I. Постановка задачи

Изучить датасет топ 2000 списка Forbes и построить модели регрессии для предсказывания прибыли (Profits) компании за 2017 год.

II. Описание последовательности действий студента по решению задачи машинного обучения.

In [1]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.metrics import r2_score, mean_squared_error, mean_absolute_error
from sklearn.preprocessing import LabelEncoder, MinMaxScaler
from sklearn.model_selection import cross_val_score

from xgboost import XGBRegressor
from sklearn.svm import SVR
from sklearn.ensemble import RandomForestRegressor
```

In [2]:

```
import warnings
warnings.filterwarnings('ignore')
```

1. Поиск и выбор набора данных для построения моделей машинного обучения. На основе выбранного набора данных студент должен построить модели машинного обучения для решения или задачи классификации, или задачи регрессии.

In [3]:

```
origin_data = pd.read_csv('forbes-top-2000-companies/Forbes Top2000 2017.csv')
origin_data.shape
```

Out[3]:

```
(2000, 10)
```

2. Проведение разведочного анализа данных. Построение графиков, необходимых для понимания структуры данных. Анализ и заполнение пропусков в данных.

1. Rank - Ранг компании на тот год
2. Company - Название компании
3. Country - Страна, которой она принадлежит
4. Sales - Продажи за тот год
5. Market Values - Рыночная стоимость за тот гож
6. Profit - Прибыль за этот год
7. Assests - Активы компании
8. Sector - Область компании.

In [4]:

```
origin_data.head(10)
```

Out[4]:

	Unnamed: 0	Rank	Company	Country	Sales	Profits	Assets	Market Value	Sector	Industry
0	NaN	1	ICBC	China	151.4	42.0	3473.2	229.8	Financials	Major Banks
1	NaN	2	China Construction Bank	China	134.2	35.0	3016.6	200.5	Financials	Regional Banks
2	NaN	3	Berkshire Hathaway	United States	222.9	24.1	620.9	409.9	Financials	Investment Services
3	NaN	4	JPMorgan Chase	United States	102.5	24.2	2513.0	306.6	Financials	Major Banks
4	NaN	5	Wells Fargo	United States	97.6	21.9	1943.4	274.4	Financials	Major Banks
5	NaN	6	Agricultural Bank of China	China	115.7	27.8	2816.0	149.2	Financials	Regional Banks
6	NaN	7	Bank of America	United States	92.2	16.6	2196.8	231.9	Financials	Major Banks
7	NaN	8	Bank of China	China	113.1	24.9	2611.5	141.3	Financials	Major Banks
8	NaN	9	Apple	United States	217.5	45.2	331.1	752.0	Information Technology	Computer Hardware
9	NaN	10	Toyota Motor	Japan	249.9	17.1	412.5	171.9	Consumer Discretionary	Auto & Truck Manufacturers

In [5]:

```
origin_data.dtypes
```

Out[5]:

```
Unnamed: 0      float64
 Rank             int64
Company          object
Country          object
Sales           float64
Profits         float64
Assets          float64
Market Value    float64
Sector           object
Industry         object
dtype: object
```

In [6]:

```
origin_data.isnull().sum()
```

Out[6]:

```
Unnamed: 0      2000
 Rank              0
Company            0
Country            0
Sales              0
Profits            0
Assets             0
Market Value       0
Sector           197
Industry         491
dtype: int64
```

In [7]:

```
origin_data.drop(["Unnamed: 0", " Rank", "Company"], axis=1, inplace=True)
```

In [8]:

```
origin_data.head(10)
```

Out[8]:

	Country	Sales	Profits	Assets	Market Value	Sector	Industry
0	China	151.4	42.0	3473.2	229.8	Financials	Major Banks
1	China	134.2	35.0	3016.6	200.5	Financials	Regional Banks
2	United States	222.9	24.1	620.9	409.9	Financials	Investment Services
3	United States	102.5	24.2	2513.0	306.6	Financials	Major Banks
4	United States	97.6	21.9	1943.4	274.4	Financials	Major Banks
5	China	115.7	27.8	2816.0	149.2	Financials	Regional Banks
6	United States	92.2	16.6	2196.8	231.9	Financials	Major Banks
7	China	113.1	24.9	2611.5	141.3	Financials	Major Banks
8	United States	217.5	45.2	331.1	752.0	Information Technology	Computer Hardware
9	Japan	249.9	17.1	412.5	171.9	Consumer Discretionary	Auto & Truck Manufacturers

In [9]:

```
origin_data.isnull().sum()
```

Out[9]:

```
Country            0
Sales              0
Profits            0
Assets             0
Market Value       0
Sector           197
Industry         491
dtype: int64
```

Удалим все строчки с пропусками

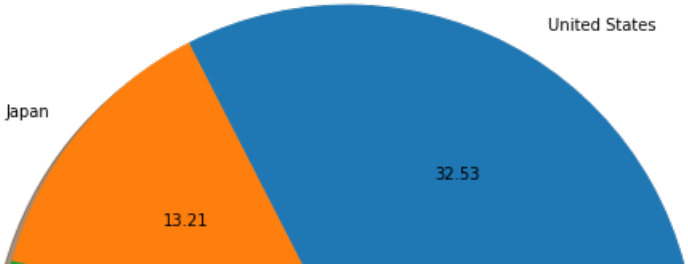
In [10]:

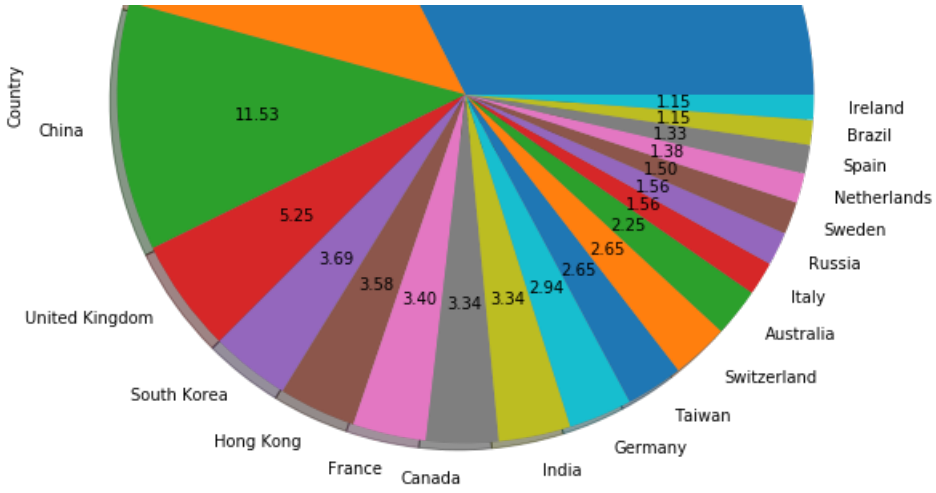
```
# data = origin_data.dropna(axis=0, how='any')
data = origin_data
data['Sector'] = ['Other' if pd.isna(i) else i for i in data['Sector']]
data['Industry'] = ['Other' if pd.isnull(i) else i for i in data['Industry']]
data.is_copy = False
```

Топ 10 стран по количеству компаний в списке Forbs

In [12]:

```
fig, ax = plt.subplots(1,1,figsize=(15,10))
data['Country'].value_counts()[:20].plot(kind='pie', autopct='%.2f', shadow=True);
plt.xlabel("Распределение стран по количеству компаний");
```





Распределение стран по количеству компаний

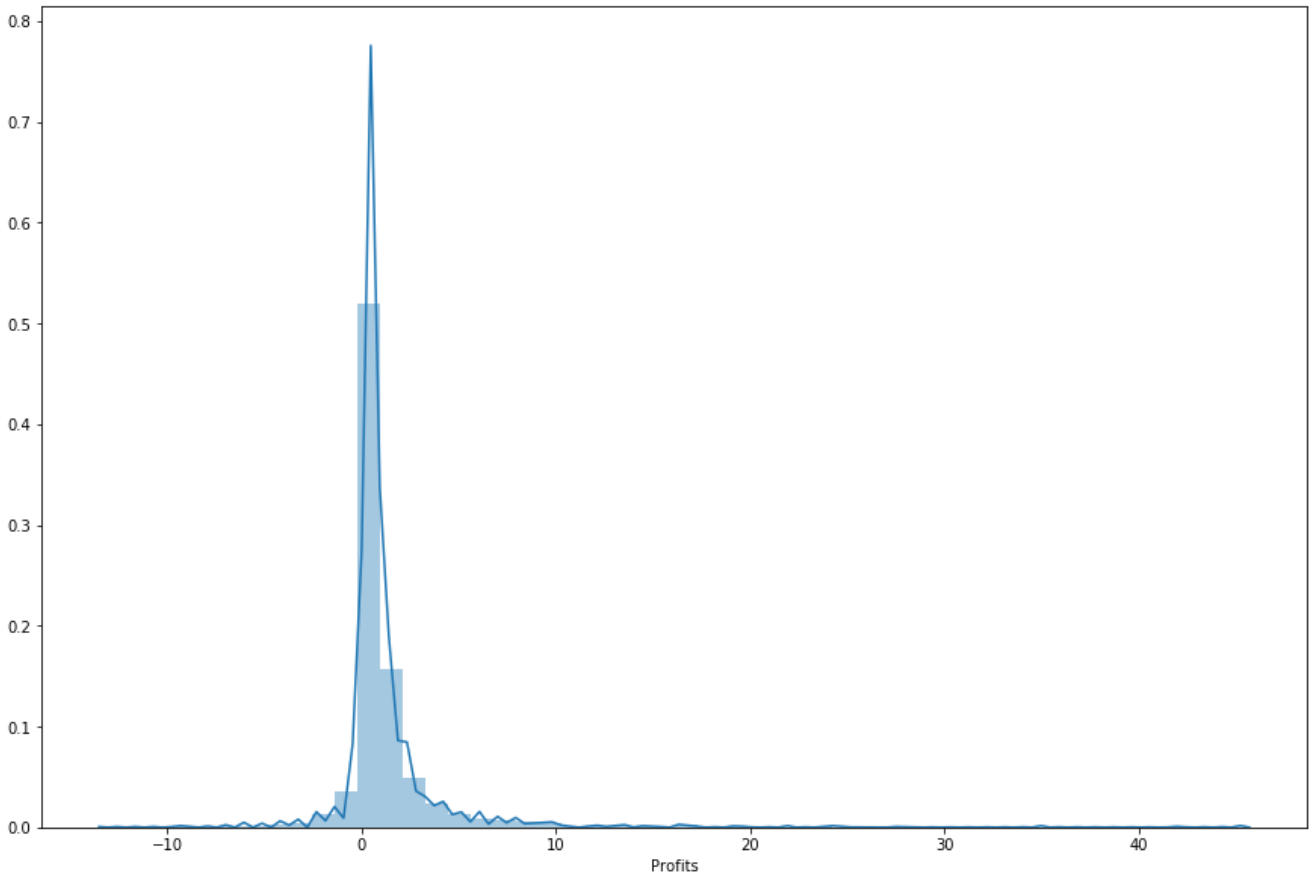
Стандартное распределение доходов компаний

In [13]:

```
fig, ax = plt.subplots(figsize=(15,10))
sns.distplot(data['Profits'])
```

Out[13]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1a2717b6d8>
```



Первые десять стран по общему заработку

In [14]:

```
countries = data[['Country', 'Profits']].groupby('Country').sum().sort_values('Profits', ascending
```

```
=False)[:10]
```

In [15]:

```
countries
```

Out[15]:

Country	Profits
United States	923.9522
China	367.7190
Japan	197.3650
France	84.3920
Hong Kong	80.6880
Germany	66.1590
United Kingdom	65.7330
South Korea	65.5960
Russia	61.1750
Switzerland	60.2560

3. Выбор признаков, подходящих для построения моделей. Кодирование категориальных признаков Масштабирование данных. Формирование вспомогательных признаков, улучшающих качество моделей.

In [16]:

```
def encode_columns(origin_data):
    data = origin_data
    data.is_copy = False
    encoder = LabelEncoder()
    cols = ["Country", "Sector", "Industry"]

    for col in cols:
        data[col] = encoder.fit_transform(data[col])

    return data
```

In [17]:

```
data = encode_columns(data)
```

4. Проведение корреляционного анализа данных. Формирование промежуточных выводов о возможности построения моделей машинного обучения. В зависимости от набора данных, порядок выполнения пунктов 2, 3, 4 может быть изменен.

In [18]:

```
corr = data.corr(method='pearson')
corr.style.background_gradient(cmap='coolwarm')
```

Out[18]:

	Country	Sales	Profits	Assets	Market Value	Sector	Industry

	Country	Sales	Profits	Assets	Market Value	Sector	Industry
Country	1	0.0232937	0.0313004	-0.0485051	0.11713	-0.064289	-0.00616826
Sales	0.0232937	1	0.544257	0.373856	0.578612	-0.105826	-0.131679
Profits	0.0313004	0.544257	1	0.56103	0.741232	-0.0598649	-0.0217602
Assets	-0.0485051	0.373856	0.56103	1	0.32899	-0.0930483	0.0487835
Market Value	0.11713	0.578612	0.741232	0.32899	1	-0.0520159	-0.0341276
Sector	-0.064289	-0.105826	-0.0598649	-0.0930483	-0.0520159	1	0.137334
Industry	-0.00616826	-0.131679	-0.0217602	0.0487835	-0.0341276	0.137334	1

In [19]:

```
# data.drop(['Sector', 'Industry', 'Country'], axis=1, inplace=True)
```

In [20]:

```
data.shape
```

Out[20]:

```
(2000, 7)
```

In [21]:

```
y = data['Profits']
data_X = data.drop(['Profits'], axis=1)

X_train, X_test, y_train, y_test = train_test_split(data_X, y, random_state = 100, test_size=0.1)
```

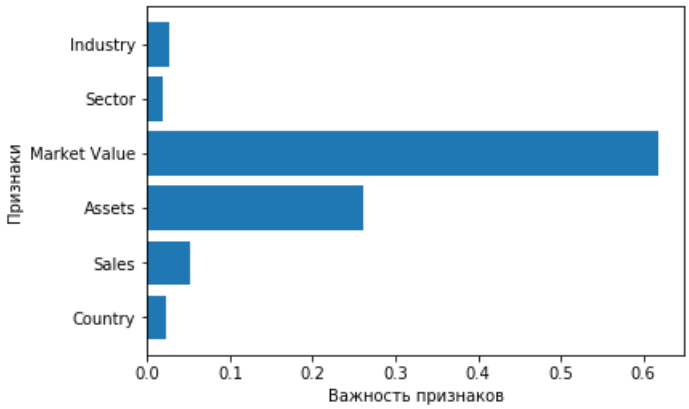
Посмотрим важности признаков с использованием RandomForestRegressor

In [22]:

```
def plot_feature_importances():
    rfr_to_plot = RandomForestRegressor(random_state=100)
    rfr_to_plot.fit(X_train, y_train)
    n_features = data.shape[1] - 1
    print(n_features)
    plt.barh(range(n_features), rfr_to_plot.feature_importances_, align='center')
    plt.yticks(np.arange(n_features), [i for i in data.columns if i != 'Profits'])
    plt.xlabel("Важность признаков")
    plt.ylabel("Признаки")

plot_feature_importances()
```

```
6
```



5. Выбор метрик для последующей оценки качества моделей. Необходимо выбрать не менее двух метрик и обосновать

выбор.

Для исследования корректности моделей выберем метрики r2_score, mean_squared_error, mean_absolute_error

6. Выбор наиболее подходящих моделей для решения задачи классификации или регрессии. Необходимо использовать не менее трех моделей, хотя бы одна из которых должна быть ансамблевой.

Будем исследовать XGBoost, SVR, RandomForestRegressor

7. Формирование обучающей и тестовой выборок на основе исходного набора данных.

In [23]:

```
def predict_test(model, X_train, X_test, y_train, y_test):
    pred_train = model.predict(X_train)
    pred_test = model.predict(X_test)

    print('root mean_squared_error train / test: {:0.3f} / {:0.3f}'.format(
        np.sqrt(mean_squared_error(y_train, pred_train)), np.sqrt(mean_squared_error(y_test, pred_t
est))))
    print('r2_score train / test: {:0.3f} / {:0.3f}'.format(
        r2_score(y_train, pred_train), r2_score(y_test, pred_test)))


def cvs_test_print(model, X_train, X_test, y_train, y_test, cv=10):
    scores = cross_val_score(model, X_train, y_train, cv=cv)
    print("Значения правильности перекрестной проверки: {}".format(scores))
    print("Среднее: {}.\nМаксимальное: {}.\nМинимальное: {}".format(np.mean(scores), np.max(scores)
, np.min(scores)))


def compare_predictions(model, test_data, y_test):
    fig, ax = plt.subplots(figsize=(15,10))
    plt.plot(np.linspace(0, len(y_test), len(test_data)), model.predict(test_data))
    plt.plot(np.linspace(0, len(y_test), len(y_test)), y_test)
```

In [24]:

```
scaler = MinMaxScaler().fit(X_train)
X_train_scaled, X_test_scaled = scaler.transform(X_train), scaler.transform(X_test)
```

8. Построение базового решения (baseline) для выбранных моделей без подбора гиперпараметров. Производится обучение моделей на основе обучающей выборки и оценка качества моделей на основе тестовой выборки.

XGBRegressor

In [25]:

```
xgb = XGBRegressor(objective='reg:linear')
cvs_test_print(xgb, X_train_scaled, X_test_scaled, y_train, y_test)

xgb.fit(X_train_scaled, y_train)
predict_test(xgb, X_train_scaled, X_test_scaled, y_train, y_test)
```

```
[01:01:52] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:52] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
```

```
[01:01:52] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
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reg:squarederror.
[01:01:52] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
Значения правильности перекрестной проверки: [0.12832129 0.64620349 0.02117703 0.69392116
0.43500426 0.32409968
 0.76928089 0.81226802 0.57296362 0.64586453]
Среднее: 0.5049103960182665.
Максимальное: 0.8122680163607557.
Минимальное: 0.021177030914538264
[01:01:52] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
root mean_squared_error train / test: 1.076 / 1.695
r2_score train / test: 0.868 / 0.527
```

SVR

In [26]:

```
svr = SVR().fit(X_train_scaled, y_train)
cvs_test_print(svr, X_train_scaled, X_test_scaled, y_train, y_test)
predict_test(svr, X_train_scaled, X_test_scaled, y_train, y_test)
```

```
Значения правильности перекрестной проверки: [0.40635753 0.33678538 0.26978726 0.46943239
0.32993553 0.23841765
 0.37125101 0.32014133 0.30767466 0.35199405]
Среднее: 0.34017767863356574.
Максимальное: 0.4694323907342888.
Минимальное: 0.23841764518380437
root mean_squared_error train / test: 2.333 / 1.862
r2_score train / test: 0.381 / 0.430
```

RFR

In [27]:

```
rfr = RandomForestRegressor().fit(X_train_scaled, y_train)
cvs_test_print(rfr, X_train_scaled, X_test_scaled, y_train, y_test)
predict_test(rfr, X_train_scaled, X_test_scaled, y_train, y_test)
```

```
Значения правильности перекрестной проверки: [-0.09770043  0.696968    0.03702469  0.75127403  0.40
807569 -0.06123274
  0.68638147  0.81152545  0.59454634  0.73099341]
Среднее: 0.45578558967926863.
Максимальное: 0.8115254450084137.
Минимальное: -0.09770043102241566
root mean_squared_error train / test: 0.732 / 1.579
r2_score train / test: 0.939 / 0.590
```

9. Подбор гиперпараметров для выбранных моделей.

10. Повторение пункта 8 для найденных оптимальных значений гиперпараметров. Сравнение качества полученных

моделей с качеством baseline-моделей.

XGBRegressor

In [28]:

```
xgb_grid_params = {
    'n_estimators': [10, 20, 50, 100, 200, 300, 500, 600, 700]
}

xgb_grid = GridSearchCV(XGBRegressor(), xgb_grid_params, cv = 10)
xgb_grid.fit(X_train, y_train)
```

```
[01:01:54] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
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```

```
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[01:01:55] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:55] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:55] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:55] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:56] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:56] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:56] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:56] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:56] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:56] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:56] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:56] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:57] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:57] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:57] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:57] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:57] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:57] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:57] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:58] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:58] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:58] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:58] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:59] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:59] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:59] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:01:59] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:00] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:00] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
```

```
reg:squarederror.
[01:02:00] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:00] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:01] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:01] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:01] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:02] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:02] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:02] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:02] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:03] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:03] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:03] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:04] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:04] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:05] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:05] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:05] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:06] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:06] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:06] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
[01:02:07] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
```

Out[28]:

```
GridSearchCV(cv=10, error_score='raise-deprecating',
       estimator=XGBRegressor(base_score=0.5, booster='gbtree', colsample_bylevel=1,
       colsample_bynode=1, colsample_bytree=1, gamma=0,
       importance_type='gain', learning_rate=0.1, max_delta_step=0,
       max_depth=3, min_child_weight=1, missing=None, n_estimators=100,
       n_jobs=1, nthread=None, objective='reg:linear', random_state=0,
       reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
       silent=None, subsample=1, verbosity=1),
       fit_params=None, iid='warn', n_jobs=None,
       param_grid={'n_estimators': [10, 20, 50, 100, 200, 300, 500, 600, 700]},
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring=None, verbose=0)
```

In [29]:

```
print("Лучший результат модели XGBoost с использованием GridSearchCV:",
      xgb_grid.best_score_)
print("Наилучшие значения параметров: {}".format(xgb_grid.best_params_))
```

```
Лучший результат модели XGBoost с использованием GridSearchCV: 0.5195560618389029
Наилучшие значения параметров: {'n_estimators': 500}
```

RFR

In [30]:

```
rfr_grid_params = {
```

```
    'max_depth': [5, 10, 20, 40, 60, 90],
}

rfr_grid = GridSearchCV(RandomForestRegressor(), rfr_grid_params, cv=10)
rfr_grid.fit(X_train_scaled, y_train)
```

Out[30]:

```
GridSearchCV(cv=10, error_score='raise-deprecating',
       estimator=RandomForestRegressor(bootstrap=True, criterion='mse', max_depth=None,
           max_features='auto', max_leaf_nodes=None,
           min_impurity_decrease=0.0, min_impurity_split=None,
           min_samples_leaf=1, min_samples_split=2,
           min_weight_fraction_leaf=0.0, n_estimators='warn', n_jobs=None,
           oob_score=False, random_state=None, verbose=0, warm_start=False),
       fit_params=None, iid='warn', n_jobs=None,
       param_grid={'max_depth': [5, 10, 20, 40, 60, 90]},
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring=None, verbose=0)
```

In [31]:

```
print("Лучший результат модели RandomForestRegressor с использованием GridSearchCV:",
      rfr_grid.best_score_)
print("Наилучшие значения параметров: {}".format(rfr_grid.best_params_))
predict_test(rfr_grid, X_train_scaled, X_test_scaled, y_train, y_test)
```

```
Лучший результат модели RandomForestRegressor с использованием GridSearchCV: 0.4994494449556189
Наилучшие значения параметров: {'max_depth': 5}
root mean_squared_error train / test: 1.260 / 1.545
r2_score train / test: 0.819 / 0.607
```

SVR

In [32]:

```
svr_grid_params = {'C': np.array([0.1, 1, 10, 100, 1000]), 'gamma': np.array([0.001, 0.01, 0.1, 1,
10])}
svr_grid = GridSearchCV(SVR(), svr_grid_params, cv=5)
svr_grid.fit(X_train_scaled, y_train)
```

Out[32]:

```
GridSearchCV(cv=5, error_score='raise-deprecating',
       estimator=SVR(C=1.0, cache_size=200, coef0=0.0, degree=3, epsilon=0.1,
  gamma='auto_deprecated', kernel='rbf', max_iter=-1, shrinking=True,
  tol=0.001, verbose=False),
       fit_params=None, iid='warn', n_jobs=None,
       param_grid={'C': array([1.e-01, 1.e+00, 1.e+01, 1.e+02, 1.e+03]), 'gamma': array([1.e-03,
1.e-02, 1.e-01, 1.e+00, 1.e+01])},
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring=None, verbose=0)
```

In [33]:

```
print("Наил знач правильности перекр проверки: {:.2f}".format(svr_grid.best_score_))
print("Наил знач правильности на тесте: {:.2f}".format(svr_grid.score(X_test_scaled, y_test)))
print("Наил параметры: ", svr_grid.best_params_)
```

```
Наил знач правильности перекр проверки: 0.58
Наил знач правильности на тесте: 0.76
Наил параметры:  {'C': 1000.0, 'gamma': 0.01}
```

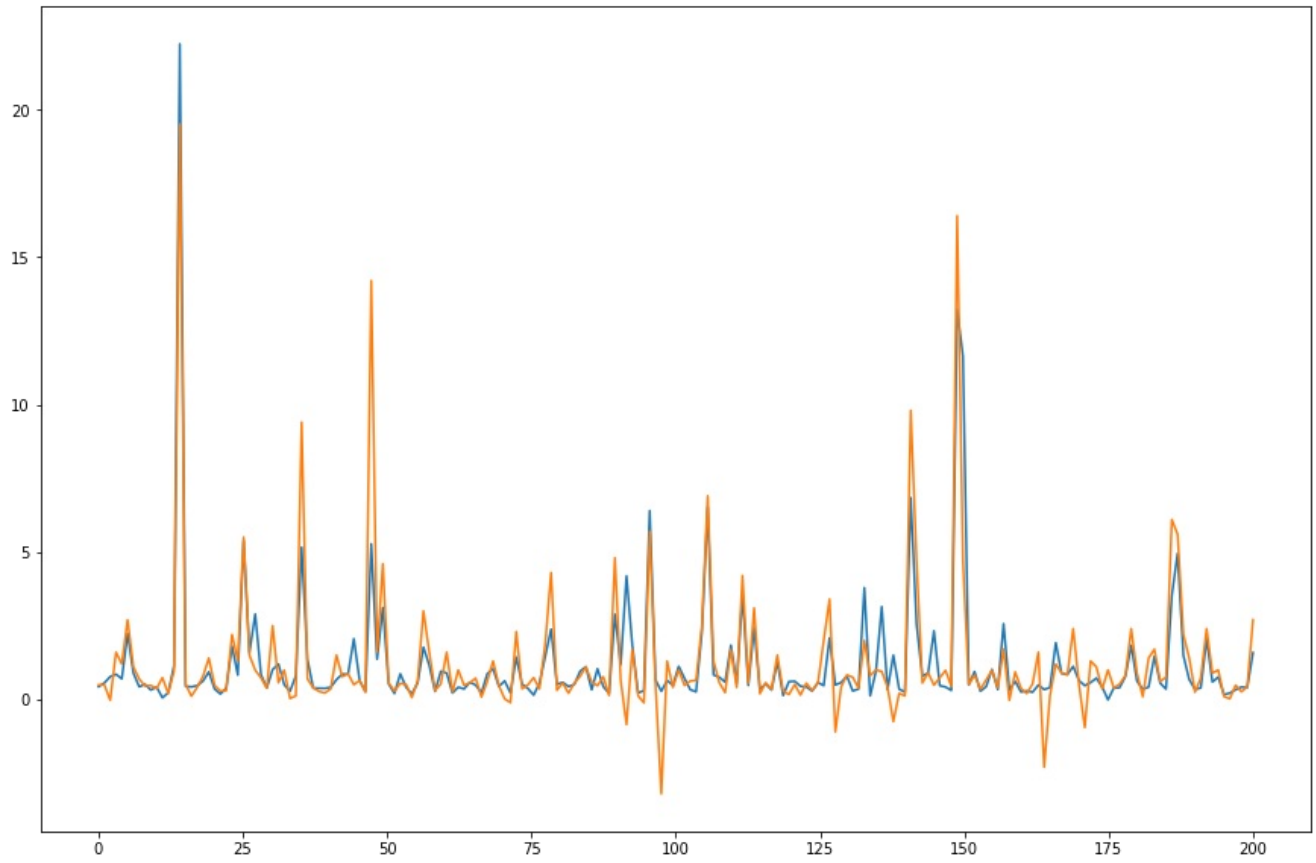
11. Формирование выводов о качестве построенных моделей на основе выбранных метрик.

Из вышеприведенных исследований можно сделать вывод, что значения правильности для каждый моделей улучшились, однако лучшей среди всех используемых моделей оказалась SVR.

Наилучшее значечние правильности cros_val_score: 0.62 Наилучшее значение правильности на тесте: 0.76 Наилучгие параметры: {'C': 1000.0, 'gamma': 1.0}

In [34]:

```
compare_predictions(svr_grid, X_test_scaled, y_test)
```



In [35]:

```
predict_test(svr_grid, X_train_scaled, X_test_scaled, y_train, y_test)
```

```
root mean_squared_error train / test: 1.725 / 1.220
r2_score train / test: 0.661 / 0.755
```

Видно, средняя квадратическая ошибка чуть больше 1 миллиарда долларов

III. Выводы:

Во время выполнения курсовой я освоил на практике кодирование категориальных признаков, удаление пустых значений, визуализацию признаков датасета, а также построение различных моделей машинного обучения

В итоге, среди используемых моделей я выбрал лучшую по характеристикам модель SVR с оценкой R2 в 0.756 и среднеквадратическую ошибку чуть выше 1 миллиарда долларов