Прогнозирование оттока клиентов

Из «Бета-Банка» стали уходить клиенты. Каждый месяц. Немного, но заметно. Банковские маркетологи посчитали: сохранять текущих клиентов дешевле, чем привлекать новых.

Нужно спрогнозировать, уйдёт клиент из банка в ближайшее время или нет. Вам предоставлены исторические данные о поведении клиентов и расторжении договоров с банком.

Построим модель с предельно большим значением *F1*-меры (более 0.59). Проверьте *F1*-меру на тестовой выборке самостоятельно.

Дополнительно измеряйте *AUC-ROC*, сравнивайте её значение с *F1*-мерой.

Источник данных: https://www.kaggle.com/barelydedicated/bank-customer-churn-modeling (https://www.kaggle.com/barelydedicated/bank-customer-churn-modeling)

Признаки:

RowNumber — индекс строки в данных

CustomerId — уникальный идентификатор клиента

Surname — фамилия

CreditScore — кредитный рейтинг

Geography — страна проживания

Gender — пол

Age — возраст

Tenure — количество недвижимости у клиента

Balance — баланс на счёте

NumOfProducts — количество продуктов банка, используемых клиентом

HasCrCard — наличие кредитной карты

IsActiveMember — активность клиента

EstimatedSalary — предполагаемая зарплата

Целевой признак:

Exited — факт ухода клиента

1. Подготовка данных

In [1]:

```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split #импортируем функцию train_test_sp
lit из библиотеки sklearn
from sklearn.metrics import r2_score
from sklearn.metrics import recall_score
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.utils import shuffle
import warnings
warnings.filterwarnings('ignore')
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.dummy import DummyClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
from sklearn.metrics import precision_recall_curve
from sklearn.metrics import roc_curve
```

In [2]:

```
df=pd.read_csv("/datasets/Churn.csv") #прочитаем файл
df.info() # изучим общую информацию по дата фрейму
df.head(100)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 14 columns):
RowNumber          10000 non-null int64
CustomerId         10000 non-null int64
Surname            10000 non-null object
CreditScore        10000 non-null int64
Geography          10000 non-null object
Gender             10000 non-null object
Age                10000 non-null int64
Tenure             9091 non-null float64
Balance            10000 non-null float64
NumOfProducts      10000 non-null int64
HasCrCard          10000 non-null int64
IsActiveMember     10000 non-null int64
EstimatedSalary    10000 non-null float64
Exited             10000 non-null int64
dtypes: float64(3), int64(8), object(3)
memory usage: 1.1+ MB
```

Out[2]:

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	Ba
0	1	15634602	Hargrave	619	France	Female	42	2.0	
1	2	15647311	Hill	608	Spain	Female	41	1.0	838
2	3	15619304	Onio	502	France	Female	42	8.0	1596
3	4	15701354	Boni	699	France	Female	39	1.0	
4	5	15737888	Mitchell	850	Spain	Female	43	2.0	1255
...	...	...	...	...	...	...	...	...	
95	96	15699461	Fiorentini	515	Spain	Male	35	10.0	1762
96	97	15738721	Graham	773	Spain	Male	41	9.0	1028
97	98	15693683	Yuille	814	Germany	Male	29	8.0	970
98	99	15604348	Allard	710	Spain	Male	22	8.0	
99	100	15633059	Fanucci	413	France	Male	34	NaN	

100 rows × 14 columns

In [3]:

```
df.isnull().sum()
```

Out[3]:

```
RowNumber            0
CustomerId           0
Surname              0
CreditScore          0
Geography            0
Gender               0
Age                  0
Tenure             909
Balance              0
NumOfProducts        0
HasCrCard            0
IsActiveMember       0
EstimatedSalary      0
Exited               0
dtype: int64
```

почти что 10% данных имеют пустое значение в признаке "количество недвижимости".

In [4]:

```
df_tenure=df.query('Tenure =="NaN"')
df_tenure
```

Out[4]:

	RowNumber	CustomerId	Surname	CreditScore	Geography	Gender	Age	Tenure	
30	31	15589475	Azikiwe	591	Spain	Female	39	NaN	
48	49	15766205	Yin	550	Germany	Male	38	NaN	10
51	52	15768193	Trevisani	585	Germany	Male	36	NaN	14
53	54	15702298	Parkhill	655	Germany	Male	41	NaN	12
60	61	15651280	Hunter	742	Germany	Male	35	NaN	13
...	...	...	...	...	...	...	...	...	
9944	9945	15703923	Cameron	744	Germany	Male	41	NaN	19
9956	9957	15707861	Nucci	520	France	Female	46	NaN	8
9964	9965	15642785	Douglas	479	France	Male	34	NaN	11
9985	9986	15586914	Nepean	659	France	Male	36	NaN	12
9999	10000	15628319	Walker	792	France	Female	28	NaN	13

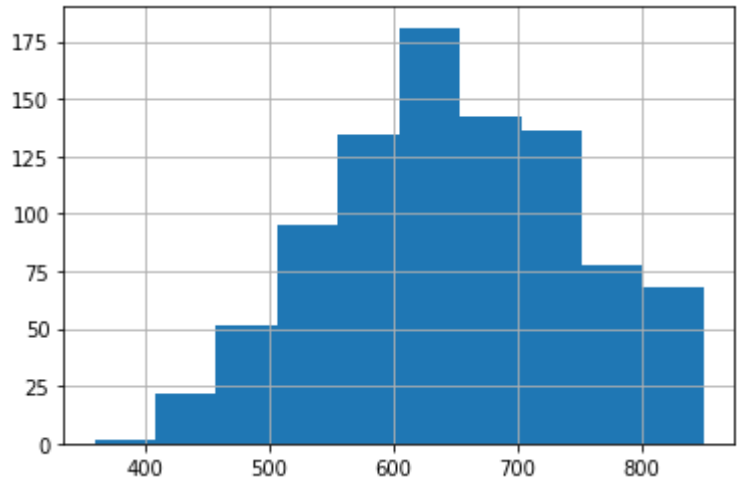
909 rows × 14 columns

In [5]:

```
df_tenure['CreditScore'].hist()
```

Out[5]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fd9a6568850>
```



In [6]:

```
df_tenure['Geography'].value_counts()
```

Out[6]:

```
France     464
Spain      229
Germany    216
Name: Geography, dtype: int64
```

In [7]:

```
#заполним NaN на 0
df['Tenure']=df['Tenure'].fillna(0)
```

In [8]:

```
#удалим столбцы id, row и surname, так как эти признаки нам не нужны
df = df.drop(['RowNumber','CustomerId','Surname'], axis=1)
```

In [9]:

```
#приведем к нижнему регистру название стобцов
df.columns=df.columns.str.lower()
```

In [10]:

```
#чтобы было по красоте, подкорректируем названия стобцов
df.columns=['credit_score','geography','gender','age','tenure','balance','num_of_produc
ts','has_cr_card','is_active_member','estimated_salary','exited']
```

In [11]:

```
df
```

Out[11]:

	credit_score	geography	gender	age	tenure	balance	num_of_products	has_cr_ca
0	619	France	Female	42	2.0	0.00	1	
1	608	Spain	Female	41	1.0	83807.86	1	
2	502	France	Female	42	8.0	159660.80	3	
3	699	France	Female	39	1.0	0.00	2	
4	850	Spain	Female	43	2.0	125510.82	1	
...	...	...	...	...	...	...	...	
9995	771	France	Male	39	5.0	0.00	2	
9996	516	France	Male	35	10.0	57369.61	1	
9997	709	France	Female	36	7.0	0.00	1	
9998	772	Germany	Male	42	3.0	75075.31	2	
9999	792	France	Female	28	0.0	130142.79	1	

10000 rows × 11 columns

In [12]:

```
columns=['tenure','balance','num_of_products','has_cr_card','is_active_member','estimated_salary']
for i in columns:
    df[i]=df[i].astype(int)
```

In [13]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 11 columns):
credit_score        10000 non-null int64
geography           10000 non-null object
gender              10000 non-null object
age                 10000 non-null int64
tenure              10000 non-null int64
balance             10000 non-null int64
num_of_products     10000 non-null int64
has_cr_card         10000 non-null int64
is_active_member    10000 non-null int64
estimated_salary    10000 non-null int64
exited              10000 non-null int64
dtypes: int64(9), object(2)
memory usage: 859.5+ KB
```

Вывод:

Данные прошли предобработку. Добалили необходимые библиотеки, изучили общую информацию по датафрейму.

In [14]:

```
#Преобразовать категориальные признаки в численные поможет техника прямого кодирования, или отображения (англ. One-Hot Encoding, OHE).
df_ohe=pd.get_dummies(df, drop_first=True)
df_ohe
```

Out[14]:

	credit_score	age	tenure	balance	num_of_products	has_cr_card	is_active_member
0	619	42	2	0	1	1	1
1	608	41	1	83807	1	0	1
2	502	42	8	159660	3	1	0
3	699	39	1	0	2	0	0
4	850	43	2	125510	1	1	1
...	...	...	...	...	...	...	...
9995	771	39	5	0	2	1	0
9996	516	35	10	57369	1	1	1
9997	709	36	7	0	1	0	1
9998	772	42	3	75075	2	1	0
9999	792	28	0	130142	1	1	0

10000 rows × 12 columns

In [15]:

```
#Разделим исходные данные на обучающую, валидационную и тестовую выборки. В ходе исслед
ования изменила с 60-20-20 на 70-15-15
df_train, df_valid_30 = train_test_split(df_ohe, test_size=0.3, random_state=12345)
df_valid, df_test = train_test_split(df_valid_30, test_size=0.5, random_state=12345)
```

In [16]:

```
#создадим переменные для признаков и целевого признака для 3х выборок:
#для обучающей
features_train = df_train.drop(['exited'], axis=1)
target_train = df_train['exited']
#для валидационной
features_valid = df_valid.drop(['exited'], axis=1)
target_valid = df_valid['exited']
#для тестовой
features_test=df_test.drop(['exited'], axis=1)
target_test=df_test['exited']
```

In [17]:

```
#изучим выборки

print(features_train.shape)
print(target_train.shape)

print(features_valid.shape)
print(target_valid.shape)

print(features_test.shape)
print(target_test.shape)
```

```
(7000, 11)
(7000,)
(1500, 11)
(1500,)
(1500, 11)
(1500,)
```

In [18]:

```
df_train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 7000 entries, 9716 to 4578
Data columns (total 12 columns):
credit_score         7000 non-null int64
age                  7000 non-null int64
tenure               7000 non-null int64
balance              7000 non-null int64
num_of_products      7000 non-null int64
has_cr_card          7000 non-null int64
is_active_member     7000 non-null int64
estimated_salary     7000 non-null int64
exited               7000 non-null int64
geography_Germany    7000 non-null uint8
geography_Spain      7000 non-null uint8
gender_Male          7000 non-null uint8
dtypes: int64(9), uint8(3)
memory usage: 567.4 KB
```

In [19]:

```
df_test.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1500 entries, 8606 to 142
Data columns (total 12 columns):
credit_score         1500 non-null int64
age                  1500 non-null int64
tenure               1500 non-null int64
balance              1500 non-null int64
num_of_products      1500 non-null int64
has_cr_card          1500 non-null int64
is_active_member     1500 non-null int64
estimated_salary     1500 non-null int64
exited               1500 non-null int64
geography_Germany    1500 non-null uint8
geography_Spain      1500 non-null uint8
gender_Male          1500 non-null uint8
dtypes: int64(9), uint8(3)
memory usage: 121.6 KB
```

In [20]:

```
#приведем численные признаки к одному масштабу. Один из методов масштабирования — станд
артизация данных.
numeric = ['credit_score','age','tenure','balance','num_of_products','estimated_salary'
]
scaler = StandardScaler() #Создадим объект этой структуры и настроим его на обучающих д
анных
scaler.fit(features_train[numeric])
features_train[numeric]=scaler.transform(features_train[numeric])
features_valid[numeric]=scaler.transform(features_valid[numeric])
#features_test[numeric]=scaler.transform(features_test[numeric])
```

Вывод:

Разделили исходные данные на обучающую, валидационную и тестовую выборки методом train_test_split в 2 подхода в пропорциях 3:1:1. Проверили методом info() правильно ли разделена выборка. Создали переменные для признаков и целевого признака для 3х выборок. Привели численные признаки к одному масштабу с помощью стандартизации данных.

2. Исследование задачи

In [21]:

```
#Исследуем баланс классов
df_ohe['exited'].value_counts()
```

Out[21]:

```
0    7963
1    2037
Name: exited, dtype: int64
```

Наблюдается дисбаланс классов. Положительного класса почти в 4 раза меньше. Сначала обучим модели с этим дисбалансом.

По отдельности полнота и точность не слишком информативны. Нужно одновременно повышать показатели обеих. Или обратиться к новой метрике, которая их объединит. Полнота и точность оценивают качество прогноза положительного класса с разных позиций. Recall описывает, как хорошо модель разобралась в особенностях этого класса и распознала его. Precision выявляет, не переусердствует ли модель, присваивая положительные метки.

recall=recall_score(target_valid,predicted_valid)

Полнота выявляет, какую долю положительных среди всех ответов выделила модель. Обычно они на вес золота, и важно понимать, как хорошо модель их находит.

precision=precision_score(target_valid,predicted_valid)

Точность определяет, как много отрицательных ответов нашла модель, пока искала положительные. Чем больше отрицательных, тем ниже точность.

f1=f1_score(target_valid, predicted_valid)

In [22]:

```
#ФУНКЦИЯ
#Исследуем качество разных моделей, меняя гиперпараметры.

#для модели решающего дерева
#в цикле проверим гиперпараметр глубины дерева от 1 до 30, кратно 2

def model_quality_dtc(features_x,target_x,features_y,target_y, depth):
    depth_and_score=pd.DataFrame(columns=["depth", 'recall', 'precision','f1','auc_roc'
])
    i=0
    model= DecisionTreeClassifier(random_state=12345, max_depth=depth)
    model.fit(features_x, target_x) #обучим модель
    predicted_y=model.predict(features_y) #предскажем по валидационной выборке
    recall=recall_score(target_y,predicted_y)
    precision=precision_score(target_y, predicted_y)
    f1=f1_score(target_y, predicted_y)
    probabilities_y = model.predict_proba(features_y)
    probabilities_one_y = probabilities_y[:, 1]
    auc_roc=roc_auc_score(target_y, probabilities_one_y )
    depth_and_score.loc[i]=[depth, recall, precision, f1, auc_roc]  #построим датафрейм
с данными по accuracy на валидационной и тестовой выборке
    i+=1
    print(depth_and_score)
```

In [23]:

```
#for depth in range(3,51,2):
    #model_quality_dtc(features_train,target_train,features_valid,target_valid, depth)
```

In [24]:

```
#для модели случайного леса

def model_quality_rfc(features_x,target_x,features_y,target_y, estim, depth):
    estim_and_score=pd.DataFrame(columns=["estimators","max_depth",'recall', 'precisio
n','f1','auc_roc'])
    i=0
    model= RandomForestClassifier(random_state=12345, n_estimators=estim, max_depth=dep
th)
    model.fit(features_x, target_x) #обучим модель
    predicted_y=model.predict(features_y) #предскажем по валидационной выборке
    recall=recall_score(target_y,predicted_y)
    precision=precision_score(target_y, predicted_y)
    f1=f1_score(target_y, predicted_y)
    probabilities_y = model.predict_proba(features_y)
    probabilities_one_y = probabilities_y[:, 1]
    auc_roc=roc_auc_score(target_y, probabilities_one_y )
    estim_and_score.loc[i]=[estim, depth, recall, precision, f1, auc_roc]  #построим да
тафрейм с данными по accuracy на валидационной и тестовой выборке
    i+=1
    print(estim_and_score)
```

In [25]:

```
#в цикле проверим качество модели для гиперпараметра количество оценщиков от 1 до 100,
 кратно 10
for estim in range(1,151,10):
    for depth in range (5,50,2):
        model_quality_rfc(features_train,target_train,features_valid,target_valid, esti
m, depth)
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	5.0	0.439739	0.733696	0.549898	0.781053
0	1.0	7.0	0.485342	0.628692	0.547794	0.785344
0	1.0	9.0	0.410423	0.673797	0.510121	0.750148
0	1.0	11.0	0.47557	0.600823	0.530909	0.741205
0	1.0	13.0	0.504886	0.536332	0.520134	0.717938
0	1.0	15.0	0.469055	0.481605	0.475248	0.673654
0	1.0	17.0	0.47557	0.462025	0.4687	0.684447
0	1.0	19.0	0.514658	0.501587	0.508039	0.69092
0	1.0	21.0	0.553746	0.504451	0.52795	0.706926
0	1.0	23.0	0.485342	0.477564	0.481422	0.674356
0	1.0	25.0	0.485342	0.477564	0.481422	0.674356
0	1.0	27.0	0.485342	0.477564	0.481422	0.674356
0	1.0	29.0	0.485342	0.477564	0.481422	0.674356
0	1.0	31.0	0.485342	0.477564	0.481422	0.674356
0	1.0	33.0	0.485342	0.477564	0.481422	0.674356
0	1.0	35.0	0.485342	0.477564	0.481422	0.674356
0	1.0	37.0	0.485342	0.477564	0.481422	0.674356
0	1.0	39.0	0.485342	0.477564	0.481422	0.674356
0	1.0	41.0	0.485342	0.477564	0.481422	0.674356
0	1.0	43.0	0.485342	0.477564	0.481422	0.674356
0	1.0	45.0	0.485342	0.477564	0.481422	0.674356
0	1.0	47.0	0.485342	0.477564	0.481422	0.674356
0	1.0	49.0	0.485342	0.477564	0.481422	0.674356
0	11.0	5.0	0.403909	0.779874	0.532189	0.843402
0	11.0	7.0	0.436482	0.802395	0.565401	0.845678
0	11.0	9.0	0.456026	0.795455	0.57971	0.848283
0	11.0	11.0	0.429967	0.795181	0.55814	0.849778
0	11.0	13.0	0.482085	0.755102	0.588469	0.838093
0	11.0	15.0	0.469055	0.72	0.568047	0.816918
0	11.0	17.0	0.478827	0.713592	0.573099	0.821951

```
   0         11.0        19.0  0.485342   0.668161  0.562264  0.826671
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        21.0  0.485342   0.716346  0.578641  0.837195
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        23.0  0.465798   0.674528  0.55106  0.818198
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        25.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        27.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        29.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        31.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        33.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        35.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        37.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        39.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        41.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        43.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        45.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        47.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        49.0  0.462541   0.666667  0.546154  0.813614
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         5.0  0.381107   0.806897  0.517699  0.844227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         7.0  0.429967       0.825  0.56531  0.850732
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         9.0  0.446254   0.815476  0.576842  0.852413
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        11.0  0.429967   0.795181  0.55814  0.852634
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        13.0  0.472313   0.788043  0.590631  0.847153
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        15.0  0.478827        0.75  0.584493  0.840541
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        17.0  0.491857       0.755  0.595661  0.835084
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        19.0  0.482085     0.72549  0.579256  0.837551
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        21.0  0.462541   0.731959  0.566866  0.844634
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        23.0  0.459283   0.734375  0.56513  0.835524
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        25.0  0.47557   0.756477  0.584  0.832084
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        27.0  0.47557   0.756477  0.584  0.832084
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        29.0  0.47557   0.756477  0.584  0.832084
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        31.0  0.47557   0.756477  0.584  0.832084
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        33.0  0.47557   0.756477  0.584  0.832084
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	35.0	0.47557	0.756477	0.584	0.832084

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	37.0	0.47557	0.756477	0.584	0.832084

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	39.0	0.47557	0.756477	0.584	0.832084

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	41.0	0.47557	0.756477	0.584	0.832084

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	43.0	0.47557	0.756477	0.584	0.832084

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	45.0	0.47557	0.756477	0.584	0.832084

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	47.0	0.47557	0.756477	0.584	0.832084

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	49.0	0.47557	0.756477	0.584	0.832084

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	5.0	0.37785	0.811189	0.515556	0.846968

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	7.0	0.442997	0.814371	0.57384	0.852343

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	9.0	0.442997	0.804734	0.571429	0.853988

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	11.0	0.446254	0.825301	0.579281	0.853604

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	13.0	0.465798	0.794444	0.587269	0.850575

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	15.0	0.47557	0.752577	0.582834	0.842452

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	17.0	0.488599	0.757576	0.594059	0.845512

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	19.0	0.491857	0.755	0.595661	0.844802

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	21.0	0.495114	0.745098	0.594912	0.844706

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	23.0	0.456026	0.732984	0.562249	0.839811

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	25.0	0.456026	0.744681	0.565657	0.836971

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	27.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	29.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	31.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	33.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	35.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	37.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	39.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	41.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	43.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	45.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	47.0	0.469055	0.75	0.577154	0.836224

	estimators	max_depth	recall	precision	f1	auc_roc

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   0         31.0       49.0  0.469055       0.75  0.577154  0.836224
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        5.0  0.361564   0.798561  0.497758  0.850324
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        7.0  0.433225   0.841772  0.572043  0.854575
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        9.0  0.446254   0.820359  0.578059  0.855992
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       11.0  0.439739   0.803571  0.568421  0.853461
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       13.0  0.456026    0.79096  0.578512  0.851364
      estimators  max_depth    recall  precision     f1   auc_roc
   0         41.0       15.0  0.469055   0.746114  0.576  0.845419
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       17.0  0.478827   0.742424  0.582178  0.846212
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       19.0  0.491857   0.770408  0.600398  0.847741
      estimators  max_depth    recall  precision     f1   auc_roc
   0         41.0       21.0  0.485342   0.772021  0.596  0.848186
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       23.0  0.462541   0.743455  0.570281  0.845551
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       25.0  0.456026   0.744681  0.565657  0.842609
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       27.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       29.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       31.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       33.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       35.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       37.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       39.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       41.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       43.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       45.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       47.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       49.0  0.465798   0.748691  0.574297  0.842514
      estimators  max_depth   recall  precision        f1   auc_roc
   0         51.0        5.0  0.34202   0.813953  0.481651  0.849882
      estimators  max_depth   recall  precision       f1   auc_roc
   0         51.0        7.0  0.42671   0.850649  0.56833  0.855001
      estimators  max_depth    recall  precision        f1   auc_roc
   0         51.0        9.0  0.436482   0.817073  0.569002  0.856945
      estimators  max_depth    recall  precision       f1   auc_roc
   0         51.0       11.0  0.446254   0.810651  0.57563  0.853224
      estimators  max_depth    recall  precision        f1   auc_roc
   0         51.0       13.0  0.446254   0.787356  0.569647  0.852798
      estimators  max_depth    recall  precision        f1   auc_roc
   0         51.0       15.0  0.472313   0.767196  0.584677  0.845532
      estimators  max_depth   recall  precision       f1   auc_roc
   0         51.0       17.0  0.47557   0.772487  0.58871  0.847218
```

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   estimators  max_depth    recall  precision        f1   auc_roc
0        51.0       19.0  0.488599   0.765306  0.596421  0.848021
   estimators  max_depth    recall  precision        f1   auc_roc
0        51.0       21.0  0.495114   0.771574  0.603175  0.850436
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       23.0  0.482085   0.766839  0.592  0.848136
   estimators  max_depth    recall  precision        f1  auc_roc
0        51.0       25.0  0.469055   0.765957  0.581818  0.84794
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       27.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       29.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       31.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       33.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       35.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       37.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       39.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       41.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       43.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       45.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       47.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision     f1   auc_roc
0        51.0       49.0  0.482085   0.766839  0.592  0.845712
   estimators  max_depth    recall  precision        f1   auc_roc
0        61.0        5.0  0.335505   0.811024  0.474654  0.849996
   estimators  max_depth   recall  precision        f1   auc_roc
0        61.0        7.0  0.42671   0.856209  0.569565  0.855348
   estimators  max_depth    recall  precision       f1   auc_roc
0        61.0        9.0  0.442997   0.814371  0.57384  0.858125
   estimators  max_depth    recall  precision        f1   auc_roc
0        61.0       11.0  0.439739   0.803571  0.568421  0.855113
   estimators  max_depth    recall  precision        f1   auc_roc
0        61.0       13.0  0.462541   0.788889  0.583162  0.855894
   estimators  max_depth    recall  precision        f1   auc_roc
0        61.0       15.0  0.472313    0.77957  0.588235  0.848549
   estimators  max_depth    recall  precision     f1  auc_roc
0        61.0       17.0  0.485342   0.772021  0.596  0.84886
   estimators  max_depth    recall  precision        f1   auc_roc
0        61.0       19.0  0.488599   0.757576  0.594059  0.847292
   estimators  max_depth    recall  precision        f1   auc_roc
0        61.0       21.0  0.495114   0.756219  0.598425  0.849875
   estimators  max_depth    recall  precision        f1  auc_roc
0        61.0       23.0  0.465798   0.744792  0.573146  0.84834
   estimators  max_depth    recall  precision        f1   auc_roc
0        61.0       25.0  0.472313   0.755208  0.581162  0.848506
   estimators  max_depth    recall  precision     f1   auc_roc
0        61.0       27.0  0.469055   0.746114  0.576  0.846668
   estimators  max_depth    recall  precision     f1   auc_roc
0        61.0       29.0  0.469055   0.746114  0.576  0.846668
   estimators  max_depth    recall  precision     f1   auc_roc
0        61.0       31.0  0.469055   0.746114  0.576  0.846668
   estimators  max_depth    recall  precision     f1   auc_roc
```

```
   0         61.0        33.0  0.469055   0.746114  0.576  0.846668
      estimators  max_depth    recall  precision     f1   auc_roc
   0         61.0        35.0  0.469055   0.746114  0.576  0.846668
      estimators  max_depth    recall  precision     f1   auc_roc
   0         61.0        37.0  0.469055   0.746114  0.576  0.846668
      estimators  max_depth    recall  precision     f1   auc_roc
   0         61.0        39.0  0.469055   0.746114  0.576  0.846668
      estimators  max_depth    recall  precision     f1   auc_roc
   0         61.0        41.0  0.469055   0.746114  0.576  0.846668
      estimators  max_depth    recall  precision     f1   auc_roc
   0         61.0        43.0  0.469055   0.746114  0.576  0.846668
      estimators  max_depth    recall  precision     f1   auc_roc
   0         61.0        45.0  0.469055   0.746114  0.576  0.846668
      estimators  max_depth    recall  precision     f1   auc_roc
   0         61.0        47.0  0.469055   0.746114  0.576  0.846668
      estimators  max_depth    recall  precision     f1   auc_roc
   0         61.0        49.0  0.469055   0.746114  0.576  0.846668
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0         5.0  0.348534   0.823077  0.489703  0.849857
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0         7.0  0.420195   0.848684  0.562092  0.854712
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0         9.0  0.439739   0.828221  0.574468  0.857248
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        11.0  0.442997   0.804734  0.571429  0.854379
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        13.0  0.465798   0.785714  0.584867  0.855706
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        15.0  0.465798   0.781421  0.583673  0.850499
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        17.0  0.478827   0.765625  0.589178  0.850485
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        19.0  0.488599   0.789474  0.603622  0.847652
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        21.0  0.488599   0.765306  0.596421  0.849688
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        23.0  0.465798   0.748691  0.574297  0.849464
      estimators  max_depth    recall  precision     f1   auc_roc
   0         71.0        25.0  0.465798   0.740933  0.572  0.848669
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        27.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        29.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        31.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        33.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        35.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        37.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        39.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        41.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        43.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        45.0  0.47557   0.744898  0.580517  0.846966
      estimators  max_depth   recall  precision        f1   auc_roc
   0         71.0        47.0  0.47557   0.744898  0.580517  0.846966
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	49.0	0.47557	0.744898	0.580517	0.846966
0	81.0	5.0	0.335505	0.830645	0.477958	0.850177
0	81.0	7.0	0.420195	0.854305	0.563319	0.855299
0	81.0	9.0	0.446254	0.840491	0.582979	0.857625
0	81.0	11.0	0.442997	0.8	0.570231	0.854474
0	81.0	13.0	0.469055	0.782609	0.586558	0.855921
0	81.0	15.0	0.472313	0.783784	0.589431	0.850566
0	81.0	17.0	0.478827	0.761658	0.588	0.85007
0	81.0	19.0	0.47557	0.784946	0.592292	0.850303
0	81.0	21.0	0.495114	0.771574	0.603175	0.850002
0	81.0	23.0	0.472313	0.747423	0.578842	0.850338
0	81.0	25.0	0.472313	0.763158	0.583501	0.848944
0	81.0	27.0	0.478827	0.753846	0.585657	0.847523
0	81.0	29.0	0.478827	0.753846	0.585657	0.847523
0	81.0	31.0	0.478827	0.753846	0.585657	0.847523
0	81.0	33.0	0.478827	0.753846	0.585657	0.847523
0	81.0	35.0	0.478827	0.753846	0.585657	0.847523
0	81.0	37.0	0.478827	0.753846	0.585657	0.847523
0	81.0	39.0	0.478827	0.753846	0.585657	0.847523
0	81.0	41.0	0.478827	0.753846	0.585657	0.847523
0	81.0	43.0	0.478827	0.753846	0.585657	0.847523
0	81.0	45.0	0.478827	0.753846	0.585657	0.847523
0	81.0	47.0	0.478827	0.753846	0.585657	0.847523
0	81.0	49.0	0.478827	0.753846	0.585657	0.847523
0	91.0	5.0	0.332248	0.829268	0.474419	0.850182
0	91.0	7.0	0.42671	0.845161	0.5671	0.854712
0	91.0	9.0	0.442997	0.84472	0.581197	0.857835
0	91.0	11.0	0.442997	0.804734	0.571429	0.855375
0	91.0	13.0	0.465798	0.790055	0.586066	0.855364
0	91.0	15.0	0.469055	0.778378	0.585366	0.852161

	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	17.0	0.488599	0.769231	0.59761	0.850096
0	91.0	19.0	0.482085	0.766839	0.592	0.849501
0	91.0	21.0	0.478827	0.753846	0.585657	0.849561
0	91.0	23.0	0.482085	0.755102	0.588469	0.849176
0	91.0	25.0	0.478827	0.773684	0.591549	0.848632
0	91.0	27.0	0.485342	0.772021	0.596	0.848157
0	91.0	29.0	0.47557	0.776596	0.589899	0.847073
0	91.0	31.0	0.47557	0.776596	0.589899	0.847073
0	91.0	33.0	0.47557	0.776596	0.589899	0.847073
0	91.0	35.0	0.47557	0.776596	0.589899	0.847073
0	91.0	37.0	0.47557	0.776596	0.589899	0.847073
0	91.0	39.0	0.47557	0.776596	0.589899	0.847073
0	91.0	41.0	0.47557	0.776596	0.589899	0.847073
0	91.0	43.0	0.47557	0.776596	0.589899	0.847073
0	91.0	45.0	0.47557	0.776596	0.589899	0.847073
0	91.0	47.0	0.47557	0.776596	0.589899	0.847073
0	91.0	49.0	0.47557	0.776596	0.589899	0.847073
0	101.0	5.0	0.332248	0.829268	0.474419	0.850163
0	101.0	7.0	0.420195	0.837662	0.559653	0.854884
0	101.0	9.0	0.446254	0.835366	0.581741	0.857685
0	101.0	11.0	0.436482	0.812121	0.567797	0.855157
0	101.0	13.0	0.459283	0.783333	0.579055	0.85597
0	101.0	15.0	0.459283	0.774725	0.576687	0.852566
0	101.0	17.0	0.488599	0.761421	0.595238	0.850508
0	101.0	19.0	0.478827	0.761658	0.588	0.849712
0	101.0	21.0	0.478827	0.765625	0.589178	0.849301
0	101.0	23.0	0.478827	0.761658	0.588	0.849348
0	101.0	25.0	0.482085	0.778947	0.595573	0.84868
0	101.0	27.0	0.469055	0.765957	0.581818	0.848361
0	101.0	29.0	0.472313	0.771277	0.585859	0.847349
0	101.0	31.0	0.472313	0.771277	0.585859	0.847349

	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	33.0	0.472313	0.771277	0.585859	0.847349
0	101.0	35.0	0.472313	0.771277	0.585859	0.847349
0	101.0	37.0	0.472313	0.771277	0.585859	0.847349
0	101.0	39.0	0.472313	0.771277	0.585859	0.847349
0	101.0	41.0	0.472313	0.771277	0.585859	0.847349
0	101.0	43.0	0.472313	0.771277	0.585859	0.847349
0	101.0	45.0	0.472313	0.771277	0.585859	0.847349
0	101.0	47.0	0.472313	0.771277	0.585859	0.847349
0	101.0	49.0	0.472313	0.771277	0.585859	0.847349
0	111.0	5.0	0.319218	0.816667	0.459016	0.850466
0	111.0	7.0	0.420195	0.837662	0.559653	0.854862
0	111.0	9.0	0.446254	0.825301	0.579281	0.857647
0	111.0	11.0	0.446254	0.80117	0.573222	0.856263
0	111.0	13.0	0.456026	0.786517	0.57732	0.857751
0	111.0	15.0	0.462541	0.78022	0.580777	0.852265
0	111.0	17.0	0.485342	0.756345	0.59127	0.850956
0	111.0	19.0	0.478827	0.761658	0.588	0.850141
0	111.0	21.0	0.47557	0.764398	0.586345	0.848724
0	111.0	23.0	0.478827	0.761658	0.588	0.849706
0	111.0	25.0	0.482085	0.774869	0.594378	0.849618
0	111.0	27.0	0.47557	0.768421	0.587525	0.849196
0	111.0	29.0	0.47557	0.760417	0.58517	0.848265
0	111.0	31.0	0.47557	0.760417	0.58517	0.848265
0	111.0	33.0	0.47557	0.760417	0.58517	0.848265
0	111.0	35.0	0.47557	0.760417	0.58517	0.848265
0	111.0	37.0	0.47557	0.760417	0.58517	0.848265
0	111.0	39.0	0.47557	0.760417	0.58517	0.848265
0	111.0	41.0	0.47557	0.760417	0.58517	0.848265
0	111.0	43.0	0.47557	0.760417	0.58517	0.848265
0	111.0	45.0	0.47557	0.760417	0.58517	0.848265

	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	47.0	0.47557	0.760417	0.58517	0.848265
0	111.0	49.0	0.47557	0.760417	0.58517	0.848265
0	121.0	5.0	0.315961	0.850877	0.460808	0.8504
0	121.0	7.0	0.413681	0.84106	0.554585	0.855173
0	121.0	9.0	0.439739	0.828221	0.574468	0.858302
0	121.0	11.0	0.442997	0.804734	0.571429	0.856631
0	121.0	13.0	0.459283	0.792135	0.581443	0.857068
0	121.0	15.0	0.47557	0.784946	0.592292	0.852159
0	121.0	17.0	0.47557	0.760417	0.58517	0.850443
0	121.0	19.0	0.47557	0.768421	0.587525	0.849607
0	121.0	21.0	0.478827	0.761658	0.588	0.847934
0	121.0	23.0	0.47557	0.764398	0.586345	0.849422
0	121.0	25.0	0.485342	0.776042	0.597194	0.849546
0	121.0	27.0	0.478827	0.786096	0.595142	0.848295
0	121.0	29.0	0.47557	0.789189	0.593496	0.847527
0	121.0	31.0	0.47557	0.789189	0.593496	0.847527
0	121.0	33.0	0.47557	0.789189	0.593496	0.847527
0	121.0	35.0	0.47557	0.789189	0.593496	0.847527
0	121.0	37.0	0.47557	0.789189	0.593496	0.847527
0	121.0	39.0	0.47557	0.789189	0.593496	0.847527
0	121.0	41.0	0.47557	0.789189	0.593496	0.847527
0	121.0	43.0	0.47557	0.789189	0.593496	0.847527
0	121.0	45.0	0.47557	0.789189	0.593496	0.847527
0	121.0	47.0	0.47557	0.789189	0.593496	0.847527
0	121.0	49.0	0.47557	0.789189	0.593496	0.847527
0	131.0	5.0	0.322476	0.846154	0.466981	0.851058
0	131.0	7.0	0.413681	0.84106	0.554585	0.855307
0	131.0	9.0	0.436482	0.8375	0.573876	0.858526
0	131.0	11.0	0.442997	0.8	0.570231	0.856912
0	131.0	13.0	0.456026	0.79096	0.578512	0.857098
0	131.0	15.0	0.47557	0.784946	0.592292	0.852489

	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	17.0	0.485342	0.764103	0.593625	0.850432
0	131.0	19.0	0.478827	0.769634	0.590361	0.849562
0	131.0	21.0	0.478827	0.761658	0.588	0.847703
0	131.0	23.0	0.482085	0.766839	0.592	0.849419
0	131.0	25.0	0.488599	0.777202	0.6	0.849777
0	131.0	27.0	0.478827	0.781915	0.593939	0.848309
0	131.0	29.0	0.478827	0.786096	0.595142	0.84763
0	131.0	31.0	0.478827	0.786096	0.595142	0.84763
0	131.0	33.0	0.478827	0.786096	0.595142	0.84763
0	131.0	35.0	0.478827	0.786096	0.595142	0.84763
0	131.0	37.0	0.478827	0.786096	0.595142	0.84763
0	131.0	39.0	0.478827	0.786096	0.595142	0.84763
0	131.0	41.0	0.478827	0.786096	0.595142	0.84763
0	131.0	43.0	0.478827	0.786096	0.595142	0.84763
0	131.0	45.0	0.478827	0.786096	0.595142	0.84763
0	131.0	47.0	0.478827	0.786096	0.595142	0.84763
0	131.0	49.0	0.478827	0.786096	0.595142	0.84763
0	141.0	5.0	0.325733	0.840336	0.469484	0.850261
0	141.0	7.0	0.416938	0.842105	0.557734	0.854895
0	141.0	9.0	0.442997	0.834356	0.578723	0.85804
0	141.0	11.0	0.446254	0.805882	0.574423	0.858179
0	141.0	13.0	0.459283	0.787709	0.580247	0.856828
0	141.0	15.0	0.478827	0.786096	0.595142	0.852612
0	141.0	17.0	0.478827	0.765625	0.589178	0.849838
0	141.0	19.0	0.47557	0.768421	0.587525	0.84952
0	141.0	21.0	0.472313	0.763158	0.583501	0.847423
0	141.0	23.0	0.482085	0.762887	0.590818	0.849884
0	141.0	25.0	0.485342	0.776042	0.597194	0.850926
0	141.0	27.0	0.485342	0.776042	0.597194	0.849749
0	141.0	29.0	0.485342	0.772021	0.596	0.849222

estimators	max_depth	recall	precision	f1	auc_roc

```
0       141.0       31.0  0.485342   0.772021  0.596  0.849222
   estimators  max_depth    recall  precision     f1   auc_roc
0       141.0       33.0  0.485342   0.772021  0.596  0.849222
   estimators  max_depth    recall  precision     f1   auc_roc
0       141.0       35.0  0.485342   0.772021  0.596  0.849222
   estimators  max_depth    recall  precision     f1   auc_roc
0       141.0       37.0  0.485342   0.772021  0.596  0.849222
   estimators  max_depth    recall  precision     f1   auc_roc
0       141.0       39.0  0.485342   0.772021  0.596  0.849222
   estimators  max_depth    recall  precision     f1   auc_roc
0       141.0       41.0  0.485342   0.772021  0.596  0.849222
   estimators  max_depth    recall  precision     f1   auc_roc
0       141.0       43.0  0.485342   0.772021  0.596  0.849222
   estimators  max_depth    recall  precision     f1   auc_roc
0       141.0       45.0  0.485342   0.772021  0.596  0.849222
   estimators  max_depth    recall  precision     f1   auc_roc
0       141.0       47.0  0.485342   0.772021  0.596  0.849222
   estimators  max_depth    recall  precision     f1   auc_roc
0       141.0       49.0  0.485342   0.772021  0.596  0.849222
```

In [26]:

```
#для модели логистической регрессии

def model_quality_lr(features_x,target_x,features_y,target_y):
    model = LogisticRegression(solver='liblinear', random_state=12345)
    model.fit(features_x, target_x) #обучим модель
    predicted_y=model.predict(features_y)
    recall=recall_score(target_y,predicted_y)
    precision=precision_score(target_y, predicted_y)
    f1=f1_score(target_y, predicted_y)
    probabilities_y = model.predict_proba(features_y)
    probabilities_one_y = probabilities_y[:, 1]
    auc_roc=roc_auc_score(target_y, probabilities_one_y )
    print("Полнота:", recall)
    print("Точность:", precision)
    print("F1-мера:", f1)
    print("AUC-ROC:", auc_roc)
```

In [27]:

```
model_quality_lr(features_train,target_train,features_valid,target_valid)
```

```
Полнота: 0.2247557003257329
Точность: 0.5798319327731093
F1-мера: 0.323943661971831
AUC-ROC: 0.7751378153233711
```

Вывод:

Для 3х моделей были посчитаны оптимальные значения f1, методом перебора гиперпараметров.

Для модели решающего дерева максимальное значение f1 0.577031 достигается при глубине дерева 9, при этом значение полноты 0.492823, а точности 0.695946.

Для модели случайного леса максимальное значение f1 0.571429 достигается при глубине дерева 9, количество оценциков 21, при этом значение полноты 0.435407, а точности 0.83105.

Для логистической регрессии F1-мера составила 0.33389544688026984, Полнота: 0.23684210526315788, Точность: 0.5657142857142857

Ни одна модель не достигла требуемого показателя f1, так как наблюдается дисбаланс классов.

В дополнении можно было бы построить ROC-кривые и исследовать матрицу ошибок для исходных данных.

3. Борьба с дисбалансом

In [28]:

```
#сбалансируем классы для модели дерева решений
def model_quality_dtc_balanced(features_x,target_x,features_y,target_y, depth):
    depth_and_score=pd.DataFrame(columns=["depth", 'recall', 'precision','f1','auc_roc'
])
    i=0
    model= DecisionTreeClassifier(class_weight='balanced', random_state=12345, max_dept
h=depth)
    model.fit(features_x, target_x) #обучим модель
    predicted_y=model.predict(features_y) #предскажем по валидационной выборке
    recall=recall_score(target_y,predicted_y)
    precision=precision_score(target_y, predicted_y)
    f1=f1_score(target_y, predicted_y)
    probabilities_y = model.predict_proba(features_y)
    probabilities_one_y = probabilities_y[:, 1]
    auc_roc=roc_auc_score(target_y, probabilities_one_y )
    depth_and_score.loc[i]=[depth, recall, precision, f1, auc_roc]  #построим датафрейм
с данными по accuracy на валидационной и тестовой выборке
    i+=1
    print(depth_and_score)
```

In [29]:

```
#подберем гиперпараметры для того, чтобы достичь макс f1
for depth in range(3,31,2):
    model_quality_dtc_balanced(features_train,target_train,features_valid,target_valid,
depth)
```

```
   depth    recall  precision        f1   auc_roc
0    3.0  0.677524   0.450216  0.540962  0.800072
   depth    recall  precision        f1  auc_roc
0    5.0  0.693811   0.518248  0.593315  0.83681
   depth   recall  precision        f1  auc_roc
0    7.0  0.71987   0.444668  0.549751  0.80599
   depth    recall  precision        f1   auc_roc
0    9.0  0.703583   0.442623  0.543396  0.790192
   depth    recall  precision        f1   auc_roc
0   11.0  0.615635   0.422819  0.501326  0.723154
   depth    recall  precision        f1   auc_roc
0   13.0  0.579805   0.429952  0.493759  0.700929
   depth    recall  precision        f1   auc_roc
0   15.0  0.543974    0.46648  0.502256  0.692543
   depth    recall  precision        f1   auc_roc
0   17.0  0.485342   0.474522  0.479871  0.673473
   depth    recall  precision        f1   auc_roc
0   19.0  0.485342   0.480645  0.482982  0.675361
   depth    recall  precision        f1   auc_roc
0   21.0  0.472313   0.461783  0.466989  0.665327
   depth    recall  precision        f1   auc_roc
0   23.0  0.472313   0.461783  0.466989  0.665327
   depth    recall  precision        f1   auc_roc
0   25.0  0.472313   0.461783  0.466989  0.665327
   depth    recall  precision        f1   auc_roc
0   27.0  0.472313   0.461783  0.466989  0.665327
   depth    recall  precision        f1   auc_roc
0   29.0  0.472313   0.461783  0.466989  0.665327
```

Максимальное значение f1 у модели с глубиной 5 - 0,59

In [30]:

```
#сбалансируем классы для модели случаного дерева
def model_quality_rfc_balanced(features_x,target_x,features_y,target_y, estim, depth):
    estim_and_score=pd.DataFrame(columns=["estimators","max_depth",'recall', 'precisio
n','f1','auc_roc'])
    i=0
    model= RandomForestClassifier(class_weight='balanced', random_state=12345, n_estima
tors=estim, max_depth=depth)
    model.fit(features_x, target_x) #обучим модель
    predicted_y=model.predict(features_y) #предскажем по валидационной выборке
    recall=recall_score(target_y,predicted_y)
    precision=precision_score(target_y, predicted_y)
    f1=f1_score(target_y, predicted_y)
    probabilities_y = model.predict_proba(features_y)
    probabilities_one_y = probabilities_y[:, 1]
    auc_roc=roc_auc_score(target_y, probabilities_one_y )
    estim_and_score.loc[i]=[estim, depth, recall, precision, f1, auc_roc]  #построим да
тафрейм с данными по accuracy на валидационной и тестовой выборке
    i+=1
    print(estim_and_score)
```

In [31]:

```
#подберем гиперпараметры для того, чтобы достичь макс f1
for estim in range(1,151,10):
    for depth in range (5,50,2):
        model_quality_rfc_balanced(features_train,target_train,features_valid,target_va
lid, estim, depth)
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	5.0	0.625407	0.498701	0.554913	0.800876
0	1.0	7.0	0.703583	0.393443	0.504673	0.75582
0	1.0	9.0	0.726384	0.449597	0.555417	0.788035
0	1.0	11.0	0.651466	0.4662	0.543478	0.764159
0	1.0	13.0	0.586319	0.453401	0.511364	0.722451
0	1.0	15.0	0.459283	0.447619	0.453376	0.659721
0	1.0	17.0	0.491857	0.496711	0.494272	0.684943
0	1.0	19.0	0.521173	0.528053	0.52459	0.70398
0	1.0	21.0	0.488599	0.477707	0.483092	0.677175
0	1.0	23.0	0.495114	0.490323	0.492707	0.681337
0	1.0	25.0	0.495114	0.490323	0.492707	0.681337
0	1.0	27.0	0.495114	0.490323	0.492707	0.681337
0	1.0	29.0	0.495114	0.490323	0.492707	0.681337
0	1.0	31.0	0.495114	0.490323	0.492707	0.681337
0	1.0	33.0	0.495114	0.490323	0.492707	0.681337
0	1.0	35.0	0.495114	0.490323	0.492707	0.681337
0	1.0	37.0	0.495114	0.490323	0.492707	0.681337
0	1.0	39.0	0.495114	0.490323	0.492707	0.681337
0	1.0	41.0	0.495114	0.490323	0.492707	0.681337
0	1.0	43.0	0.495114	0.490323	0.492707	0.681337
0	1.0	45.0	0.495114	0.490323	0.492707	0.681337
0	1.0	47.0	0.495114	0.490323	0.492707	0.681337
0	1.0	49.0	0.495114	0.490323	0.492707	0.681337
0	11.0	5.0	0.710098	0.508159	0.592391	0.839688
0	11.0	7.0	0.713355	0.518957	0.600823	0.846501
0	11.0	9.0	0.687296	0.562667	0.618768	0.851674
0	11.0	11.0	0.62215	0.643098	0.63245	0.842093
0	11.0	13.0	0.550489	0.695473	0.614545	0.8342
0	11.0	15.0	0.47557	0.682243	0.560461	0.820196
0	11.0	17.0	0.446254	0.709845	0.548	0.828254

```
   0         11.0        19.0  0.501629   0.723005  0.592308  0.817087
      estimators  max_depth    recall  precision        f1  auc_roc
   0         11.0        21.0  0.482085   0.729064  0.580392  0.82159
      estimators  max_depth   recall  precision     f1   auc_roc
   0         11.0        23.0  0.47557   0.756477  0.584  0.822241
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        25.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        27.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        29.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        31.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        33.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        35.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        37.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        39.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        41.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        43.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        45.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        47.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        49.0  0.456026    0.71066  0.555556  0.828227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         5.0  0.726384   0.515012  0.602703  0.848496
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         7.0  0.713355   0.538084  0.613445  0.853602
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         9.0  0.687296   0.578082  0.627976  0.857512
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        11.0  0.618893   0.669014  0.642978  0.851432
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        13.0  0.530945   0.708696  0.607076  0.847288
      estimators  max_depth   recall  precision        f1   auc_roc
   0         21.0        15.0  0.47557   0.737374  0.578218  0.835001
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        17.0  0.462541   0.759358  0.574899  0.837599
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        19.0  0.495114    0.77551  0.604374  0.839506
      estimators  max_depth    recall  precision        f1  auc_roc
   0         21.0        21.0  0.462541   0.739583  0.569138  0.83314
      estimators  max_depth    recall  precision        f1  auc_roc
   0         21.0        23.0  0.462541   0.759358  0.574899  0.83219
      estimators  max_depth    recall  precision        f1  auc_roc
   0         21.0        25.0  0.452769   0.747312  0.563895  0.83816
      estimators  max_depth    recall  precision        f1  auc_roc
   0         21.0        27.0  0.452769   0.747312  0.563895  0.83816
      estimators  max_depth    recall  precision        f1  auc_roc
   0         21.0        29.0  0.452769   0.747312  0.563895  0.83816
      estimators  max_depth    recall  precision        f1  auc_roc
   0         21.0        31.0  0.452769   0.747312  0.563895  0.83816
      estimators  max_depth    recall  precision        f1  auc_roc
   0         21.0        33.0  0.452769   0.747312  0.563895  0.83816
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	35.0	0.452769	0.747312	0.563895	0.83816
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	37.0	0.452769	0.747312	0.563895	0.83816
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	39.0	0.452769	0.747312	0.563895	0.83816
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	41.0	0.452769	0.747312	0.563895	0.83816
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	43.0	0.452769	0.747312	0.563895	0.83816
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	45.0	0.452769	0.747312	0.563895	0.83816
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	47.0	0.452769	0.747312	0.563895	0.83816
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	49.0	0.452769	0.747312	0.563895	0.83816
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	5.0	0.736156	0.517162	0.607527	0.851756
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	7.0	0.723127	0.548148	0.623596	0.85545
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	9.0	0.674267	0.579832	0.623494	0.858164
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	11.0	0.628664	0.66323	0.645485	0.855361
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	13.0	0.534202	0.713043	0.610801	0.847445
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	15.0	0.482085	0.743719	0.58498	0.842497
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	17.0	0.462541	0.755319	0.573737	0.843955
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	19.0	0.478827	0.794595	0.597561	0.837431
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	21.0	0.469055	0.757895	0.579477	0.844086
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	23.0	0.456026	0.752688	0.567951	0.841519
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	25.0	0.446254	0.744565	0.558045	0.842009
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	27.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	29.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	31.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	33.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	35.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	37.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	39.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	41.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	43.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	45.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	47.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc

0	31.0	49.0	0.442997	0.73913	0.553971	0.840233
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	5.0	0.739414	0.520642	0.611036	0.853503
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	7.0	0.71987	0.541667	0.618182	0.856974
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	9.0	0.697068	0.5961	0.642643	0.860549
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	11.0	0.631922	0.666667	0.648829	0.854392
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	13.0	0.530945	0.708696	0.607076	0.846263
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	15.0	0.491857	0.755	0.595661	0.842257
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	17.0	0.456026	0.773481	0.57377	0.846037
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	19.0	0.472313	0.796703	0.593047	0.841574
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	21.0	0.459283	0.762162	0.573171	0.847225
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	23.0	0.446254	0.756906	0.561475	0.844731
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	25.0	0.459283	0.754011	0.57085	0.844264
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	27.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	29.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	31.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	33.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	35.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	37.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	39.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	41.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	43.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	45.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	47.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	49.0	0.446254	0.744565	0.558045	0.843267
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	5.0	0.742671	0.513514	0.60719	0.853396
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	7.0	0.726384	0.5575	0.630835	0.858044
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	9.0	0.687296	0.606322	0.644275	0.857748
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	11.0	0.612378	0.655052	0.632997	0.853592
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	13.0	0.530945	0.721239	0.611632	0.849675
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	15.0	0.485342	0.741294	0.586614	0.842721
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	17.0	0.465798	0.781421	0.583673	0.84968

	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	19.0	0.465798	0.790055	0.586066	0.843852
0	51.0	21.0	0.439739	0.767045	0.559006	0.849677
0	51.0	23.0	0.439739	0.762712	0.557851	0.848177
0	51.0	25.0	0.449511	0.758242	0.564417	0.847962
0	51.0	27.0	0.449511	0.754098	0.563265	0.847061
0	51.0	29.0	0.449511	0.754098	0.563265	0.847061
0	51.0	31.0	0.449511	0.754098	0.563265	0.847061
0	51.0	33.0	0.449511	0.754098	0.563265	0.847061
0	51.0	35.0	0.449511	0.754098	0.563265	0.847061
0	51.0	37.0	0.449511	0.754098	0.563265	0.847061
0	51.0	39.0	0.449511	0.754098	0.563265	0.847061
0	51.0	41.0	0.449511	0.754098	0.563265	0.847061
0	51.0	43.0	0.449511	0.754098	0.563265	0.847061
0	51.0	45.0	0.449511	0.754098	0.563265	0.847061
0	51.0	47.0	0.449511	0.754098	0.563265	0.847061
0	51.0	49.0	0.449511	0.754098	0.563265	0.847061
0	61.0	5.0	0.749186	0.509978	0.60686	0.853386
0	61.0	7.0	0.726384	0.55198	0.627286	0.85877
0	61.0	9.0	0.684039	0.601719	0.640244	0.858081
0	61.0	11.0	0.615635	0.651724	0.633166	0.853224
0	61.0	13.0	0.537459	0.720524	0.615672	0.852006
0	61.0	15.0	0.495114	0.767677	0.60198	0.843513
0	61.0	17.0	0.478827	0.794595	0.597561	0.849995
0	61.0	19.0	0.465798	0.798883	0.588477	0.84576
0	61.0	21.0	0.442997	0.777143	0.564315	0.849652
0	61.0	23.0	0.439739	0.762712	0.557851	0.850489
0	61.0	25.0	0.449511	0.762431	0.565574	0.850914
0	61.0	27.0	0.449511	0.754098	0.563265	0.850527
0	61.0	29.0	0.449511	0.754098	0.563265	0.850527
0	61.0	31.0	0.449511	0.754098	0.563265	0.850527

0	61.0	33.0	0.449511	0.754098	0.563265	0.850527
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	35.0	0.449511	0.754098	0.563265	0.850527
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	37.0	0.449511	0.754098	0.563265	0.850527
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	39.0	0.449511	0.754098	0.563265	0.850527
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	41.0	0.449511	0.754098	0.563265	0.850527
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	43.0	0.449511	0.754098	0.563265	0.850527
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	45.0	0.449511	0.754098	0.563265	0.850527
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	47.0	0.449511	0.754098	0.563265	0.850527
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	49.0	0.449511	0.754098	0.563265	0.850527
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	5.0	0.745928	0.501094	0.599476	0.853011
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	7.0	0.726384	0.564557	0.635328	0.858212
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	9.0	0.677524	0.597701	0.635115	0.859034
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	11.0	0.612378	0.661972	0.63621	0.855149
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	13.0	0.543974	0.713675	0.617375	0.85312
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	15.0	0.498371	0.765	0.60355	0.84557
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	17.0	0.469055	0.778378	0.585366	0.850604
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	19.0	0.462541	0.793296	0.584362	0.847827
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	21.0	0.433225	0.764368	0.553015	0.847689
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	23.0	0.433225	0.76	0.551867	0.848871
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	25.0	0.439739	0.758427	0.556701	0.849061
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	27.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	29.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	31.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	33.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	35.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	37.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	39.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	41.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	43.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	45.0	0.429967	0.75	0.546584	0.848931
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	47.0	0.429967	0.75	0.546584	0.848931

	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	49.0	0.429967	0.75	0.546584	0.848931
0	81.0	5.0	0.742671	0.501099	0.598425	0.853999
0	81.0	7.0	0.726384	0.55198	0.627286	0.857947
0	81.0	9.0	0.677524	0.597701	0.635115	0.857977
0	81.0	11.0	0.609121	0.663121	0.634975	0.85523
0	81.0	13.0	0.540717	0.721739	0.61825	0.853738
0	81.0	15.0	0.491857	0.758794	0.596838	0.846637
0	81.0	17.0	0.462541	0.771739	0.578411	0.852634
0	81.0	19.0	0.462541	0.80226	0.586777	0.847897
0	81.0	21.0	0.436482	0.765714	0.556017	0.847751
0	81.0	23.0	0.442997	0.768362	0.561983	0.849544
0	81.0	25.0	0.436482	0.757062	0.553719	0.850026
0	81.0	27.0	0.439739	0.762712	0.557851	0.849968
0	81.0	29.0	0.439739	0.762712	0.557851	0.849968
0	81.0	31.0	0.439739	0.762712	0.557851	0.849968
0	81.0	33.0	0.439739	0.762712	0.557851	0.849968
0	81.0	35.0	0.439739	0.762712	0.557851	0.849968
0	81.0	37.0	0.439739	0.762712	0.557851	0.849968
0	81.0	39.0	0.439739	0.762712	0.557851	0.849968
0	81.0	41.0	0.439739	0.762712	0.557851	0.849968
0	81.0	43.0	0.439739	0.762712	0.557851	0.849968
0	81.0	45.0	0.439739	0.762712	0.557851	0.849968
0	81.0	47.0	0.439739	0.762712	0.557851	0.849968
0	81.0	49.0	0.439739	0.762712	0.557851	0.849968
0	91.0	5.0	0.749186	0.506608	0.604468	0.853729
0	91.0	7.0	0.732899	0.552826	0.630252	0.858493
0	91.0	9.0	0.684039	0.603448	0.641221	0.857794
0	91.0	11.0	0.615635	0.665493	0.639594	0.85582
0	91.0	13.0	0.543974	0.713675	0.617375	0.853725
0	91.0	15.0	0.488599	0.757576	0.594059	0.847211

	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	17.0	0.465798	0.794444	0.587269	0.853322
0	91.0	19.0	0.462541	0.793296	0.584362	0.849484
0	91.0	21.0	0.439739	0.784884	0.563674	0.849101
0	91.0	23.0	0.436482	0.765714	0.556017	0.850693
0	91.0	25.0	0.429967	0.77193	0.552301	0.852291
0	91.0	27.0	0.429967	0.77193	0.552301	0.852306
0	91.0	29.0	0.433225	0.768786	0.554167	0.852637
0	91.0	31.0	0.433225	0.773256	0.555324	0.851891
0	91.0	33.0	0.429967	0.77193	0.552301	0.852134
0	91.0	35.0	0.429967	0.77193	0.552301	0.852134
0	91.0	37.0	0.429967	0.77193	0.552301	0.852134
0	91.0	39.0	0.429967	0.77193	0.552301	0.852134
0	91.0	41.0	0.429967	0.77193	0.552301	0.852134
0	91.0	43.0	0.429967	0.77193	0.552301	0.852134
0	91.0	45.0	0.429967	0.77193	0.552301	0.852134
0	91.0	47.0	0.429967	0.77193	0.552301	0.852134
0	91.0	49.0	0.429967	0.77193	0.552301	0.852134
0	101.0	5.0	0.749186	0.503282	0.602094	0.854029
0	101.0	7.0	0.729642	0.554455	0.630098	0.858673
0	101.0	9.0	0.687296	0.604585	0.643293	0.858854
0	101.0	11.0	0.618893	0.664336	0.640809	0.855779
0	101.0	13.0	0.537459	0.705128	0.609982	0.853914
0	101.0	15.0	0.498371	0.765	0.60355	0.849143
0	101.0	17.0	0.459283	0.792135	0.581443	0.853834
0	101.0	19.0	0.469055	0.79558	0.590164	0.849159
0	101.0	21.0	0.429967	0.77193	0.552301	0.850437
0	101.0	23.0	0.433225	0.782353	0.557652	0.851121
0	101.0	25.0	0.439739	0.780347	0.5625	0.852112
0	101.0	27.0	0.436482	0.774566	0.558333	0.85203
0	101.0	29.0	0.436482	0.770115	0.557173	0.852254
0	101.0	31.0	0.436482	0.774566	0.558333	0.851727

	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	33.0	0.436482	0.774566	0.558333	0.851839
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	35.0	0.436482	0.774566	0.558333	0.851839
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	37.0	0.436482	0.774566	0.558333	0.851839
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	39.0	0.436482	0.774566	0.558333	0.851839
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	41.0	0.436482	0.774566	0.558333	0.851839
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	43.0	0.436482	0.774566	0.558333	0.851839
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	45.0	0.436482	0.774566	0.558333	0.851839
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	47.0	0.436482	0.774566	0.558333	0.851839
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	49.0	0.436482	0.774566	0.558333	0.851839
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	5.0	0.7557	0.502165	0.603381	0.854452
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	7.0	0.736156	0.547215	0.627778	0.858717
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	9.0	0.687296	0.60114	0.641337	0.859198
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	11.0	0.615635	0.670213	0.641766	0.856964
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	13.0	0.547231	0.717949	0.621072	0.854452
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	15.0	0.491857	0.758794	0.596838	0.849793
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	17.0	0.465798	0.785714	0.584867	0.853431
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	19.0	0.465798	0.794444	0.587269	0.850718
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	21.0	0.446254	0.765363	0.563786	0.850447
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	23.0	0.433225	0.777778	0.556485	0.851692
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	25.0	0.436482	0.77907	0.559499	0.851284
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	27.0	0.439739	0.771429	0.560166	0.851367
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	29.0	0.439739	0.762712	0.557851	0.851568
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	31.0	0.439739	0.771429	0.560166	0.850994
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	33.0	0.439739	0.767045	0.559006	0.851194
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	35.0	0.439739	0.767045	0.559006	0.851194
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	37.0	0.439739	0.767045	0.559006	0.851194
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	39.0	0.439739	0.767045	0.559006	0.851194
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	41.0	0.439739	0.767045	0.559006	0.851194
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	43.0	0.439739	0.767045	0.559006	0.851194
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	45.0	0.439739	0.767045	0.559006	0.851194
	estimators	max_depth	recall	precision	f1	auc_roc

```
   0       111.0       47.0  0.439739   0.767045  0.559006  0.851194
      estimators  max_depth    recall  precision        f1   auc_roc
   0       111.0       49.0  0.439739   0.767045  0.559006  0.851194
      estimators  max_depth  recall  precision        f1   auc_roc
   0       121.0        5.0  0.7557   0.503254  0.604167  0.854542
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0        7.0  0.732899   0.551471  0.629371  0.858458
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0        9.0  0.684039   0.598291  0.638298  0.859503
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       11.0  0.615635    0.65625  0.635294  0.856617
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       13.0  0.550489   0.716102  0.622468  0.853925
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       15.0  0.491857   0.758794  0.596838  0.850332
      estimators  max_depth    recall  precision        f1  auc_roc
   0       121.0       17.0  0.459283   0.779006  0.577869  0.85419
      estimators  max_depth    recall  precision        f1  auc_roc
   0       121.0       19.0  0.469055   0.804469  0.592593  0.85165
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       21.0  0.449511    0.77095  0.567901  0.850596
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       23.0  0.433225   0.777778  0.556485  0.852017
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       25.0  0.436482    0.77907  0.559499  0.851988
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       27.0  0.442997   0.777143  0.564315  0.852058
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       29.0  0.439739   0.762712  0.557851  0.852086
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       31.0  0.439739   0.767045  0.559006  0.851622
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       33.0  0.442997   0.772727  0.563147  0.851759
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       35.0  0.442997   0.772727  0.563147  0.851759
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       37.0  0.442997   0.772727  0.563147  0.851759
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       39.0  0.442997   0.772727  0.563147  0.851759
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       41.0  0.442997   0.772727  0.563147  0.851759
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       43.0  0.442997   0.772727  0.563147  0.851759
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       45.0  0.442997   0.772727  0.563147  0.851759
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       47.0  0.442997   0.772727  0.563147  0.851759
      estimators  max_depth    recall  precision        f1   auc_roc
   0       121.0       49.0  0.442997   0.772727  0.563147  0.851759
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0        5.0  0.752443   0.506579  0.605505  0.855108
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0        7.0  0.736156   0.552567  0.631285  0.858387
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0        9.0  0.677524   0.590909  0.631259  0.859643
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       11.0  0.612378   0.659649  0.635135  0.856798
      estimators  max_depth    recall  precision        f1  auc_roc
   0       131.0       13.0  0.553746   0.723404  0.627306  0.85337
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       15.0  0.495114        0.76  0.599606  0.849549
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	17.0	0.459283	0.779006	0.577869	0.854489
0	131.0	19.0	0.462541	0.788889	0.583162	0.851128
0	131.0	21.0	0.452769	0.785311	0.57438	0.851284
0	131.0	23.0	0.439739	0.775862	0.561331	0.852204
0	131.0	25.0	0.442997	0.772727	0.563147	0.852559
0	131.0	27.0	0.446254	0.778409	0.567288	0.852441
0	131.0	29.0	0.446254	0.765363	0.563786	0.852465
0	131.0	31.0	0.446254	0.774011	0.566116	0.852026
0	131.0	33.0	0.446254	0.774011	0.566116	0.852215
0	131.0	35.0	0.446254	0.774011	0.566116	0.852215
0	131.0	37.0	0.446254	0.774011	0.566116	0.852215
0	131.0	39.0	0.446254	0.774011	0.566116	0.852215
0	131.0	41.0	0.446254	0.774011	0.566116	0.852215
0	131.0	43.0	0.446254	0.774011	0.566116	0.852215
0	131.0	45.0	0.446254	0.774011	0.566116	0.852215
0	131.0	47.0	0.446254	0.774011	0.566116	0.852215
0	131.0	49.0	0.446254	0.774011	0.566116	0.852215
0	141.0	5.0	0.7557	0.50989	0.608924	0.854712
0	141.0	7.0	0.736156	0.553922	0.632168	0.858553
0	141.0	9.0	0.680782	0.590395	0.632375	0.85958
0	141.0	11.0	0.615635	0.665493	0.639594	0.857437
0	141.0	13.0	0.557003	0.72766	0.630996	0.854309
0	141.0	15.0	0.501629	0.766169	0.606299	0.849323
0	141.0	17.0	0.459283	0.779006	0.577869	0.854904
0	141.0	19.0	0.462541	0.78022	0.580777	0.851121
0	141.0	21.0	0.449511	0.784091	0.571429	0.851726
0	141.0	23.0	0.439739	0.771429	0.560166	0.852234
0	141.0	25.0	0.442997	0.781609	0.565489	0.852582
0	141.0	27.0	0.439739	0.780347	0.5625	0.852627
0	141.0	29.0	0.439739	0.775862	0.561331	0.852708

```
0       141.0       31.0  0.439739   0.775862  0.561331  0.852295
   estimators  max_depth    recall  precision        f1   auc_roc
0       141.0       33.0  0.439739   0.775862  0.561331  0.852373
   estimators  max_depth    recall  precision        f1   auc_roc
0       141.0       35.0  0.439739   0.775862  0.561331  0.852373
   estimators  max_depth    recall  precision        f1   auc_roc
0       141.0       37.0  0.439739   0.775862  0.561331  0.852373
   estimators  max_depth    recall  precision        f1   auc_roc
0       141.0       39.0  0.439739   0.775862  0.561331  0.852373
   estimators  max_depth    recall  precision        f1   auc_roc
0       141.0       41.0  0.439739   0.775862  0.561331  0.852373
   estimators  max_depth    recall  precision        f1   auc_roc
0       141.0       43.0  0.439739   0.775862  0.561331  0.852373
   estimators  max_depth    recall  precision        f1   auc_roc
0       141.0       45.0  0.439739   0.775862  0.561331  0.852373
   estimators  max_depth    recall  precision        f1   auc_roc
0       141.0       47.0  0.439739   0.775862  0.561331  0.852373
   estimators  max_depth    recall  precision        f1   auc_roc
0       141.0       49.0  0.439739   0.775862  0.561331  0.852373
```

In [32]:

```
# сбалансируем классы для модели логистической регрессии

def model_quality_lr_balanced(features_x,target_x,features_y,target_y):
    model = LogisticRegression(class_weight='balanced',solver='liblinear', random_state
=12345)
    model.fit(features_x, target_x) #обучим модель
    predicted_y=model.predict(features_y)
    recall=recall_score(target_y,predicted_y)
    precision=precision_score(target_y, predicted_y)
    f1=f1_score(target_y, predicted_y)
    probabilities_y = model.predict_proba(features_y)
    probabilities_one_y = probabilities_y[:, 1]
    auc_roc=roc_auc_score(target_y, probabilities_one_y )
    print("Полнота:", recall)
    print("Точность:", precision)
    print("F1-мера:", f1)
    print("AUC-ROC:", auc_roc)
```

In [33]:

```
model_quality_lr_balanced(features_train,target_train,features_valid,target_valid)
```

```
Полнота: 0.7296416938110749
Точность: 0.3855421686746988
F1-мера: 0.5045045045045046
AUC-ROC: 0.7792251761769933
```

мы получили максимальное значение f1 при том же гиперпараметре (глубина 7) у модели дерева решений после использования взвешивания классов, 0,5576 вместо 0,5503. макс значение f1 до взвешивания классов у модели случаного леса 0.54102 - для этих же гиперпараметров (оценцики 31, глубина 9) после балансирования классов показатель f1 увеличился до 0,59!

In [34]:

```
# Увеличим выборку, проведем upsampling:

# Разделим обучающую выборку на отрицательные и положительные объекты
features_zeros = features_train[target_train==0]
features_ones = features_train[target_train==1]
target_zeros = target_train[target_train==0]
target_ones = target_train[target_train==1]
print(features_zeros.shape)
print(features_ones.shape)
print(target_zeros.shape)
print(target_ones.shape)
```

```
(5589, 11)
(1411, 11)
(5589,)
(1411,)
```

In [35]:

```
# Скопируем несколько раз положительные объекты
# С учётом полученных данных создадим новую обучающую выборку

features_upsampled = pd.concat([features_zeros] + [features_ones] * 5)
target_upsampled = pd.concat([target_zeros] + [target_ones] * 5)

# Перемешаем данные
features_upsampled, target_upsampled=shuffle(features_upsampled, target_upsampled, rand
om_state=12345)
```

In [36]:

```
print(features_upsampled.shape)
print(target_upsampled.shape)
```

```
(12644, 11)
(12644,)
```

In [37]:

```
print(target_upsampled.shape)
```

```
(12644,)
```

In [38]:

```
# Разделим валидационную выборку на отрицательные и положительные объекты
features_zeros_valid = features_valid[target_valid==0]
features_ones_valid = features_valid[target_valid==1]
target_zeros_valid = target_valid[target_valid==0]
target_ones_valid = target_valid[target_valid==1]
print(features_zeros_valid.shape)
print(features_ones_valid.shape)
print(target_zeros_valid.shape)
print(target_ones_valid.shape)
```

```
(1193, 11)
(307, 11)
(1193,)
(307,)
```

In [39]:

```
# Скопируем несколько раз положительные объекты
# С учётом полученных данных создадим новую валидационную выборку

features_upsampled_valid = pd.concat([features_zeros_valid] + [features_ones_valid] * 5
)
target_upsampled_valid = pd.concat([target_zeros_valid] + [target_ones_valid] * 5)

# Перемешаем данные
features_upsampled_valid, target_upsampled_valid=shuffle(features_upsampled_valid, targ
et_upsampled_valid, random_state=12345)
```

In [40]:

```
features_zeros_test = features_test[target_test==0]
features_ones_test = features_test[target_test==1]
target_zeros_test = target_test[target_test==0]
target_ones_test = target_test[target_test==1]
print(features_zeros_test.shape)
print(features_ones_test.shape)
print(target_zeros_test.shape)
print(target_ones_test.shape)
```

```
(1181, 11)
(319, 11)
(1181,)
(319,)
```

In [41]:

```
# Скопируем несколько раз положительные объекты
# С учётом полученных данных создадим новую тестовую выборку

features_upsampled_test = pd.concat([features_zeros_test] + [features_ones_test] * 5)
target_upsampled_test = pd.concat([target_zeros_test] + [target_ones_test] * 5)

# Перемешаем данные
features_upsampled_test, target_upsampled_test=shuffle(features_upsampled_test, target_
upsampled_test, random_state=12345)
```

In [42]:

```
print(features_upsampled_test.shape)
print(target_upsampled_test.shape)
```

```
(2776, 11)
(2776,)
```

In [43]:

```
#Исследуем качество разных моделей, меняя гиперпараметры, на увеличенной выборке.

#для модели решающего дерева
#в цикле проверим гиперпараметр глубины дерева от 1 до 30, кратно 2
for depth in range(1,31,2):
    model_quality_dtc(features_upsampled,target_upsampled,features_upsampled_valid,targ
et_upsampled_valid, depth)
```

```
   depth    recall  precision       f1   auc_roc
0    1.0  0.732899   0.741107  0.73698  0.701739
   depth    recall  precision        f1   auc_roc
0    3.0  0.771987   0.747163  0.759372  0.793643
   depth    recall  precision        f1   auc_roc
0    5.0  0.824104   0.767597  0.794848  0.831514
   depth   recall  precision        f1   auc_roc
0    7.0  0.80456   0.780657  0.792429  0.826974
   depth    recall  precision        f1   auc_roc
0    9.0  0.739414   0.781142  0.759705  0.790398
   depth    recall  precision        f1   auc_roc
0   11.0  0.697068   0.800898  0.745385  0.764816
   depth    recall  precision        f1   auc_roc
0   13.0  0.618893   0.801688  0.698529  0.723452
   depth    recall  precision        f1   auc_roc
0   15.0  0.543974   0.819431  0.653876  0.704619
   depth   recall  precision        f1   auc_roc
0   17.0  0.52443   0.825641  0.641434  0.691098
   depth    recall  precision        f1   auc_roc
0   19.0  0.517915   0.832461  0.638554  0.691707
   depth    recall  precision        f1  auc_roc
0   21.0  0.498371   0.833333  0.623726  0.68444
   depth    recall  precision       f1   auc_roc
0   23.0  0.508143    0.83871  0.63286  0.691214
   depth    recall  precision        f1   auc_roc
0   25.0  0.501629   0.831533  0.625762  0.685433
   depth    recall  precision        f1   auc_roc
0   27.0  0.498371   0.831522  0.623218  0.684223
   depth    recall  precision        f1   auc_roc
0   29.0  0.498371   0.831522  0.623218  0.684223
```

показатель f1 после увеличения выборки уменьшился, но остался на той же глубине 7.

In [44]:

```
#посчитаем для модели со сбалансированными классами и расширенной выборкой
for depth in range(1,31,2):
    model_quality_dtc_balanced(features_upsampled,target_upsampled,features_upsampled_v
alid,target_upsampled_valid, depth)
```

```
   depth    recall  precision        f1   auc_roc
0    1.0  0.618893   0.794979  0.695971  0.706764
   depth    recall  precision        f1   auc_roc
0    3.0  0.677524   0.803709  0.735242  0.800072
   depth    recall  precision        f1  auc_roc
0    5.0  0.693811    0.84323  0.761258  0.83681
   depth    recall  precision        f1   auc_roc
0    7.0  0.723127   0.800288  0.759754  0.808644
   depth    recall  precision        f1   auc_roc
0    9.0  0.703583   0.798226  0.747922  0.788953
   depth    recall  precision        f1  auc_roc
0   11.0  0.612378   0.786611  0.688645   0.7213
   depth    recall  precision        f1   auc_roc
0   13.0  0.576547   0.794434  0.668177  0.699649
   depth    recall  precision        f1   auc_roc
0   15.0  0.521173   0.818833  0.636943  0.686334
   depth    recall  precision        f1   auc_roc
0   17.0  0.488599   0.819672  0.612245  0.673499
   depth   recall  precision        f1   auc_roc
0   19.0  0.47557   0.828604  0.604305  0.674266
   depth    recall  precision        f1   auc_roc
0   21.0  0.472313    0.83047  0.602159  0.674128
   depth    recall  precision        f1   auc_roc
0   23.0  0.472313    0.83047  0.602159  0.674128
   depth    recall  precision        f1   auc_roc
0   25.0  0.472313    0.83047  0.602159  0.674128
   depth    recall  precision        f1   auc_roc
0   27.0  0.472313    0.83047  0.602159  0.674128
   depth    recall  precision        f1   auc_roc
0   29.0  0.472313    0.83047  0.602159  0.674128
```

Максимальное значение f1 снизилось на сбалансированной (0,79) и расширенной выборке по сравнению с просто расширенной выборкой (0,76).

In [45]:

```
#построим функцию для постотроения графиков полнота-точность для модели, показавшей луч
шее значение f1. Чем выше кривая, тем лучше модель.

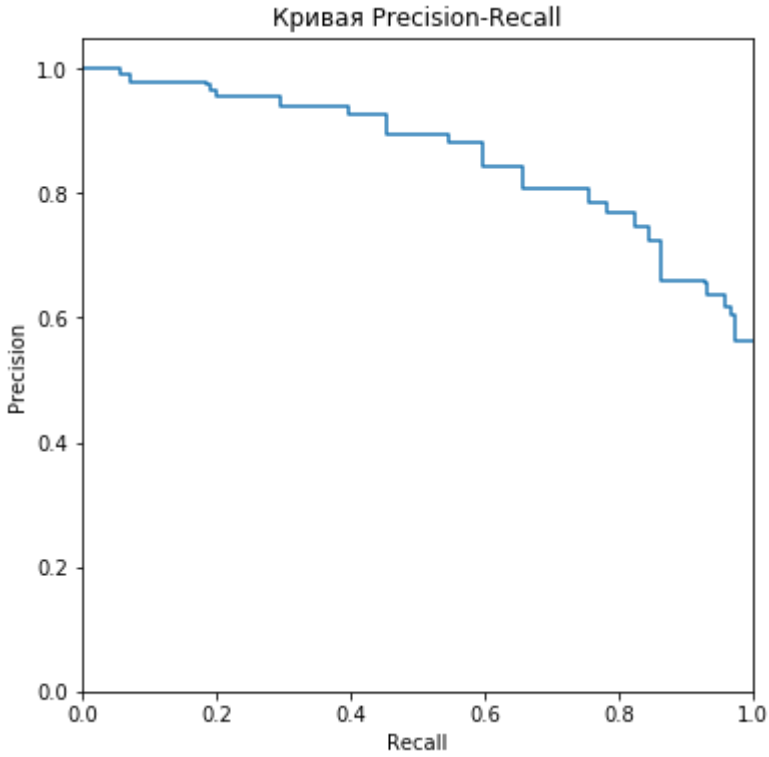
def model_quality_dtc_plt(features_x,target_x,features_y,target_y, depth):
    model= DecisionTreeClassifier(random_state=12345, max_depth=depth)
    model.fit(features_x, target_x) #обучим модель
    predicted_y=model.predict(features_y) #предскажем по валидационной выборке
    recall=recall_score(target_y,predicted_y)
    precision=precision_score(target_y, predicted_y)
    probabilities_y = model.predict_proba(features_y)
    probabilities_one_y = probabilities_y[:, 1]
    precision, recall, thresholds = precision_recall_curve(target_y, probabilities_y[:,
1])
    plt.figure(figsize=(6, 6))
    plt.step(recall, precision, where='post')
    plt.xlabel('Recall')
    plt.ylabel('Precision')
    plt.ylim([0.0, 1.05])
    plt.xlim([0.0, 1.0])
    print("График для глубины", depth)
    plt.title('Кривая Precision-Recall')
    plt.show()

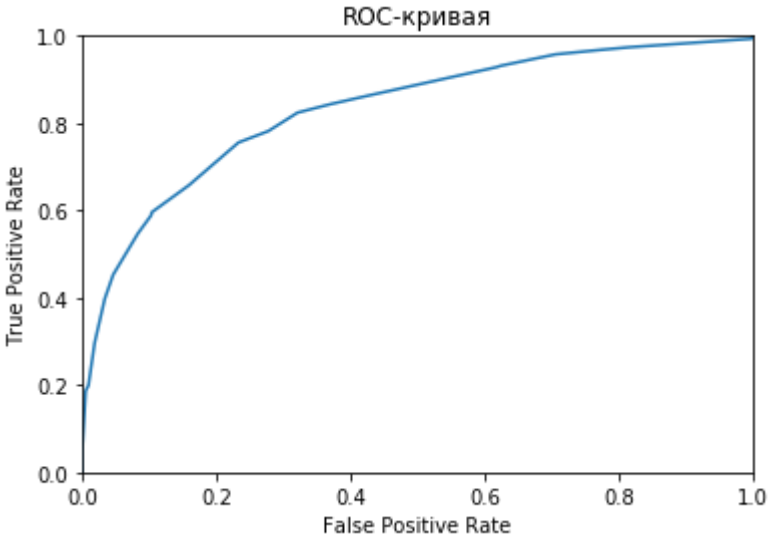
    fpr, tpr, thresholds = roc_curve(target_y, probabilities_one_y)
    plt.figure()
    plt.plot(fpr, tpr)
    plt.xlim([0.0, 1.0])# < применим функции plt.xlim() и plt.ylim(), чтобы
    plt.ylim([0.0, 1.0])#   установить границы осей от 0 до 1 >
    plt.xlabel('False Positive Rate')# < применим функции plt.xlabel() и plt.ylabel(),
 чтобы
    plt.ylabel('True Positive Rate')#   подписать оси "False Positive Rate" и "True Pos
itive Rate" >
    plt.title('ROC-кривая')# < добавим к графику заголовок "ROC-кривая" функцией plt.ti
tle() >
    plt.show()
```

In [46]:

```
model_quality_dtc_plt(features_upsampled,target_upsampled,features_upsampled_valid,targ
et_upsampled_valid, 5)
```

```
График для глубины 5
```





In [47]:

```
#для модели случайного леса с расширенной выборкой
#в цикле проверим качество модели для гиперпараметра количество оценщиков от 1 до 100,
 кратно 10
for estim in range(1,151,10):
    for depth in range (1,30,2):
        model_quality_rfc(features_upsampled, target_upsampled,features_upsampled_valid
,target_upsampled_valid, estim, depth)
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	1.0	1.0	0.562683	0.72015	0.566261
0	1.0	3.0	0.81759	0.727115	0.769703	0.723885
0	1.0	5.0	0.76873	0.763754	0.766234	0.798912
0	1.0	7.0	0.801303	0.765401	0.782941	0.806149
0	1.0	9.0	0.7557	0.773333	0.764415	0.790885
0	1.0	11.0	0.693811	0.798351	0.742419	0.759284
0	1.0	13.0	0.638436	0.786517	0.704782	0.723392
0	1.0	15.0	0.631922	0.803645	0.707513	0.730737
0	1.0	17.0	0.570033	0.794732	0.663885	0.697724
0	1.0	19.0	0.557003	0.799813	0.656682	0.689118
0	1.0	21.0	0.605863	0.812227	0.69403	0.713003
0	1.0	23.0	0.530945	0.79902	0.637965	0.681348
0	1.0	25.0	0.576547	0.817175	0.676089	0.70529
0	1.0	27.0	0.576547	0.817175	0.676089	0.70529
0	1.0	29.0	0.576547	0.817175	0.676089	0.70529
0	11.0	1.0	0.938111	0.622837	0.748635	0.74502
0	11.0	3.0	0.814332	0.758495	0.785423	0.835946
0	11.0	5.0	0.794788	0.803689	0.799214	0.853439
0	11.0	7.0	0.801303	0.820547	0.810811	0.855202
0	11.0	9.0	0.7557	0.835133	0.793434	0.845024
0	11.0	11.0	0.710098	0.846273	0.772228	0.84262
0	11.0	13.0	0.628664	0.870153	0.729955	0.824121
0	11.0	15.0	0.599349	0.867107	0.708783	0.822137
0	11.0	17.0	0.57329	0.887097	0.696478	0.82491
0	11.0	19.0	0.596091	0.889213	0.713729	0.824357
0	11.0	21.0	0.566775	0.893224	0.693503	0.827677
0	11.0	23.0	0.547231	0.886076	0.676601	0.820328
0	11.0	25.0	0.557003	0.893417	0.686196	0.819162
0	11.0	27.0	0.557003	0.893417	0.686196	0.819162
0	11.0	29.0	0.557003	0.893417	0.686196	0.819162

```
   0         21.0         1.0  0.938111   0.622837  0.748635  0.792358
      estimators  max_depth   recall  precision        f1   auc_roc
   0         21.0         3.0  0.80456   0.755814  0.779426  0.839476
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         5.0  0.798046    0.79288  0.795455  0.850323
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         7.0  0.801303    0.81457  0.807882  0.857633
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         9.0  0.752443   0.834538  0.791367  0.850059
      estimators  max_depth   recall  precision        f1   auc_roc
   0         21.0        11.0  0.70684   0.851648  0.772517  0.849442
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        13.0  0.631922   0.866845  0.730972  0.835856
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        15.0  0.589577   0.887255  0.708415  0.841397
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        17.0  0.589577    0.89604  0.711198  0.831478
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        19.0  0.563518    0.88627  0.688969  0.831658
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        21.0  0.553746   0.901379  0.686037  0.837104
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        23.0  0.570033   0.903926  0.699161  0.836589
      estimators  max_depth    recall  precision      f1   auc_roc
   0         21.0        25.0  0.563518   0.904812  0.6945  0.834837
      estimators  max_depth    recall  precision      f1   auc_roc
   0         21.0        27.0  0.563518   0.904812  0.6945  0.834837
      estimators  max_depth    recall  precision      f1   auc_roc
   0         21.0        29.0  0.563518   0.904812  0.6945  0.834837
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0         1.0  0.908795   0.664602  0.767749  0.792612
      estimators  max_depth   recall  precision        f1   auc_roc
   0         31.0         3.0  0.80456   0.756277  0.779672  0.835943
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0         5.0  0.811075   0.789975  0.800386  0.850201
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0         7.0  0.807818   0.810988  0.809399  0.858467
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0         9.0  0.765472   0.834517  0.798505  0.852972
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0        11.0  0.710098   0.860979  0.778293  0.852598
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0        13.0  0.641694   0.877897  0.741438  0.846295
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0        15.0  0.605863    0.89942  0.724017  0.845473
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0        17.0  0.586319   0.895522  0.708661  0.839042
      estimators  max_depth   recall  precision        f1   auc_roc
   0         31.0        19.0  0.57329   0.892495  0.698136  0.837527
      estimators  max_depth    recall  precision        f1  auc_roc
   0         31.0        21.0  0.560261   0.903361  0.691596  0.84386
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0        23.0  0.566775    0.90249  0.696279  0.841928
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0        25.0  0.566775   0.907195  0.697674  0.840384
      estimators  max_depth   recall  precision        f1   auc_roc
   0         31.0        27.0  0.57329   0.906282  0.702314  0.840641
      estimators  max_depth   recall  precision        f1   auc_roc
   0         31.0        29.0  0.57329   0.906282  0.702314  0.840641
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0         1.0  0.908795   0.664602  0.767749  0.802616
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	3.0	0.807818	0.75841	0.782334	0.84072
0	41.0	5.0	0.811075	0.791985	0.801416	0.850548
0	41.0	7.0	0.811075	0.811604	0.811339	0.8593
0	41.0	9.0	0.758958	0.825071	0.790635	0.853775
0	41.0	11.0	0.703583	0.850394	0.770053	0.852555
0	41.0	13.0	0.644951	0.873016	0.741851	0.845783
0	41.0	15.0	0.589577	0.891626	0.709804	0.845319
0	41.0	17.0	0.583062	0.904954	0.709192	0.841052
0	41.0	19.0	0.547231	0.889831	0.677693	0.839091
0	41.0	21.0	0.547231	0.906149	0.682372	0.84568
0	41.0	23.0	0.553746	0.903294	0.686591	0.844076
0	41.0	25.0	0.557003	0.904762	0.689516	0.842874
0	41.0	27.0	0.560261	0.905263	0.692153	0.843165
0	41.0	29.0	0.560261	0.905263	0.692153	0.843165
0	51.0	1.0	0.908795	0.642857	0.753036	0.802997
0	51.0	3.0	0.807818	0.755637	0.780856	0.840815
0	51.0	5.0	0.807818	0.790312	0.798969	0.850975
0	51.0	7.0	0.814332	0.81011	0.812216	0.857988
0	51.0	9.0	0.7557	0.824449	0.788579	0.853852
0	51.0	11.0	0.70684	0.85098	0.772242	0.851233
0	51.0	13.0	0.654723	0.875436	0.749161	0.845574
0	51.0	15.0	0.596091	0.893555	0.715123	0.845035
0	51.0	17.0	0.57329	0.90535	0.702034	0.840837
0	51.0	19.0	0.553746	0.897571	0.684932	0.843846
0	51.0	21.0	0.543974	0.901728	0.678586	0.845468
0	51.0	23.0	0.543974	0.908596	0.680522	0.842974
0	51.0	25.0	0.550489	0.907626	0.68532	0.841207
0	51.0	27.0	0.543974	0.904659	0.679414	0.841887
0	51.0	29.0	0.543974	0.904659	0.679414	0.841887
0	61.0	1.0	0.889251	0.675408	0.767717	0.804646

```
   0         61.0         3.0  0.811075   0.754088  0.781544  0.840807
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0         5.0  0.811075   0.790978  0.800901  0.850362
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0         7.0  0.80456    0.811966  0.808246  0.856672
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0         9.0  0.765472   0.826882  0.794993  0.854646
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0        11.0  0.703583    0.85443  0.771704  0.851861
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0        13.0  0.651466   0.878735  0.748223  0.847307
      estimators  max_depth    recall  precision        f1  auc_roc
   0         61.0        15.0  0.579805   0.896274  0.704114  0.84748
      estimators  max_depth    recall  precision        f1  auc_roc
   0         61.0        17.0  0.57329    0.90535  0.702034  0.84366
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0        19.0  0.550489   0.898936  0.682828  0.844125
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0        21.0  0.553746   0.904255  0.686869  0.846233
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0        23.0  0.537459   0.905598  0.674571  0.845237
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0        25.0  0.557003   0.906681  0.690073  0.843607
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0        27.0  0.557003   0.904762  0.689516  0.844242
      estimators  max_depth    recall  precision        f1   auc_roc
   0         61.0        29.0  0.557003   0.904762  0.689516  0.844242
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0         1.0  0.918567    0.64768  0.759698  0.807064
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0         3.0  0.807818   0.755177  0.780611  0.839061
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0         5.0  0.807818   0.789809  0.798712  0.849973
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0         7.0  0.811075   0.811075  0.811075  0.856402
      estimators  max_depth    recall  precision        f1  auc_roc
   0         71.0         9.0  0.765472   0.827465  0.795262  0.85611
      estimators  max_depth    recall  precision      f1   auc_roc
   0         71.0        11.0  0.697068    0.85327  0.7673  0.852533
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        13.0  0.648208   0.878199  0.745877  0.846499
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        15.0  0.579805   0.896274  0.704114  0.848081
      estimators  max_depth    recall  precision       f1   auc_roc
   0         71.0        17.0  0.553746   0.900424  0.68576  0.843341
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        19.0  0.553746   0.901379  0.686037  0.846227
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        21.0  0.550489   0.905681  0.684765  0.847277
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        23.0  0.547231   0.907127  0.682649  0.846091
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        25.0  0.553746   0.909091  0.688259  0.845626
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        27.0  0.550489   0.908602  0.685598  0.846212
      estimators  max_depth    recall  precision        f1   auc_roc
   0         71.0        29.0  0.550489   0.908602  0.685598  0.846212
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0         1.0  0.90228    0.65054  0.756004  0.807674
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0         3.0  0.811075   0.753176  0.781054  0.841046
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	5.0	0.80456	0.792174	0.798319	0.850637
0	81.0	7.0	0.807818	0.813648	0.810722	0.857486
0	81.0	9.0	0.765472	0.823406	0.793383	0.856039
0	81.0	11.0	0.703583	0.855107	0.77198	0.852091
0	81.0	13.0	0.644951	0.88	0.744361	0.84752
0	81.0	15.0	0.579805	0.895372	0.703836	0.84954
0	81.0	17.0	0.566775	0.90625	0.697395	0.843901
0	81.0	19.0	0.557003	0.902851	0.688961	0.847594
0	81.0	21.0	0.557003	0.907643	0.690351	0.848769
0	81.0	23.0	0.560261	0.909091	0.693269	0.847103
0	81.0	25.0	0.560261	0.906217	0.692432	0.846631
0	81.0	27.0	0.563518	0.908613	0.695617	0.84688
0	81.0	29.0	0.566775	0.909091	0.698234	0.846607
0	91.0	1.0	0.879479	0.681818	0.768137	0.806465
0	91.0	3.0	0.807818	0.753799	0.779874	0.841839
0	91.0	5.0	0.807818	0.792839	0.800258	0.850691
0	91.0	7.0	0.80456	0.8125	0.808511	0.857996
0	91.0	9.0	0.752443	0.823236	0.786249	0.855602
0	91.0	11.0	0.697068	0.853951	0.767575	0.85206
0	91.0	13.0	0.641694	0.88025	0.742276	0.848956
0	91.0	15.0	0.586319	0.893744	0.708104	0.847897
0	91.0	17.0	0.563518	0.904812	0.6945	0.844869
0	91.0	19.0	0.566775	0.904366	0.696836	0.84757
0	91.0	21.0	0.550489	0.90958	0.685877	0.848443
0	91.0	23.0	0.553746	0.909091	0.688259	0.846933
0	91.0	25.0	0.550489	0.905681	0.684765	0.846359
0	91.0	27.0	0.547231	0.906149	0.682372	0.846601
0	91.0	29.0	0.560261	0.909091	0.693269	0.846346
0	101.0	1.0	0.882736	0.680563	0.768576	0.80792
0	101.0	3.0	0.814332	0.756659	0.784437	0.841336

```
   0       101.0        5.0  0.81759   0.793801  0.80552  0.85035
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0        7.0  0.811075   0.815858  0.81346  0.858764
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0        9.0  0.752443   0.824411  0.786785  0.855304
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0       11.0  0.697068   0.853951  0.767575  0.851897
      estimators  max_depth    recall  precision       f1  auc_roc
   0       101.0       13.0  0.648208   0.881311  0.746997  0.84954
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0       15.0  0.592834   0.897436  0.714005  0.847832
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0       17.0  0.563518   0.905759  0.694779  0.844904
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0       19.0  0.557003   0.904762  0.689516  0.848661
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0       21.0  0.550489    0.91056  0.686155  0.848116
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0       23.0  0.550489   0.908602  0.685598  0.846664
      estimators  max_depth    recall  precision       f1  auc_roc
   0       101.0       25.0  0.553746    0.90715  0.687702  0.84705
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0       27.0  0.550489   0.905681  0.684765  0.846881
      estimators  max_depth    recall  precision       f1   auc_roc
   0       101.0       29.0  0.553746    0.90812  0.687981  0.846802
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0        1.0  0.889251   0.671752  0.765349  0.808488
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0        3.0  0.814332   0.757576  0.784929  0.840493
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0        5.0  0.820847   0.794953  0.807692  0.851013
      estimators  max_depth   recall  precision       f1   auc_roc
   0       111.0        7.0  0.80456   0.814644  0.809571  0.858616
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0        9.0  0.752443    0.82618  0.787589  0.855192
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0       11.0  0.710098   0.856245  0.776353  0.853065
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0       13.0  0.648208   0.881311  0.746997  0.849893
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0       15.0  0.592834   0.895669  0.713446  0.848516
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0       17.0  0.566775   0.905307  0.697115  0.845078
      estimators  max_depth    recall  precision       f1  auc_roc
   0       111.0       19.0  0.550489   0.903743  0.684211  0.84811
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0       21.0  0.553746   0.909091  0.688259  0.846985
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0       23.0  0.547231   0.908108  0.682927  0.846201
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0       25.0  0.553746   0.905218  0.687146  0.846641
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0       27.0  0.550489   0.906652  0.685043  0.847079
      estimators  max_depth    recall  precision       f1   auc_roc
   0       111.0       29.0  0.553746    0.90812  0.687981  0.846915
      estimators  max_depth   recall  precision       f1   auc_roc
   0       121.0        1.0  0.90228   0.650235  0.755798  0.810074
      estimators  max_depth    recall  precision       f1  auc_roc
   0       121.0        3.0  0.814332   0.757117  0.784683  0.84111
      estimators  max_depth    recall  precision       f1   auc_roc
   0       121.0        5.0  0.820847   0.793951  0.807175  0.851114
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	7.0	0.80456	0.815182	0.809836	0.857983
0	121.0	9.0	0.749186	0.825556	0.785519	0.855591
0	121.0	11.0	0.70684	0.853659	0.773343	0.852243
0	121.0	13.0	0.648208	0.881311	0.746997	0.850562
0	121.0	15.0	0.589577	0.896928	0.711478	0.848056
0	121.0	17.0	0.57329	0.910031	0.703437	0.845387
0	121.0	19.0	0.550489	0.901814	0.683657	0.848398
0	121.0	21.0	0.550489	0.908602	0.685598	0.846721
0	121.0	23.0	0.547231	0.910076	0.683483	0.846056
0	121.0	25.0	0.547231	0.911063	0.683761	0.846238
0	121.0	27.0	0.553746	0.910064	0.688538	0.846642
0	121.0	29.0	0.553746	0.91104	0.688817	0.84637
0	131.0	1.0	0.889251	0.663265	0.759811	0.809408
0	131.0	3.0	0.811075	0.75961	0.784499	0.841508
0	131.0	5.0	0.81759	0.792798	0.805003	0.851196
0	131.0	7.0	0.80456	0.814107	0.809305	0.857887
0	131.0	9.0	0.749186	0.824964	0.785251	0.854957
0	131.0	11.0	0.70684	0.854331	0.773619	0.852806
0	131.0	13.0	0.641694	0.879464	0.741996	0.849903
0	131.0	15.0	0.589577	0.89604	0.711198	0.848678
0	131.0	17.0	0.57329	0.910031	0.703437	0.845819
0	131.0	19.0	0.550489	0.902778	0.683934	0.849072
0	131.0	21.0	0.553746	0.909091	0.688259	0.846178
0	131.0	23.0	0.550489	0.91056	0.686155	0.846319
0	131.0	25.0	0.550489	0.913514	0.686992	0.846753
0	131.0	27.0	0.553746	0.912017	0.689096	0.847181
0	131.0	29.0	0.557003	0.912487	0.691748	0.847026
0	141.0	1.0	0.895765	0.654139	0.756118	0.809747
0	141.0	3.0	0.814332	0.759878	0.786164	0.841019
0	141.0	5.0	0.824104	0.795597	0.8096	0.851501

```
   0       141.0        7.0  0.801303   0.816191  0.808679  0.858237
      estimators  max_depth  recall  precision        f1   auc_roc
   0       141.0        9.0  0.7557   0.827389  0.789922  0.855498
      estimators  max_depth    recall  precision       f1   auc_roc
   0       141.0       11.0  0.703583   0.855107  0.77198  0.852544
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       13.0  0.638436   0.878136  0.739344  0.850507
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       15.0  0.583062   0.894106  0.705836  0.849207
      estimators  max_depth   recall  precision        f1   auc_roc
   0       141.0       17.0  0.57329   0.910031  0.703437  0.846026
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       19.0  0.550489   0.903743  0.684211  0.849381
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       21.0  0.553746    0.90715  0.687702  0.846549
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       23.0  0.543974   0.908596  0.680522  0.846702
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       25.0  0.550489    0.90958  0.685877  0.847484
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       27.0  0.547231   0.909091  0.683205  0.847648
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       29.0  0.553746    0.90812  0.687981  0.847647
```

In [48]:

```
#для модели случайного леса с расширенной выборкой и сбалансированными классами
for estim in range(1,151,10):
    for depth in range (1,50,2):
        model_quality_rfc_balanced(features_upsampled, target_upsampled,features_upsamp
led_valid,target_upsampled_valid, estim, depth)
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	1.0	0.140065	0.959821	0.244457	0.566261

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	3.0	0.81759	0.727115	0.769703	0.723885

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	5.0	0.618893	0.835532	0.711078	0.798912

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	7.0	0.726384	0.808557	0.765271	0.806149

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	9.0	0.71987	0.803052	0.759189	0.800355

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	11.0	0.628664	0.790336	0.70029	0.715052

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	13.0	0.661238	0.799213	0.723708	0.744211

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	15.0	0.586319	0.795756	0.675169	0.703696

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	17.0	0.530945	0.78668	0.633995	0.675377

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	19.0	0.517915	0.783251	0.623529	0.667778

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	21.0	0.511401	0.794534	0.622275	0.670772

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	23.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	25.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	27.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	29.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	31.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	33.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	35.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	37.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	39.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	41.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	43.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	45.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	47.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	49.0	0.553746	0.789963	0.651092	0.682154

	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	1.0	0.65798	0.806709	0.724794	0.750487

	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	3.0	0.745928	0.804073	0.77391	0.838627

	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	5.0	0.732899	0.840179	0.782881	0.854239

	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	7.0	0.739414	0.854669	0.792875	0.857254

	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	9.0	0.716612	0.846154	0.776014	0.84866

	estimators	max_depth	recall	precision	f1	auc_roc

```
   0         11.0        11.0  0.67101   0.869932  0.757631  0.838342
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        13.0  0.612378   0.872795  0.719755  0.826583
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        15.0  0.612378   0.881801  0.722799  0.819296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        17.0  0.566775   0.878788  0.689109  0.825744
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        19.0  0.570033   0.893769  0.696102  0.825943
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        21.0  0.563518   0.899168  0.692831  0.836551
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        23.0  0.566775   0.892308  0.693227  0.827266
      estimators  max_depth    recall  precision       f1   auc_roc
   0         11.0        25.0  0.563518   0.884458  0.68842  0.826067
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        27.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        29.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        31.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        33.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        35.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        37.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        39.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        41.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        43.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        45.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        47.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        49.0  0.570033   0.885628  0.693619  0.825274
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         1.0  0.749186   0.782845  0.765646  0.801165
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         3.0  0.758958   0.802342  0.780047  0.840394
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         5.0  0.745928   0.836377  0.788567  0.852555
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         7.0  0.723127   0.852535  0.782517  0.858466
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         9.0  0.713355    0.85214  0.776596  0.852966
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        11.0  0.667752   0.867174  0.754509  0.844067
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        13.0  0.625407   0.883165  0.732265  0.844447
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        15.0  0.586319         0.9  0.710059  0.835063
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        17.0  0.566775   0.895984  0.694334  0.842885
      estimators  max_depth    recall  precision     f1  auc_roc
   0         21.0        19.0  0.566775   0.901554  0.696  0.83619
      estimators  max_depth    recall  precision        f1  auc_roc
   0         21.0        21.0  0.563518   0.903866  0.694222  0.84339
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	23.0	0.550489	0.89135	0.680628	0.835276
0	21.0	25.0	0.550489	0.895127	0.681727	0.835114
0	21.0	27.0	0.547231	0.895522	0.679337	0.834753
0	21.0	29.0	0.547231	0.895522	0.679337	0.834753
0	21.0	31.0	0.547231	0.895522	0.679337	0.834753
0	21.0	33.0	0.547231	0.895522	0.679337	0.834753
0	21.0	35.0	0.547231	0.895522	0.679337	0.834753
0	21.0	37.0	0.547231	0.895522	0.679337	0.834753
0	21.0	39.0	0.547231	0.895522	0.679337	0.834753
0	21.0	41.0	0.547231	0.895522	0.679337	0.834753
0	21.0	43.0	0.547231	0.895522	0.679337	0.834753
0	21.0	45.0	0.547231	0.895522	0.679337	0.834753
0	21.0	47.0	0.547231	0.895522	0.679337	0.834753
0	21.0	49.0	0.547231	0.895522	0.679337	0.834753
0	31.0	1.0	0.76873	0.772251	0.770486	0.802773
0	31.0	3.0	0.762215	0.804124	0.782609	0.837749
0	31.0	5.0	0.745928	0.839443	0.789928	0.851614
0	31.0	7.0	0.749186	0.849963	0.796399	0.858385
0	31.0	9.0	0.71987	0.862607	0.784801	0.855943
0	31.0	11.0	0.667752	0.873083	0.756737	0.848574
0	31.0	13.0	0.615635	0.885661	0.726364	0.84949
0	31.0	15.0	0.586319	0.9	0.710059	0.837311
0	31.0	17.0	0.566775	0.893224	0.693503	0.841315
0	31.0	19.0	0.563518	0.904812	0.6945	0.838671
0	31.0	21.0	0.563518	0.905759	0.694779	0.843258
0	31.0	23.0	0.570033	0.900206	0.698045	0.840581
0	31.0	25.0	0.560261	0.898642	0.690209	0.84414
0	31.0	27.0	0.560261	0.903361	0.691596	0.841841
0	31.0	29.0	0.560261	0.903361	0.691596	0.842295
0	31.0	31.0	0.557003	0.900948	0.688406	0.842452

```
   0         31.0       33.0  0.553746   0.902335  0.686314  0.843278
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0       35.0  0.553746   0.902335  0.686314  0.843278
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0       37.0  0.553746   0.902335  0.686314  0.843278
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0       39.0  0.553746   0.902335  0.686314  0.843278
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0       41.0  0.553746   0.902335  0.686314  0.843278
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0       43.0  0.553746   0.902335  0.686314  0.843278
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0       45.0  0.553746   0.902335  0.686314  0.843278
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0       47.0  0.553746   0.902335  0.686314  0.843278
      estimators  max_depth    recall  precision        f1   auc_roc
   0         31.0       49.0  0.553746   0.902335  0.686314  0.843278
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        1.0  0.758958   0.779786  0.769231  0.808698
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        3.0  0.758958   0.811281  0.784248  0.840074
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        5.0  0.742671   0.840088  0.788382  0.852183
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        7.0  0.749186   0.848083  0.795572  0.859576
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        9.0  0.723127   0.863142  0.786955  0.856688
      estimators  max_depth   recall  precision        f1   auc_roc
   0         41.0       11.0  0.67101   0.874363  0.759307  0.852364
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       13.0  0.625407   0.889713  0.734507  0.849306
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       15.0  0.599349   0.898438  0.719031  0.839112
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       17.0  0.576547   0.905834  0.704618  0.847266
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       19.0  0.570033   0.902062  0.698603  0.842205
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       21.0  0.560261   0.903361  0.691596  0.845671
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       23.0  0.557003   0.899054  0.687852  0.842671
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       25.0  0.560261   0.903361  0.691596  0.846669
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       27.0  0.557003   0.906681  0.690073  0.845147
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       29.0  0.557003   0.904762  0.689516  0.845703
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       31.0  0.557003    0.90572  0.689794  0.845777
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       33.0  0.557003   0.904762  0.689516  0.846452
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       35.0  0.557003   0.904762  0.689516  0.846452
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       37.0  0.557003   0.904762  0.689516  0.846452
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       39.0  0.557003   0.904762  0.689516  0.846452
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       41.0  0.557003   0.904762  0.689516  0.846452
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       43.0  0.557003   0.904762  0.689516  0.846452
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	45.0	0.557003	0.904762	0.689516	0.846452
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	47.0	0.557003	0.904762	0.689516	0.846452
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	49.0	0.557003	0.904762	0.689516	0.846452
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	1.0	0.775244	0.776256	0.77575	0.807469
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	3.0	0.771987	0.815554	0.793173	0.840354
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	5.0	0.7557	0.839363	0.795338	0.852728
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	7.0	0.749186	0.848083	0.795572	0.858469
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	9.0	0.729642	0.858238	0.788732	0.857977
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	11.0	0.661238	0.874246	0.752967	0.853308
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	13.0	0.625407	0.889713	0.734507	0.850572
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	15.0	0.592834	0.898322	0.714286	0.842156
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	17.0	0.560261	0.897704	0.689932	0.847879
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	19.0	0.543974	0.897849	0.677485	0.845102
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	21.0	0.557003	0.908608	0.69063	0.848791
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	23.0	0.547231	0.903226	0.681542	0.843293
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	25.0	0.550489	0.902778	0.683934	0.846672
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	27.0	0.560261	0.909091	0.693269	0.845252
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	29.0	0.557003	0.904762	0.689516	0.845624
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	31.0	0.553746	0.905218	0.687146	0.845669
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	33.0	0.557003	0.904762	0.689516	0.846181
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	35.0	0.557003	0.904762	0.689516	0.846181
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	37.0	0.557003	0.904762	0.689516	0.846181
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	39.0	0.557003	0.904762	0.689516	0.846181
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	41.0	0.557003	0.904762	0.689516	0.846181
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	43.0	0.557003	0.904762	0.689516	0.846181
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	45.0	0.557003	0.904762	0.689516	0.846181
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	47.0	0.557003	0.904762	0.689516	0.846181
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	49.0	0.557003	0.904762	0.689516	0.846181
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	1.0	0.745928	0.792936	0.768714	0.808884
	estimators	max_depth	recall	precision	f1	auc_roc
0	61.0	3.0	0.775244	0.817869	0.795987	0.840118
	estimators	max_depth	recall	precision	f1	auc_roc

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   0        61.0        5.0  0.7557   0.839363  0.795338  0.852063
      estimators  max_depth  recall  precision        f1   auc_roc
   0        61.0        7.0  0.7557   0.843636  0.797251  0.857437
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0        9.0  0.723127   0.861133  0.786119  0.858067
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       11.0  0.654723   0.869377  0.746934  0.853737
      estimators  max_depth    recall  precision        f1  auc_roc
   0        61.0       13.0  0.625407   0.891365  0.735069  0.84982
      estimators  max_depth    recall  precision      f1   auc_roc
   0        61.0       15.0  0.586319   0.902708  0.7109  0.842914
      estimators  max_depth   recall  precision        f1   auc_roc
   0        61.0       17.0  0.57329   0.903491  0.701475  0.848264
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       19.0  0.557003   0.898109  0.687575  0.843953
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       21.0  0.553746   0.909091  0.688259  0.850428
      estimators  max_depth    recall  precision       f1   auc_roc
   0        61.0       23.0  0.553746   0.900424  0.68576  0.843344
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       25.0  0.553746   0.904255  0.686869  0.848183
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       27.0  0.560261   0.902413  0.691318  0.846391
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       29.0  0.553746   0.901379  0.686037  0.846785
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       31.0  0.557003   0.902851  0.688961  0.846843
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       33.0  0.557003   0.901899  0.688683  0.847209
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       35.0  0.557003   0.901899  0.688683  0.847209
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       37.0  0.557003   0.901899  0.688683  0.847209
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       39.0  0.557003   0.901899  0.688683  0.847209
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       41.0  0.557003   0.901899  0.688683  0.847209
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       43.0  0.557003   0.901899  0.688683  0.847209
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       45.0  0.557003   0.901899  0.688683  0.847209
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       47.0  0.557003   0.901899  0.688683  0.847209
      estimators  max_depth    recall  precision        f1   auc_roc
   0        61.0       49.0  0.557003   0.901899  0.688683  0.847209
      estimators  max_depth  recall  precision        f1   auc_roc
   0        71.0        1.0  0.7557   0.781145  0.768212  0.810263
      estimators  max_depth   recall  precision       f1   auc_roc
   0        71.0        3.0  0.76873   0.813793  0.79062  0.838568
      estimators  max_depth    recall  precision        f1  auc_roc
   0        71.0        5.0  0.758958   0.836324  0.795765  0.85168
      estimators  max_depth    recall  precision        f1   auc_roc
   0        71.0        7.0  0.752443   0.841837  0.794634  0.857639
      estimators  max_depth    recall  precision        f1  auc_roc
   0        71.0        9.0  0.729642   0.862202  0.790402  0.85902
      estimators  max_depth    recall  precision        f1   auc_roc
   0        71.0       11.0  0.648208   0.870516  0.743092  0.853737
      estimators  max_depth    recall  precision        f1   auc_roc
   0        71.0       13.0  0.628664   0.895176  0.738615  0.851057
      estimators  max_depth    recall  precision        f1   auc_roc
   0        71.0       15.0  0.592834   0.903674  0.715972  0.844669
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	17.0	0.576547	0.901222	0.703218	0.847609
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	19.0	0.553746	0.900424	0.68576	0.844074
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	21.0	0.560261	0.911983	0.694108	0.851042
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	23.0	0.550489	0.902778	0.683934	0.844108
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	25.0	0.557003	0.903805	0.689238	0.848029
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	27.0	0.553746	0.903294	0.686591	0.846977
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	29.0	0.560261	0.906217	0.692432	0.847303
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	31.0	0.557003	0.903805	0.689238	0.847315
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	33.0	0.560261	0.905263	0.692153	0.847598
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	35.0	0.560261	0.905263	0.692153	0.847598
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	37.0	0.560261	0.905263	0.692153	0.847598
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	39.0	0.560261	0.905263	0.692153	0.847598
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	41.0	0.560261	0.905263	0.692153	0.847598
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	43.0	0.560261	0.905263	0.692153	0.847598
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	45.0	0.560261	0.905263	0.692153	0.847598
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	47.0	0.560261	0.905263	0.692153	0.847598
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	49.0	0.560261	0.905263	0.692153	0.847598
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	1.0	0.7557	0.784314	0.769741	0.810689
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	3.0	0.76873	0.819444	0.793277	0.84037
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	5.0	0.762215	0.836312	0.797546	0.852138
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	7.0	0.762215	0.845376	0.801644	0.8584
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	9.0	0.716612	0.862069	0.78264	0.858641
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	11.0	0.651466	0.87108	0.745434	0.854106
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	13.0	0.62215	0.892523	0.733205	0.851497
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	15.0	0.583062	0.902218	0.70835	0.847813
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	17.0	0.576547	0.904908	0.704337	0.847753
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	19.0	0.557003	0.907643	0.690351	0.844594
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	21.0	0.563518	0.908613	0.695617	0.852848
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	23.0	0.553746	0.904255	0.686869	0.845639
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	25.0	0.557003	0.902851	0.688961	0.848884
	estimators	max_depth	recall	precision	f1	auc_roc

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   0         81.0        27.0  0.553746   0.905218  0.687146  0.84794
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        29.0  0.550489   0.904711  0.684488  0.848232
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        31.0  0.553746   0.903294  0.686591  0.848269
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        33.0  0.550489   0.901814  0.683657  0.848445
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        35.0  0.550489   0.901814  0.683657  0.848445
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        37.0  0.550489   0.901814  0.683657  0.848445
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        39.0  0.550489   0.901814  0.683657  0.848445
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        41.0  0.550489   0.901814  0.683657  0.848445
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        43.0  0.550489   0.901814  0.683657  0.848445
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        45.0  0.550489   0.901814  0.683657  0.848445
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        47.0  0.550489   0.901814  0.683657  0.848445
      estimators  max_depth    recall  precision        f1   auc_roc
   0         81.0        49.0  0.550489   0.901814  0.683657  0.848445
      estimators  max_depth    recall  precision        f1   auc_roc
   0         91.0         1.0  0.739414   0.792598  0.765083  0.809075
      estimators  max_depth    recall  precision        f1   auc_roc
   0         91.0         3.0  0.758958   0.818118  0.787428  0.841165
      estimators  max_depth  recall  precision        f1   auc_roc
   0         91.0         5.0  0.7557   0.834532  0.793162  0.852059
      estimators  max_depth  recall  precision        f1   auc_roc
   0         91.0         7.0  0.7557   0.843636  0.797251  0.859064
      estimators  max_depth    recall  precision        f1   auc_roc
   0         91.0         9.0  0.713355   0.859498  0.779637  0.857707
      estimators  max_depth    recall  precision        f1   auc_roc
   0         91.0        11.0  0.654723   0.871639  0.747768  0.853106
      estimators  max_depth    recall  precision       f1   auc_roc
   0         91.0        13.0  0.625407   0.892193  0.73535  0.851585
      estimators  max_depth    recall  precision      f1   auc_roc
   0         91.0        15.0  0.586319   0.902708  0.7109  0.848163
      estimators  max_depth   recall  precision        f1   auc_roc
   0         91.0        17.0  0.57329   0.909091  0.703156  0.848631
      estimators  max_depth    recall  precision        f1  auc_roc
   0         91.0        19.0  0.550489   0.906652  0.685043  0.84573
      estimators  max_depth    recall  precision        f1   auc_roc
   0         91.0        21.0  0.550489    0.90958  0.685877  0.852112
      estimators  max_depth    recall  precision        f1   auc_roc
   0         91.0        23.0  0.550489   0.903743  0.684211  0.846088
      estimators  max_depth    recall  precision        f1  auc_roc
   0         91.0        25.0  0.563518   0.905759  0.694779  0.84843
      estimators  max_depth    recall  precision        f1   auc_roc
   0         91.0        27.0  0.563518   0.908613  0.695617  0.847894
      estimators  max_depth    recall  precision       f1   auc_roc
   0         91.0        29.0  0.560261   0.907173  0.69271  0.848099
      estimators  max_depth    recall  precision       f1  auc_roc
   0         91.0        31.0  0.560261   0.907173  0.69271  0.84811
      estimators  max_depth    recall  precision       f1   auc_roc
   0         91.0        33.0  0.560261   0.907173  0.69271  0.848344
      estimators  max_depth    recall  precision       f1   auc_roc
   0         91.0        35.0  0.560261   0.907173  0.69271  0.848344
      estimators  max_depth    recall  precision       f1   auc_roc
   0         91.0        37.0  0.560261   0.907173  0.69271  0.848344
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	39.0	0.560261	0.907173	0.69271	0.848344
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	41.0	0.560261	0.907173	0.69271	0.848344
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	43.0	0.560261	0.907173	0.69271	0.848344
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	45.0	0.560261	0.907173	0.69271	0.848344
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	47.0	0.560261	0.907173	0.69271	0.848344
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	49.0	0.560261	0.907173	0.69271	0.848344
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	1.0	0.742671	0.790021	0.765615	0.809656
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	3.0	0.76873	0.818308	0.792744	0.84051
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	5.0	0.762215	0.834522	0.796731	0.852035
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	7.0	0.7557	0.843636	0.797251	0.859165
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	9.0	0.710098	0.858944	0.777461	0.858237
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	11.0	0.667752	0.873828	0.757016	0.854133
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	13.0	0.625407	0.893023	0.735632	0.850723
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	15.0	0.586319	0.902708	0.7109	0.850138
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	17.0	0.57329	0.90535	0.702034	0.848657
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	19.0	0.553746	0.90715	0.687702	0.845756
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	21.0	0.566775	0.909091	0.698234	0.852119
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	23.0	0.550489	0.901814	0.683657	0.847955
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	25.0	0.557003	0.903805	0.689238	0.849625
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	27.0	0.553746	0.906183	0.687424	0.849299
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	29.0	0.553746	0.904255	0.686869	0.849432
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	31.0	0.553746	0.903294	0.686591	0.849475
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	33.0	0.553746	0.903294	0.686591	0.849716
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	35.0	0.553746	0.903294	0.686591	0.849716
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	37.0	0.553746	0.903294	0.686591	0.849716
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	39.0	0.553746	0.903294	0.686591	0.849716
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	41.0	0.553746	0.903294	0.686591	0.849716
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	43.0	0.553746	0.903294	0.686591	0.849716
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	45.0	0.553746	0.903294	0.686591	0.849716
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	47.0	0.553746	0.903294	0.686591	0.849716
	estimators	max_depth	recall	precision	f1	auc_roc

0	101.0	49.0	0.553746	0.903294	0.686591	0.849716
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	1.0	0.739414	0.793706	0.765599	0.809886
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	3.0	0.765472	0.819958	0.791779	0.839794
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	5.0	0.762215	0.834522	0.796731	0.852313
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	7.0	0.7557	0.842411	0.796703	0.859138
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	9.0	0.71987	0.863281	0.78508	0.859184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	11.0	0.674267	0.878608	0.762993	0.854179
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	13.0	0.625407	0.893855	0.735914	0.851635
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	15.0	0.596091	0.902367	0.717929	0.849961
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	17.0	0.57329	0.904419	0.701754	0.848178
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	19.0	0.547231	0.909091	0.683205	0.846471
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	21.0	0.560261	0.908131	0.69299	0.850299
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	23.0	0.543974	0.899784	0.678035	0.846608
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	25.0	0.557003	0.904762	0.689516	0.848724
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	27.0	0.557003	0.908608	0.69063	0.848284
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	29.0	0.553746	0.90812	0.687981	0.848354
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	31.0	0.557003	0.907643	0.690351	0.848321
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	33.0	0.557003	0.907643	0.690351	0.848556
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	35.0	0.557003	0.907643	0.690351	0.848556
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	37.0	0.557003	0.907643	0.690351	0.848556
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	39.0	0.557003	0.907643	0.690351	0.848556
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	41.0	0.557003	0.907643	0.690351	0.848556
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	43.0	0.557003	0.907643	0.690351	0.848556
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	45.0	0.557003	0.907643	0.690351	0.848556
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	47.0	0.557003	0.907643	0.690351	0.848556
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	49.0	0.557003	0.907643	0.690351	0.848556
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	1.0	0.739414	0.793706	0.765599	0.811639
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	3.0	0.762215	0.818754	0.789474	0.840202
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	5.0	0.7557	0.834532	0.793162	0.852417
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	7.0	0.7557	0.84058	0.795883	0.858581
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	9.0	0.726384	0.861004	0.787986	0.859187

	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	11.0	0.67101	0.874363	0.759307	0.854021
0	121.0	13.0	0.625407	0.894688	0.736196	0.851334
0	121.0	15.0	0.583062	0.902218	0.70835	0.849509
0	121.0	17.0	0.566775	0.90249	0.696279	0.848344
0	121.0	19.0	0.543974	0.90368	0.679138	0.846869
0	121.0	21.0	0.550489	0.907626	0.68532	0.85034
0	121.0	23.0	0.547231	0.905172	0.682095	0.846897
0	121.0	25.0	0.560261	0.909091	0.693269	0.849415
0	121.0	27.0	0.560261	0.910053	0.693548	0.849101
0	121.0	29.0	0.563518	0.909569	0.695897	0.849072
0	121.0	31.0	0.560261	0.909091	0.693269	0.849073
0	121.0	33.0	0.563518	0.908613	0.695617	0.849312
0	121.0	35.0	0.563518	0.908613	0.695617	0.849312
0	121.0	37.0	0.563518	0.908613	0.695617	0.849312
0	121.0	39.0	0.563518	0.908613	0.695617	0.849312
0	121.0	41.0	0.563518	0.908613	0.695617	0.849312
0	121.0	43.0	0.563518	0.908613	0.695617	0.849312
0	121.0	45.0	0.563518	0.908613	0.695617	0.849312
0	121.0	47.0	0.563518	0.908613	0.695617	0.849312
0	121.0	49.0	0.563518	0.908613	0.695617	0.849312
0	131.0	1.0	0.739414	0.793706	0.765599	0.810822
0	131.0	3.0	0.762215	0.81761	0.788941	0.840732
0	131.0	5.0	0.7557	0.836337	0.793977	0.852403
0	131.0	7.0	0.7557	0.841189	0.796156	0.858788
0	131.0	9.0	0.726384	0.862336	0.788543	0.859031
0	131.0	11.0	0.674267	0.877863	0.762712	0.854174
0	131.0	13.0	0.625407	0.895522	0.736479	0.851834
0	131.0	15.0	0.592834	0.904573	0.716253	0.850092
0	131.0	17.0	0.566775	0.90249	0.696279	0.847912
0	131.0	19.0	0.547231	0.908108	0.682927	0.847503

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   0       131.0       21.0  0.560261   0.909091  0.693269  0.85006
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       23.0  0.543974   0.906623  0.679967  0.847207
      estimators  max_depth    recall  precision        f1  auc_roc
   0       131.0       25.0  0.566775   0.910995  0.698795  0.84963
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       27.0  0.566775    0.91195  0.699076  0.849448
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       29.0  0.563518   0.909569  0.695897  0.849559
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       31.0  0.563518    0.90766  0.695338  0.849558
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       33.0  0.560261   0.909091  0.693269  0.849725
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       35.0  0.560261   0.909091  0.693269  0.849725
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       37.0  0.560261   0.909091  0.693269  0.849725
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       39.0  0.560261   0.909091  0.693269  0.849725
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       41.0  0.560261   0.909091  0.693269  0.849725
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       43.0  0.560261   0.909091  0.693269  0.849725
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       45.0  0.560261   0.909091  0.693269  0.849725
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       47.0  0.560261   0.909091  0.693269  0.849725
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       49.0  0.560261   0.909091  0.693269  0.849725
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0        1.0  0.739414   0.793706  0.765599  0.810293
      estimators  max_depth   recall  precision        f1   auc_roc
   0       141.0        3.0  0.76873   0.819444  0.793277  0.840302
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0        5.0  0.752443   0.835745  0.791909  0.852395
      estimators  max_depth  recall  precision        f1   auc_roc
   0       141.0        7.0  0.7557   0.842411  0.796703  0.858955
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0        9.0  0.723127   0.861801  0.786397  0.859113
      estimators  max_depth   recall  precision        f1  auc_roc
   0       141.0       11.0  0.67101   0.872881  0.758748  0.85478
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       13.0  0.628664   0.895176  0.738615  0.851113
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       15.0  0.605863   0.908203  0.726846  0.850774
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       17.0  0.566775   0.905307  0.697115  0.847965
      estimators  max_depth    recall  precision        f1  auc_roc
   0       141.0       19.0  0.553746   0.909091  0.688259  0.84734
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       21.0  0.566775   0.908142  0.697954  0.850437
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       23.0  0.540717   0.907104  0.677551  0.847755
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       25.0  0.557003   0.909574  0.690909  0.850104
      estimators  max_depth    recall  precision        f1  auc_roc
   0       141.0       27.0  0.557003   0.907643  0.690351  0.85002
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       29.0  0.553746    0.90715  0.687702  0.850085
      estimators  max_depth    recall  precision       f1   auc_roc
   0       141.0       31.0  0.560261   0.907173  0.69271  0.850126
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	33.0	0.557003	0.907643	0.690351	0.850317
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	35.0	0.557003	0.907643	0.690351	0.850317
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	37.0	0.557003	0.907643	0.690351	0.850317
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	39.0	0.557003	0.907643	0.690351	0.850317
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	41.0	0.557003	0.907643	0.690351	0.850317
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	43.0	0.557003	0.907643	0.690351	0.850317
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	45.0	0.557003	0.907643	0.690351	0.850317
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	47.0	0.557003	0.907643	0.690351	0.850317
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	49.0	0.557003	0.907643	0.690351	0.850317

применение расширения выборки и балансирования классов на расширенной выборке у модели случайного леса значение F1 в среднем ниже, чем у случайного леса с расширенной выборкой. Лучшее значение f1 достигается у случайного леса на расширенной выборке с гиперпараметрами 41 оценщик и глубина 7 - 0,8113.

In [49]:

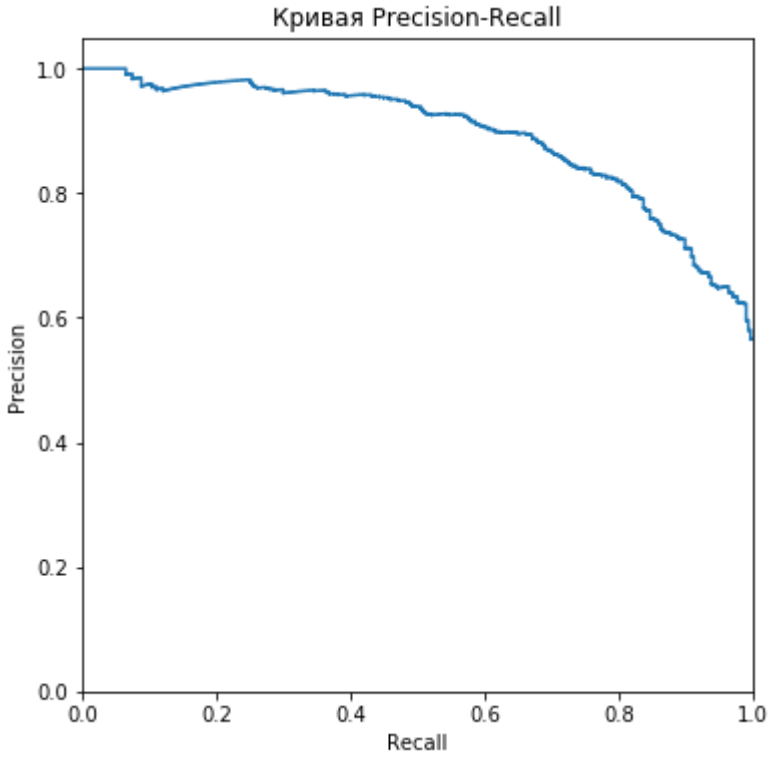
```
#построим функцию для постотроения графиков полнота-точность для модели, показавшей луч
шее значение f1. Чем выше кривая, тем лучше модель.

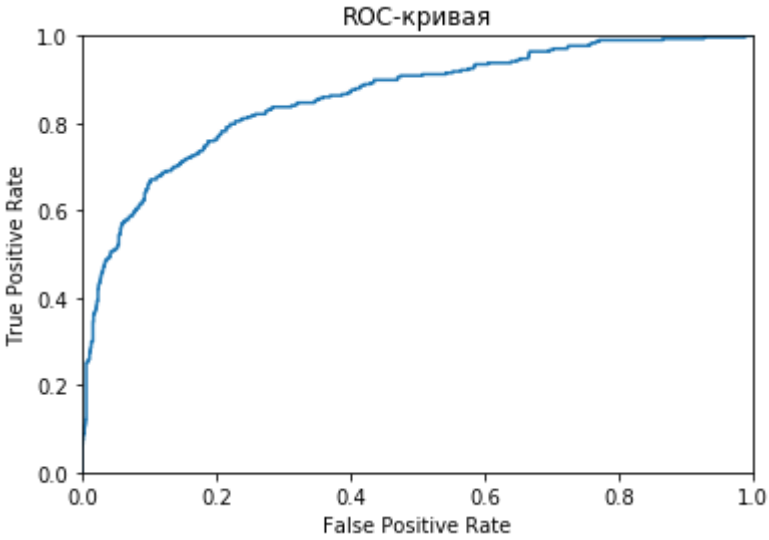
def model_quality_rfc_plt(features_x,target_x,features_y,target_y, estim, depth):
    model= RandomForestClassifier(random_state=12345, n_estimators=estim, max_depth=dep
th)
    model.fit(features_x, target_x) #обучим модель
    predicted_y=model.predict(features_y) #предскажем по валидационной выборке
    recall=recall_score(target_y,predicted_y)
    precision=precision_score(target_y, predicted_y)
    probabilities_y = model.predict_proba(features_y)
    probabilities_one_y = probabilities_y[:, 1]
    precision, recall, thresholds = precision_recall_curve(target_y, probabilities_y[:,
1])
    plt.figure(figsize=(6, 6))
    plt.step(recall, precision, where='post')
    plt.xlabel('Recall')
    plt.ylabel('Precision')
    plt.ylim([0.0, 1.05])
    plt.xlim([0.0, 1.0])
    print("График количества оценщиков", estim,", для глубины ", depth)
    plt.title('Кривая Precision-Recall')
    plt.show()
    fpr, tpr, thresholds = roc_curve(target_y, probabilities_one_y)
    plt.figure()
    plt.plot(fpr, tpr)
    plt.xlim([0.0, 1.0])# < применим функции plt.xlim() и plt.ylim(), чтобы
    plt.ylim([0.0, 1.0])#   установить границы осей от 0 до 1 >
    plt.xlabel('False Positive Rate')# < применим функции plt.xlabel() и plt.ylabel(),
 чтобы
    plt.ylabel('True Positive Rate')#   подписать оси "False Positive Rate" и "True Pos
itive Rate" >
    plt.title('ROC-кривая')# < добавим к графику заголовок "ROC-кривая" функцией plt.ti
tle() >
    plt.show()
```

In [50]:

```
model_quality_rfc_plt(features_upsampled, target_upsampled,features_upsampled_valid,tar
get_upsampled_valid, 41, 7)
```

```
График количества оценщиков 41 , для глубины  7
```





In [51]:

```
# для модели логистической регрессии
model_quality_lr(features_upsampled, target_upsampled,features_upsampled_valid,target_u
psampled_valid)
```

```
Полнота: 0.7980456026058632
Точность: 0.7278669043374926
F1-мера: 0.7613424487259168
AUC-ROC: 0.7797384853556713
```

In [52]:

```
# Уменьшим выборку, проведем downsampling:
#обучающую выборку уже разделили на отрицательные и положительные объекты на предыдущем
upsampling
```

In [53]:

```
#Случайным образом отбросить часть из отрицательных объектов при помощи метода sample()
#С учётом полученных данных создадим новую обучающую выборку
features_downsampled=pd.concat([features_zeros.sample(frac=0.22, random_state=12345)]+[
features_ones])
target_downsampled=pd.concat([target_zeros.sample(frac=0.22, random_state=12345)]+[targ
et_ones])
#Перемешаем данные
features_downsampled, target_downsampled = shuffle(features_downsampled, target_downsam
pled, random_state=12345)
```

In [54]:

```
print(features_downsampled.shape)
print(target_downsampled.shape)
```

```
(2641, 11)
(2641,)
```

In [55]:

```
#Случайным образом отбросить часть из отрицательных объектов при помощи метода sample()
#С учётом полученных данных создадим новую обучающую выборку
features_downsampled_valid=pd.concat([features_zeros_valid.sample(frac=0.22, random_sta
te=12345)]+[features_ones_valid])
target_downsampled_valid=pd.concat([target_zeros_valid.sample(frac=0.22, random_state=1
2345)]+[target_ones_valid])
#Перемешаем данные
features_downsampled_valid, target_downsampled_valid = shuffle(features_downsampled_val
id, target_downsampled_valid, random_state=12345)
```

In [56]:

```
#Исследуем качество разных моделей, меняя гиперпараметры, на уменьшенной выборке.

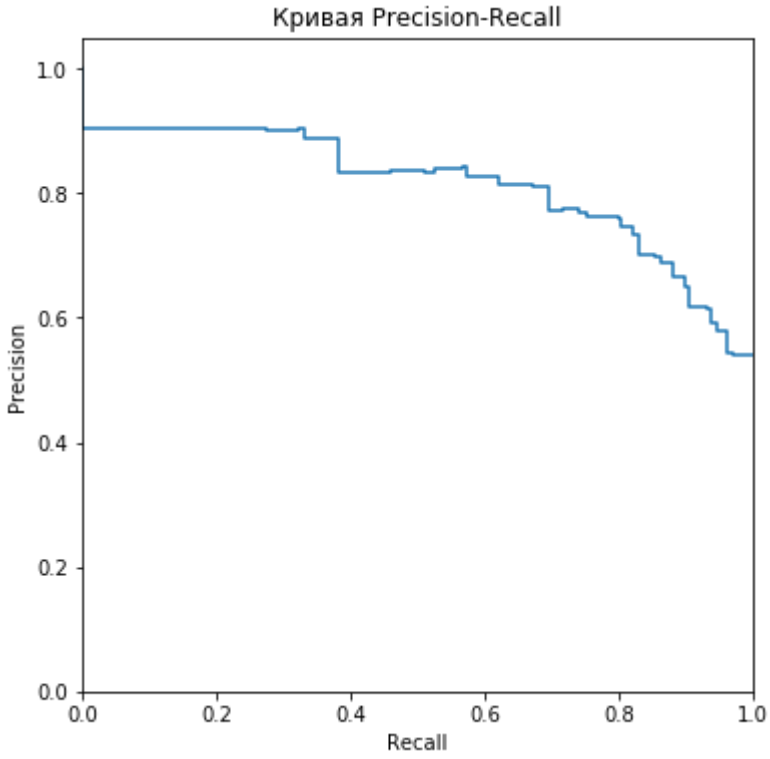
#для модели решающего дерева
#в цикле проверим гиперпараметр глубины дерева от 1 до 30, кратно 2
for depth in range(1,31,2):
    model_quality_dtc(features_downsampled, target_downsampled,features_downsampled_val
id,target_downsampled_valid, depth)
```

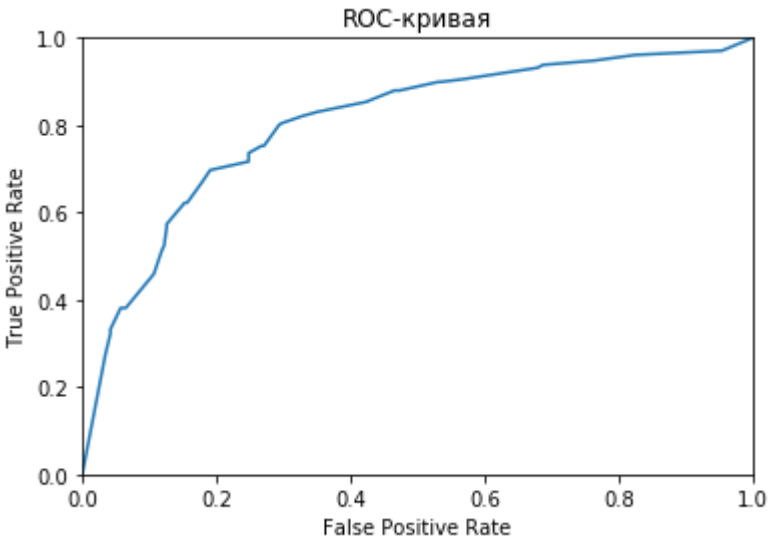
```
   depth    recall  precision        f1   auc_roc
0    1.0  0.732899   0.735294  0.734095  0.711869
   depth    recall  precision        f1   auc_roc
0    3.0  0.771987   0.740625  0.755981  0.792992
   depth   recall  precision        f1   auc_roc
0    5.0  0.80456   0.774295  0.789137  0.828549
   depth    recall  precision        f1   auc_roc
0    7.0  0.801303    0.76161  0.780952  0.804734
   depth    recall  precision        f1  auc_roc
0    9.0  0.716612   0.718954  0.717781  0.76367
   depth    recall  precision        f1   auc_roc
0   11.0  0.729642   0.722581  0.726094  0.708699
   depth    recall  precision        f1   auc_roc
0   13.0  0.736156   0.689024  0.711811  0.690597
   depth    recall  precision        f1   auc_roc
0   15.0  0.713355   0.684375  0.698565  0.664762
   depth    recall  precision        f1   auc_roc
0   17.0  0.739414   0.702786  0.720635  0.686283
   depth    recall  precision        f1   auc_roc
0   19.0  0.742671   0.688822  0.714734  0.678103
   depth    recall  precision        f1   auc_roc
0   21.0  0.739414     0.69419  0.716088  0.678867
   depth    recall  precision        f1   auc_roc
0   23.0  0.739414     0.69419  0.716088  0.678867
   depth    recall  precision        f1   auc_roc
0   25.0  0.739414     0.69419  0.716088  0.678867
   depth    recall  precision        f1   auc_roc
0   27.0  0.739414     0.69419  0.716088  0.678867
   depth    recall  precision        f1   auc_roc
0   29.0  0.739414     0.69419  0.716088  0.678867
```

In [57]:

```
model_quality_dtc_plt(features_downsampled, target_downsampled,features_downsampled_val
id,target_downsampled_valid, 7)
```

График для глубины 7





In [58]:

```
#для модели случайного леса
#в цикле проверим качество модели для гиперпараметра количество оценщиков от 1 до 100,
 кратно 10

for estim in range(1,151,10):
    for depth in range (10,51,2):
        model_quality_rfc(features_downsampled, target_downsampled,features_downsampled
_valid,target_downsampled_valid, estim, depth)
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	10.0	0.677524	0.729825	0.702703	0.718166
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	12.0	0.700326	0.707237	0.703764	0.692848
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	14.0	0.690554	0.706667	0.698517	0.679918
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	16.0	0.693811	0.707641	0.700658	0.682212
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	18.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	20.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	22.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	24.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	26.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	28.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	30.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	32.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	34.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	36.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	38.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	40.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	42.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	44.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	46.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	48.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	50.0	0.710098	0.712418	0.711256	0.68711
	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	10.0	0.778502	0.786184	0.782324	0.831197
	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	12.0	0.758958	0.768977	0.763934	0.821239
	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	14.0	0.7557	0.750809	0.753247	0.811212
	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	16.0	0.749186	0.737179	0.743134	0.800911
	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	18.0	0.742671	0.754967	0.748768	0.824819
	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	20.0	0.762215	0.75	0.756058	0.809036
	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	22.0	0.758958	0.749196	0.754045	0.808296
	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	24.0	0.758958	0.749196	0.754045	0.808296
	estimators	max_depth	recall	precision	f1	auc_roc
0	11.0	26.0	0.758958	0.749196	0.754045	0.808296
	estimators	max_depth	recall	precision	f1	auc_roc

```
   0         11.0       28.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       30.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       32.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       34.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       36.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       38.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       40.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       42.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       44.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       46.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       48.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0       50.0  0.758958   0.749196  0.754045  0.808296
      estimators  max_depth    recall  precision        f1  auc_roc
   0         21.0       10.0  0.794788   0.784566  0.789644  0.83903
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       12.0  0.781759   0.771704  0.776699  0.829152
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       14.0  0.785016   0.767516  0.776167  0.818895
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       16.0  0.778502   0.742236  0.759936  0.818255
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       18.0  0.781759   0.759494  0.770465  0.827834
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       20.0  0.778502   0.761146  0.769726  0.819454
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       22.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       24.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       26.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       28.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       30.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       32.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       34.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       36.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       38.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       40.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       42.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       44.0  0.781759   0.761905  0.771704  0.815899
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0       46.0  0.781759   0.761905  0.771704  0.815899
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	48.0	0.781759	0.761905	0.771704	0.815899

	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	50.0	0.781759	0.761905	0.771704	0.815899

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	10.0	0.801303	0.778481	0.789727	0.840354

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	12.0	0.791531	0.773885	0.782609	0.835611

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	14.0	0.798046	0.775316	0.786517	0.830849

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	16.0	0.788274	0.758621	0.773163	0.826839

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	18.0	0.775244	0.757962	0.766506	0.83175

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	20.0	0.778502	0.75873	0.768489	0.820654

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	22.0	0.765472	0.753205	0.759289	0.819318

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	24.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	26.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	28.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	30.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	32.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	34.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	36.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	38.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	40.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	42.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	44.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	46.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	48.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	50.0	0.765472	0.753205	0.759289	0.819287

	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	10.0	0.794788	0.769716	0.782051	0.841423

	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	12.0	0.794788	0.77707	0.785829	0.83589

	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	14.0	0.794788	0.767296	0.7808	0.832975

	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	16.0	0.80456	0.762346	0.782884	0.832117

	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	18.0	0.791531	0.766562	0.778846	0.834293

	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	20.0	0.781759	0.761905	0.771704	0.828195

	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	22.0	0.791531	0.759375	0.77512	0.827399

	estimators	max_depth	recall	precision	f1	auc_roc

0	41.0	24.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	26.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	28.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	30.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	32.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	34.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	36.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	38.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	40.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	42.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	44.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	46.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	48.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	41.0	50.0	0.794788	0.7625	0.778309	0.82462
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	10.0	0.788274	0.778135	0.783172	0.840615
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	12.0	0.801303	0.76875	0.784689	0.837444
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	14.0	0.791531	0.764151	0.7776	0.832801
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	16.0	0.794788	0.755418	0.774603	0.832645
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	18.0	0.794788	0.7625	0.778309	0.836543
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	20.0	0.791531	0.768987	0.780096	0.829979
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	22.0	0.80456	0.76947	0.786624	0.829742
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	24.0	0.801303	0.763975	0.782194	0.827766
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	26.0	0.801303	0.763975	0.782194	0.827766
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	28.0	0.801303	0.763975	0.782194	0.827766
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	30.0	0.801303	0.763975	0.782194	0.827766
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	32.0	0.801303	0.763975	0.782194	0.827766
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	34.0	0.801303	0.763975	0.782194	0.827766
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	36.0	0.801303	0.763975	0.782194	0.827766
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	38.0	0.801303	0.763975	0.782194	0.827766
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	40.0	0.801303	0.763975	0.782194	0.827766
	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	42.0	0.801303	0.763975	0.782194	0.827766

	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	44.0	0.801303	0.763975	0.782194	0.827766
0	51.0	46.0	0.801303	0.763975	0.782194	0.827766
0	51.0	48.0	0.801303	0.763975	0.782194	0.827766
0	51.0	50.0	0.801303	0.763975	0.782194	0.827766
0	61.0	10.0	0.801303	0.783439	0.792271	0.841883
0	61.0	12.0	0.798046	0.780255	0.78905	0.836475
0	61.0	14.0	0.791531	0.764151	0.7776	0.835424
0	61.0	16.0	0.798046	0.768025	0.782748	0.836071
0	61.0	18.0	0.778502	0.761146	0.769726	0.835213
0	61.0	20.0	0.775244	0.767742	0.771475	0.829376
0	61.0	22.0	0.791531	0.773885	0.782609	0.82881
0	61.0	24.0	0.791531	0.764151	0.7776	0.827337
0	61.0	26.0	0.791531	0.764151	0.7776	0.827337
0	61.0	28.0	0.791531	0.764151	0.7776	0.827337
0	61.0	30.0	0.791531	0.764151	0.7776	0.827337
0	61.0	32.0	0.791531	0.764151	0.7776	0.827337
0	61.0	34.0	0.791531	0.764151	0.7776	0.827337
0	61.0	36.0	0.791531	0.764151	0.7776	0.827337
0	61.0	38.0	0.791531	0.764151	0.7776	0.827337
0	61.0	40.0	0.791531	0.764151	0.7776	0.827337
0	61.0	42.0	0.791531	0.764151	0.7776	0.827337
0	61.0	44.0	0.791531	0.764151	0.7776	0.827337
0	61.0	46.0	0.791531	0.764151	0.7776	0.827337
0	61.0	48.0	0.791531	0.764151	0.7776	0.827337
0	61.0	50.0	0.791531	0.764151	0.7776	0.827337
0	71.0	10.0	0.807818	0.779874	0.7936	0.84202
0	71.0	12.0	0.794788	0.772152	0.783307	0.835878
0	71.0	14.0	0.785016	0.767516	0.776167	0.836779
0	71.0	16.0	0.80456	0.76947	0.786624	0.836661
0	71.0	18.0	0.791531	0.766562	0.778846	0.837034

0	71.0	20.0	0.778502	0.766026	0.772213	0.833503
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	22.0	0.791531	0.768987	0.780096	0.832446
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	24.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	26.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	28.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	30.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	32.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	34.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	36.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	38.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	40.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	42.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	44.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	46.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	48.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	50.0	0.788274	0.775641	0.781906	0.83083
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	10.0	0.807818	0.775	0.791069	0.84335
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	12.0	0.791531	0.773885	0.782609	0.838252
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	14.0	0.788274	0.765823	0.776886	0.836823
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	16.0	0.798046	0.76324	0.780255	0.836207
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	18.0	0.791531	0.766562	0.778846	0.837028
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	20.0	0.785016	0.762658	0.773676	0.834175
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	22.0	0.801303	0.77116	0.785942	0.833534
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	24.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	26.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	28.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	30.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	32.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	34.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	36.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	38.0	0.801303	0.76875	0.784689	0.832266

	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	40.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	42.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	44.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	46.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	48.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	50.0	0.801303	0.76875	0.784689	0.832266
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	10.0	0.811075	0.775701	0.792994	0.841895
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	12.0	0.801303	0.766355	0.783439	0.837904
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	14.0	0.775244	0.762821	0.768982	0.837942
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	16.0	0.794788	0.769716	0.782051	0.837718
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	18.0	0.794788	0.76489	0.779553	0.835163
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	20.0	0.798046	0.768025	0.782748	0.834199
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	22.0	0.798046	0.77044	0.784	0.83387
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	24.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	26.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	28.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	30.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	32.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	34.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	36.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	38.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	40.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	42.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	44.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	46.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	48.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	50.0	0.801303	0.766355	0.783439	0.833174
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	10.0	0.807818	0.772586	0.789809	0.841895
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	12.0	0.80456	0.76947	0.786624	0.839533
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	14.0	0.778502	0.766026	0.772213	0.838091
	estimators	max_depth	recall	precision	f1	auc_roc

0	101.0	16.0	0.801303	0.76875	0.784689	0.83865
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	18.0	0.791531	0.759375	0.77512	0.835144
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	20.0	0.801303	0.77116	0.785942	0.833696
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	22.0	0.807818	0.772586	0.789809	0.833926
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	24.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	26.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	28.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	30.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	32.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	34.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	36.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	38.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	40.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	42.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	44.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	46.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	48.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	50.0	0.80456	0.76947	0.786624	0.832925
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	10.0	0.81759	0.774691	0.795563	0.840565
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	12.0	0.807818	0.770186	0.788553	0.838501
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	14.0	0.781759	0.766773	0.774194	0.836263
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	16.0	0.80456	0.76947	0.786624	0.838855
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	18.0	0.801303	0.76875	0.784689	0.835754
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	20.0	0.807818	0.775	0.791069	0.834119
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	22.0	0.80456	0.771875	0.787879	0.834069
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	24.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	26.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	28.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	30.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	32.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	34.0	0.80456	0.771875	0.787879	0.833404

	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	36.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	38.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	40.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	42.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	44.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	46.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	48.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	50.0	0.80456	0.771875	0.787879	0.833404
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	10.0	0.811075	0.775701	0.792994	0.841261
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	12.0	0.80456	0.771875	0.787879	0.837047
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	14.0	0.794788	0.767296	0.7808	0.836817
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	16.0	0.798046	0.768025	0.782748	0.839216
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	18.0	0.798046	0.765625	0.781499	0.834193
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	20.0	0.801303	0.76875	0.784689	0.834318
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	22.0	0.798046	0.768025	0.782748	0.833752
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	24.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	26.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	28.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	30.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	32.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	34.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	36.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	38.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	40.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	42.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	44.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	46.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	48.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	50.0	0.80456	0.764706	0.784127	0.832732
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	10.0	0.807818	0.775	0.791069	0.84064
	estimators	max_depth	recall	precision	f1	auc_roc

```
   0       131.0       12.0  0.80456   0.774295  0.789137  0.837743
      estimators  max_depth    recall  precision        f1  auc_roc
   0       131.0       14.0  0.801303    0.77116  0.785942  0.83773
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       16.0  0.80456    0.76947  0.786624  0.838501
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       18.0  0.801303    0.76875  0.784689  0.834945
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       20.0  0.811075   0.768519  0.789223  0.834709
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       22.0  0.80456    0.76947  0.786624  0.834765
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       24.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       26.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       28.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       30.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       32.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       34.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       36.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       38.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       40.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       42.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       44.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       46.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       48.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       131.0       50.0  0.807818   0.770186  0.788553  0.833721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       10.0  0.807818      0.775  0.791069  0.840005
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       12.0  0.807818   0.777429  0.792332  0.837929
      estimators  max_depth    recall  precision       f1  auc_roc
   0       141.0       14.0  0.80456    0.77673  0.7904  0.83957
      estimators  max_depth    recall  precision       f1   auc_roc
   0       141.0       16.0  0.794788   0.767296  0.7808  0.839371
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       18.0  0.801303   0.763975  0.782194  0.835847
      estimators  max_depth    recall  precision       f1   auc_roc
   0       141.0       20.0  0.807818   0.763077  0.78481  0.835387
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       22.0  0.811075   0.770898  0.790476  0.835524
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       24.0  0.811075   0.768519  0.789223  0.834492
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       26.0  0.811075   0.768519  0.789223  0.834492
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       28.0  0.811075   0.768519  0.789223  0.834492
      estimators  max_depth    recall  precision        f1   auc_roc
   0       141.0       30.0  0.811075   0.768519  0.789223  0.834492
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	32.0	0.811075	0.768519	0.789223	0.834492

	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	34.0	0.811075	0.768519	0.789223	0.834492

	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	36.0	0.811075	0.768519	0.789223	0.834492

	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	38.0	0.811075	0.768519	0.789223	0.834492

	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	40.0	0.811075	0.768519	0.789223	0.834492

	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	42.0	0.811075	0.768519	0.789223	0.834492

	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	44.0	0.811075	0.768519	0.789223	0.834492

	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	46.0	0.811075	0.768519	0.789223	0.834492

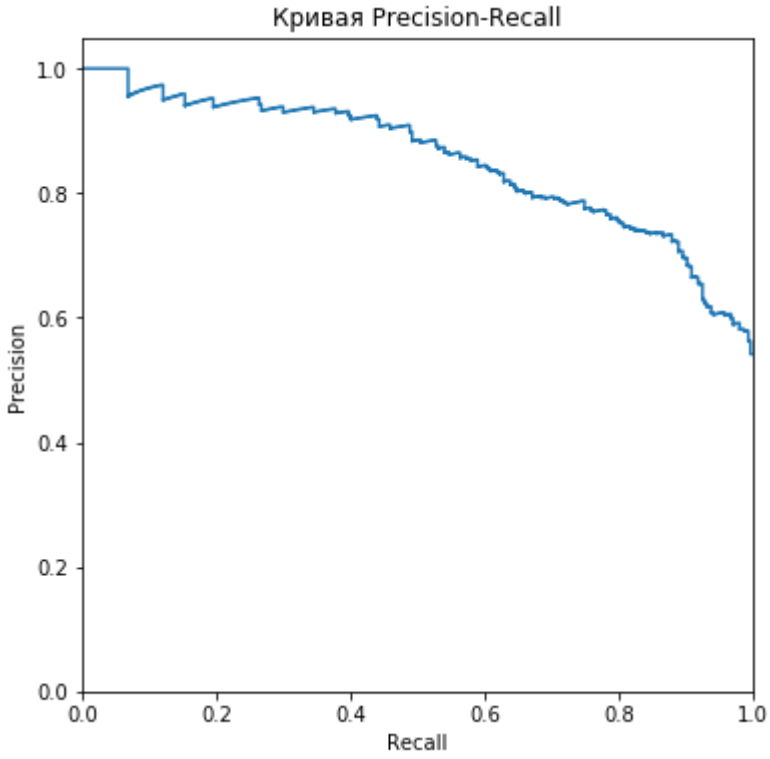
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	48.0	0.811075	0.768519	0.789223	0.834492

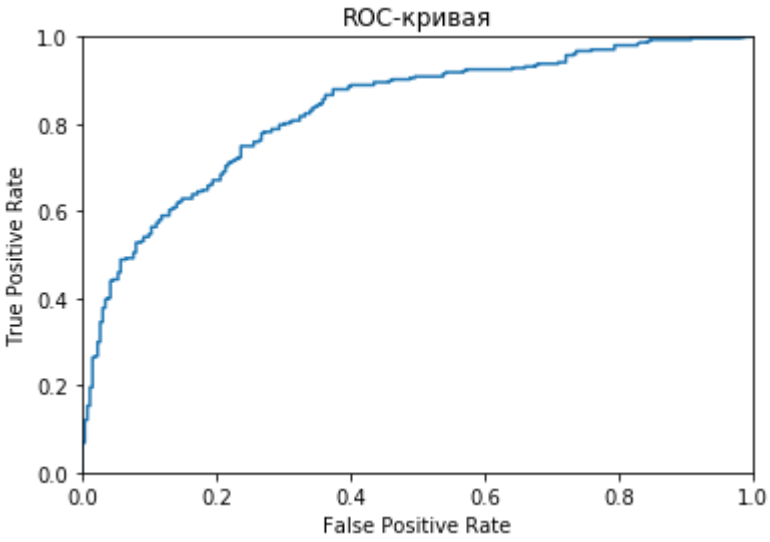
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	50.0	0.811075	0.768519	0.789223	0.834492

In [59]:

```
model_quality_rfc_plt(features_downsampled, target_downsampled,features_downsampled_val
id,target_downsampled_valid, 21, 5)
```

```
График количества оценщиков 21 , для глубины  5
```





In [60]:

```
#для модели случайного леса с уменьшенной выборкой и сбалансированными классами
for estim in range(1,151,10):
    for depth in range (5,50,2):
        model_quality_rfc_balanced(features_downsampled, target_downsampled,features_do
wnsampled_valid,target_downsampled_valid, estim, depth)
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	1.0	5.0	0.700326	0.776173	0.736301	0.773355
0	1.0	7.0	0.641694	0.775591	0.702317	0.761506
0	1.0	9.0	0.684039	0.739437	0.71066	0.727889
0	1.0	11.0	0.70684	0.70684	0.70684	0.698859
0	1.0	13.0	0.687296	0.722603	0.704508	0.68747
0	1.0	15.0	0.703583	0.701299	0.702439	0.671837
0	1.0	17.0	0.723127	0.735099	0.729064	0.708892
0	1.0	19.0	0.723127	0.735099	0.729064	0.708892
0	1.0	21.0	0.723127	0.735099	0.729064	0.708892
0	1.0	23.0	0.723127	0.735099	0.729064	0.708892
0	1.0	25.0	0.723127	0.735099	0.729064	0.708892
0	1.0	27.0	0.723127	0.735099	0.729064	0.708892
0	1.0	29.0	0.723127	0.735099	0.729064	0.708892
0	1.0	31.0	0.723127	0.735099	0.729064	0.708892
0	1.0	33.0	0.723127	0.735099	0.729064	0.708892
0	1.0	35.0	0.723127	0.735099	0.729064	0.708892
0	1.0	37.0	0.723127	0.735099	0.729064	0.708892
0	1.0	39.0	0.723127	0.735099	0.729064	0.708892
0	1.0	41.0	0.723127	0.735099	0.729064	0.708892
0	1.0	43.0	0.723127	0.735099	0.729064	0.708892
0	1.0	45.0	0.723127	0.735099	0.729064	0.708892
0	1.0	47.0	0.723127	0.735099	0.729064	0.708892
0	1.0	49.0	0.723127	0.735099	0.729064	0.708892
0	11.0	5.0	0.703583	0.791209	0.744828	0.833553
0	11.0	7.0	0.745928	0.78157	0.763333	0.830165
0	11.0	9.0	0.732899	0.78125	0.756303	0.819461
0	11.0	11.0	0.794788	0.753086	0.773376	0.82058
0	11.0	13.0	0.778502	0.766026	0.772213	0.817484
0	11.0	15.0	0.801303	0.77116	0.785942	0.818242
0	11.0	17.0	0.749186	0.746753	0.747967	0.804479

```
   0         11.0        19.0  0.771987   0.733746  0.752381  0.808452
      estimators  max_depth    recall  precision        f1  auc_roc
   0         11.0        21.0  0.778502   0.739938  0.75873   0.8123
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        23.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        25.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        27.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        29.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        31.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        33.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        35.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        37.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        39.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        41.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        43.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        45.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        47.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         11.0        49.0  0.781759   0.743034  0.761905  0.813593
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         5.0  0.749186   0.779661  0.76412  0.832708
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         7.0  0.752443   0.780405  0.766169  0.834442
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0         9.0  0.758958   0.776667  0.76771  0.828219
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        11.0  0.762215    0.75974  0.760976  0.828536
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        13.0  0.775244   0.750789  0.762821  0.826833
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        15.0  0.801303   0.778481  0.789727  0.841988
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        17.0  0.781759   0.774194  0.777958  0.820629
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        19.0  0.762215   0.754839  0.758509  0.830426
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        21.0  0.771987    0.76699  0.769481  0.828139
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        23.0  0.775244   0.772727  0.773984  0.829121
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        25.0  0.775244   0.772727  0.773984  0.829121
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        27.0  0.775244   0.772727  0.773984  0.829121
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        29.0  0.775244   0.772727  0.773984  0.829121
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        31.0  0.775244   0.772727  0.773984  0.829121
      estimators  max_depth    recall  precision        f1   auc_roc
   0         21.0        33.0  0.775244   0.772727  0.773984  0.829121
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	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	35.0	0.775244	0.772727	0.773984	0.829121
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	37.0	0.775244	0.772727	0.773984	0.829121
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	39.0	0.775244	0.772727	0.773984	0.829121
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	41.0	0.775244	0.772727	0.773984	0.829121
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	43.0	0.775244	0.772727	0.773984	0.829121
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	45.0	0.775244	0.772727	0.773984	0.829121
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	47.0	0.775244	0.772727	0.773984	0.829121
	estimators	max_depth	recall	precision	f1	auc_roc
0	21.0	49.0	0.775244	0.772727	0.773984	0.829121
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	5.0	0.758958	0.779264	0.768977	0.830184
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	7.0	0.765472	0.788591	0.77686	0.83645
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	9.0	0.76873	0.776316	0.772504	0.830159
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	11.0	0.778502	0.775974	0.777236	0.834262
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	13.0	0.785016	0.769968	0.777419	0.828592
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	15.0	0.807818	0.775	0.791069	0.839135
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	17.0	0.788274	0.768254	0.778135	0.823396
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	19.0	0.778502	0.770968	0.774716	0.831949
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	21.0	0.788274	0.768254	0.778135	0.830047
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	23.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	25.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	27.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	29.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	31.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	33.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	35.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	37.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	39.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	41.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	43.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	45.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc
0	31.0	47.0	0.785016	0.772436	0.778675	0.830681
	estimators	max_depth	recall	precision	f1	auc_roc

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   0         31.0       49.0  0.785016   0.772436  0.778675  0.830681
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        5.0  0.765472   0.785953  0.775578  0.832969
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0        7.0  0.775244   0.788079  0.781609  0.840664
      estimators  max_depth   recall  precision       f1   auc_roc
   0         41.0        9.0  0.76873   0.778878  0.77377  0.832049
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       11.0  0.778502   0.770968  0.774716  0.835803
      estimators  max_depth    recall  precision       f1   auc_roc
   0         41.0       13.0  0.785016   0.765079  0.77492  0.833677
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       15.0  0.811075   0.773292  0.791733  0.838725
      estimators  max_depth    recall  precision      f1   auc_roc
   0         41.0       17.0  0.801303   0.773585  0.7872  0.829345
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       19.0  0.798046   0.765625  0.781499  0.839782
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       21.0  0.788274   0.770701  0.779388  0.836742
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       23.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       25.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       27.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       29.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       31.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       33.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       35.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       37.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       39.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       41.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       43.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       45.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       47.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         41.0       49.0  0.794788    0.77707  0.785829  0.838078
      estimators  max_depth    recall  precision        f1   auc_roc
   0         51.0        5.0  0.762215       0.78  0.771005  0.834038
      estimators  max_depth    recall  precision        f1   auc_roc
   0         51.0        7.0  0.781759   0.789474  0.785597  0.840341
      estimators  max_depth    recall  precision        f1   auc_roc
   0         51.0        9.0  0.765472   0.773026  0.769231  0.833628
      estimators  max_depth    recall  precision        f1   auc_roc
   0         51.0       11.0  0.778502   0.773463  0.775974  0.837419
      estimators  max_depth    recall  precision        f1   auc_roc
   0         51.0       13.0  0.798046    0.76324  0.780255  0.833093
      estimators  max_depth    recall  precision        f1  auc_roc
   0         51.0       15.0  0.811075   0.773292  0.791733  0.83765
      estimators  max_depth    recall  precision      f1   auc_roc
   0         51.0       17.0  0.794788   0.767296  0.7808  0.830955
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	estimators	max_depth	recall	precision	f1	auc_roc
0	51.0	19.0	0.798046	0.777778	0.787781	0.83903
0	51.0	21.0	0.801303	0.766355	0.783439	0.836114
0	51.0	23.0	0.798046	0.772871	0.785256	0.839185
0	51.0	25.0	0.798046	0.772871	0.785256	0.839005
0	51.0	27.0	0.798046	0.772871	0.785256	0.839005
0	51.0	29.0	0.798046	0.772871	0.785256	0.839005
0	51.0	31.0	0.798046	0.772871	0.785256	0.839005
0	51.0	33.0	0.798046	0.772871	0.785256	0.839005
0	51.0	35.0	0.798046	0.772871	0.785256	0.839005
0	51.0	37.0	0.798046	0.772871	0.785256	0.839005
0	51.0	39.0	0.798046	0.772871	0.785256	0.839005
0	51.0	41.0	0.798046	0.772871	0.785256	0.839005
0	51.0	43.0	0.798046	0.772871	0.785256	0.839005
0	51.0	45.0	0.798046	0.772871	0.785256	0.839005
0	51.0	47.0	0.798046	0.772871	0.785256	0.839005
0	51.0	49.0	0.798046	0.772871	0.785256	0.839005
0	61.0	5.0	0.765472	0.783333	0.7743	0.835965
0	61.0	7.0	0.781759	0.797342	0.789474	0.840304
0	61.0	9.0	0.76873	0.778878	0.77377	0.835381
0	61.0	11.0	0.76873	0.776316	0.772504	0.838178
0	61.0	13.0	0.798046	0.77044	0.784	0.836997
0	61.0	15.0	0.811075	0.775701	0.792994	0.838197
0	61.0	17.0	0.801303	0.773585	0.7872	0.831185
0	61.0	19.0	0.794788	0.769716	0.782051	0.840658
0	61.0	21.0	0.807818	0.770186	0.788553	0.836891
0	61.0	23.0	0.791531	0.776358	0.783871	0.838744
0	61.0	25.0	0.794788	0.77707	0.785829	0.838632
0	61.0	27.0	0.794788	0.77707	0.785829	0.838632
0	61.0	29.0	0.794788	0.77707	0.785829	0.838632
0	61.0	31.0	0.794788	0.77707	0.785829	0.838632

estimators	max_depth	recall	precision	f1	auc_roc

0	61.0	33.0	0.794788	0.77707	0.785829	0.838632	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	61.0	35.0	0.794788	0.77707	0.785829	0.838632	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	61.0	37.0	0.794788	0.77707	0.785829	0.838632	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	61.0	39.0	0.794788	0.77707	0.785829	0.838632	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	61.0	41.0	0.794788	0.77707	0.785829	0.838632	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	61.0	43.0	0.794788	0.77707	0.785829	0.838632	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	61.0	45.0	0.794788	0.77707	0.785829	0.838632	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	61.0	47.0	0.794788	0.77707	0.785829	0.838632	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	61.0	49.0	0.794788	0.77707	0.785829	0.838632	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	5.0	0.76873	0.786667	0.777595	0.834485	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	7.0	0.798046	0.79288	0.795455	0.841584	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	9.0	0.771987	0.77451	0.773246	0.83543	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	11.0	0.778502	0.768489	0.773463	0.838066	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	13.0	0.794788	0.772152	0.783307	0.839434	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	15.0	0.807818	0.767802	0.787302	0.836928	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	17.0	0.80456	0.764706	0.784127	0.833093	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	19.0	0.794788	0.767296	0.7808	0.841143	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	21.0	0.807818	0.770186	0.788553	0.837419	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	23.0	0.807818	0.777429	0.792332	0.839564	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	25.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	27.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	29.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	31.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	33.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	35.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	37.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	39.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	41.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	43.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	45.0	0.80456	0.77918	0.791667	0.839514	
	estimators	max_depth	recall	precision	f1	auc_roc	
0	71.0	47.0	0.80456	0.77918	0.791667	0.839514	

	estimators	max_depth	recall	precision	f1	auc_roc
0	71.0	49.0	0.80456	0.77918	0.791667	0.839514
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	5.0	0.76873	0.784053	0.776316	0.835492
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	7.0	0.798046	0.795455	0.796748	0.843163
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	9.0	0.76873	0.778878	0.77377	0.836723
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	11.0	0.785016	0.769968	0.777419	0.83967
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	13.0	0.801303	0.773585	0.7872	0.840055
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	15.0	0.801303	0.766355	0.783439	0.839371
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	17.0	0.80456	0.767081	0.785374	0.83249
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	19.0	0.791531	0.771429	0.78135	0.841174
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	21.0	0.801303	0.776025	0.788462	0.836251
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	23.0	0.794788	0.774603	0.784566	0.839079
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	25.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	27.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	29.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	31.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	33.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	35.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	37.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	39.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	41.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	43.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	45.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	47.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	81.0	49.0	0.798046	0.775316	0.786517	0.838998
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	5.0	0.771987	0.787375	0.779605	0.835903
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	7.0	0.801303	0.801303	0.801303	0.841734
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	9.0	0.771987	0.782178	0.777049	0.836711
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	11.0	0.785016	0.769968	0.777419	0.840043
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	13.0	0.794788	0.77707	0.785829	0.841236
	estimators	max_depth	recall	precision	f1	auc_roc
0	91.0	15.0	0.801303	0.763975	0.782194	0.839508
	estimators	max_depth	recall	precision	f1	auc_roc

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   0        91.0       17.0  0.794788   0.767296  0.7808  0.834784
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       19.0  0.798046   0.772871  0.785256  0.841162
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       21.0  0.80456   0.767081  0.785374  0.835803
      estimators  max_depth    recall  precision        f1  auc_roc
   0        91.0       23.0  0.807818   0.772586  0.789809  0.83847
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       25.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       27.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       29.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       31.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       33.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       35.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       37.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       39.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       41.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       43.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       45.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       47.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0        91.0       49.0  0.807818   0.772586  0.789809  0.838445
      estimators  max_depth    recall  precision        f1   auc_roc
   0       101.0        5.0  0.771987   0.787375  0.779605  0.836549
      estimators  max_depth    recall  precision        f1   auc_roc
   0       101.0        7.0  0.791531   0.799342  0.795417  0.841721
      estimators  max_depth    recall  precision        f1   auc_roc
   0       101.0        9.0  0.775244   0.782895  0.779051  0.838091
      estimators  max_depth    recall  precision        f1   auc_roc
   0       101.0       11.0  0.785016   0.772436  0.778675  0.839968
      estimators  max_depth    recall  precision        f1   auc_roc
   0       101.0       13.0  0.80456    0.76947  0.786624  0.841062
      estimators  max_depth    recall  precision        f1   auc_roc
   0       101.0       15.0  0.80456   0.771875  0.787879  0.839937
      estimators  max_depth    recall  precision      f1   auc_roc
   0       101.0       17.0  0.794788   0.767296  0.7808  0.835126
      estimators  max_depth    recall  precision        f1   auc_roc
   0       101.0       19.0  0.801303    0.76875  0.784689  0.840584
      estimators  max_depth    recall  precision        f1   auc_roc
   0       101.0       21.0  0.798046    0.76324  0.780255  0.836127
      estimators  max_depth    recall  precision        f1   auc_roc
   0       101.0       23.0  0.798046   0.768025  0.782748  0.838215
      estimators  max_depth    recall  precision     f1   auc_roc
   0       101.0       25.0  0.798046    0.77044  0.784  0.838165
      estimators  max_depth    recall  precision     f1   auc_roc
   0       101.0       27.0  0.798046    0.77044  0.784  0.838165
      estimators  max_depth    recall  precision     f1   auc_roc
   0       101.0       29.0  0.798046    0.77044  0.784  0.838165
      estimators  max_depth    recall  precision     f1   auc_roc
   0       101.0       31.0  0.798046    0.77044  0.784  0.838165
```

	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	33.0	0.798046	0.77044	0.784	0.838165
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	35.0	0.798046	0.77044	0.784	0.838165
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	37.0	0.798046	0.77044	0.784	0.838165
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	39.0	0.798046	0.77044	0.784	0.838165
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	41.0	0.798046	0.77044	0.784	0.838165
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	43.0	0.798046	0.77044	0.784	0.838165
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	45.0	0.798046	0.77044	0.784	0.838165
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	47.0	0.798046	0.77044	0.784	0.838165
	estimators	max_depth	recall	precision	f1	auc_roc
0	101.0	49.0	0.798046	0.77044	0.784	0.838165
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	5.0	0.76873	0.784053	0.776316	0.837419
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	7.0	0.791531	0.796721	0.794118	0.842057
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	9.0	0.775244	0.780328	0.777778	0.838862
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	11.0	0.785016	0.777419	0.781199	0.839023
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	13.0	0.80456	0.77673	0.7904	0.839421
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	15.0	0.801303	0.76875	0.784689	0.840105
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	17.0	0.798046	0.768025	0.782748	0.836481
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	19.0	0.80456	0.774295	0.789137	0.839732
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	21.0	0.794788	0.767296	0.7808	0.836375
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	23.0	0.801303	0.766355	0.783439	0.838271
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	25.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	27.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	29.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	31.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	33.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	35.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	37.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	39.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	41.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	43.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	45.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc

0	111.0	47.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	111.0	49.0	0.798046	0.765625	0.781499	0.838184
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	5.0	0.771987	0.787375	0.779605	0.836984
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	7.0	0.794788	0.794788	0.794788	0.841286
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	9.0	0.785016	0.777419	0.781199	0.83819
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	11.0	0.778502	0.775974	0.777236	0.838812
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	13.0	0.801303	0.766355	0.783439	0.839744
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	15.0	0.80456	0.76947	0.786624	0.839465
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	17.0	0.801303	0.77116	0.785942	0.836226
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	19.0	0.807818	0.775	0.791069	0.8388
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	21.0	0.794788	0.769716	0.782051	0.836176
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	23.0	0.798046	0.768025	0.782748	0.837301
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	25.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	27.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	29.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	31.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	33.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	35.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	37.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	39.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	41.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	43.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	45.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	47.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	121.0	49.0	0.798046	0.768025	0.782748	0.837183
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	5.0	0.775244	0.777778	0.776509	0.836984
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	7.0	0.794788	0.797386	0.796085	0.842094
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	9.0	0.791531	0.78135	0.786408	0.83967
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	11.0	0.781759	0.779221	0.780488	0.83824
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	13.0	0.798046	0.772871	0.785256	0.839545
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	15.0	0.80456	0.76947	0.786624	0.840391

	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	17.0	0.801303	0.776025	0.788462	0.836537
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	19.0	0.801303	0.773585	0.7872	0.83765
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	21.0	0.801303	0.766355	0.783439	0.836717
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	23.0	0.794788	0.76489	0.779553	0.837917
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	25.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	27.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	29.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	31.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	33.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	35.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	37.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	39.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	41.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	43.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	45.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	47.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	131.0	49.0	0.794788	0.76489	0.779553	0.837861
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	5.0	0.771987	0.779605	0.775777	0.836686
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	7.0	0.798046	0.79288	0.795455	0.841995
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	9.0	0.788274	0.780645	0.784441	0.839371
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	11.0	0.781759	0.774194	0.777958	0.838576
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	13.0	0.801303	0.77116	0.785942	0.839894
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	15.0	0.801303	0.776025	0.788462	0.839682
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	17.0	0.801303	0.773585	0.7872	0.836984
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	19.0	0.798046	0.775316	0.786517	0.836779
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	21.0	0.798046	0.765625	0.781499	0.835567
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	23.0	0.801303	0.763975	0.782194	0.837127
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	25.0	0.798046	0.76324	0.780255	0.83704
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	27.0	0.798046	0.76324	0.780255	0.83704
	estimators	max_depth	recall	precision	f1	auc_roc
0	141.0	29.0	0.798046	0.76324	0.780255	0.83704
	estimators	max_depth	recall	precision	f1	auc_roc

```
0       141.0       31.0  0.798046    0.76324  0.780255  0.83704
   estimators  max_depth    recall  precision        f1  auc_roc
0       141.0       33.0  0.798046    0.76324  0.780255  0.83704
   estimators  max_depth    recall  precision        f1  auc_roc
0       141.0       35.0  0.798046    0.76324  0.780255  0.83704
   estimators  max_depth    recall  precision        f1  auc_roc
0       141.0       37.0  0.798046    0.76324  0.780255  0.83704
   estimators  max_depth    recall  precision        f1  auc_roc
0       141.0       39.0  0.798046    0.76324  0.780255  0.83704
   estimators  max_depth    recall  precision        f1  auc_roc
0       141.0       41.0  0.798046    0.76324  0.780255  0.83704
   estimators  max_depth    recall  precision        f1  auc_roc
0       141.0       43.0  0.798046    0.76324  0.780255  0.83704
   estimators  max_depth    recall  precision        f1  auc_roc
0       141.0       45.0  0.798046    0.76324  0.780255  0.83704
   estimators  max_depth    recall  precision        f1  auc_roc
0       141.0       47.0  0.798046    0.76324  0.780255  0.83704
   estimators  max_depth    recall  precision        f1  auc_roc
0       141.0       49.0  0.798046    0.76324  0.780255  0.83704
```

In [61]:

```
model_quality_lr(features_downsampled, target_downsampled,features_downsampled_valid,ta
rget_downsampled_valid)
```

```
Полнота: 0.7687296416938111
Точность: 0.7173252279635258
F1-мера: 0.7421383647798742
AUC-ROC: 0.7712907476937613
```

Вывод:

upsampling позволяет поднять показатель f1 до 0,81 на модели случайного леса при гиперпараметрах estimators 41, depth 7. показатель f1 на расширенной выборке и со сбалансированными классами чуть ниже. у модели дерева решений максимальное значение f1 при расширенной выборке с глубиной 5 - 0,59. downsampling позволяет поднять показатель f1 только до 0,78, при балансировании классов и сокращении выборки показатель f1 чуть выше. У логистической регрессии значение на расширенной выборке - 0.76, на сокращенной 0,74.

4. Тестирование модели

Проведем тестирование моделей показавших лучший результат

In [62]:

```
model_quality_rfc(features_upsampled,target_upsampled,features_upsampled_test,target_up
sampled_test, 41, 7)
```

```
   estimators  max_depth    recall  precision        f1   auc_roc
0        41.0        7.0  0.520376   0.553333  0.536349  0.471665
```

In [63]:

```
#для модели решающего дерева с гиперпараметром глубины дерева 5
model_quality_dtc(features_upsampled, target_upsampled,features_upsampled_test,target_u
psampled_test, 5)
```

```
   depth  recall  precision        f1   auc_roc
0    5.0  0.9279   0.640415  0.757808  0.616173
```

In [64]:

```
#для модели логистической регрессии
model_quality_lr(features_upsampled, target_upsampled,features_upsampled_test,target_up
sampled_test)
```

```
Полнота: 1.0
Точность: 0.5745677233429395
F1-мера: 0.7298101121024938
AUC-ROC: 0.4972859194296317
```

Вывод:

Для 3х моделей были посчитаны оптимальные значения f1 перебором гиперпараметров. Для модели решающего дерева максимальное значение f1 достигается при глубине дерева 5 на расширенной выборке 0.794848, при этом значение полноты 0.824104, а точности 0.767597, AUC-ROC: 0.831514. на тестовой выборке данная модель достигла необходимого уровна f1 0.757808. Для модели случайного леса максимальное значение f1 0.8113 достигается при глубине дерева 7, количество оценциков 41. на тестовой выборке эта модель показала полноту 0.520376, точность 0.553333, f1 0.536349, AUC-ROC: 0.471665. Нужного показателя не достигла. Для логистической регрессии на расширенной выборке F1-мера составила 0.7613, Полнота: 0.7980, Точность: 0.72786, AUC-ROC: 0.7797. На тестовой выборке следующие результаты: Полнота 1.0, Точность 0.5745, F1-мера: 0.7298, AUC-ROC: 0.497285.

Ни одна модель не достигла требуемого показателя f1, без ликвидации дисбаланса классов.