model.predict_proba(testX)
# keep probabilities for the positive outcome only
lr_probs = lr_probs[:, 1]
# predict class values
yhat = model.predict(testX)
# calculate precision and recall for each threshold
lr_precision, lr_recall, _ = precision_recall_curve(testy, lr_probs)
# calculate scores
lr_f1, lr_auc = f1_score(testy, yhat), auc(lr_recall, lr_precision)
# summarize scores
print('Logistic: f1=% .3f auc=% .3f' % (lr_f1, lr_auc))
# plot the precision-recall curves
no_skill = len(y_test[y_test==1]) / len(y_test)
pyplot.plot([0, 1], [no_skill, no_skill], linestyle='--', label='No Skill')
pyplot.plot(lr_recall, lr_precision, marker='.', label='Logistic')
# axis labels
pyplot.xlabel('Recall')
pyplot.ylabel('Precision')
# show the legend
pyplot.legend()
# show the plot
pyplot.show()
1
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```

```
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38
# precision-recall curve and f1 for an imbalanced dataset
from sklearn.datasets import make_classification
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import precision_recall_curve
from sklearn.metrics import f1_score
from sklearn.metrics import auc
from matplotlib import pyplot
# generate 2 class dataset
X, y = make_classification(n_samples=1000, n_classes=2, weights=[0.99,0.01], ran
# split into train/test sets
trainX, testX, trainy, testy = train_test_split(X, y, test_size=0.5, random_stat
# fit a model
model = LogisticRegression(solver='lbfgs')
model.fit(trainX, trainy)
# predict probabilities
lr_probs = model.predict_proba(testX)
# keep probabilities for the positive outcome only
lr_probs = lr_probs[:, 1]
# predict class values
yhat = model.predict(testX)
# calculate precision and recall for each threshold
lr_precision, lr_recall, _ = precision_recall_curve(testy, lr_probs)
# calculate scores
lr_f1, lr_auc = f1_score(testy, yhat), auc(lr_recall, lr_precision)
# summarize scores
print('Logistic: f1=% .3f auc=% .3f' % (lr_f1, lr_auc))
# plot the precision-recall curves
no_skill = len(testy[testy==1]) / len(testy)
```

```
pyplot.plot([0, 1], [no_skill, no_skill], linestyle='--', label='No Skill')
pyplot.plot(lr_recall, lr_precision, marker='.', label='Logistic')
# axis labels
pyplot.xlabel('Recall')
pyplot.ylabel('Precision')
# show the legend
pyplot.legend()
# show the plot
pyplot.show()
```

In []:

```
##### Had missed and need to add back in
fpr, tpr, thresholds = roc_curve(df_eval['in_sf'],
                                  df_eval['proba_sf'])
#####
```

In [44]:

```
def plot_roc(true, probas):
    auc = roc_auc_score(true, probas)

    plt.plot(fpr, tpr, marker='o')
    plt.xlabel('1 - Specificity (FPR)')
    plt.ylabel('Sensitivity (TPR)');
    plt.title(f"Area Under the ROC Curve: {round(auc, 3)}");
```

In [84]:

```
#plot_roc(df_validate['isFraud'], lm_2.predict_proba(X_validate)[:, 1])
```

In [48]:

```
import statsmodels.api as sm
```

In [58]:

```
# This will help with plotting. Look up Pandas.Categorical for more methods ...
logistic_test.loc[:, 'isFraud'] = logistic_test['isFraud'].astype('category')
```

In [62]:

```
test_transaction_identity.info
```

Out[62]:

	nAmt	ProductCD	card1	card2	TransactionID	TransactionDT	Transactio
0	3663549		18403224		31.950	W	10409 111.0
1	3663550		18403263		49.000	W	4272 111.0
2	3663551		18403310		171.000	W	4476 574.0
3	3663552		18403310		284.950	W	10989 360.0
4	3663553		18403317		67.950	W	18018 452.0
...
506686	4170235		34214279		94.679	C	13832 375.0
506687	4170236		34214287		12.173	C	3154 408.0
506688	4170237		34214326		49.000	W	16661 490.0
506689	4170238		34214337		202.000	W	16621 516.0
506690	4170239		34214345		24.346	C	5713 168.0
	card3		card4	card5	card6	...	id-31 id-32 \
0	150.0		visa	226.0	debit	...	NaN NaN
1	150.0		visa	226.0	debit	...	NaN NaN
2	150.0		visa	226.0	debit	...	NaN NaN
3	150.0		visa	166.0	debit	...	NaN NaN
4	150.0	mastercard		117.0	debit	...	NaN NaN
...

2/15/2021

project_03

```
506686 185.0 mastercard 224.0 debit ...           NaN   NaN
506687 185.0 mastercard 224.0 debit ... chrome 43.0 for android   NaN
506688 150.0      visa 226.0 debit ...           NaN   NaN
506689 150.0 mastercard 224.0 debit ...           NaN   NaN
506690 144.0      visa 147.0 credit ... samsung browser 8.2   NaN
```

```
          id-33  id-34  id-35  id-36  id-37  id-38  DeviceType \
0        NaN    NaN    NaN    NaN    NaN    NaN    NaN
1        NaN    NaN    NaN    NaN    NaN    NaN    NaN
2        NaN    NaN    NaN    NaN    NaN    NaN    NaN
3        NaN    NaN    NaN    NaN    NaN    NaN    NaN
4        NaN    NaN    NaN    NaN    NaN    NaN    NaN
...     ...
506686  NaN    NaN    NaN    NaN    NaN    NaN    NaN
506687  NaN    NaN      F      F      T      F    mobile
506688  NaN    NaN    NaN    NaN    NaN    NaN    NaN
506689  NaN    NaN    NaN    NaN    NaN    NaN    NaN
506690  NaN    NaN      F      F      T      F    mobile
```

```
          DeviceInfo
0                  NaN
1                  NaN
2                  NaN
3                  NaN
4                  NaN
...
506686      ...
506687 ALE-L23 Build/HuaweiALE-L23
506688      ...
506689      ...
506690      SAMSUNG
```

[506691 rows x 433 columns]>

In [63]:

```
df_train
```

Out[63]:

	isFraud	hour	TransactionAmt	card6
18516	0	18	100.00	credit
47538	0	0	75.00	credit
62390	0	12	47.95	credit
289062	0	5	67.50	debit
212038	0	22	59.00	debit
...
110268	0	23	25.00	debit
259178	0	21	357.95	credit
365840	0	1	30.00	debit
131932	0	6	59.00	debit
121958	1	18	44.00	credit

472430 rows x 4 columns

In [64]:

```
df_validate
```

Out[64]:

	isFraud	hour	TransactionAmt	card6
119790	0	0	59.000	debit
366115	0	3	88.950	debit
289710	0	16	67.950	credit
204502	0	2	158.110	debit
153597	0	19	29.733	credit
...
561581	0	0	26.000	debit
541525	0	4	34.000	debit
5307	0	0	59.000	debit
191580	0	18	29.000	debit
344795	0	13	100.000	credit

118108 rows × 4 columns

In [65]:

```
df_train.loc[:, 'isFraud'] = df_train['isFraud'].astype('category')
```

```
/Users/arcarter/opt/anaconda3/lib/python3.8/site-packages/pandas/core/indexing.py:1743: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
`isetter(ilocs[0], value)`

In [66]:

```
df_validate.loc[:, 'isFraud'] = df_validate['isFraud'].astype('category')
```

In [67]:

```
# For this first example, we'll employ statsmodels
lm_1 = sm.Logit(df_train['isFraud'], # with statsmodels, `y` comes first
                 sm.add_constant(df_train[['hour']]))) # and then `x`
lm_1 = lm_1.fit()
```

Optimization terminated successfully.
 Current function value: 0.150777
 Iterations 7

In [68]:

```
lm_1.summary()
```

Out[68]:

Logit Regression Results

Dep. Variable:	isFraud	No. Observations:	472430
Model:	Logit	Df Residuals:	472428
Method:	MLE	Df Model:	1
Date:	Mon, 01 Feb 2021	Pseudo R-squ.:	0.0006706
Time:	09:08:57	Log-Likelihood:	-71231.

```

converged:          True      LL-Null: -71279.
Covariance Type: nonrobust   LLR p-value: 1.410e-22

            coef  std err      z  P>|z|  [0.025  0.975]
const    -3.1876    0.016 -202.480  0.000  -3.218  -3.157
hour     -0.0101    0.001   -9.848  0.000  -0.012  -0.008

```

In [69]:

```
# Let's go down the sklearn path, since this is better used in model pipelines
from sklearn.linear_model import LogisticRegression
```

In [70]:

```
# By default, LogisticRegression will fit an intercept, as we did with statsmodels
lm_1 = LogisticRegression(solver='newton-cg', # For comparison, use the same so
                           C=100000) # No regularization

lm_1.fit(df_train[['hour']], df_train['isFraud'])
```

Out[70]: LogisticRegression(C=100000, solver='newton-cg')

In [71]:

```
# We can see that the coefficient in question matches the one from statsmodels
print('intercept: ', round(lm_1.intercept_[0], 4))
print('hour coef: ', round(lm_1.coef_[0][0], 4))
```

intercept: -3.1876
hour coef: -0.0101

In [79]:

```
df_validate.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 118108 entries, 119790 to 344795
Data columns (total 4 columns):
 #   Column           Non-Null Count   Dtype  
--- 
 0   isFraud          118108 non-null   category
 1   hour              118108 non-null   int64   
 2   TransactionAmt   118108 non-null   float64 
 3   card6             117773 non-null   object  
dtypes: category(1), float64(1), int64(1), object(1)
memory usage: 3.7+ MB
```

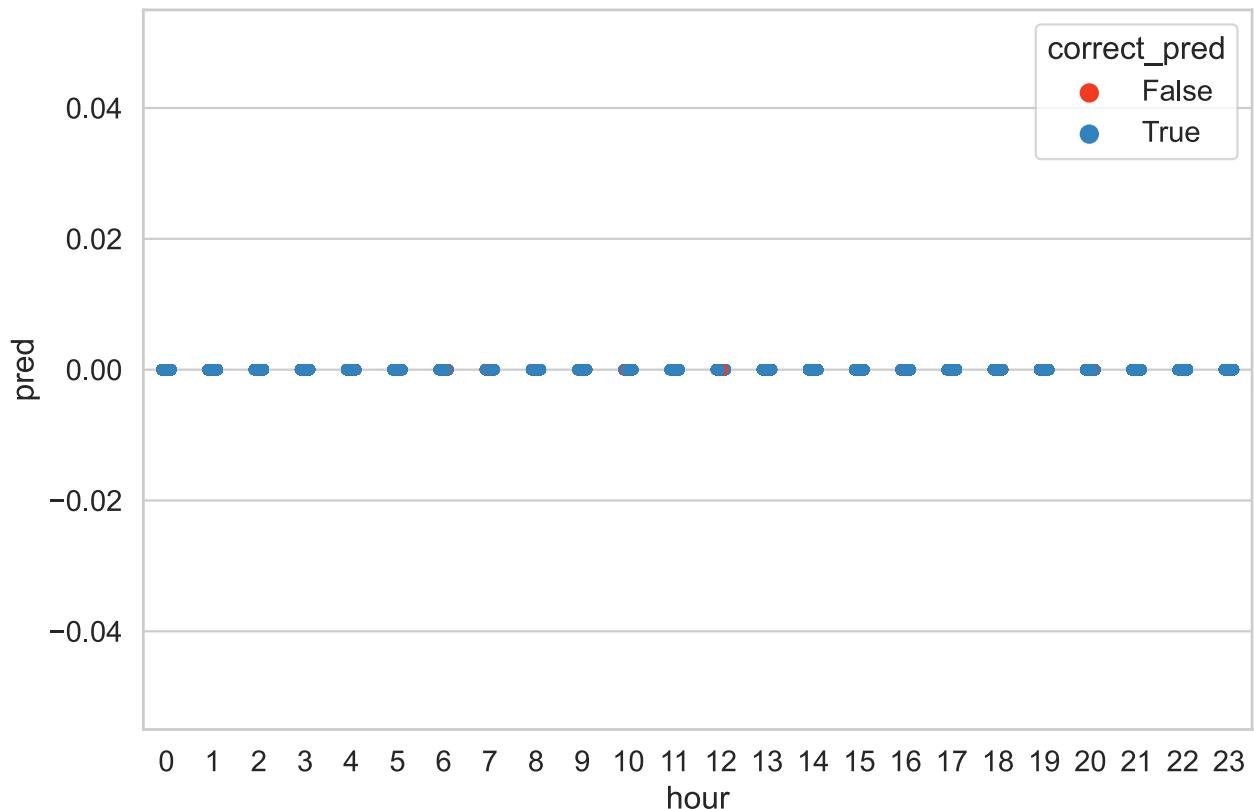
In [82]:

```
df_eval.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 118108 entries, 119790 to 344795
Data columns (total 6 columns):
 #   Column           Non-Null Count   Dtype  
--- 
 0   isFraud          118108 non-null   category
 1   hour              118108 non-null   int64   
 2   TransactionAmt   118108 non-null   float64 
 3   card6             117773 non-null   object  
 4   pred              118108 non-null   int64   
 5   correct_pred     118108 non-null   bool  
dtypes: bool(1), category(1), float64(1), int64(2), object(1)
memory usage: 4.7+ MB
```

```
In [81]: df_eval = df_validate.copy()
df_eval['pred'] = lm_1.predict(df_validate[['hour']])
#df_eval.loc[:, 'pred'] = df_eval['pred'].astype('category')
df_eval['correct_pred'] = df_eval['pred'] == df_eval['isFraud']
```

```
In [83]: sns.stripplot(data=df_eval,
                    x='hour',
                    y='pred',
                    hue='correct_pred',
                    palette={False: '#f03b20', True: '#3182bd'});
```



```
In [19]: df_column_completion = pd.DataFrame((np.sum(pd.isnull(train_transaction_identity)
                                                sort_values(ascending=False)/len(train_transaction_identity))
```

```
In [29]: df_column_completion.rename(columns = {0:'% Null'}, inplace = True)
```

```
In [249...]: df_column_completion.head(20)
```

	% Null
id_24	99.196157
id_25	99.130962
id_07	99.127067
id_08	99.127067

	% Null
id_21	99.126390
id_26	99.125712
id_22	99.124696
id_23	99.124696
id_27	99.124696
dist2	93.628352
D7	93.409908
id_18	92.360695
D13	89.509227
D14	89.469433
D12	89.041010
id_04	88.768885
id_03	88.768885
D6	87.606725
id_33	87.589452
id_10	87.312247

```
In [21]: train_transaction_identity2 = train_transaction_identity.copy()
```

```
In [81]: #Remove variables with missing values more than 30 percent

A = (np.sum(pd.isnull(train_transaction_identity2)).sort_values(ascending=False))
Removed_col = A[A>0.3].index
print(Removed_col)
#train_transaction_identity2.drop(columns=Removed_col, inplace=True)
```

Index([], dtype='object')

```
In [23]: train_transaction_identity2.shape
```

```
Out[23]: (590540, 110)
```

```
In [24]: train_transaction_identity2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 590540 entries, 0 to 590539
Columns: 110 entries, TransactionID to V321
dtypes: float64(103), int64(4), object(3)
memory usage: 520.1+ MB
```

```
In [25]: train_transaction_identity2.describe()
```

Out[25]:

	TransactionID	isFraud	TransactionDT	TransactionAmt	card1	c
count	5.905400e+05	590540.000000	5.905400e+05	590540.000000	590540.000000	588975.00
mean	3.282270e+06	0.034990	7.372311e+06	135.027176	9898.734658	153.19
std	1.704744e+05	0.183755	4.617224e+06	239.162522	4901.170153	11.33
min	2.987000e+06	0.000000	8.640000e+04	0.251000	1000.000000	100.00
25%	3.134635e+06	0.000000	3.027058e+06	43.321000	6019.000000	150.00
50%	3.282270e+06	0.000000	7.306528e+06	68.769000	9678.000000	150.00
75%	3.429904e+06	0.000000	1.124662e+07	125.000000	14184.000000	150.00
max	3.577539e+06	1.000000	1.581113e+07	31937.391000	18396.000000	231.00

In [80]:

train_transaction_identity2.head(25)

Out[80]:

	TransactionID	isFraud	TransactionDT	TransactionAmt	ProductCD	card1	card3	card4
0	2987000	0	86400	68.500	W	13926	150.0	discover
1	2987001	0	86401	29.000	W	2755	150.0	mastercard
2	2987002	0	86469	59.000	W	4663	150.0	visa
3	2987003	0	86499	50.000	W	18132	150.0	mastercard
4	2987004	0	86506	50.000	H	4497	150.0	mastercard
5	2987005	0	86510	49.000	W	5937	150.0	visa
6	2987006	0	86522	159.000	W	12308	150.0	visa
7	2987007	0	86529	422.500	W	12695	150.0	visa
8	2987008	0	86535	15.000	H	2803	150.0	visa
9	2987009	0	86536	117.000	W	17399	150.0	mastercard
10	2987010	0	86549	75.887	C	16496	117.0	mastercard
11	2987011	0	86555	16.495	C	4461	185.0	mastercard
12	2987012	0	86564	50.000	W	3786	150.0	visa
13	2987013	0	86585	40.000	W	12866	150.0	visa
14	2987014	0	86596	10.500	W	11839	150.0	visa
15	2987015	0	86618	57.950	W	7055	150.0	visa
16	2987016	0	86620	30.000	H	1790	150.0	visa
17	2987017	0	86668	100.000	H	11492	150.0	mastercard
18	2987018	0	86725	47.950	W	4663	150.0	visa
19	2987019	0	86730	186.000	W	7005	150.0	visa
20	2987020	0	86761	39.000	W	7875	150.0	mastercard
21	2987021	0	86769	159.950	W	11401	150.0	mastercard
22	2987022	0	86786	50.000	H	1724	150.0	visa

	TransactionID	isFraud	TransactionDT	TransactionAmt	ProductCD	card1	card3	card4
23	2987023	0	86808	107.950		W	2392	150.0 mastercard
24	2987024	0	86821	73.950		W	10112	150.0 visa

25 rows × 110 columns

```
In [44]: train_transaction_identity2['card6'].value_counts()
```

```
Out[44]: debit          439938
credit         148986
debit or credit      30
charge card        15
Name: card6, dtype: int64
```

```
In [79]: categorical_col_orig = train_transaction_identity.select_dtypes(include=['object'])
for i in categorical_col_orig:
    print('% Missing: ',(np.sum(pd.isnull(train_transaction_identity[i]))/len(train_transaction_identity[i]))*100)
    print(train_transaction_identity[i].value_counts())
    print('\n')
```

```
% Missing:  0.0
W      439670
C      68519
R      37699
H      33024
S      11628
Name: ProductCD, dtype: int64
```

```
% Missing:  0.267043722694483
visa           384767
mastercard     189217
american express  8328
discover       6651
Name: card4, dtype: int64
```

```
% Missing:  0.26602770345785215
debit          439938
credit         148986
debit or credit      30
charge card        15
Name: card6, dtype: int64
```

```
% Missing:  15.99485216920107
gmail.com       228355
yahoo.com        100934
hotmail.com      45250
anonymous.com    36998
aol.com          28289
comcast.net      7888
icloud.com       6267
outlook.com       5096
msn.com          4092
att.net          4033
live.com          3041
```

sbcglobal.net	2970
verizon.net	2705
ymail.com	2396
bellsouth.net	1909
yahoo.com.mx	1543
me.com	1522
cox.net	1393
optonline.net	1011
charter.net	816
live.com.mx	749
rocketmail.com	664
mail.com	559
earthlink.net	514
gmail	496
outlook.es	438
mac.com	436
juno.com	322
aim.com	315
roadrunner.com	305
hotmail.es	305
windstream.net	305
hotmail.fr	295
frontier.com	280
embarqmail.com	260
web.de	240
twc.com	230
netzero.com	230
prodigy.net.mx	207
centurylink.net	205
netzero.net	196
frontiernet.net	195
q.com	189
suddenlink.net	175
cfl.rr.com	172
sc.rr.com	164
cableone.net	159
gmx.de	149
yahoo.fr	143
yahoo.es	134
hotmail.co.uk	112
protonmail.com	76
yahoo.de	74
ptd.net	68
live.fr	56
yahoo.co.uk	49
hotmail.de	43
servicios-ta.com	35
yahoo.co.jp	32

Name: P_emaildomain, dtype: int64

```
% Missing: 76.75161716395164
gmail.com      57147
hotmail.com    27509
anonymous.com  20529
yahoo.com      11842
aol.com        3701
outlook.com    2507
comcast.net    1812
yahoo.com.mx   1508
icloud.com    1398
msn.com       852
live.com      762
live.com.mx   754
verizon.net   620
```

me.com	556
sbcglobal.net	552
cox.net	459
outlook.es	433
att.net	430
bellsouth.net	422
hotmail.fr	293
hotmail.es	292
web.de	237
mac.com	218
prodigy.net.mx	207
ymail.com	207
optonline.net	187
gmx.de	147
yahoo.fr	137
charter.net	127
mail.com	122
hotmail.co.uk	105
gmail	95
earthlink.net	79
yahoo.de	75
rocketmail.com	69
embarqmail.com	68
scranton.edu	63
yahoo.es	57
live.fr	55
roadrunner.com	53
juno.com	53
frontier.com	52
windstream.net	47
hotmail.de	42
protonmail.com	41
yahoo.co.uk	39
cfl.rr.com	37
aim.com	36
servicios-ta.com	35
yahoo.co.jp	33
twc.com	29
ptd.net	27
cableone.net	27
suddenlink.net	25
q.com	25
frontiernet.net	14
netzero.com	14
centurylink.net	12
netzero.net	9
sc.rr.com	8

Name: R_emaildomain, dtype: int64

% Missing: 45.90713584177194
T 319415
F 25
Name: M1, dtype: int64

% Missing: 45.90713584177194
T 285468
F 33972
Name: M2, dtype: int64

% Missing: 45.90713584177194
T 251731
F 67709

```
Name: M3, dtype: int64
```

```
% Missing: 47.658753005723575
M0      196405
M2      59865
M1      52826
Name: M4, dtype: int64
```

```
% Missing: 59.34940901547736
F      132491
T      107567
Name: M5, dtype: int64
```

```
% Missing: 28.678836319300977
F      227856
T      193324
Name: M6, dtype: int64
```

```
% Missing: 58.63531682866528
F      211374
T      32901
Name: M7, dtype: int64
```

```
% Missing: 58.633115453652586
F      155251
T      89037
Name: M8, dtype: int64
```

```
% Missing: 58.633115453652586
T      205656
F      38632
Name: M9, dtype: int64
```

```
% Missing: 75.5760829071697
NotFound    123025
Found       21208
Name: id_12, dtype: int64
```

```
% Missing: 76.12608798726589
Found       67728
New        61612
Unknown    11645
Name: id_15, dtype: int64
```

```
% Missing: 78.098011989027
Found       66324
NotFound    63016
Name: id_16, dtype: int64
```

```
% Missing: 99.1246994276425
IP_PROXY:TRANSPARENT      3489
IP_PROXY:ANONYMOUS        1071
IP_PROXY:HIDDEN            609
Name: id_23, dtype: int64
```

```
% Missing: 99.1246994276425
Found      5155
NotFound     14
Name: id_27, dtype: int64
```

```
% Missing: 76.12727334304196
Found      76232
New       64746
Name: id_28, dtype: int64
```

```
% Missing: 76.12727334304196
Found      74926
NotFound   66052
Name: id_29, dtype: int64
```

```
% Missing: 86.8654113184543
Windows 10          21155
Windows 7           13110
iOS 11.2.1          3722
iOS 11.1.2          3699
Android 7.0          2871
Mac OS X 10_12_6      2559
Mac OS X 10_11_6      2348
iOS 11.3.0          2016
Windows 8.1           1914
Mac OS X 10_10_5      1651
iOS 11.2.6          1647
iOS 10.3.3          1558
Mac OS X 10_13_2      1421
Mac OS X 10_13_1      1211
iOS 11.2.5          1200
Linux                 1136
Android                1079
iOS 11.2.2          902
Mac OS X 10_13_3      860
iOS 11.2.0          852
Mac OS X 10_13_4      759
iOS 11.1.1          700
iOS 11.0.3          659
Android 7.1.1          630
Mac OS X 10_9_5          570
Android 6.0.1          566
iOS 10.3.2          428
iOS 9.3.5           414
Android 5.1.1          350
Android 8.0.0          343
Mac                   303
Mac OS X 10.13         287
iOS 10.2.1          285
iOS                  274
iOS 11.1.0           271
Windows Vista          246
iOS 10.3.1           236
Mac OS X 10.12         218
Mac OS X 10_12_5        217
Mac OS X 10.11          200
Android 8.1.0           192
Windows 8              180
iOS 11.0.2           166
iOS 10.2.0            149
iOS 11.0.0             144
```

iOS 11.3.1	136
Mac OS X 10.10	135
Windows XP	131
iOS 11.0.1	127
Mac OS X 10_12_4	103
iOS 10.1.1	96
iOS 10.0.2	95
Mac OS X 10_12_3	95
Mac OS X 10_7_5	93
Mac OS X 10_11_5	82
Android 6.0	80
Mac OS X 10_8_5	74
Android 4.4.2	63
Mac OS X 10.9	58
Android 5.0.2	55
Mac OS X 10_11_3	54
Mac OS X 10_11_4	53
Mac OS X 10_6_8	50
Mac OS X 10_12	49
Mac OS X 10.6	49
Mac OS X 10_12_1	44
Android 5.0	41
Android 7.1.2	33
Mac OS X 10_12_2	33
other	15
func	10
iOS 11.4.0	5
Mac OS X 10_13_5	4
Windows	3
iOS 11.4.1	1

Name: id_30, dtype: int64

% Missing:	76.24513157449114
chrome 63.0	22000
mobile safari 11.0	13423
mobile safari generic	11474
ie 11.0 for desktop	9030
safari generic	8195
chrome 62.0	7182
chrome 65.0	6871
chrome 64.0	6711
chrome 63.0 for android	5806
chrome generic	4778
chrome 66.0	4264
edge 16.0	4188
chrome 64.0 for android	3473
chrome 65.0 for android	3336
firefox 57.0	3315
mobile safari 10.0	2779
chrome 66.0 for android	2349
chrome 62.0 for android	2097
edge 15.0	1600
chrome generic for android	1158
firefox 59.0	1099
samsung browser 6.2	1061
firefox 58.0	833
chrome 49.0	719
firefox	673
ie 11.0 for tablet	647
chrome 61.0	642
safari 11.0	550
mobile safari 9.0	541
chrome 61.0 for android	538
samsung browser 6.4	509

chrome	428
edge 14.0	419
firefox 52.0	394
chrome 60.0	371
chrome 60.0 for android	325
other	312
chrome 55.0 for android	302
android webview 4.0	285
chrome 58.0 for android	262
chrome 56.0 for android	238
chrome 59.0 for android	227
firefox 60.0	225
chrome 63.0 for ios	222
samsung browser generic	210
chrome 58.0	188
firefox 48.0	179
chrome 66.0 for ios	159
chrome 52.0 for android	152
Samsung/SM-G532M	150
chrome 50.0 for android	145
opera 49.0	138
chrome 59.0	133
firefox 56.0	126
safari 10.0	111
firefox generic	110
samsung browser 7.0	101
android browser 4.0	100
chrome 56.0	98
mobile safari uiwebview	97
chrome 57.0	94
chrome 57.0 for android	87
opera	83
chrome 54.0 for android	82
Generic/Android 7.0	81
chrome 65.0 for ios	79
opera generic	78
edge 17.0	74
chrome 43.0 for android	72
chrome 46.0 for android	69
chrome 55.0	64
edge 13.0	62
chrome 62.0 for ios	61
edge	58
Generic/Android	57
ie	56
chrome 51.0	56
google search application 48.0	55
opera 52.0	55
google search application 49.0	55
mobile safari 8.0	54
chrome 49.0 for android	53
Samsung/SM-G531H	52
opera 51.0	49
chrome 64.0 for ios	46
opera 53.0	46
chrome 51.0 for android	45
samsung browser 5.4	43
safari 9.0	43
chrome 53.0 for android	42
samsung browser 5.2	41
firefox 47.0	37
samsung browser 4.0	37
google	36
chrome 67.0	33
Microsoft/Windows	25

firefox 55.0	20
silk	19
samsung browser 4.2	18
samsung	16
safari	14
mobile	11
ZTE/Blade	9
samsung browser 3.3	8
maxthon	6
comodo	6
line	6
icedragon	5
Mozilla/Firefox	5
aol	5
Lanix/Ilium	3
palemoon	2
facebook	2
puffin	2
waterfox	2
BLU/Dash	1
Inco/Minion	1
M4Tel/M4	1
Nokia/Lumia	1
chromium	1
Cherry	1
android	1
chrome 67.0 for android	1
chrome 69.0	1
seamonkey	1
firefox mobile 61.0	1
cyberfox	1
Samsung/SCH	1
iron	1
LG/K-200	1

Name: id_31, dtype: int64

% Missing: 87.58949436109323
1920x1080 16874
1366x768 8605
1334x750 6447
2208x1242 4900
1440x900 4384

...

3840x2162 1
1408x792 1
3072x1728 1
1440x759 1
1441x901 1

Name: id_33, Length: 260, dtype: int64

% Missing: 86.82477054898906
match_status:2 60011
match_status:1 17376
match_status:0 415
match_status:-1 3
Name: id_34, dtype: int64

% Missing: 76.12608798726589
T 77814
F 63171
Name: id_35, dtype: int64

```
% Missing: 76.12608798726589
F      134066
T      6919
Name: id_36, dtype: int64
```

```
% Missing: 76.12608798726589
T      110452
F      30533
Name: id_37, dtype: int64
```

```
% Missing: 76.12608798726589
F      73922
T      67063
Name: id_38, dtype: int64
```

```
% Missing: 76.15572188166763
desktop    85165
mobile     55645
Name: DeviceType, dtype: int64
```

```
% Missing: 79.90551021099333
Windows      47722
iOS Device   19782
MacOS        12573
Trident/7.0  7440
rv:11.0       1901
...
Infinit      1
QTASUN1      1
X900+        1
SM-G930P     1
LGMS323      1
Name: DeviceInfo, Length: 1786, dtype: int64
```

```
In [68]: np.sum(pd.isnull(train_transaction_identity['card6']))
```

```
Out[68]: 1571
```

```
In [ ]: for i in categorical_col_orig:
    pyplot.hist((data['colname'])**(1/i), bins=50)
    pyplot.title(f'Transform=1/{i}')
    pyplot.show()
```

```
In [85]: df = train_transaction_identity
```

```
In [ ]: def plot_features(df, sample_size=1000):
    # We don't need to plot the id (prod and user), and the latest cart is a list
    sample = df[['product_id', 'user_id', 'latest_cart'], axis=1] \
        .sample(sample_size, random_state=44)

    g = sns.pairplot(sample, hue='in_cart', plot_kws=dict(alpha=.3, edgecolor='n
```

```
plot_features(df_X)
```

```
In [ ]: def plot_features(df, sample_size=1000):
    # We don't need to plot the id (prod and user), and the latest cart is a list
    sample = df.drop(['product_id', 'user_id', 'latest_cart'], axis=1) \
        .sample(sample_size, random_state=44)

    g = sns.pairplot(sample, hue='in_cart', plot_kws=dict(alpha=.3, edgecolor='n')
plot_features(df_X)
```

```
In [69]: 1571/590540
```

```
Out[69]: 0.0026602770345785214
```

```
In [57]: (np.sum(pd.isnull(train_transaction_identity['card6'])) \
/len(train_transaction_identity['card6']))*100
```

```
Out[57]: 0.26602770345785215
```

```
In [86]: for i in ['isFraud', 'card6']:
    print('% Missing: ', (np.sum(pd.isnull(df_train[i])) \
        /len(df_train[i]))*100)
    print(df_train[i].value_counts())
    print('\n')
```

```
% Missing: 0.0
0      456014
1      16416
Name: isFraud, dtype: int64
```

```
% Missing: 0.2616260610037466
debit          352050
credit         119106
debit or credit     25
charge card       13
Name: card6, dtype: int64
```

```
In [87]: for i in ['isFraud', 'card6']:
    print('% Missing: ', (np.sum(pd.isnull(df_validate[i])) \
        /len(df_validate[i]))*100)
    print(df_validate[i].value_counts())
    print('\n')
```

```
% Missing: 0.0
0      113861
1      4247
Name: isFraud, dtype: int64
```

```
% Missing: 0.28363870355945403
debit          87888
```

```
credit           29878
debit or credit      5
charge card          2
Name: card6, dtype: int64
```

In [76]:

```
categorical_col = train_transaction_identity2.select_dtypes(include=['object']).  
for i in categorical_col:  
    print('% Missing: ',(np.sum(pd.isnull(train_transaction_identity[i]))/  
        len(train_transaction_identity[i]))*100)  
    print(train_transaction_identity2[i].value_counts())  
    print('\n')
```

```
% Missing:  0.0
W      439670
C      68519
R      37699
H      33024
S      11628
Name: ProductCD, dtype: int64
```

```
% Missing:  0.267043722694483
visa            384767
mastercard       189217
american express   8328
discover          6651
Name: card4, dtype: int64
```

```
% Missing:  0.26602770345785215
debit           439938
credit          148986
debit or credit     30
charge card         15
Name: card6, dtype: int64
```

In [77]:

```
categorical_col = train_transaction_identity2.select_dtypes(include=['object']).  
for i in categorical_col:  
    print('% Missing: ',(np.sum(pd.isnull(train_transaction_identity[i]))/  
        len(train_transaction_identity[i]))*100)  
    print(train_transaction_identity2[i].value_counts())  
    print('\n')
```

```
% Missing:  0.0
W      439670
C      68519
R      37699
H      33024
S      11628
Name: ProductCD, dtype: int64
```

```
% Missing:  0.267043722694483
visa            384767
mastercard       189217
american express   8328
discover          6651
Name: card4, dtype: int64
```

```
% Missing: 0.26602770345785215
debit           439938
credit          148986
debit or credit    30
charge card       15
Name: card6, dtype: int64
```

```
In [ ]:
```

```
In [36]: dataframe_dtypes = pd.DataFrame(train_transaction_identity2.dtypes)
```

```
In [59]: pd.set_option('display.max_rows', 200)
pd.set_option('display.max_columns', 50)
```

```
In [39]: dataframe_dtypes
```

```
Out[39]:
```

	0
TransactionID	int64
isFraud	int64
TransactionDT	int64
TransactionAmt	float64
ProductCD	object
card1	int64
card3	float64
card4	object
card6	object
C1	float64
C2	float64
C3	float64
C4	float64
C5	float64
C6	float64
C7	float64
C8	float64
C9	float64
C10	float64
C11	float64

	0
C12	float64
C13	float64
C14	float64
D1	float64
V95	float64
V96	float64
V97	float64
V98	float64
V99	float64
V100	float64
V101	float64
V102	float64
V103	float64
V104	float64
V105	float64
V106	float64
V107	float64
V108	float64
V109	float64
V110	float64
V111	float64
V112	float64
V113	float64
V114	float64
V115	float64
V116	float64
V117	float64
V118	float64
V119	float64
V120	float64
V121	float64
V122	float64
V123	float64
V124	float64
V125	float64

0

V126 float64
V127 float64
V128 float64
V129 float64
V130 float64
V131 float64
V132 float64
V133 float64
V134 float64
V135 float64
V136 float64
V137 float64
V279 float64
V280 float64
V281 float64
V282 float64
V283 float64
V284 float64
V285 float64
V286 float64
V287 float64
V288 float64
V289 float64
V290 float64
V291 float64
V292 float64
V293 float64
V294 float64
V295 float64
V296 float64
V297 float64
V298 float64
V299 float64
V300 float64
V301 float64

0

```
V302    float64
V303    float64
V304    float64
V305    float64
V306    float64
V307    float64
V308    float64
V309    float64
V310    float64
V311    float64
V312    float64
V313    float64
V314    float64
V315    float64
V316    float64
V317    float64
V318    float64
V319    float64
V320    float64
V321    float64
```

```
In [ ]: pd.set_option('display.max_rows', 100)
pd.set_option('display.max_columns', 500)
```

```
In [41]: train_dummy = pd.get_dummies(train_transaction_identity2, drop_first=True)
train_dummy.head()
```

	TransactionID	isFraud	TransactionDT	TransactionAmt	card1	card3	C1	C2	C3	C4	C5
0	2987000	0	86400	68.5	13926	150.0	1.0	1.0	0.0	0.0	0.0
1	2987001	0	86401	29.0	2755	150.0	1.0	1.0	0.0	0.0	0.0
2	2987002	0	86469	59.0	4663	150.0	1.0	1.0	0.0	0.0	0.0
3	2987003	0	86499	50.0	18132	150.0	2.0	5.0	0.0	0.0	0.0
4	2987004	0	86506	50.0	4497	150.0	1.0	1.0	0.0	0.0	0.0

5 rows × 117 columns

In []: