Чем лучше бустить? Тестируем алгоритмы бустинга в бою.

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

```
!pip install catboost
```

```
Requirement already satisfied: catboost in /usr/local/lib/python3.7/dist-packages (0.25)
Requirement already satisfied: numpy>=1.16.0 in /usr/local/lib/python3.7/dist-packages (from catboost) (1.19.5)
Requirement already satisfied: pandas>=0.24.0 in /usr/local/lib/python3.7/dist-packages (from catboost) (1.1.5)
Requirement already satisfied: plotly in /usr/local/lib/python3.7/dist-packages (from catboost) (4.4.1)
Requirement already satisfied: graphviz in /usr/local/lib/python3.7/dist-packages (from catboost) (0.10.1)
Requirement already satisfied: scipy in /usr/local/lib/python3.7/dist-packages (from catboost) (1.4.1)
Requirement already satisfied: matplotlib in /usr/local/lib/python3.7/dist-packages (from catboost) (3.2.2)
Requirement already satisfied: six in /usr/local/lib/python3.7/dist-packages (from catboost) (1.15.0)
Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.7/dist-packages (from pandas>=0.24.0->catboost) (2018.9)
Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python3.7/dist-packages (from pandas>=0.24.0->catboost) (2.8.1)
Requirement already satisfied: retrying>=1.3.3 in /usr/local/lib/python3.7/dist-packages (from plotly->catboost) (1.3.3)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.7/dist-packages (from matplotlib->catboost) (0.10.0)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /usr/local/lib/python3.7/dist-packages (from matplotlib->catbo
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.7/dist-packages (from matplotlib->catboost) (1.3.1)
```

Часть 1. EDA, Часть 2. Preprocessing & Feature Engineering

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

import warnings
warnings.simplefilter(action='ignore', category=FutureWarning)
```

```
from sklearn.preprocessing import LabelEncoder
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split,cross_val_score, StratifiedKFold, GridSearchCV
from sklearn.metrics import accuracy_score,confusion_matrix,roc_auc_score,roc_curve,classification_report, precision_score, recall_score, f1_sc
from xgboost.sklearn import XGBClassifier
from catboost import CatBoostClassifier
from lightgbm import LGBMClassifier


%matplotlib inline
plt.rcParams["figure.figsize"] = (12,8)


data = pd.read_csv('/content/drive/MyDrive/STUDY/otus/HW/3/WA_Fn-UseC_-Telco-Customer-Churn.csv')


data.head()
```

	customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBa
0	7590-VHVEG	Female	0	Yes	No	1	No	No phone service	DSL	No	
1	5575-GNVDE	Male	0	No	No	34	Yes	No	DSL	Yes	
2	3668-QPYBK	Male	0	No	No	2	Yes	No	DSL	Yes	
3	7795-CFOCW	Male	0	No	No	45	No	No phone service	DSL	Yes	
4	9237-HQITU	Female	0	No	No	2	Yes	No	Fiber optic	No	

проверка на дубликаты

```
data[data.duplicated(['customerID'], keep=False)]
```

```
data[data.duplicated(['customerID'], keep=False)]
```

customerID	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBacl

```
data.describe()
```

	SeniorCitizen	tenure	MonthlyCharges
count	7043.000000	7043.000000	7043.000000
mean	0.162147	32.371149	64.761692
std	0.368612	24.559481	30.090047
min	0.000000	0.000000	18.250000
25%	0.000000	9.000000	35.500000
50%	0.000000	29.000000	70.350000
75%	0.000000	55.000000	89.850000
max	1.000000	72.000000	118.750000

```
data.columns
```

```
Index(['customerID', 'gender', 'SeniorCitizen', 'Partner', 'Dependents',
       'tenure', 'PhoneService', 'MultipleLines', 'InternetService',
       'OnlineSecurity', 'OnlineBackup', 'DeviceProtection', 'TechSupport',
       'StreamingTV', 'StreamingMovies', 'Contract', 'PaperlessBilling',
       'PaymentMethod', 'MonthlyCharges', 'TotalCharges', 'Churn'],
      dtype='object')
```

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 7043 entries, 0 to 7042
Data columns (total 21 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
```

```
 0   customerID        7043 non-null   object
 1   gender            7043 non-null   object
 2   SeniorCitizen     7043 non-null   int64
 3   Partner           7043 non-null   object
 4   Dependents        7043 non-null   object
 5   tenure            7043 non-null   int64
 6   PhoneService      7043 non-null   object
 7   MultipleLines     7043 non-null   object
 8   InternetService   7043 non-null   object
 9   OnlineSecurity    7043 non-null   object
 10  OnlineBackup      7043 non-null   object
 11  DeviceProtection  7043 non-null   object
 12  TechSupport       7043 non-null   object
 13  StreamingTV       7043 non-null   object
 14  StreamingMovies   7043 non-null   object
 15  Contract          7043 non-null   object
 16  PaperlessBilling  7043 non-null   object
 17  PaymentMethod     7043 non-null   object
 18  MonthlyCharges    7043 non-null   float64
 19  TotalCharges      7043 non-null   object
 20  Churn             7043 non-null   object
dtypes: float64(1), int64(2), object(18)
memory usage: 1.1+ MB


data.tail()
```

проверим на пропуски

7036 RESVB Male 0 Yes Yes 24 Yes Yes DSL Yes

```
data.isnull().sum()
```

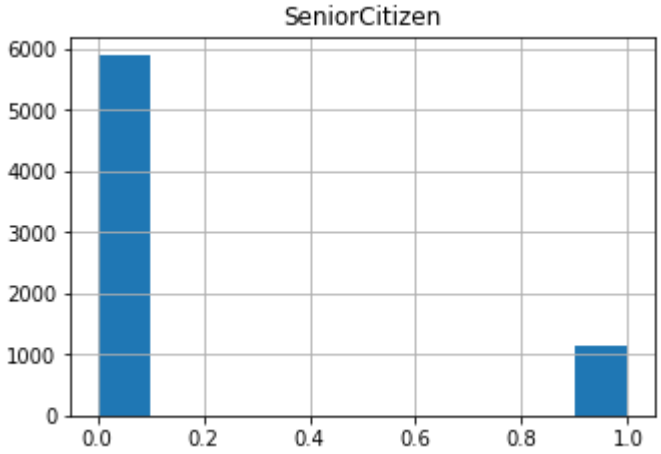
```
customerID          0
gender              0
SeniorCitizen       0
Partner             0
Dependents          0
tenure              0
PhoneService        0
MultipleLines       0
InternetService     0
OnlineSecurity      0
OnlineBackup        0
DeviceProtection    0
TechSupport         0
StreamingTV         0
StreamingMovies     0
Contract            0
PaperlessBilling    0
PaymentMethod       0
MonthlyCharges      0
TotalCharges        0
Churn               0
dtype: int64
```

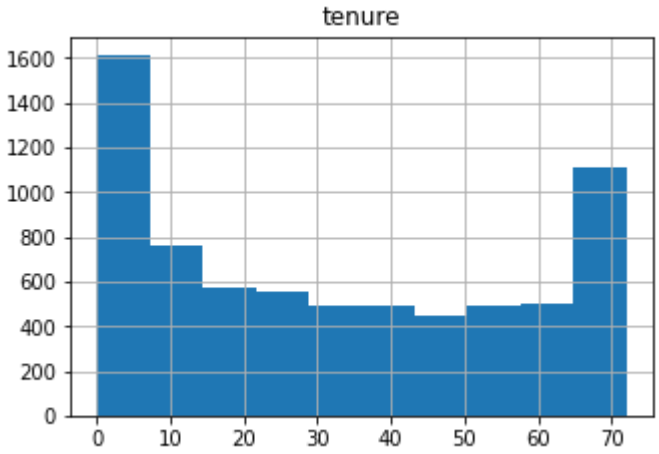
удалим лишнюю колонку

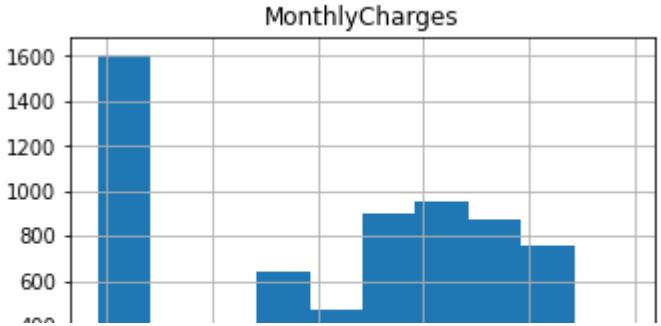
```
data.drop(columns=['customerID'], inplace = True)
```

```
data.hist()
```

```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x7f74453bb5d0>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x7f7445300bd0>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x7f74452c5250>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x7f74452798d0>]],
      dtype=object)
```

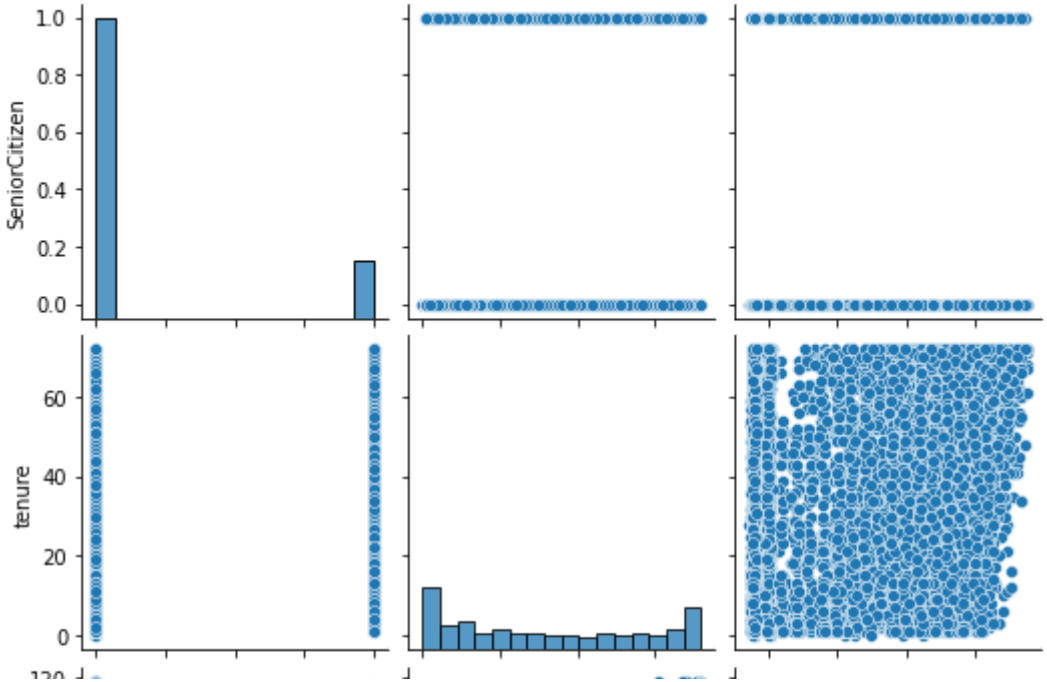







```
sns.pairplot(data)
```

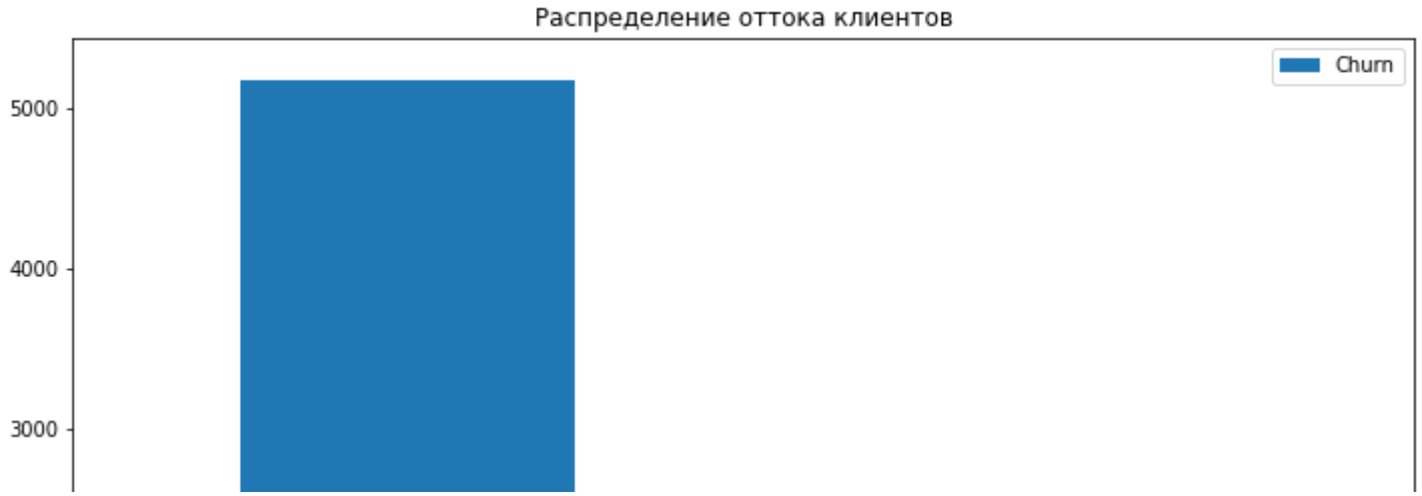
```
<seaborn.axisgrid.PairGrid at 0x7f7444c56090>
```



Target: Churn

```
data['Churn'].value_counts().plot(kind='bar', label='Churn').legend()
plt.title('Распределение оттока клиентов')
```

```
Text(0.5, 1.0, 'Распределение оттока клиентов')
```



оцифруем целевую переменную

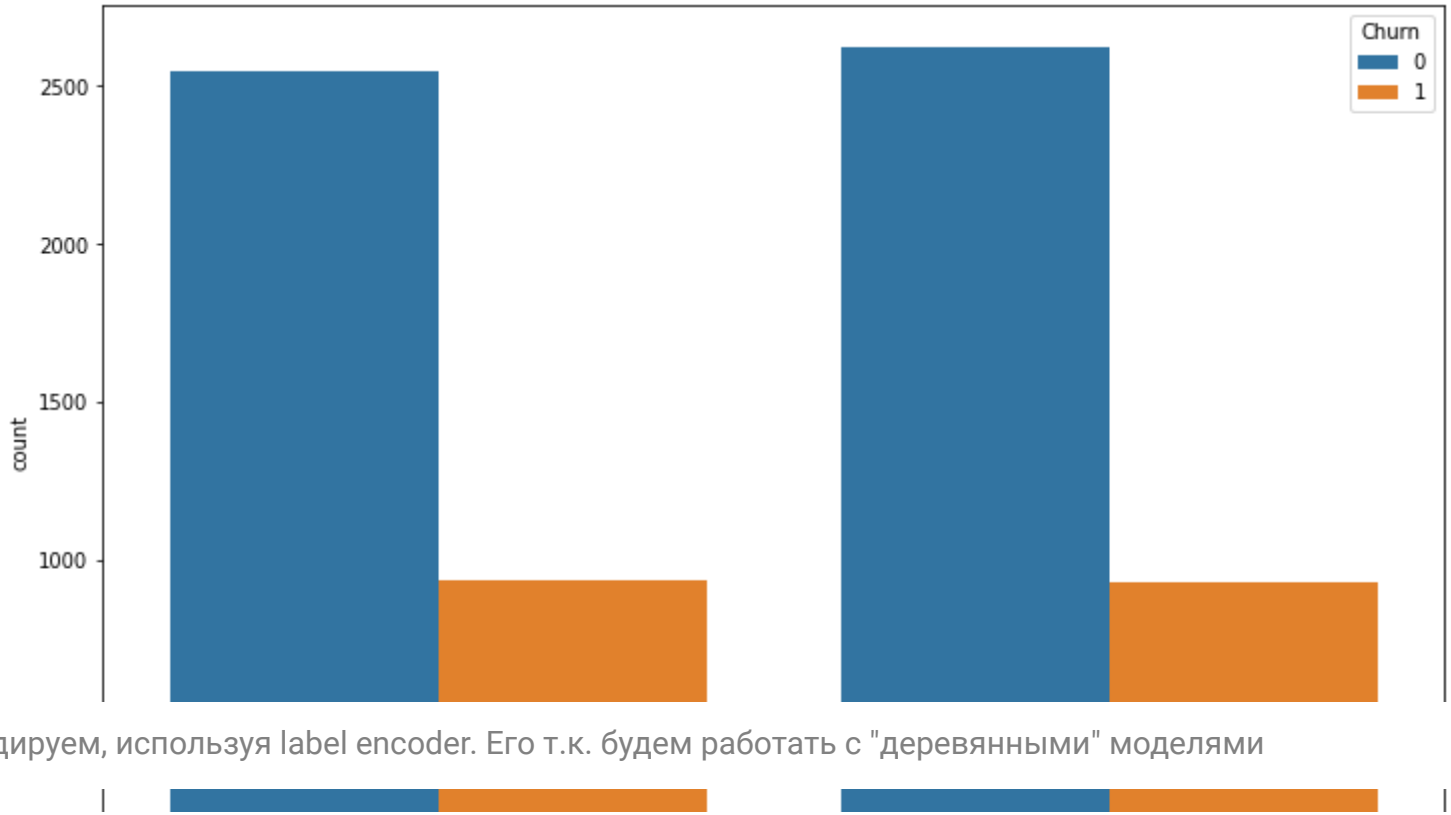
```
data['Churn'] = data['Churn'].apply(lambda x: 1 if x == 'Yes' else 0)
```

gender

```
data.gender.value_counts()
```

```
Male      3555
Female    3488
Name: gender, dtype: int64
```

```
sns.countplot(x='gender', hue='Churn', data=data);
```



закодируем, используя label encoder. Его т.к. будем работать с "деревянными" моделями

```
le = LabelEncoder()
```

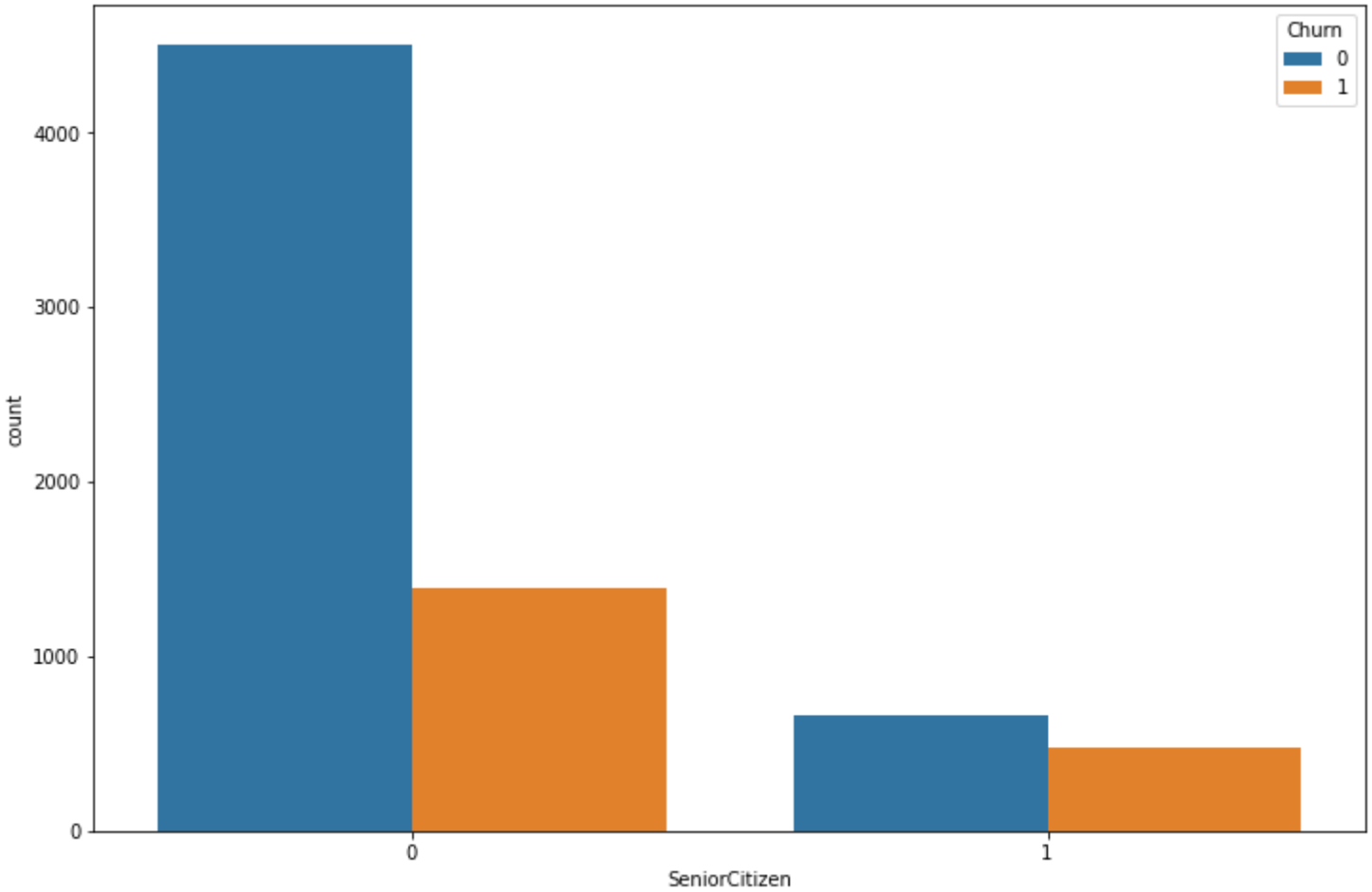
```
data.gender = le.fit_transform(data.gender)
```

SeniorCitizen

```
data.SeniorCitizen.value_counts()
```

```
0    5901
1    1142
Name: SeniorCitizen, dtype: int64
```

```
sns.countplot(x='SeniorCitizen', hue='Churn', data=data);
```



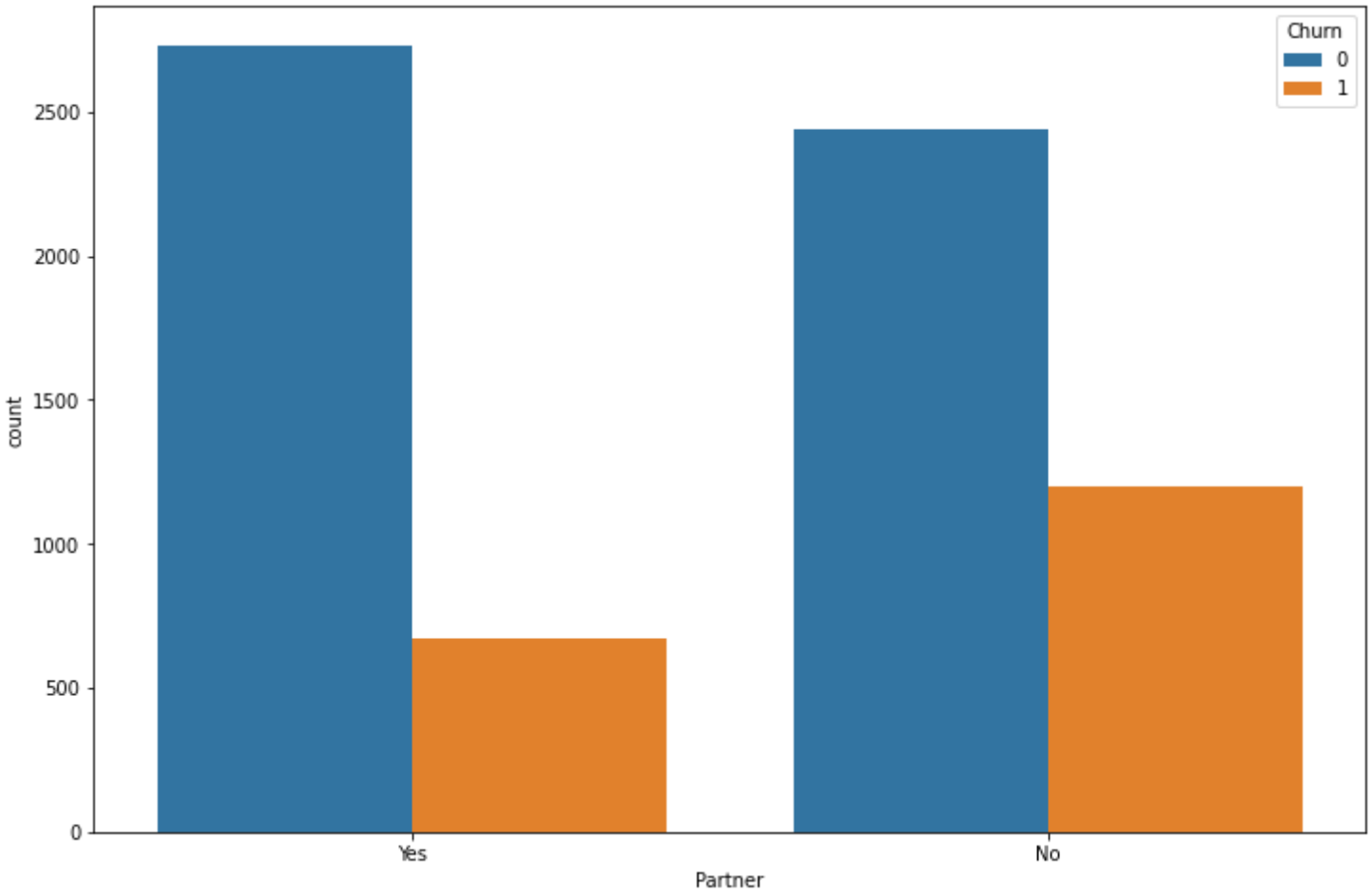

```
data.SeniorCitizen = le.fit_transform(data.SeniorCitizen)
```

Partneer

```
data.Partner.value_counts()
```

```
No     3641
Yes    3402
Name: Partner, dtype: int64
```

```
sns.countplot(x='Partner', hue='Churn', data=data);
```



интересный признак, люди без партнера чаще уходят от оператора, возможно это связано с тем, что одному проще сменить оператора. В паре нужно менять всем,т.к. звонки между одним и тем же оператором - дешевле

```
data.Partner = le.fit_transform(data.Partner)
```

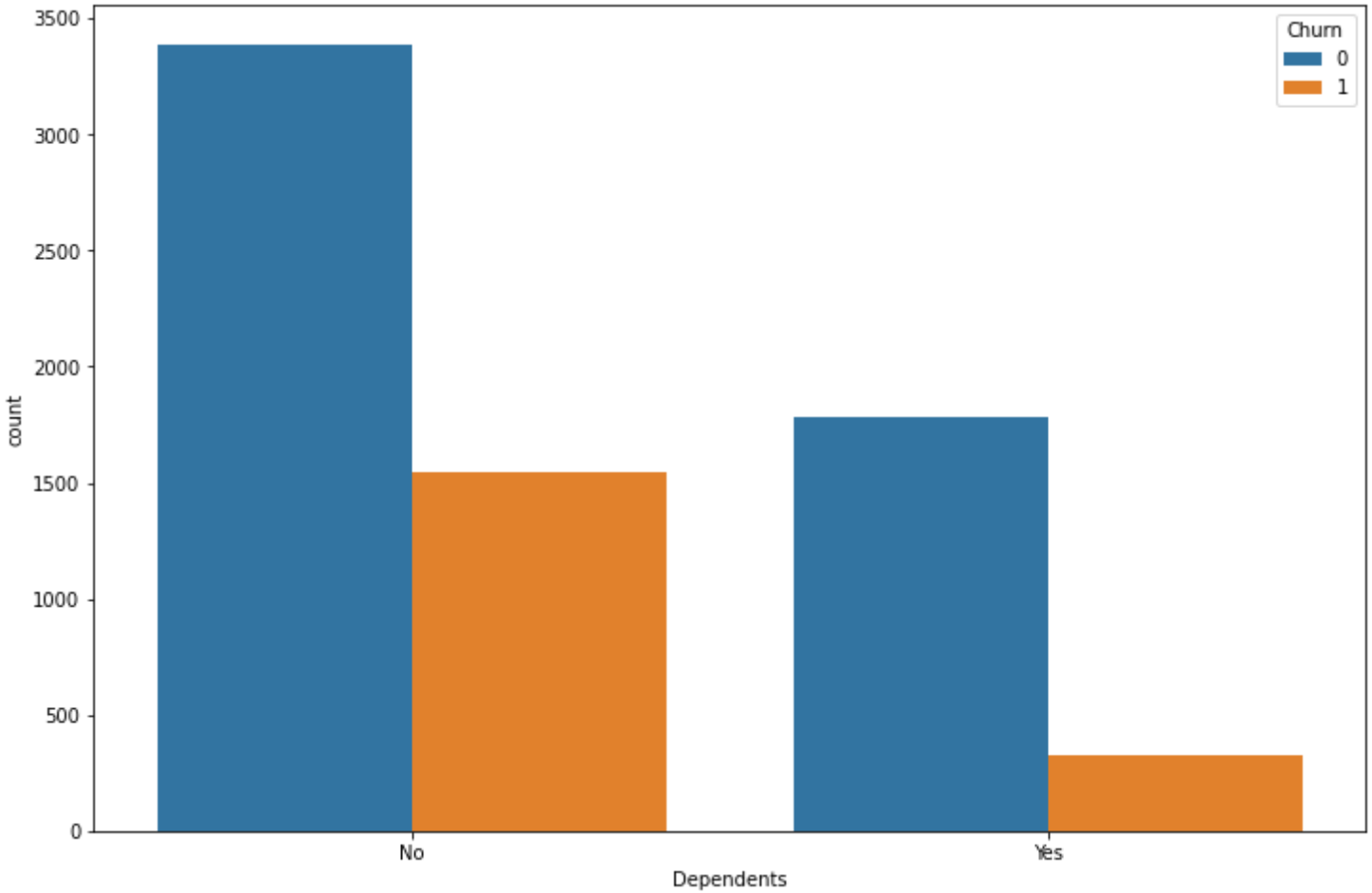
Dependents

```
data.Dependents.value_counts()
```

```
data.Dependents.value_counts()
```

```
No     4933
Yes    2110
Name: Dependents, dtype: int64
```

```
sns.countplot(x='Dependents', hue='Churn', data=data);
```



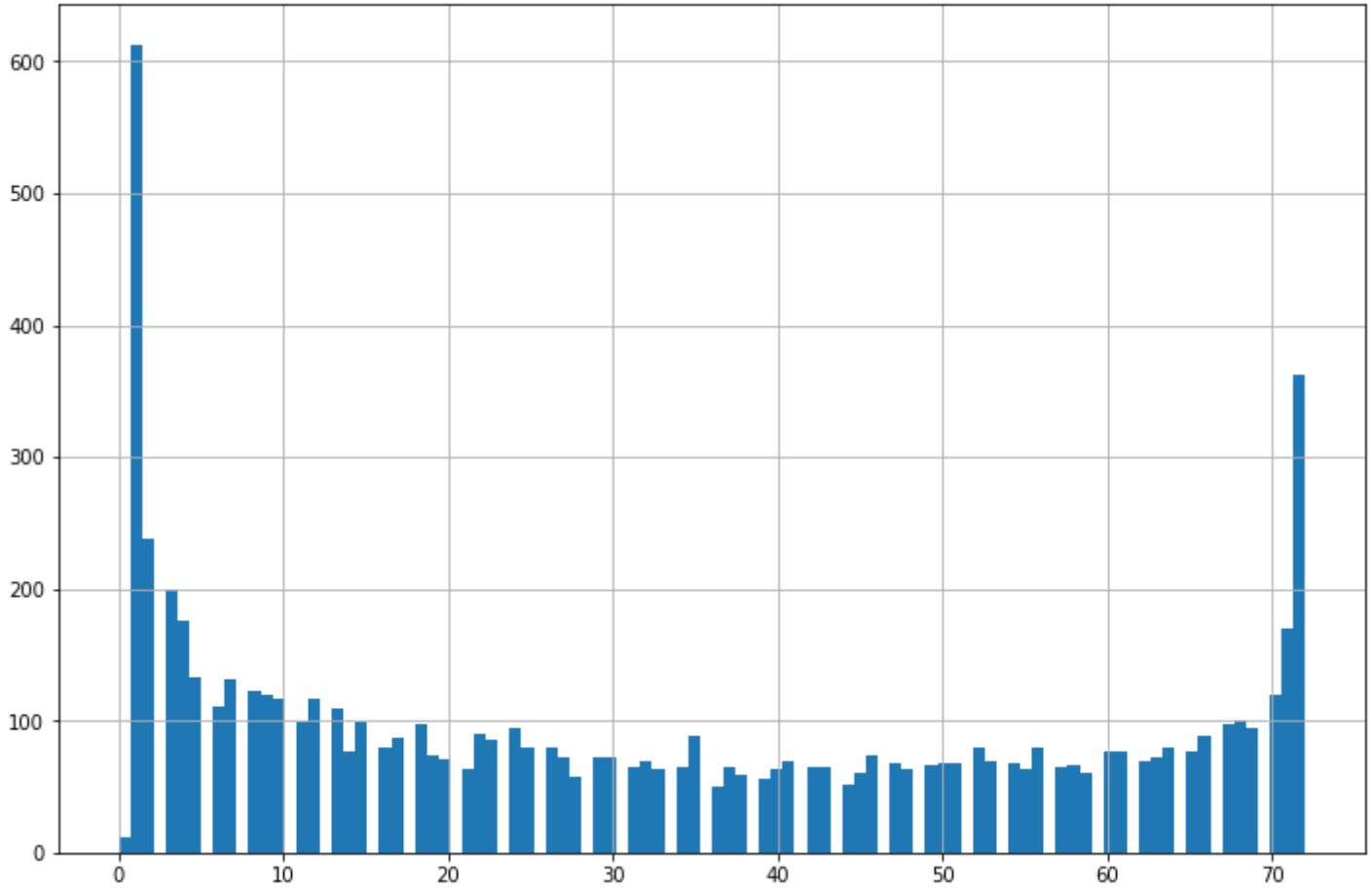
клиенты без иждивенцев чаще уходят

```
data.Dependents = le.fit_transform(data.Dependents)
```

tenure

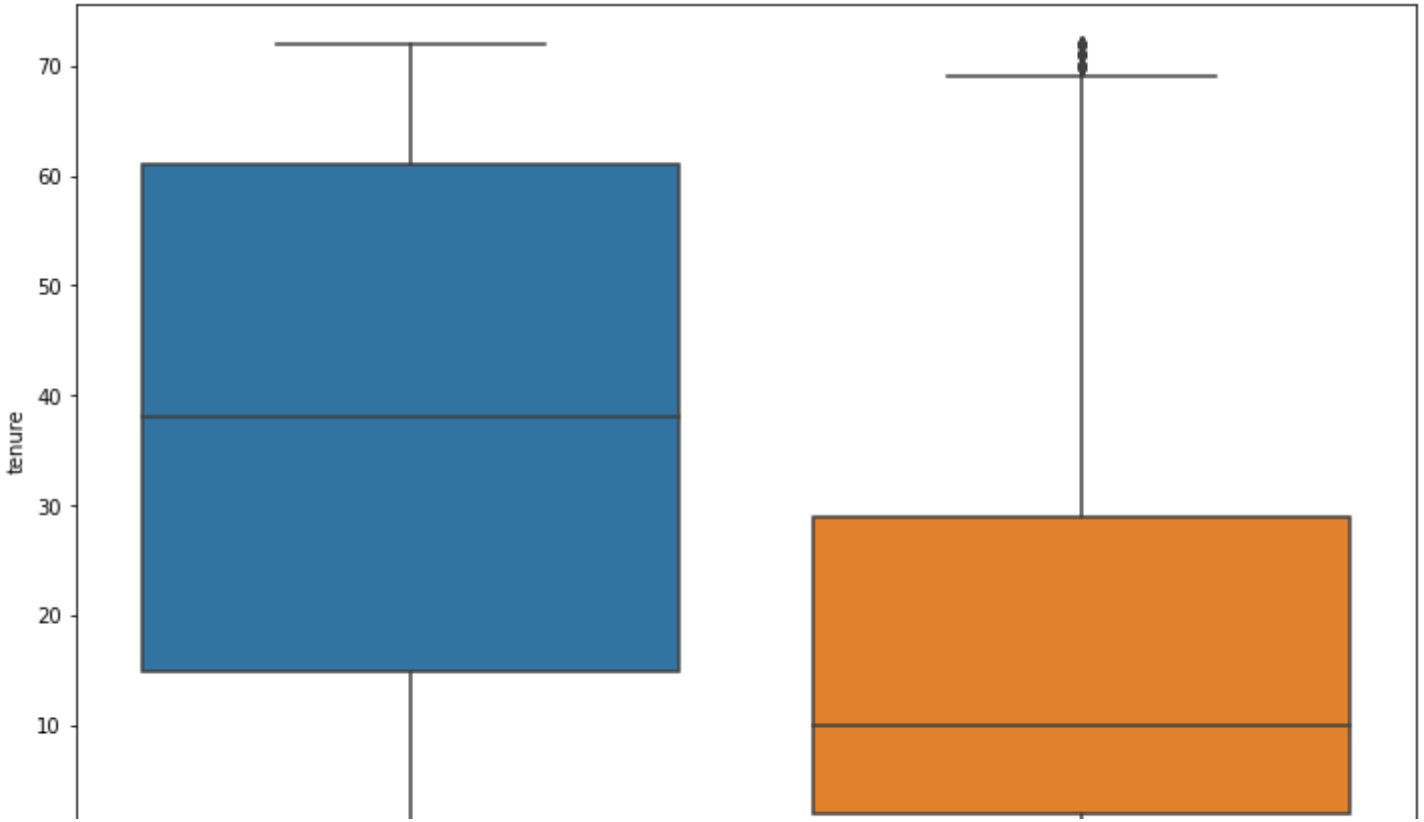
```
data.tenure.hist(bins = 100)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f743a2dd190>
```




```
sns.boxplot(x='Churn', y='tenure', data=data)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f743a145050>
```



видим, что иим что уходящие пользуются связью не так долго как постоянные клиенты

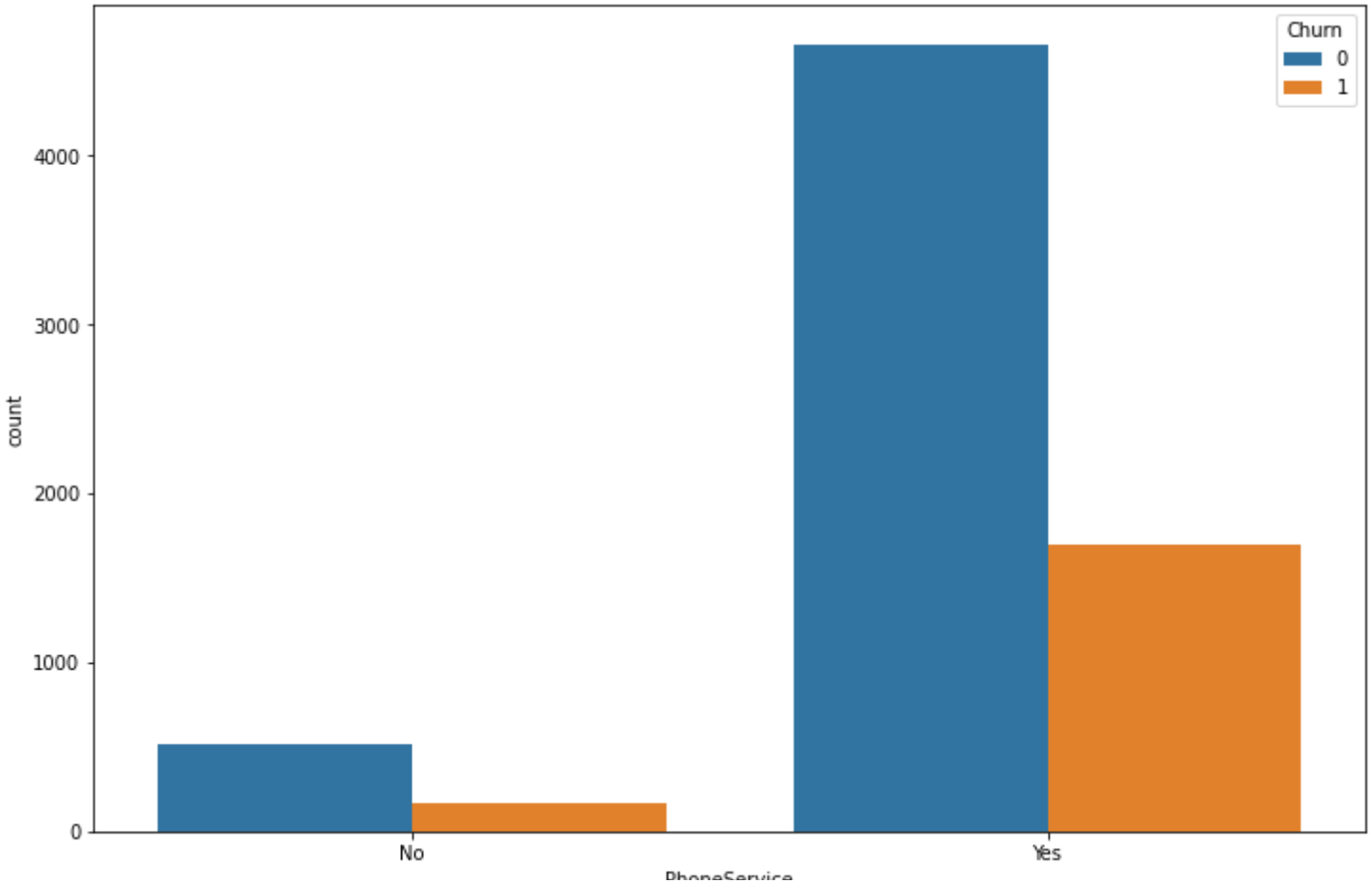
Churn

PhoneService

```
data.PhoneService.value_counts()
```

```
Yes    6361
No      682
Name: PhoneService, dtype: int64
```

```
sns.countplot(x='PhoneService', hue='Churn', data=data);
```



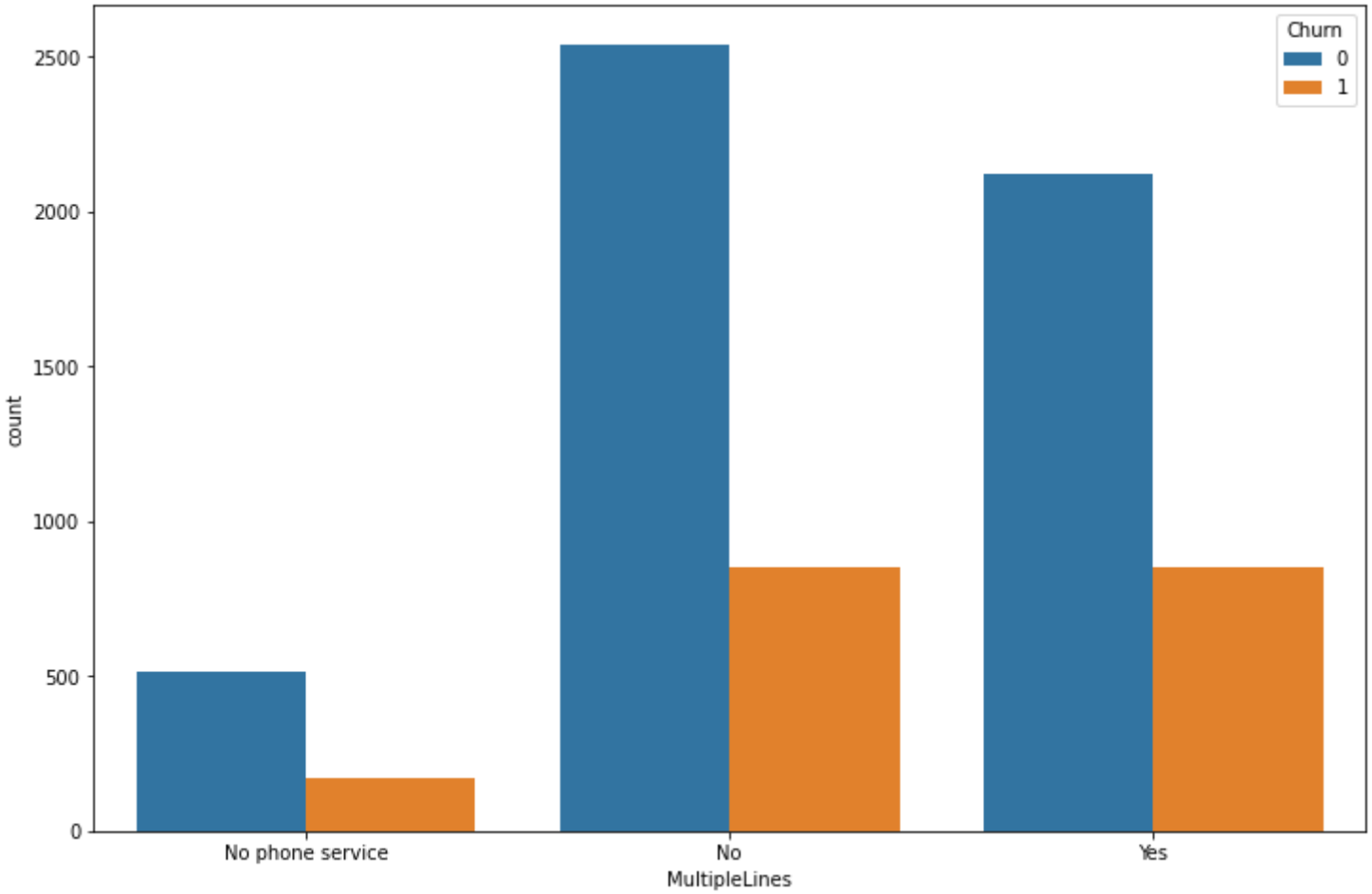

```
data.PhoneService = le.fit_transform(data.PhoneService)
```

MultipleLines

```
data.MultipleLines.value_counts()
```

```
No                  3390
Yes                 2971
No phone service     682
Name: MultipleLines, dtype: int64
```

```
sns.countplot(x='MultipleLines', hue='Churn', data=data);
```




```
data.MultipleLines = le.fit_transform(data.MultipleLines)
```

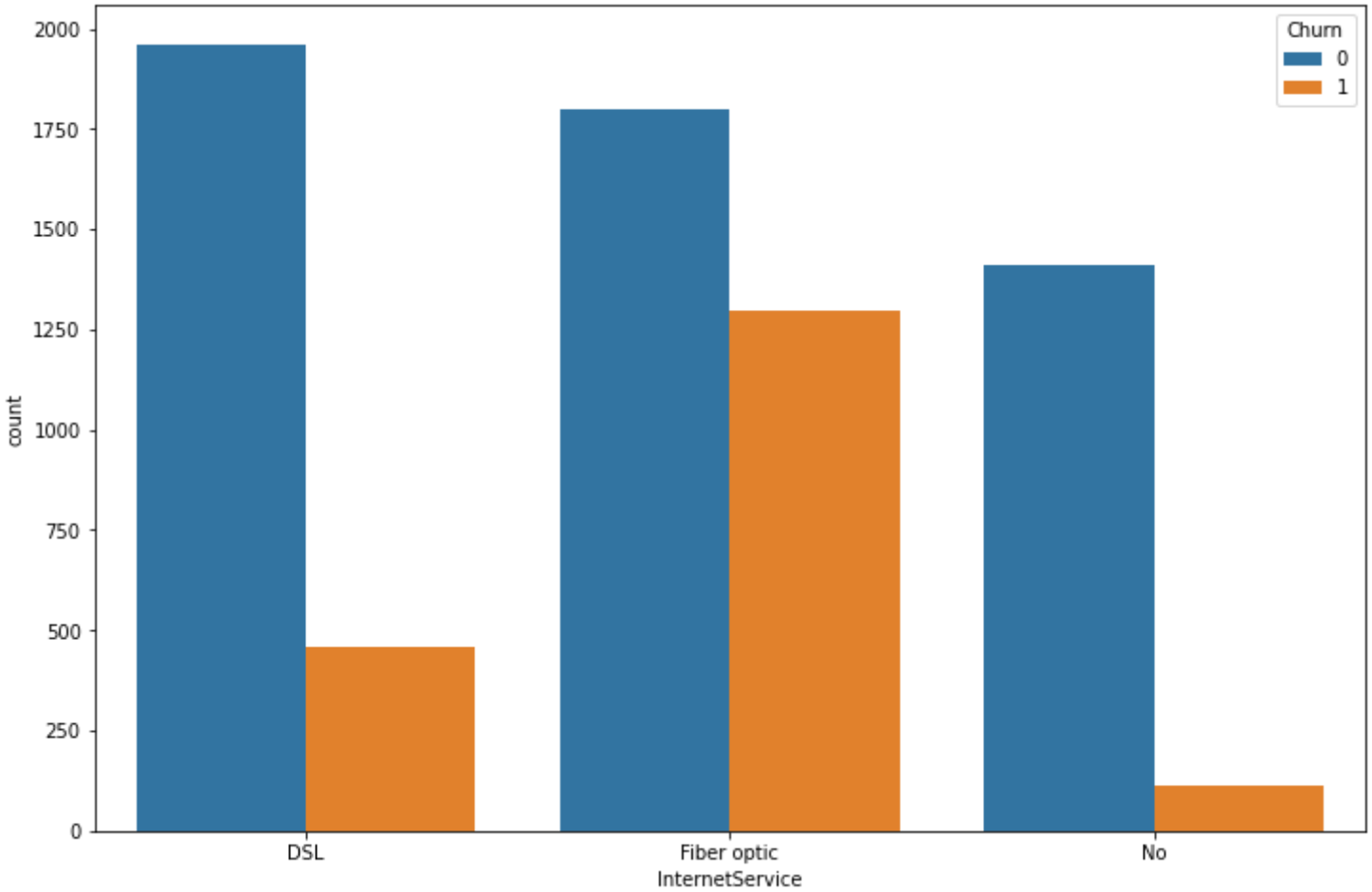
InternetService

```
data.InternetService.value_counts()
```

```
Fiber optic    3096
DSL            2421
```

```
No              1526
Name: InternetService, dtype: int64
```

```
sns.countplot(x='InternetService', hue='Churn', data=data);
```



интересное замечание, клиенты с оптоволокном лидируют по оттоку..

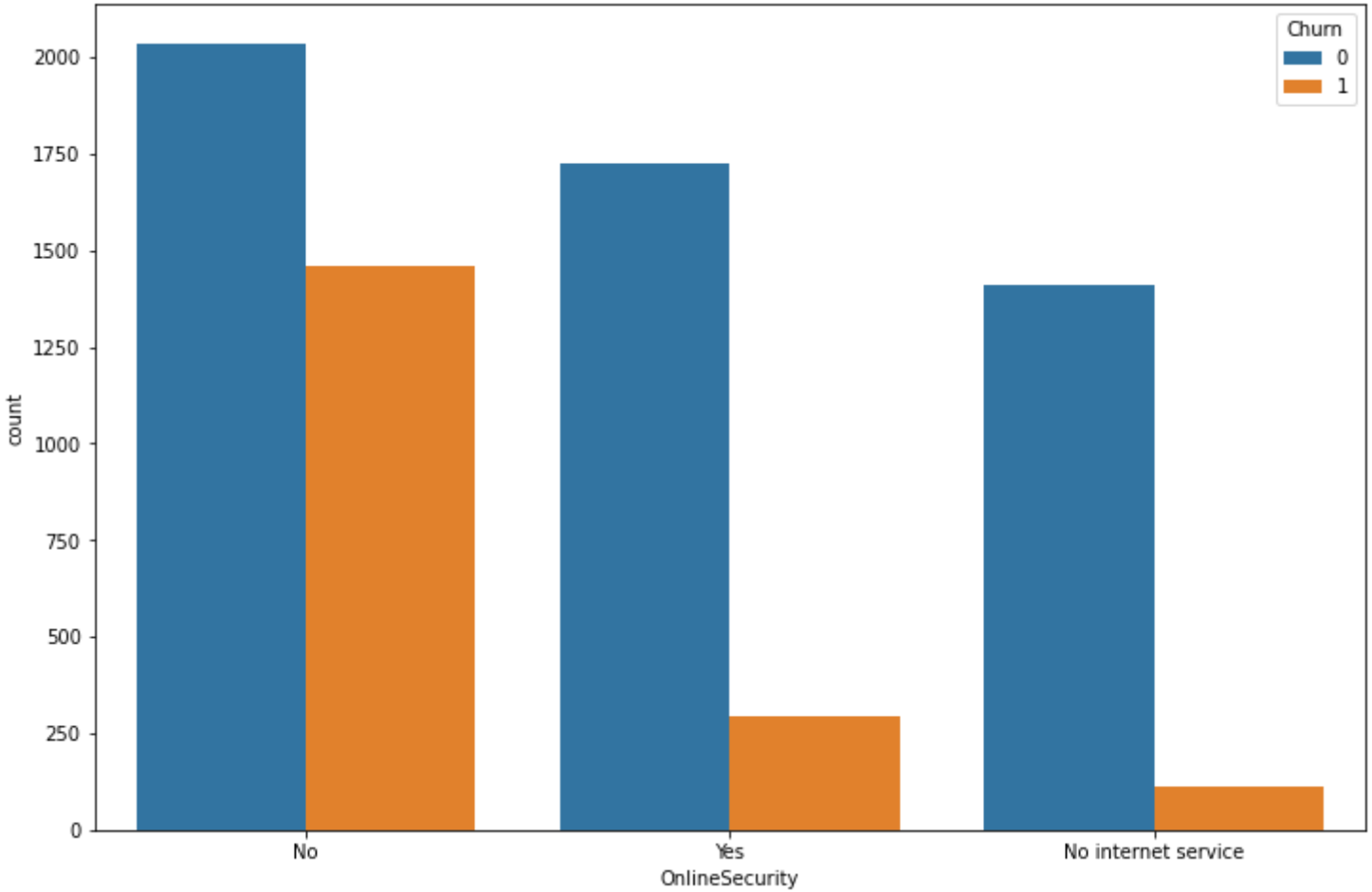
```
data.InternetService = le.fit_transform(data.InternetService)
```

OnlineSecurity

```
data.OnlineSecurity.value_counts()
```

```
No                     3498
Yes                    2019
No internet service    1526
Name: OnlineSecurity, dtype: int64
```

```
sns.countplot(x='OnlineSecurity', hue='Churn', data=data);
```



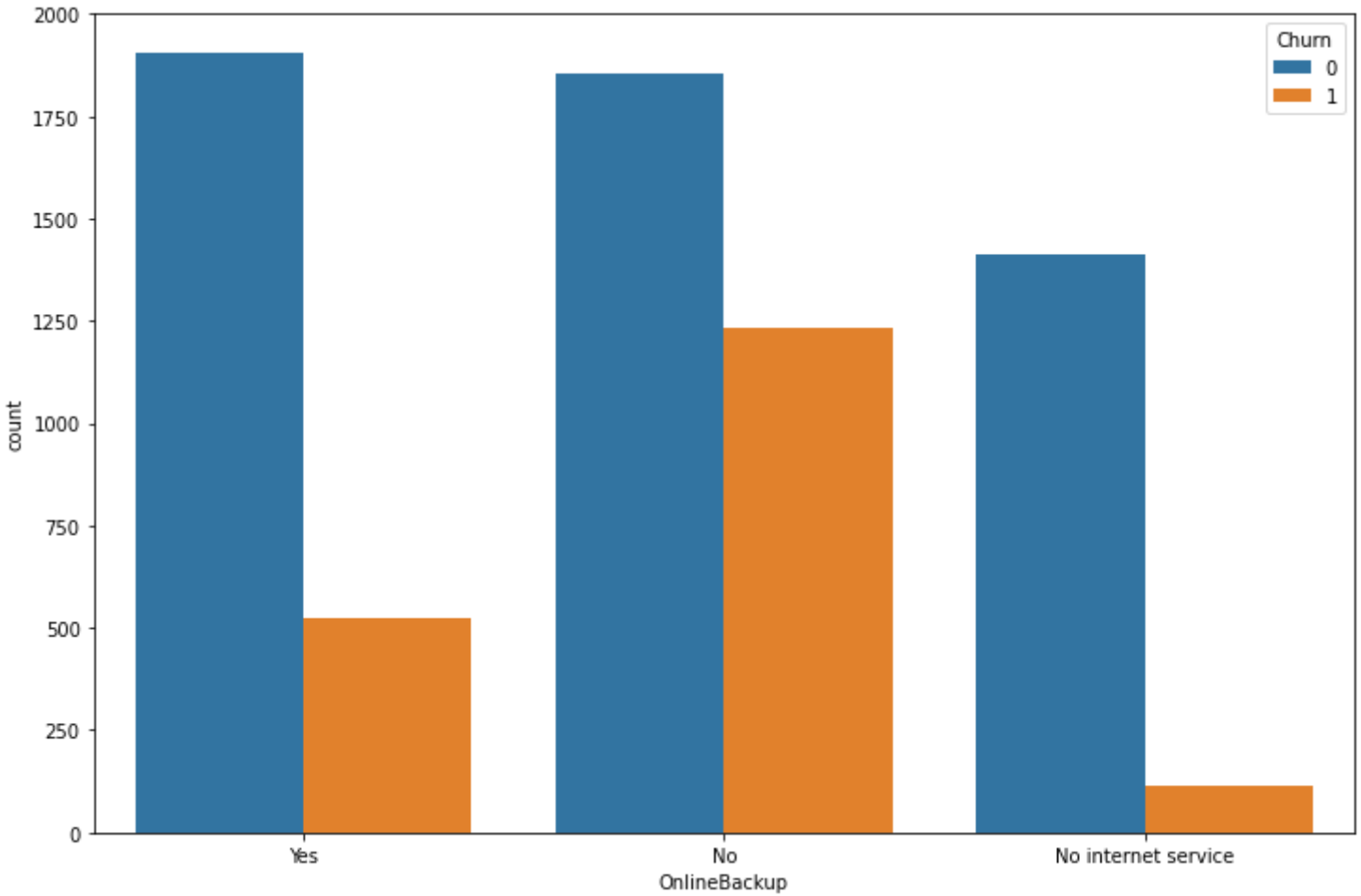

```
data.OnlineSecurity = le.fit_transform(data.OnlineSecurity)
```

OnlineBackup

```
data.OnlineBackup.value_counts()
```

```
No                     3088
Yes                    2429
No internet service    1526
Name: OnlineBackup, dtype: int64
```

```
sns.countplot(x='OnlineBackup', hue='Churn', data=data);
```



```
data.OnlineBackup = le.fit_transform(data.OnlineBackup)
```

DeviceProtection

```
data.DeviceProtection.value_counts()
```

```
No                     3095
Yes                    2422
No internet service    1526
Name: DeviceProtection, dtype: int64
```

```
sns.countplot(x='DeviceProtection', hue='Churn', data=data);
```

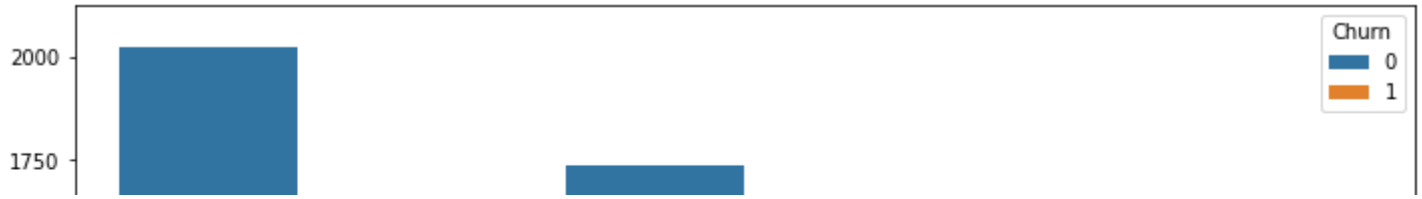

```
data.DeviceProtection = le.fit_transform(data.DeviceProtection)
```

TechSupport


```
data.TechSupport.value_counts()
```

```
No                     3473
Yes                    2044
No internet service    1526
Name: TechSupport, dtype: int64
```

```
sns.countplot(x='TechSupport', hue='Churn', data=data);
```




```
data.TechSupport = le.fit_transform(data.TechSupport)
```

StreamingTV

```
data.StreamingTV.value_counts()
```

```
No                     2810
Yes                    2707
No internet service    1526
Name: StreamingTV, dtype: int64
```

```
sns.countplot(x='StreamingTV', hue='Churn', data=data);
```

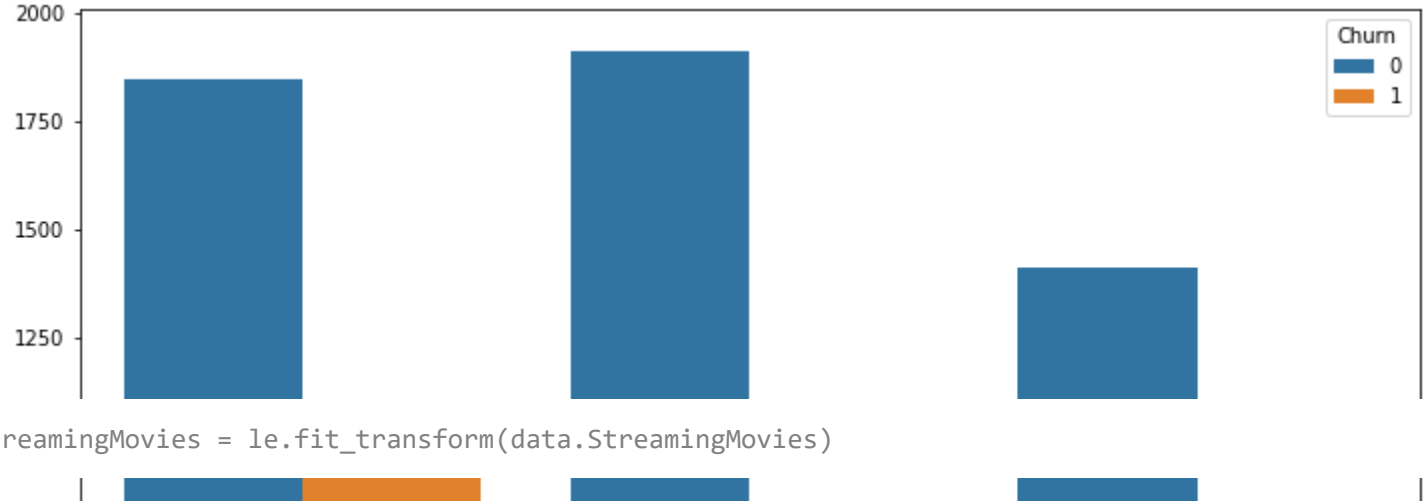

```
data.StreamingTV = le.fit_transform(data.StreamingTV)
```

StreamingMovies

```
data.StreamingMovies.value_counts()
```

```
No                     2785
Yes                    2732
No internet service    1526
Name: StreamingMovies, dtype: int64
```

```
sns.countplot(x='StreamingMovies', hue='Churn', data=data);
```




```
data.StreamingMovies = le.fit_transform(data.StreamingMovies)
```

```
data.head()
```

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	Device
0	0	0	1	0	1	0	1	0	0	2	
1	1	0	0	0	34	1	0	0	2	0	
2	1	0	0	0	2	1	0	0	2	2	
3	1	0	0	0	45	0	1	0	2	0	
4	0	0	0	0	2	1	0	1	0	0	

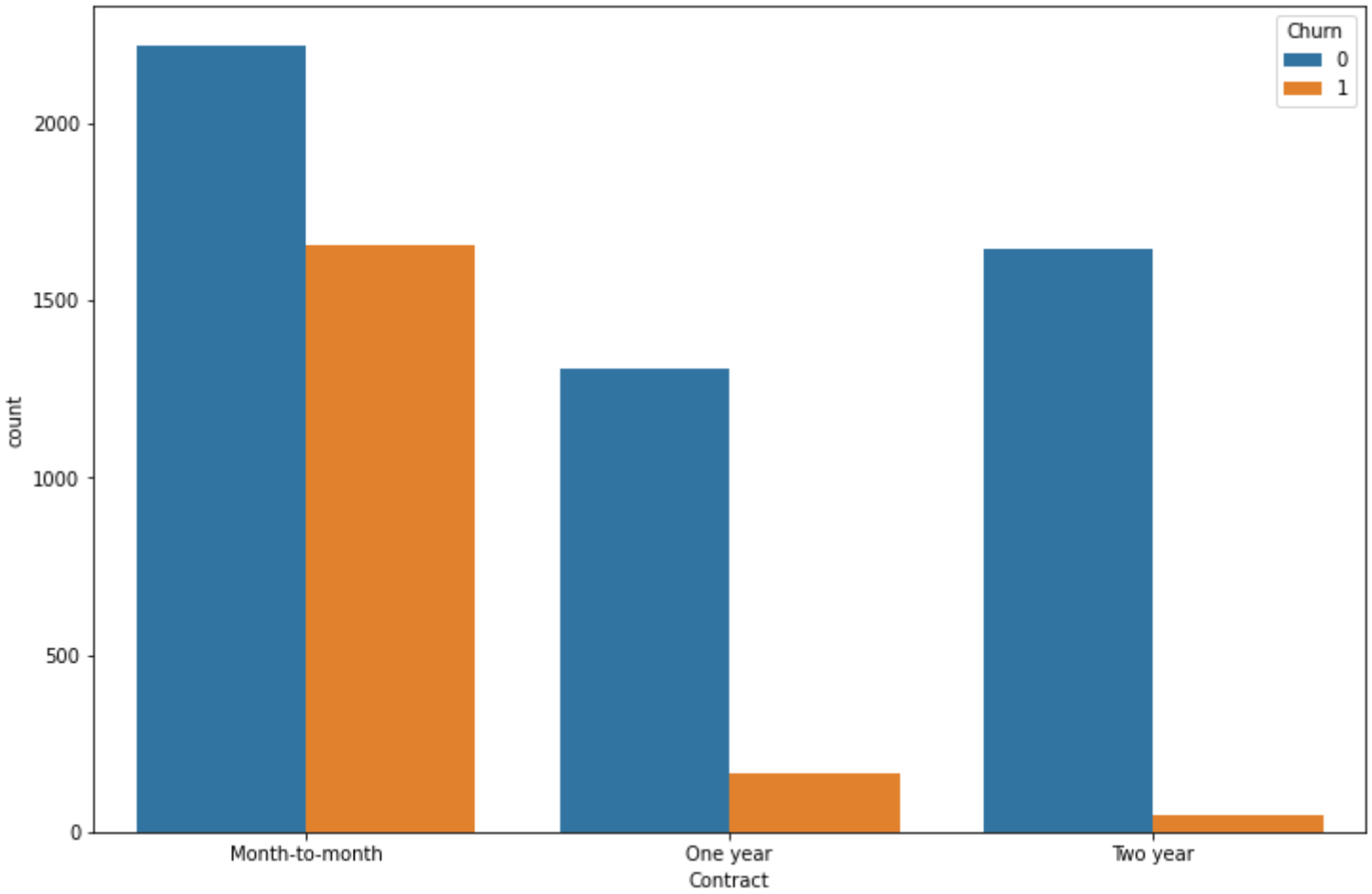
Contract

```
data.Contract.value_counts()
```

```
Month-to-month    3875
Two year          1695
```

```
One year          1473
Name: Contract, dtype: int64
```

```
sns.countplot(x='Contract', hue='Churn', data=data);
```



крутой признак, месячники уходят чаще

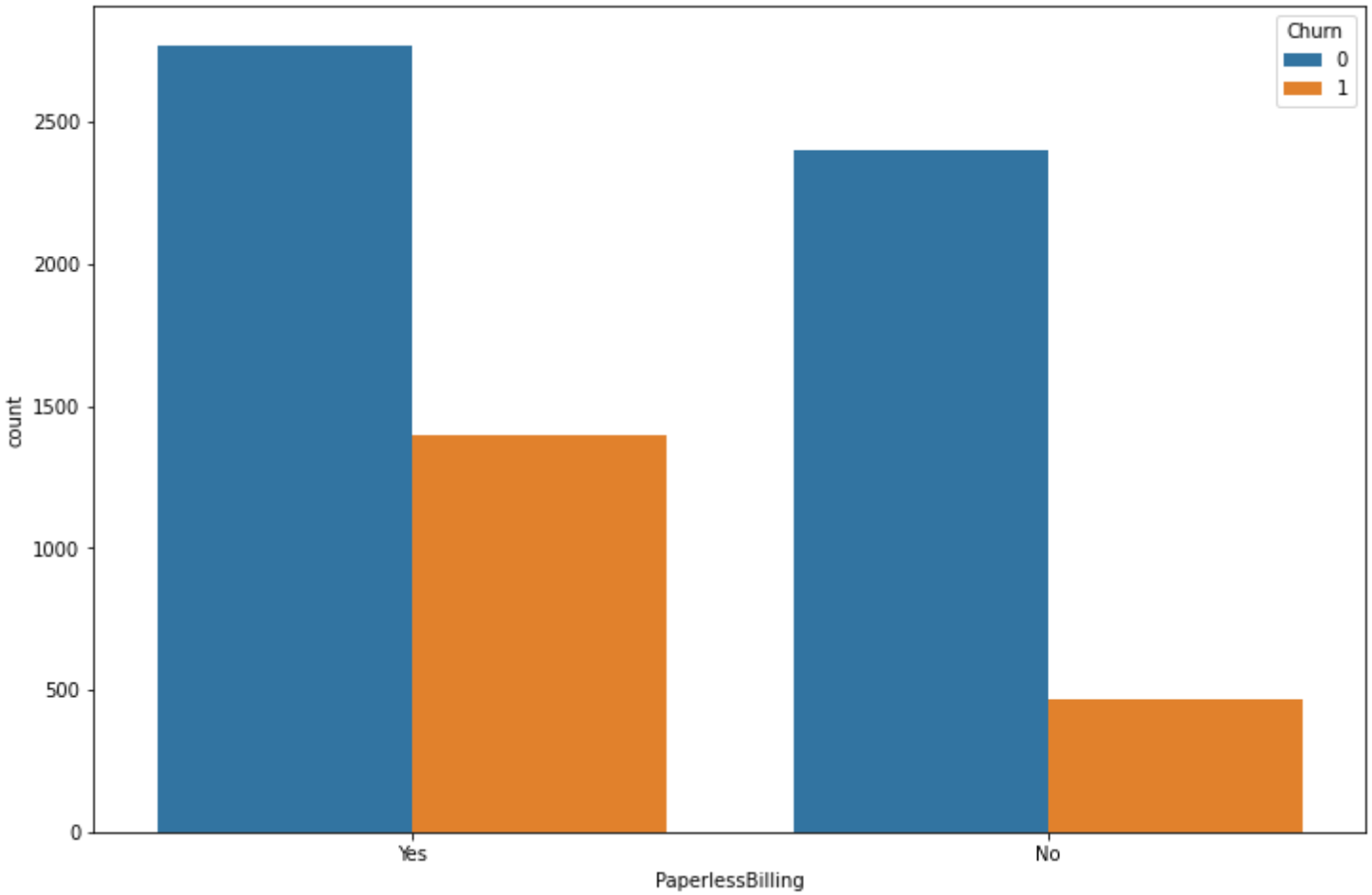
```
data.Contract = le.fit_transform(data.Contract)
```

PaperlessBilling

```
data.PaperlessBilling.value_counts()
```

```
Yes    4171
No     2872
Name: PaperlessBilling, dtype: int64
```

```
sns.countplot(x='PaperlessBilling', hue='Churn', data=data);
```



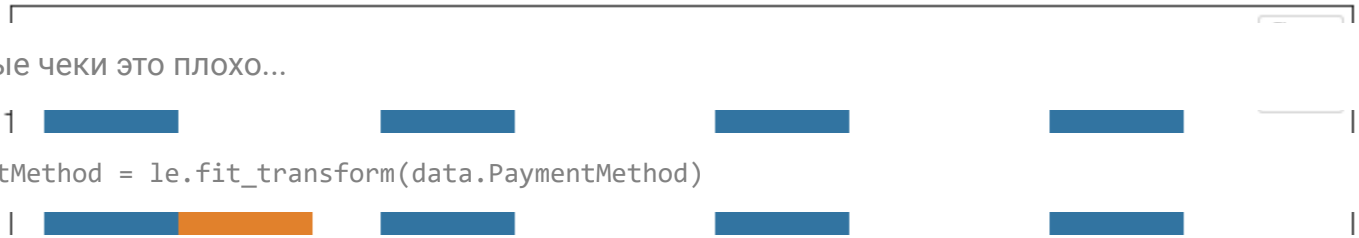

```
data.PaperlessBilling = le.fit_transform(data.PaperlessBilling)
```

PaymentMethod

```
data.PaymentMethod.value_counts()
```

```
Electronic check             2365
Mailed check                 1612
Bank transfer (automatic)    1544
Credit card (automatic)      1522
Name: PaymentMethod, dtype: int64
```

```
sns.countplot(x='PaymentMethod', hue='Churn', data=data);
```



электронные чеки это плохо...

```
data.PaymentMethod = le.fit_transform(data.PaymentMethod)
```



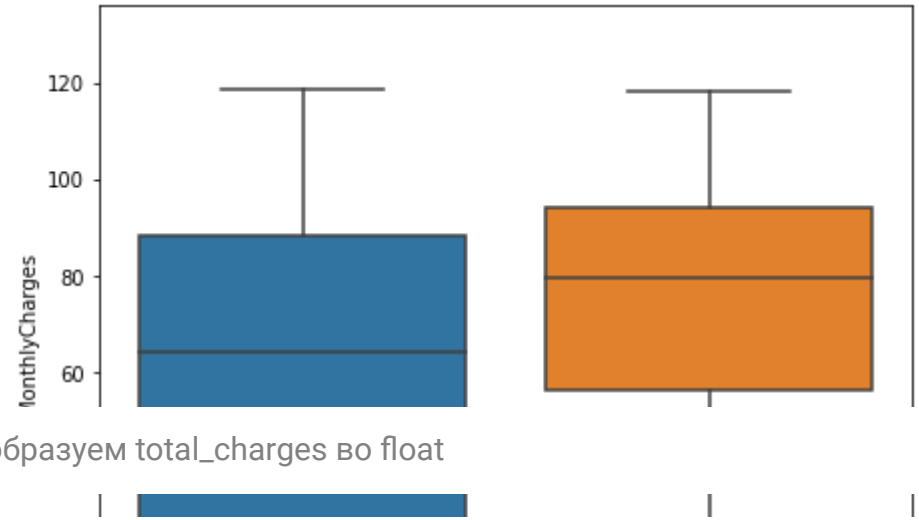
```
data.head()
```

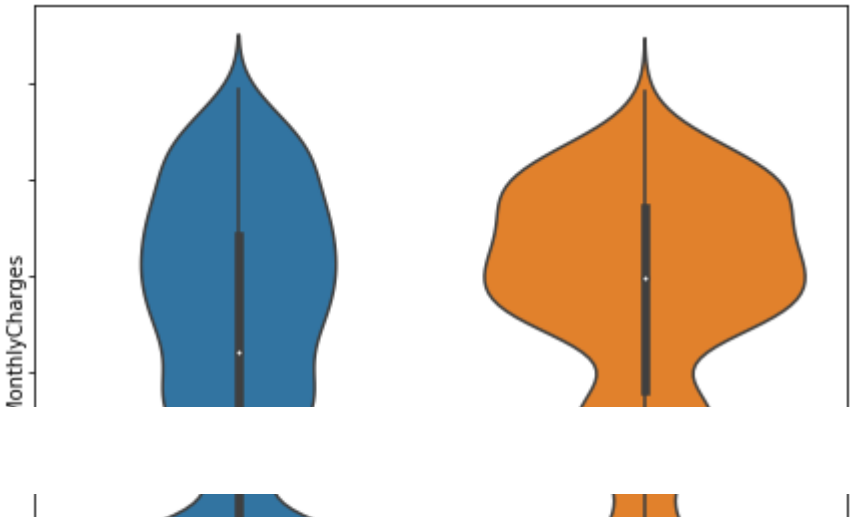
	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	Device
0	0	0	1	0	1	0	1	0	0	2	
1	1	0	0	0	34	1	0	0	2	0	
2	1	0	0	0	2	1	0	0	2	2	
3	1	0	0	0	45	0	1	0	2	0	
4	0	0	0	0	2	1	0	1	0	0	

MonthlyCharges TotalCharges

```
_, axes = plt.subplots(1, 2, sharey=True, figsize=(16,6))

sns.boxplot(x='Churn', y='MonthlyCharges', data=data, ax=axes[0]);
sns.violinplot(x='Churn', y='MonthlyCharges', data=data, ax=axes[1]);
```





преобразуем total_charges во float

```
data['TotalCharges']
```

```
0         29.85
1        1889.5
2        108.15
3       1840.75
4        151.65
         ...
7038     1990.5
7039     7362.9
7040     346.45
7041      306.6
7042     6844.5
Name: TotalCharges, Length: 7043, dtype: object
```

```
data[data['TotalCharges'].str.match(' ') == False]
```

	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	Dev
0	0	0	1	0	1	0	1	0	0	2	
1	1	0	0	0	34	1	0	0	2	0	
2	1	0	0	0	2	1	0	0	2	2	
3	1	0	0	0	45	0	1	0	2	0	
4	0	0	0	0	2	1	0	1	0	0	
...	...	...	...	...	...	...	...	...	...	...	...
7038	1	0	1	1	24	1	2	0	2	0	
7039	0	0	1	1	72	1	2	1	0	2	

```
data['TotalCharges'] = data['TotalCharges'].apply(lambda x: 0 if x == ' ' else x)
```

```
data[data['TotalCharges'] == 0]
```

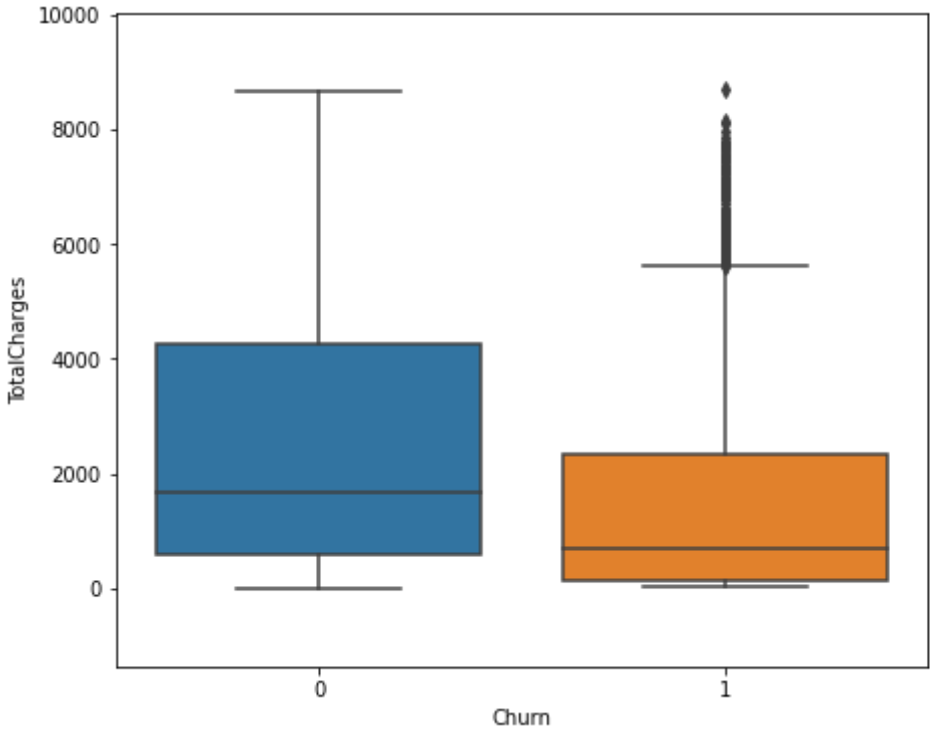
	gender	SeniorCitizen	Partner	Dependents	tenure	PhoneService	MultipleLines	InternetService	OnlineSecurity	OnlineBackup	Dev

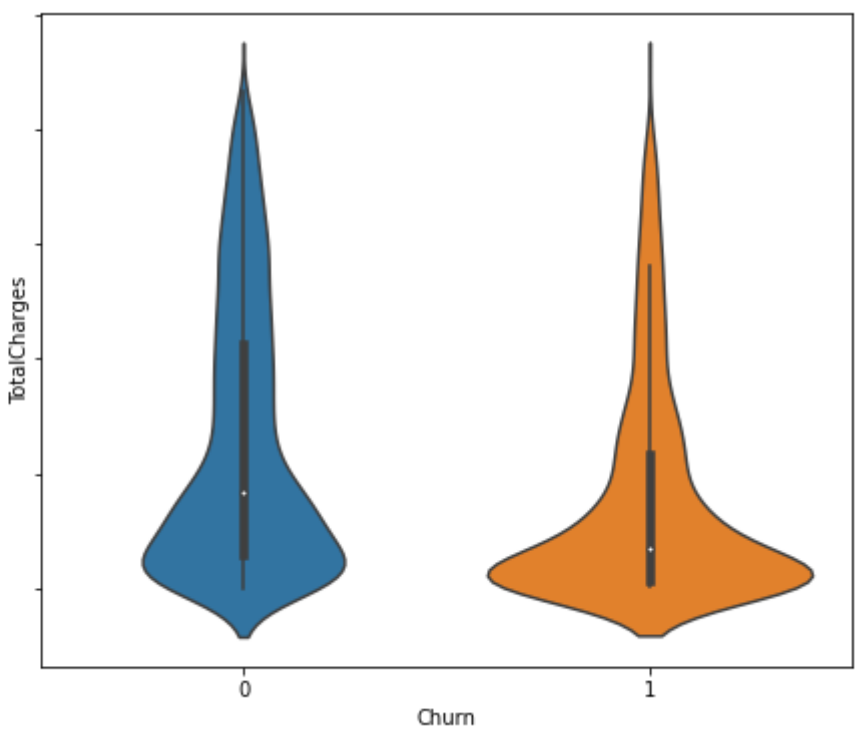
```
data['TotalCharges'] = data['TotalCharges'].astype('float64')
```

753	1	0	0	1	0	1	0	2	1	1	

```
_, axes = plt.subplots(1, 2, sharey=True, figsize=(16,6))

sns.boxplot(x='Churn', y='TotalCharges', data=data, ax=axes[0]);
sns.violinplot(x='Churn', y='TotalCharges', data=data, ax=axes[1]);
```



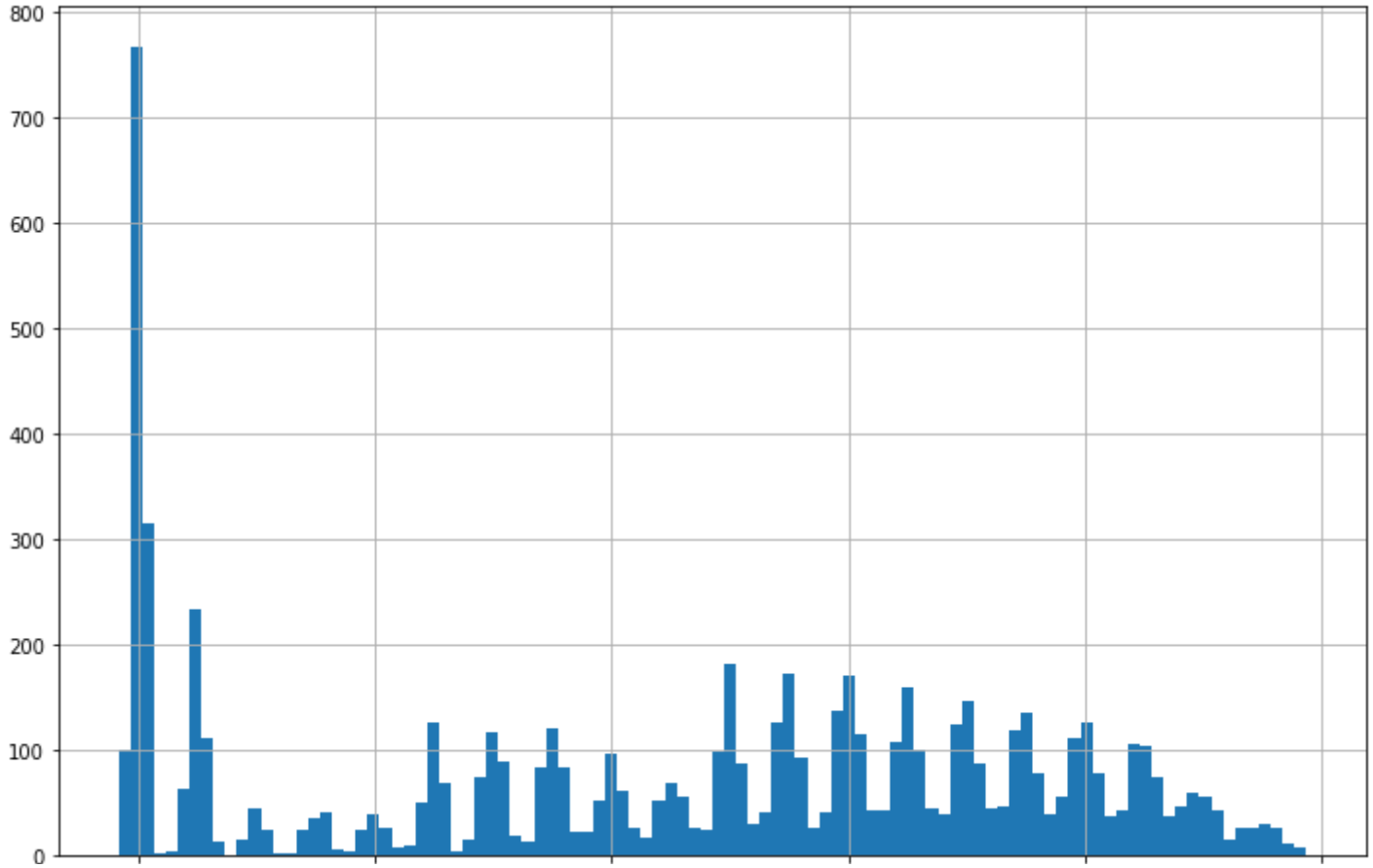



```
data.TotalCharges.corr(data.MonthlyCharges)
```

```
0.6511738315787841
```

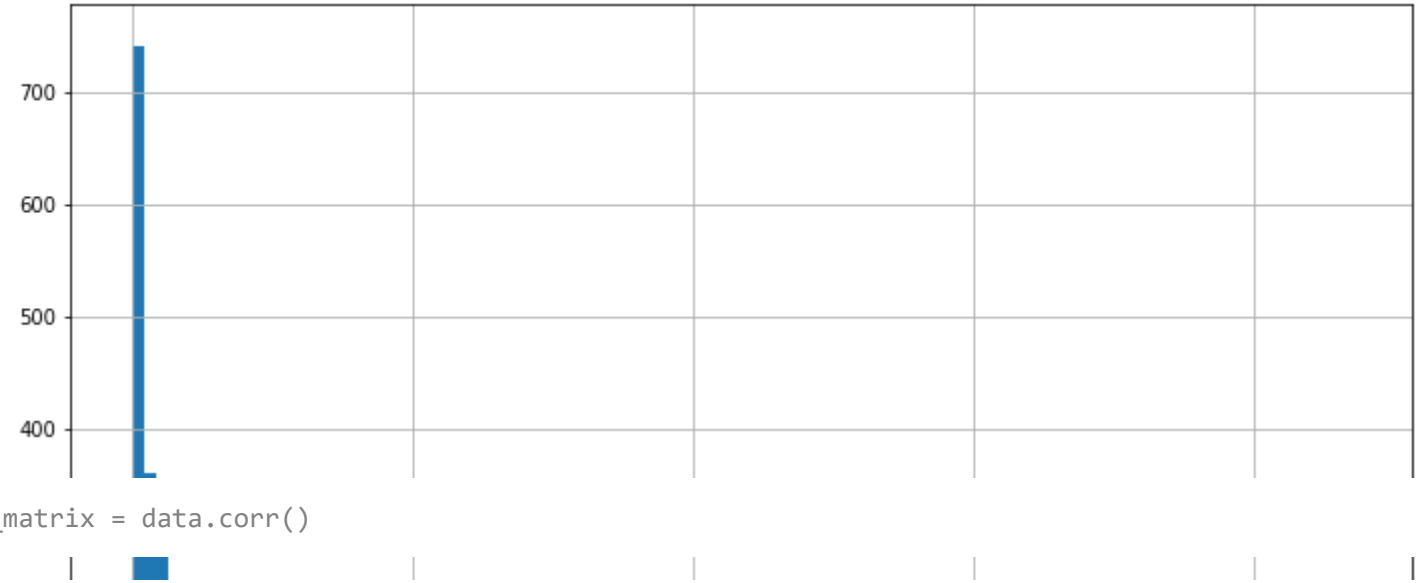
```
data.MonthlyCharges.hist(bins = 100)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f743a3aa7d0>
```




```
data.TotalCharges.hist(bins = 100)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f744513d050>
```




```
corr_matrix = data.corr()
```



```
sns.heatmap(corr_matrix);
```

Часть 3.Who's the mightiest of them all?

функция качества модели


```
def quality(prediction_y, true_y):
    accuracy = accuracy_score(prediction_y, true_y)
    precision = precision_score(prediction_y, true_y)
    recall = recall_score(prediction_y, true_y)
    f1 = f1_score(prediction_y, true_y)
    print("Accuracy:  {:.3f}\nPrecision: {:.3f}\nRecall:    {:.3f}\nF1-score:  {:.3f}".format(
        accuracy, precision, recall, f1
    ))
```

функция построения кривой roc_auc

```
def plot_roc_curve(prob_prediction, actual):
    fpr, tpr, thresholds = roc_curve(y_test, prob_prediction)
    auc_score = roc_auc_score(y_test, prob_prediction)

    plt.plot(fpr, tpr, label='ROC curve ')
    plt.plot([0, 1], [0, 1])
    plt.xlim([0.0, 1.0])
    plt.ylim([0.0, 1.05])
    plt.xlabel('False Positive Rate')
```

```
    plt.ylabel('True Positive Rate')
    plt.title('ROC AUC: {:.3f}'.format(auc_score))
    plt.show()
```

sklearn RandomForest

```
X_train, X_test, y_train, y_test = train_test_split(
    data.drop(['Churn'], axis = 1), data.Churn, test_size=0.3, random_state=2021, stratify=data.Churn.values)
```

```
clfRF = RandomForestClassifier(random_state=2021)
clfRF.fit(X_train, y_train)
```

```
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='gini', max_depth=None, max_features='auto',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=100,
                       n_jobs=None, oob_score=False, random_state=2021,
                       verbose=0, warm_start=False)
```

```
predRF = clfRF.predict(X_test)
```

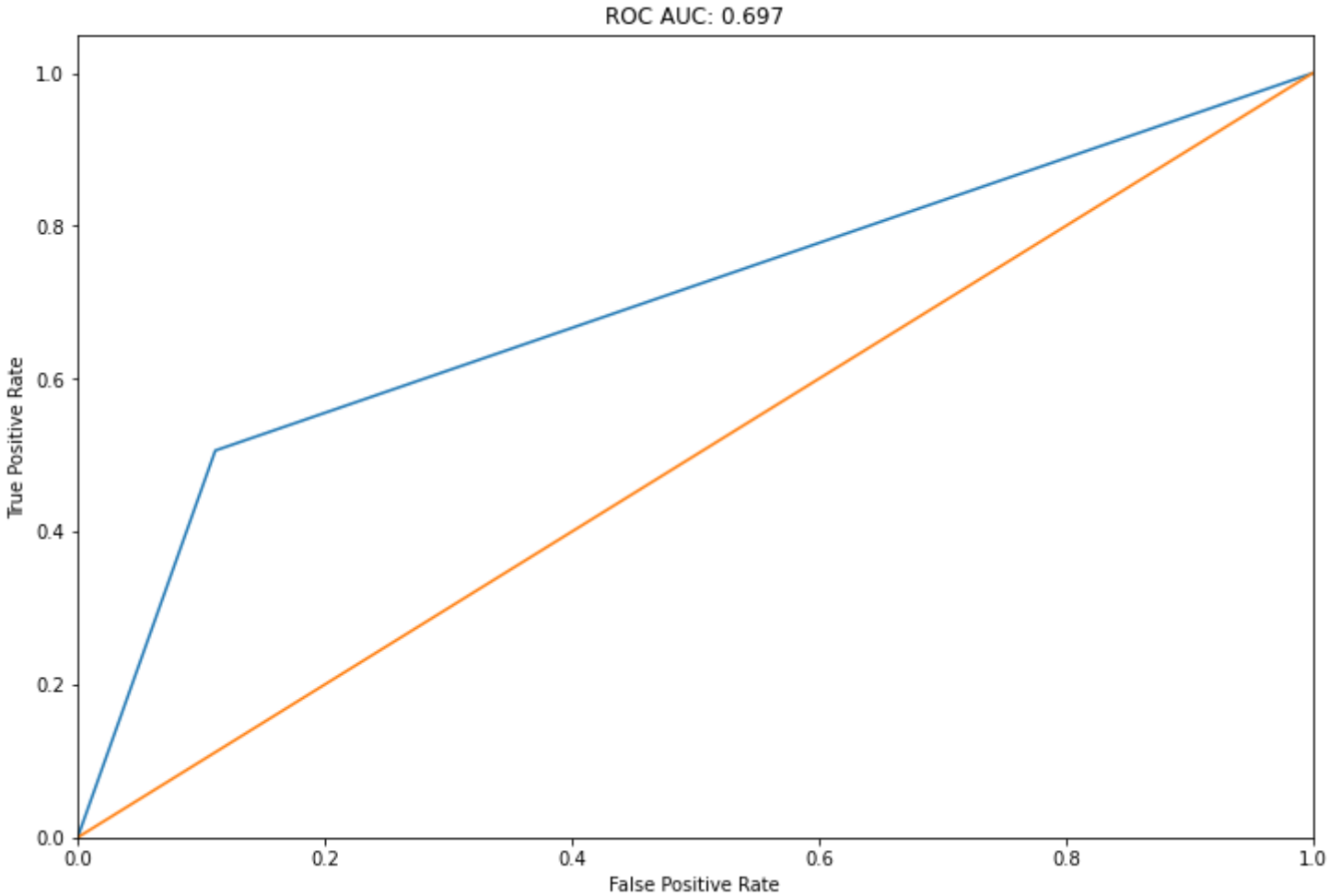
```
print("Train quality:")
quality(clfRF.predict(X_train), y_train)
print("\nTest quality:")
quality(predRF, y_test)
```

```
Train quality:
Accuracy:  0.998
Precision: 0.995
Recall:    0.995
F1-score:  0.995

Test quality:
Accuracy:  0.787
Precision: 0.506
```

```
Recall:    0.621
F1-score:  0.558
```

```
plot_roc_curve(predRF, y_test)
```



XGBoost

```
clfXGB = XGBClassifier(random_state=2021)
clfXGB.fit(X_train, y_train)
```

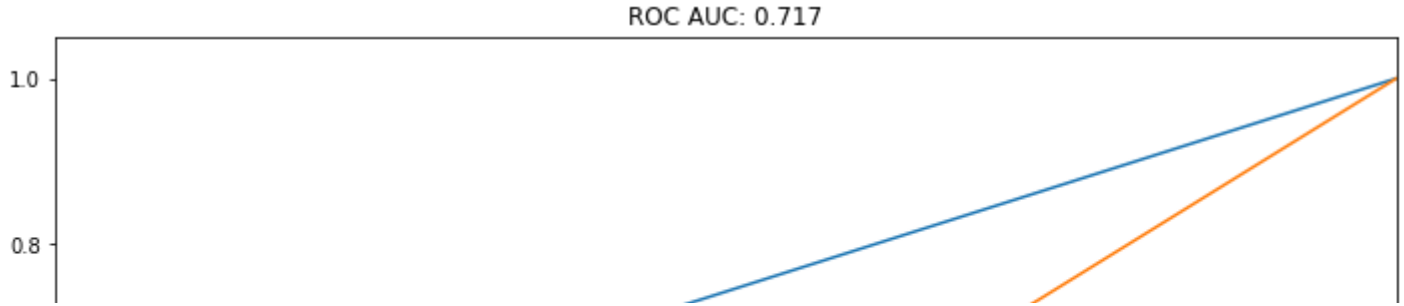
```
predXGB = clfXGB.predict(X_test)


print("Train quality:")
quality(clfXGB.predict(X_train), y_train)
print("\nTest quality:")
quality(predXGB, y_test)
```

```
     Train quality:
     Accuracy:  0.828
     Precision: 0.573
     Recall:    0.722
     F1-score:  0.639

     Test quality:
     Accuracy:  0.799
     Precision: 0.542
     Recall:    0.644
     F1-score:  0.589
```

```
plot_roc_curve(predXGB, y_test)
```



CatBost

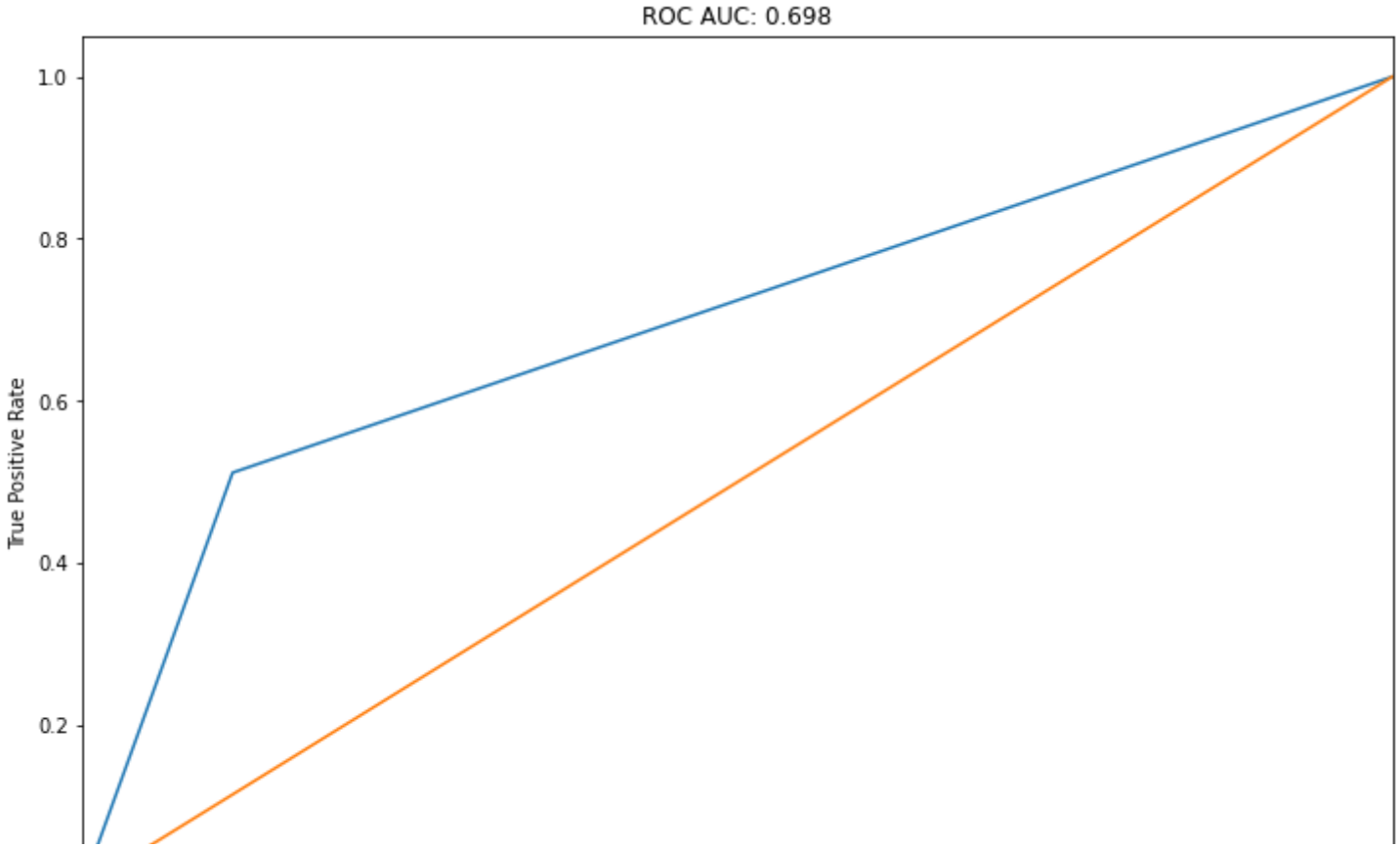
```
clfcat = CatBoostClassifier(eval_metric='AUC', random_state = 2021)
clfcat.fit(X_train, y_train, silent= True)
predcat = clfcat.predict(X_test)
```

```
print("Train quality:")
quality(clfcat.predict(X_train), y_train)
print("\nTest quality:")
quality(predcat, y_test)
```

```
    Train quality:
    Accuracy:  0.878
    Precision: 0.687
    Recall:    0.825
    F1-score:  0.750

    Test quality:
    Accuracy:  0.786
    Precision: 0.512
    Recall:    0.617
    F1-score:  0.559
```

```
plot_roc_curve(predcat, y_test)
```



LightGBM

```
clfLBM = LGBMClassifier(random_state = 2021)
clfLBM.fit(X_train, y_train)
predLBM = clfLBM.predict(X_test)
```

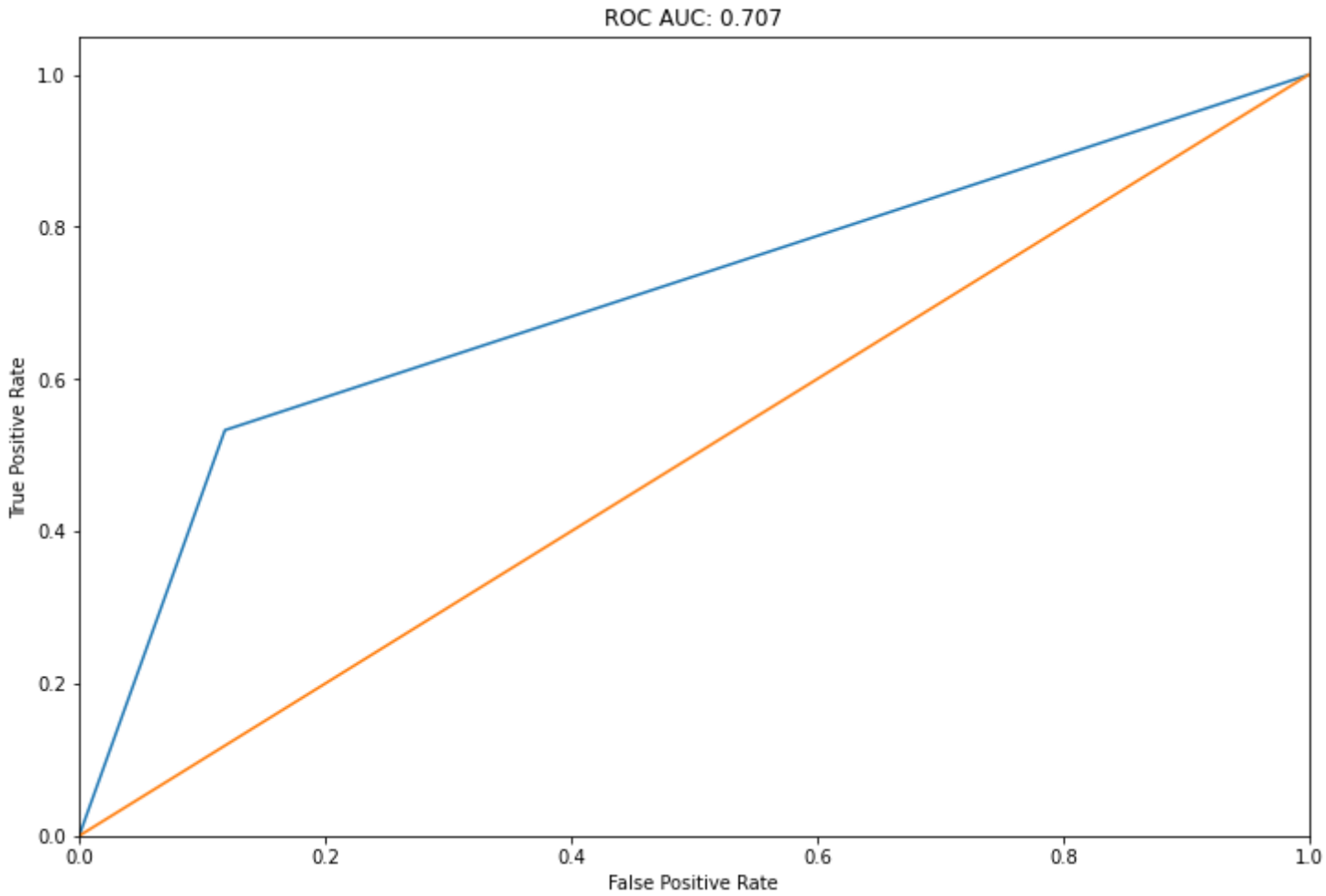
```
print("Train quality:")
quality(clfLBM.predict(X_train), y_train)
print("\nTest quality:")
quality(predLBM, y_test)
```

```
Train quality:
Accuracy:  0.886
Precision: 0.729
```

```
Recall:    0.822
F1-score:  0.773

Test quality:
Accuracy:  0.789
Precision: 0.533
Recall:    0.619
F1-score:  0.573
```

```
plot_roc_curve(predLBM, y_test)
```



sklearn GradientBoosting

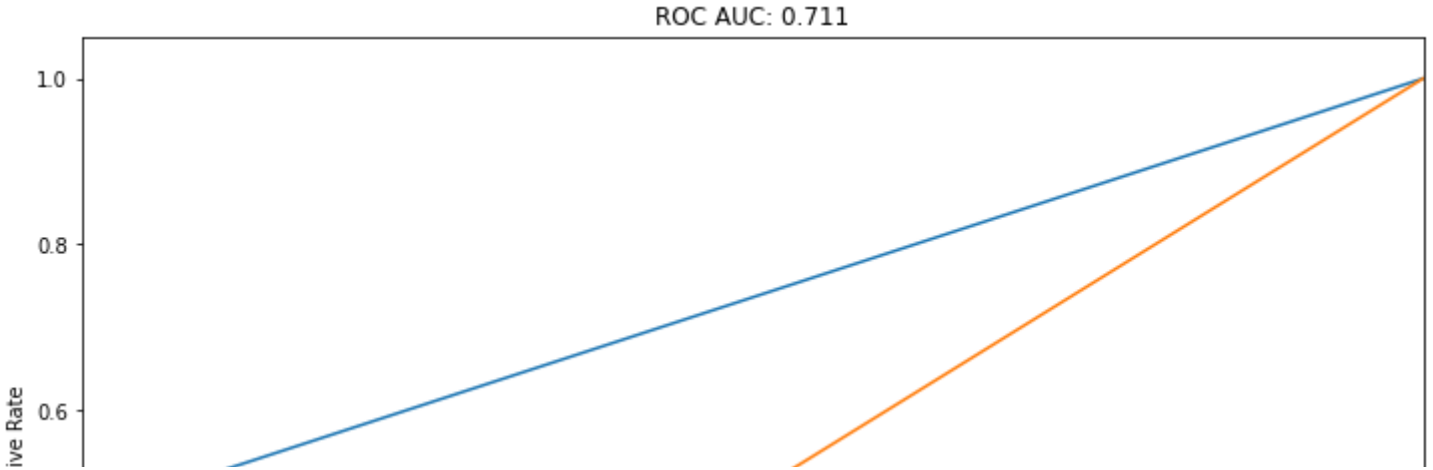
```
clfGB = GradientBoostingClassifier(random_state=2021)
clfGB.fit(X_train, y_train)
predGB = clfGB.predict(X_test)


print("Train quality:")
quality(clfGB.predict(X_train), y_train)
print("\nTest quality:")
quality(predGB, y_test)
```

```
     Train quality:
     Accuracy:  0.834
     Precision: 0.589
     Recall:    0.731
     F1-score:  0.653

     Test quality:
     Accuracy:  0.796
     Precision: 0.529
     Recall:    0.640
     F1-score:  0.580
```

```
plot_roc_curve(predGB, y_test)
```



sklearn RandomForest, XGBoost, CatBost, LightGBM, skrearn.GradientBoosting (настройка гиперпараметров)

Инициализируем страфицированную разбивку нашего датасета для валидации

```
skf = StratifiedKFold(n_splits=5, shuffle=True, random_state=42)
```

sklearn RandomForest


```
parameters = {'max_features': [4, 7, 10, 13], 'min_samples_leaf': [1, 3, 5, 7], 'max_depth': [5,10,15,20]}
rfc = RandomForestClassifier(n_estimators=100, random_state=2021,
                             n_jobs=-1, oob_score=True)
gcv_rf = GridSearchCV(rfc, parameters, n_jobs=-1, cv=skf, verbose=1)
gcv_rf.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 64 candidates, totalling 320 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done  46 tasks      | elapsed:   19.4s
[Parallel(n_jobs=-1)]: Done 196 tasks      | elapsed:  1.7min
[Parallel(n_jobs=-1)]: Done 320 out of 320 | elapsed:  2.9min finished
GridSearchCV(cv=StratifiedKFold(n_splits=5, random_state=42, shuffle=True),
             error_score=nan,
             estimator=RandomForestClassifier(bootstrap=True, ccp_alpha=0.0,
```

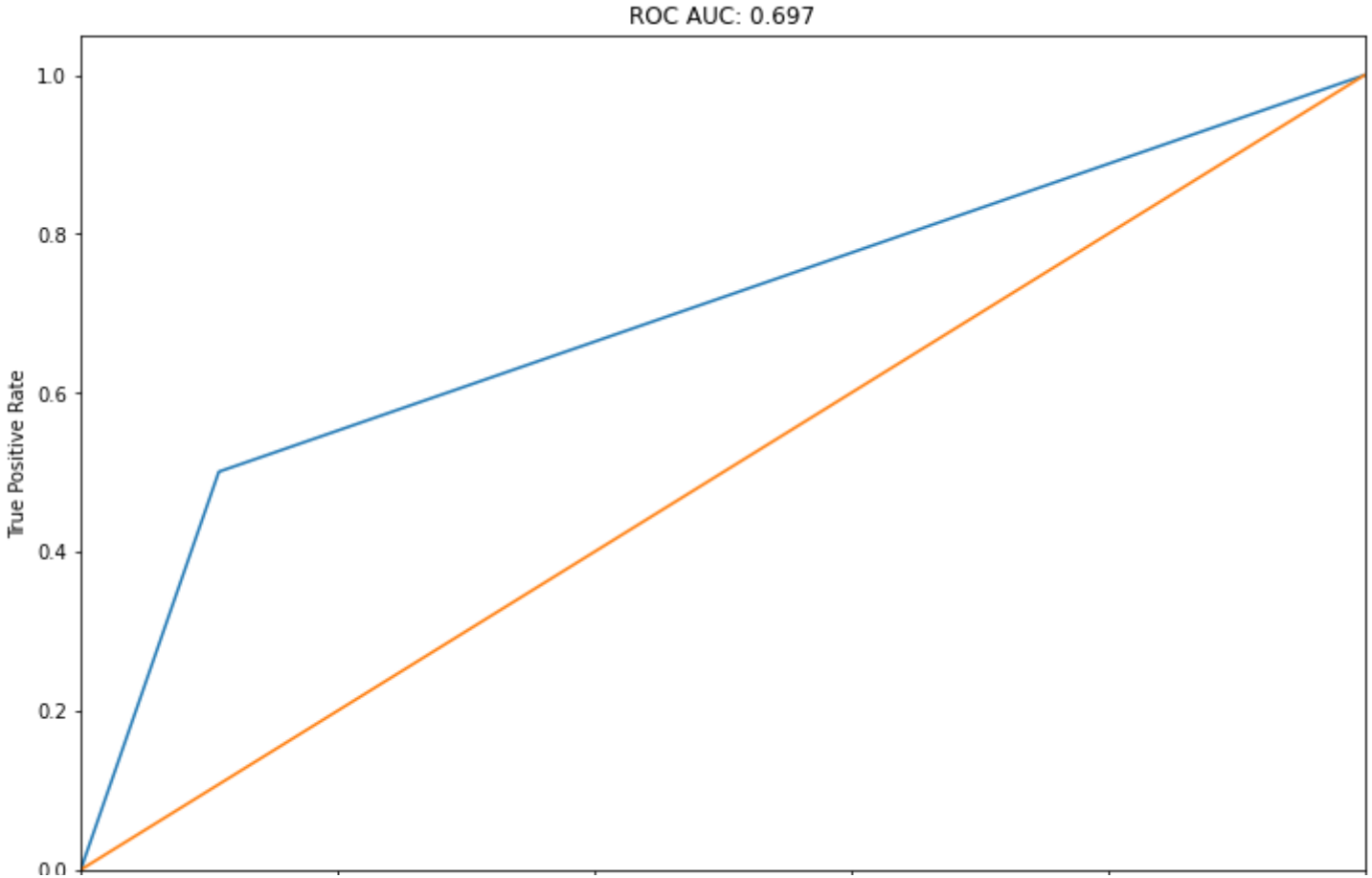
```
                                             class_weight=None,
                                             criterion='gini', max_depth=None,
                                             max_features='auto',
                                             max_leaf_nodes=None,
                                             max_samples=None,
                                             min_impurity_decrease=0.0,
                                             min_impurity_split=None,
                                             min_samples_leaf=1,
                                             min_samples_split=2,
                                             min_weight_fraction_leaf=0.0,
                                             n_estimators=100, n_jobs=-1,
                                             oob_score=True, random_state=2021,
                                             verbose=0, warm_start=False),
                   iid='deprecated', n_jobs=-1,
                   param_grid={'max_depth': [5, 10, 15, 20],
                               'max_features': [4, 7, 10, 13],
                               'min_samples_leaf': [1, 3, 5, 7]},
                   pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
                   scoring=None, verbose=1)


print("Train quality:")
quality(gcv_rf.predict(X_train), y_train)
print("\nTest quality:")
quality(gcv_rf.predict(X_test), y_test)

     Train quality:
     Accuracy:  0.866
     Precision: 0.641
     Recall:    0.815
     F1-score:  0.718

     Test quality:
     Accuracy:  0.788
     Precision: 0.501
     Recall:    0.627
     F1-score:  0.557


plot_roc_curve(gcv_rf.predict(X_test), y_test)
```



XGBoost

```
xgbc = XGBClassifier(n_estimators=100, random_state=2021,
                             n_jobs=-1, oob_score=True)
gcv_x = GridSearchCV(xgbc, parameters, n_jobs=-1, cv=skf, verbose=1)
gcv_x.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 64 candidates, totalling 320 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done  46 tasks      | elapsed:   16.8s
[Parallel(n_jobs=-1)]: Done 196 tasks      | elapsed:  2.2min
[Parallel(n_jobs=-1)]: Done 320 out of 320 | elapsed:  4.8min finished
GridSearchCV(cv=StratifiedKFold(n_splits=5, random_state=42, shuffle=True),
             error_score=nan,
```

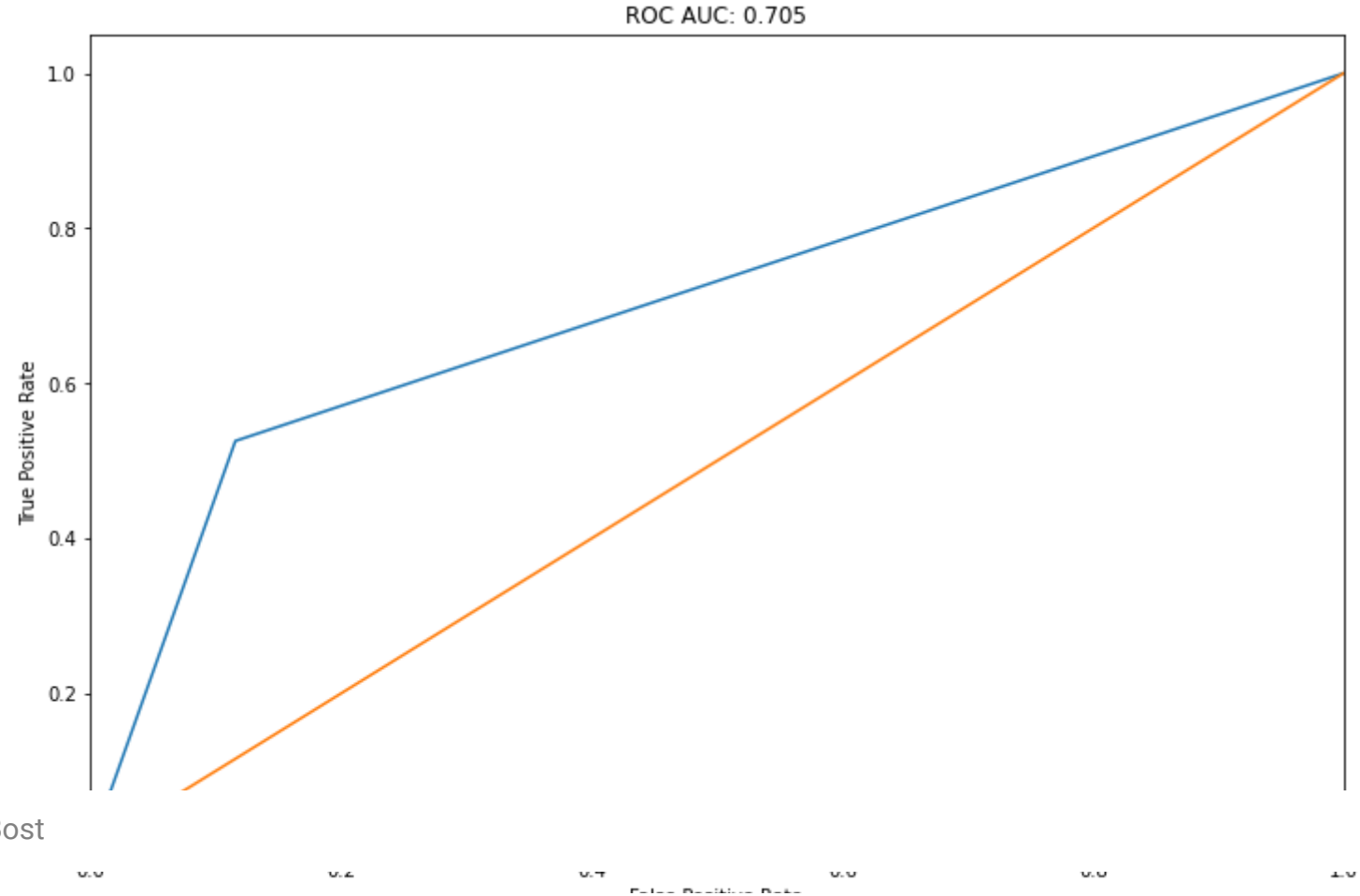
```
                   estimator=XGBClassifier(base_score=0.5, booster='gbtree',
                                           colsample_bylevel=1, colsample_bynode=1,
                                           colsample_bytree=1, gamma=0,
                                           learning_rate=0.1, max_delta_step=0,
                                           max_depth=3, min_child_weight=1,
                                           missing=None, n_estimators=100, n_jobs=-1,
                                           nthread=None, objective='binary:logistic',
                                           oob_score=True, random_state=2021,
                                           reg_alpha=0, reg_lambda=1,
                                           scale_pos_weight=1, seed=None, silent=None,
                                           subsample=1, verbosity=1),
                   iid='deprecated', n_jobs=-1,
                   param_grid={'max_depth': [5, 10, 15, 20],
                               'max_features': [4, 7, 10, 13],
                               'min_samples_leaf': [1, 3, 5, 7]},
                   pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
                   scoring=None, verbose=1)


print("Train quality:")
quality(gcv_x.predict(X_train), y_train)
print("\nTest quality:")
quality(gcv_x.predict(X_test), y_test)

     Train quality:
     Accuracy:  0.858
     Precision: 0.645
     Recall:    0.782
     F1-score:  0.707

     Test quality:
     Accuracy:  0.789
     Precision: 0.526
     Recall:    0.621
     F1-score:  0.569


plot_roc_curve(gcv_x.predict(X_test), y_test)
```



CatBost

```
param_cat = {'iterations': [1,5,10,20,50], 'subsample': [0.66, 0.8,1], 'max_depth': [5,10,15,20]}
catc = CatBoostClassifier(random_state=2021,
                          eval_metric='AUC')
gcv_c = GridSearchCV(catc, param_cat, n_jobs=-1, cv=skf, verbose=1)
gcv_c.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 60 candidates, totalling 300 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
/usr/local/lib/python3.7/dist-packages/joblib/externals/loky/process_executor.py:691: UserWarning: A worker stopped while some jobs were
  "timeout or by a memory leak.", UserWarning
[Parallel(n_jobs=-1)]: Done  84 tasks      | elapsed:    5.4s
[Parallel(n_jobs=-1)]: Done 252 tasks      | elapsed:  2.1min
Learning rate set to 0.5
0:      total: 3.15ms   remaining: 28.3ms
```

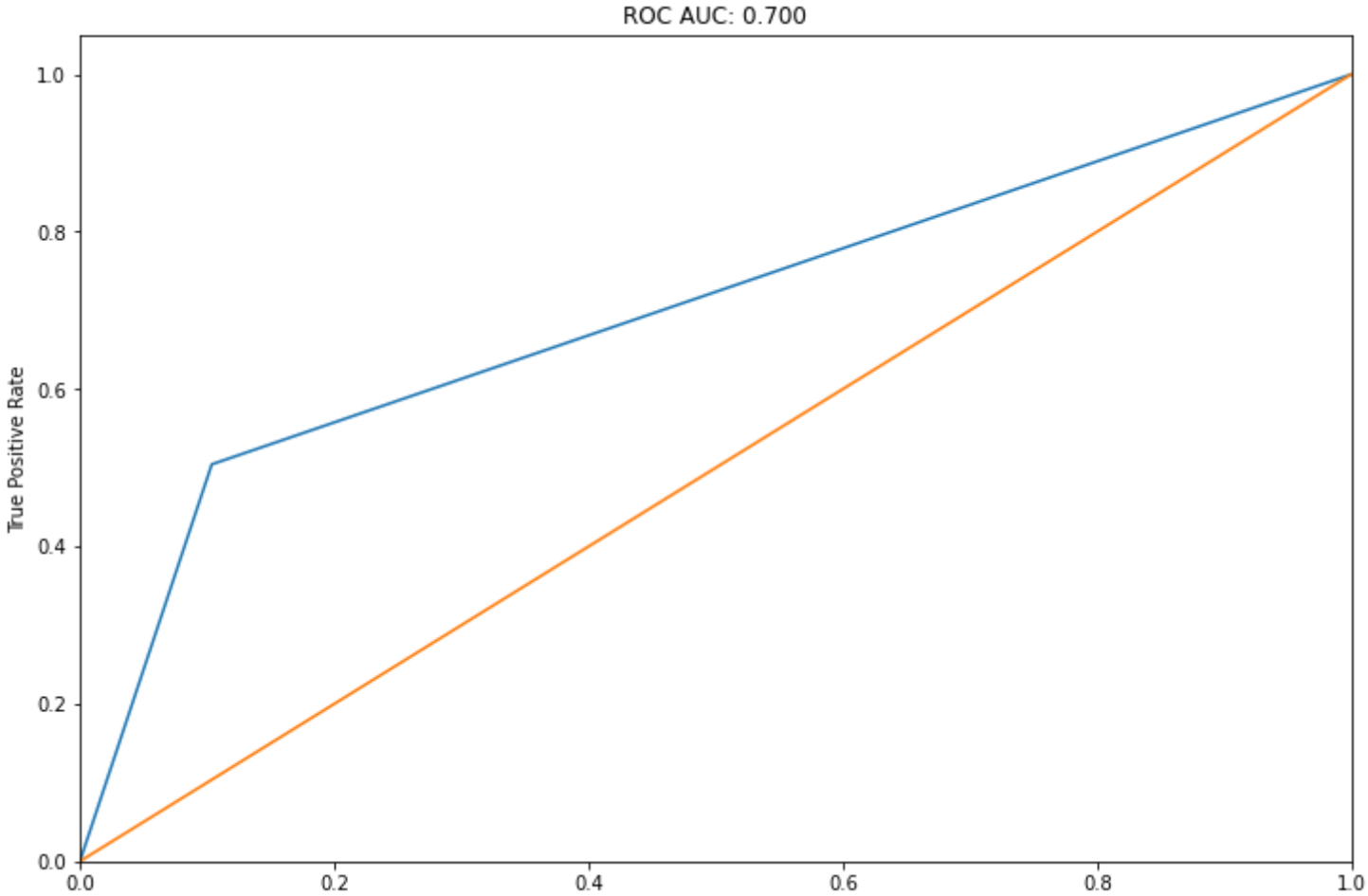
```
     1:      total: 10.1ms   remaining: 40.4ms
     2:      total: 16.3ms   remaining: 38.1ms
     3:      total: 21.1ms   remaining: 31.7ms
     4:      total: 23.2ms   remaining: 23.2ms
     5:      total: 24.6ms   remaining: 16.4ms
     6:      total: 26.7ms   remaining: 11.4ms
     7:      total: 28.8ms   remaining: 7.2ms
     8:      total: 30.9ms   remaining: 3.43ms
     9:      total: 32.7ms   remaining: 0us
     [Parallel(n_jobs=-1)]: Done 300 out of 300 | elapsed:  5.3min finished
     GridSearchCV(cv=StratifiedKFold(n_splits=5, random_state=42, shuffle=True),
                  error_score=nan,
                  estimator=<catboost.core.CatBoostClassifier object at 0x7f7439e96a10>,
                  iid='deprecated', n_jobs=-1,
                  param_grid={'iterations': [1, 5, 10, 20, 50],
                              'max_depth': [5, 10, 15, 20],
                              'subsample': [0.66, 0.8, 1]},
                  pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
                  scoring=None, verbose=1)
```

```
print("Train quality:")
quality(gcv_c.predict(X_train), y_train)
print("\nTest quality:")
quality(gcv_c.predict(X_test), y_test)
```

```
     Train quality:
     Accuracy:  0.818
     Precision: 0.545
     Recall:    0.702
     F1-score:  0.614

     Test quality:
     Accuracy:  0.792
     Precision: 0.504
     Recall:    0.637
     F1-score:  0.563
```

```
plot_roc_curve(gcv_c.predict(X_test), y_test)
```



LightGBM

```
lgbmc = LGBMClassifier(n_estimators=100, random_state=2021,
                       n_jobs=-1, oob_score=True)
gcv_l = GridSearchCV(lgbmc, parameters, n_jobs=-1, cv=skf, verbose=1)
gcv_l.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 64 candidates, totalling 320 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done  46 tasks      | elapsed:    4.8s
[Parallel(n_jobs=-1)]: Done 196 tasks      | elapsed:   22.1s
[Parallel(n_jobs=-1)]: Done 320 out of 320 | elapsed:   37.3s finished
GridSearchCV(cv=StratifiedKFold(n_splits=5, random_state=42, shuffle=True),
```

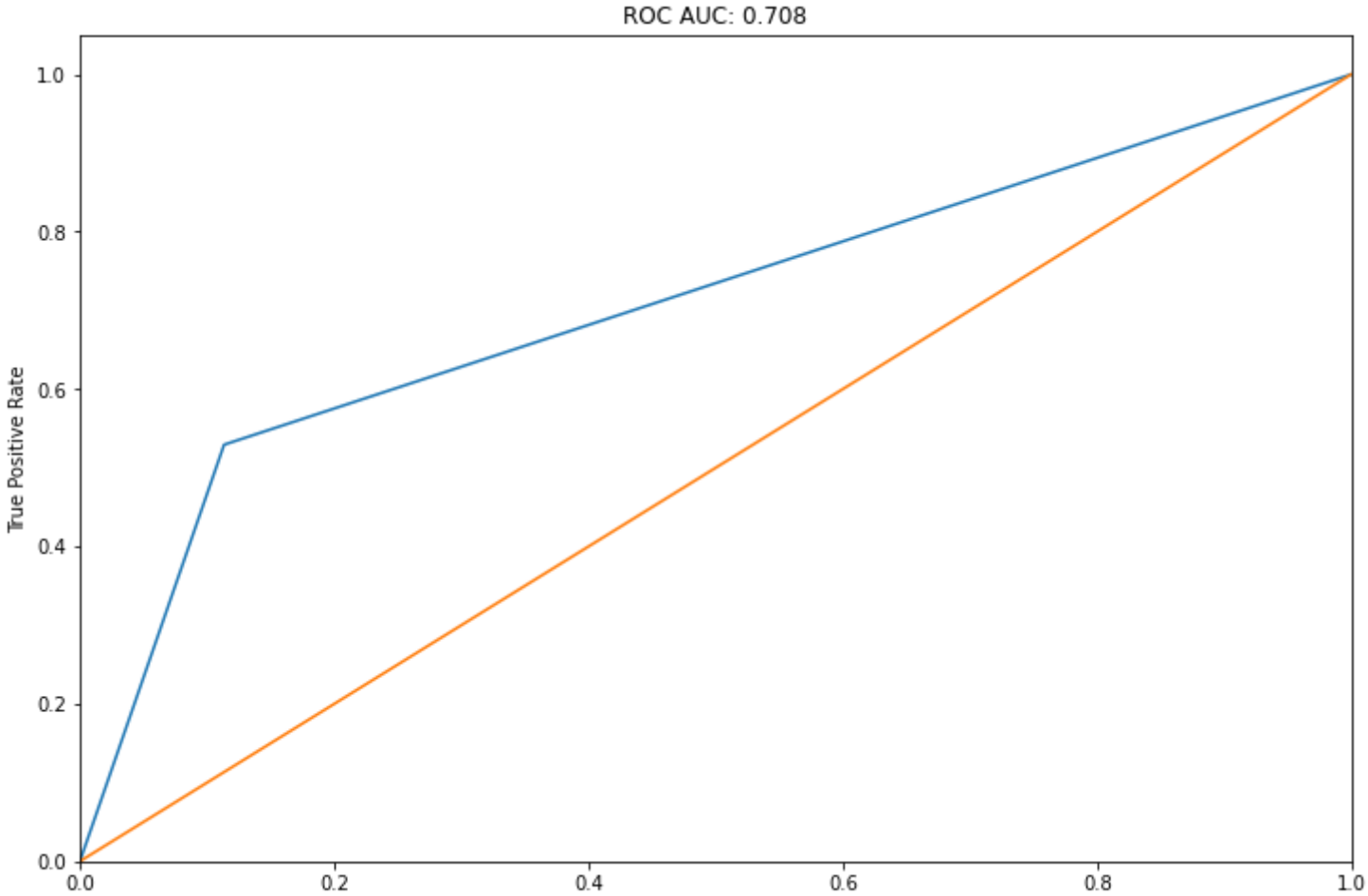
```
                   error_score=nan,
                   estimator=LGBMClassifier(boosting_type='gbdt', class_weight=None,
                                            colsample_bytree=1.0,
                                            importance_type='split',
                                            learning_rate=0.1, max_depth=-1,
                                            min_child_samples=20,
                                            min_child_weight=0.001,
                                            min_split_gain=0.0, n_estimators=100,
                                            n_jobs=-1, num_leaves=31, objective=None,
                                            oob_score=True, random_state=2021,
                                            reg_alpha=0.0, reg_lambda=0.0,
                                            silent=True, subsample=1.0,
                                            subsample_for_bin=200000,
                                            subsample_freq=0),
                   iid='deprecated', n_jobs=-1,
                   param_grid={'max_depth': [5, 10, 15, 20],
                               'max_features': [4, 7, 10, 13],
                               'min_samples_leaf': [1, 3, 5, 7]},
                   pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
                   scoring=None, verbose=1)


print("Train quality:")
quality(gcv_l.predict(X_train), y_train)
print("\nTest quality:")
quality(gcv_l.predict(X_test), y_test)

     Train quality:
     Accuracy:  0.849
     Precision: 0.628
     Recall:    0.760
     F1-score:  0.688

     Test quality:
     Accuracy:  0.792
     Precision: 0.529
     Recall:    0.628
     F1-score:  0.574


plot_roc_curve(gcv_l.predict(X_test), y_test)
```



sklearn Gradient Boosting

```
skgbc = GradientBoostingClassifier(n_estimators=100, random_state=2021,
                                   )
gcv_s = GridSearchCV(skgbc, parameters, n_jobs=-1, cv=skf, verbose=1)
gcv_s.fit(X_train, y_train)
```

```
Fitting 5 folds for each of 64 candidates, totalling 320 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done  46 tasks      | elapsed:   17.3s
[Parallel(n_jobs=-1)]: Done 196 tasks      | elapsed:  3.8min
[Parallel(n_jobs=-1)]: Done 320 out of 320 | elapsed:  8.7min finished
GridSearchCV(cv=StratifiedKFold(n_splits=5, random_state=42, shuffle=True),
```

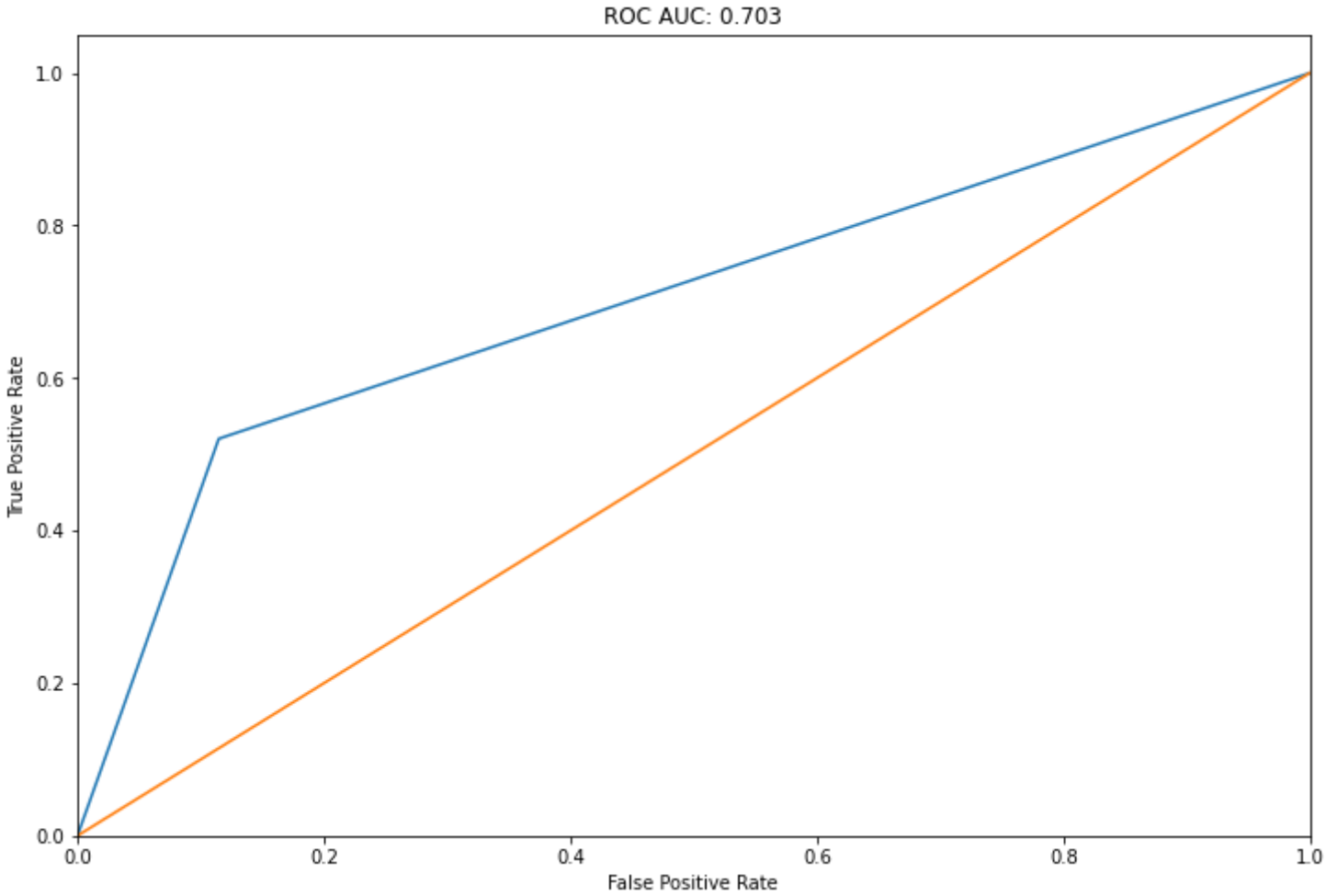
```
                   error_score=nan,
                   estimator=GradientBoostingClassifier(ccp_alpha=0.0,
                                                        criterion='friedman_mse',
                                                        init=None, learning_rate=0.1,
                                                        loss='deviance', max_depth=3,
                                                        max_features=None,
                                                        max_leaf_nodes=None,
                                                        min_impurity_decrease=0.0,
                                                        min_impurity_split=None,
                                                        min_samples_leaf=1,
                                                        min_samples_split=2,
                                                        mi...
                                                        n_estimators=100,
                                                        n_iter_no_change=None,
                                                        presort='deprecated',
                                                        random_state=2021,
                                                        subsample=1.0, tol=0.0001,
                                                        validation_fraction=0.1,
                                                        verbose=0, warm_start=False),
                   iid='deprecated', n_jobs=-1,
                   param_grid={'max_depth': [5, 10, 15, 20],
                               'max_features': [4, 7, 10, 13],
                               'min_samples_leaf': [1, 3, 5, 7]},
                   pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
                   scoring=None, verbose=1)


print("Train quality:")
quality(gcv_s.predict(X_train), y_train)
print("\nTest quality:")
quality(gcv_s.predict(X_test), y_test)

     Train quality:
     Accuracy:  0.854
     Precision: 0.641
     Recall:    0.769
     F1-score:  0.699

     Test quality:
     Accuracy:  0.788
     Precision: 0.520
     Recall:    0.621
     F1-score:  0.566
```

```
plot_roc_curve(gcv_s.predict(X_test), y_test)
```



Выводы

- без настроек гимперпараметров победила модель XGBOOST auc = 0,717, 2 место - GradientBoosting от sklearn auc = 0,711 (если смотреть по метрике ROC_AUC)

- с настройками гиперпараметров на кросс валидации победила также модель LightGBM auc = 0,708, 2 место XGBOOST auc = 0,705.