Московский государственный технический университет имени Н. Э. Баумана

Кафедра «Системы обработки информации и управления»

Лабораторная работа №5

по курсу

«Методы машинного обучения»

на тему:

«Линейные модели, SVM и деревья решений»

Выполнил:

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Задание

- Выберите набор данных (датасет) для решения задачи классификации или регрессии.
- В случае необходимости проведите удаление или заполнение пропусков и кодирование категориальных признаков.
- С использованием метода train_test_split разделите выборку на обучающую и тестовую.
- Обучите следующие модели:
-   - одну из линейных моделей;
-   - SVM;
-   - дерево решений.
- Оцените качество моделей с помощью трех подходящих для задачи метрик. Сравните качество полученных моделей.
- Произведите для каждой модели подбор одного гиперпараметра с использованием GridSearchCV и кросс-валидации.
- Повторите пункт 4 для найденных оптимальных значений гиперпараметров. Сравните качество полученных моделей с качеством моделей, полученных в пункте 4.

In [1]:

```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn import preprocessing, svm
from sklearn import model_selection
from sklearn.model_selection import train_test_split
from sklearn.linear_model import BayesianRidge
from sklearn.tree import DecisionTreeClassifier, DecisionTreeRegressor, export_graphviz
from sklearn.metrics import r2_score
%matplotlib inline
sns.set(style="ticks")

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

In [2]:

```
data = pd.read_csv("data/Admission_Predict_Ver1.1.csv")
```

In [3]:

```
data.head(2)
```

Out[3]:

	Serial No.	GRE Score	TOEFL Score	University Rating	SOP	LOR	CGPA	Research	Chance of Admit
0	1	337	118	4	4.5	4.5	9.65	1	0.92
1	2	324	107	4	4.0	4.5	8.87	1	0.76

In [4]:

```
data.describe()
```

Out[4]:

	Serial No.	GRE Score	TOEFL Score	University Rating	SOP	LOR	CGPA	Research	Chance of Admit
count	500.000000	500.000000	500.000000	500.000000	500.000000	500.00000	500.000000	500.000000	500.00000
mean	250.500000	316.472000	107.192000	3.114000	3.374000	3.48400	8.576440	0.560000	0.72174
std	144.481833	11.295148	6.081868	1.143512	0.991004	0.92545	0.604813	0.496884	0.14114
min	1.000000	290.000000	92.000000	1.000000	1.000000	1.00000	6.800000	0.000000	0.34000
25%	125.750000	308.000000	103.000000	2.000000	2.500000	3.00000	8.127500	0.000000	0.63000
50%	250.500000	317.000000	107.000000	3.000000	3.500000	3.50000	8.560000	1.000000	0.72000
75%	375.250000	325.000000	112.000000	4.000000	4.000000	4.00000	9.040000	1.000000	0.82000
max	500.000000	340.000000	120.000000	5.000000	5.000000	5.00000	9.920000	1.000000	0.97000

In [5]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 500 entries, 0 to 499
Data columns (total 9 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   Serial No.         500 non-null    int64  
 1   GRE Score          500 non-null    int64  
 2   TOEFL Score        500 non-null    int64  
 3   University Rating  500 non-null    int64  
 4   SOP                500 non-null    float64
 5   LOR                500 non-null    float64
 6   CGPA               500 non-null    float64
 7   Research           500 non-null    int64  
 8   Chance of Admit    500 non-null    float64
dtypes: float64(4), int64(5)
memory usage: 35.3 KB
```

In [6]:

```
data.columns
```

Out[6]:

```
Index(['Serial No.', 'GRE Score', 'TOEFL Score', 'University Rating', 'SOP',
       'LOR ', 'CGPA', 'Research', 'Chance of Admit '],
      dtype='object')
```

In [7]:

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

Out[7]:

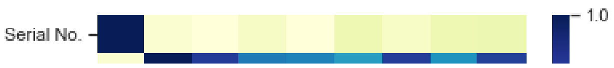
	Serial No.	GRE Score	TOEFL Score	University Rating	SOP	LOR	CGPA	Research	Chance of Admit
Serial No.	1.000000	-0.103839	-0.141696	-0.067641	-0.137352	-0.003694	-0.074289	-0.005332	0.008505
GRE Score	-0.103839	1.000000	0.827200	0.635376	0.613498	0.524679	0.825878	0.563398	0.810351
TOEFL Score	-0.141696	0.827200	1.000000	0.649799	0.644410	0.541563	0.810574	0.467012	0.792228
University Rating	-0.067641	0.635376	0.649799	1.000000	0.728024	0.608651	0.705254	0.427047	0.690132
SOP	-0.137352	0.613498	0.644410	0.728024	1.000000	0.663707	0.712154	0.408116	0.684137
LOR	-0.003694	0.524679	0.541563	0.608651	0.663707	1.000000	0.637469	0.372526	0.645365
CGPA	-0.074289	0.825878	0.810574	0.705254	0.712154	0.637469	1.000000	0.501311	0.882413
Research	-0.005332	0.563398	0.467012	0.427047	0.408116	0.372526	0.501311	1.000000	0.545871
Chance of Admit	0.008505	0.810351	0.792228	0.690132	0.684137	0.645365	0.882413	0.545871	1.000000

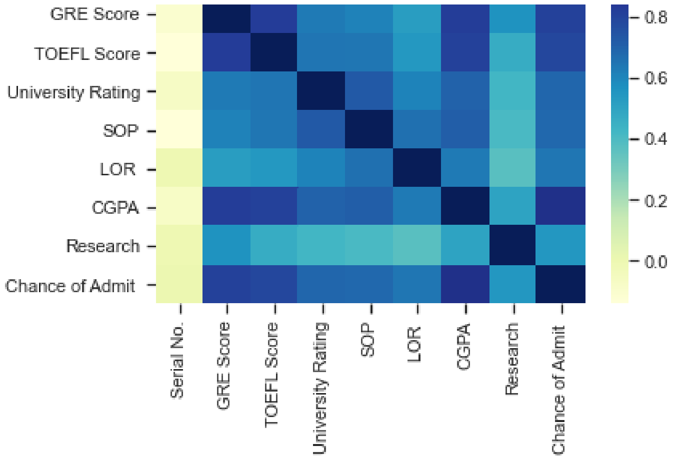
In [8]:

```
sns.heatmap(corr,
        xticklabels=corr.columns,
        yticklabels=corr.columns,
           cmap='YlGnBu')
```

Out[8]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x17de383b588>
```





Между CGPA и Chance of Admit есть корреляция 0.88

In [10]:

```
x = data["CGPA"].values
y = data["Chance of Admit "].values

reg = BayesianRidge(fit_intercept=True).fit(x.reshape(-1, 1), y.reshape(-1, 1))
reg.coef_
reg.intercept_
```

Out[10]:

```
-1.0433288693280354
```

In [12]:

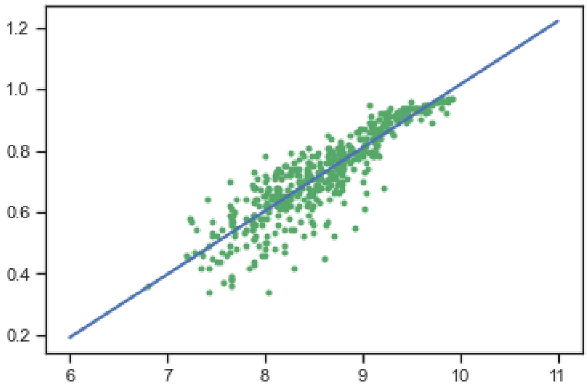
```
def func(w, b, x):
    return w*x + b
```

In [17]:

```
x_t = list(range(6, 12))
y_t = [func(reg.coef_[0], reg.intercept_, x) for x in x_t]
y_tt = reg.predict(x.reshape(-1, 1))
```

In [18]:

```
plt.plot(x, y, 'g.')
plt.plot(x_t, y_t, 'b', linewidth=2.0)
plt.show()
```



Модель линейной регрессии дала неплохой результат

SVM

In [19]:

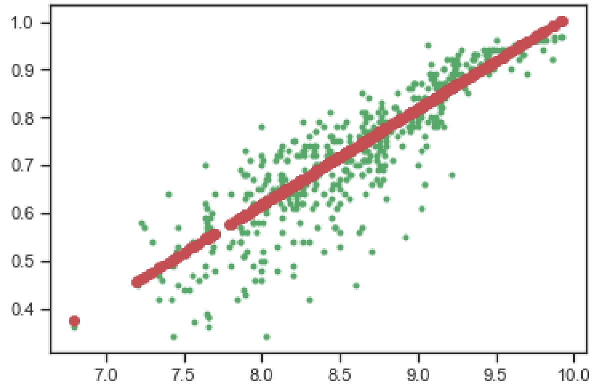
```
from sklearn.svm import SVC, NuSVC, LinearSVC, OneClassSVM, SVR, NuSVR, LinearSVR
```

In [20]:

```
lin_SVR = LinearSVR(C=1.0, max_iter=10000)
lin_SVR.fit(x.reshape(-1, 1), y)
predict = lin_SVR.predict(x.reshape(-1, 1))
plt.plot(x, y, 'g.')
plt.plot(x, predict, 'ro')
```

Out[20]:

```
[<matplotlib.lines.Line2D at 0x17de5c3fb38>]
```



Деревья решений

In [27]:

```
dec_tree = DecisionTreeRegressor(random_state=1, max_depth=2)
dec_tree.fit(data, data["Chance of Admit "])
dec_tree
```

Out[27]:

```
DecisionTreeRegressor(max_depth=2, random_state=1)
```

In [28]:

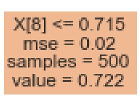
```
dec_predict = dec_tree.predict(data)
```

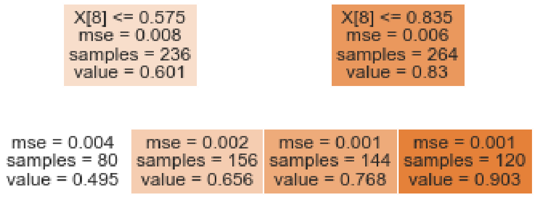
In [29]:

```
from sklearn import tree
tree.plot_tree(dec_tree, filled=True)
```

Out[29]:

```
[Text(167.4, 181.2, 'X[8] <= 0.715\nmse = 0.02\nsamples = 500\nvalue = 0.722'),
 Text(83.7, 108.72, 'X[8] <= 0.575\nmse = 0.008\nsamples = 236\nvalue = 0.601'),
 Text(41.85, 36.23999999999998, 'mse = 0.004\nsamples = 80\nvalue = 0.495'),
 Text(125.55000000000001, 36.23999999999998, 'mse = 0.002\nsamples = 156\nvalue = 0.656'),
 Text(251.10000000000002, 108.72, 'X[8] <= 0.835\nmse = 0.006\nsamples = 264\nvalue = 0.83'),
 Text(209.25, 36.23999999999998, 'mse = 0.001\nsamples = 144\nvalue = 0.768'),
 Text(292.95, 36.23999999999998, 'mse = 0.001\nsamples = 120\nvalue = 0.903')]
```





Метрики качества

In [30]:

```
from sklearn.metrics import mean_absolute_error, mean_squared_error, mean_squared_log_error,
median_absolute_error, r2_score

print("Метрики для линейной модели:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, y_tt))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, y_tt))
print("Коэффициент детерминации: ", r2_score(y, y_tt))

print("\n\nМетрики для SVM-модели:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, predict))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, predict))
print("Коэффициент детерминации: ", r2_score(y, predict))


print("\n\nМетрики для Decision Tree:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, dec_predict))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, dec_predict))
print("Коэффициент детерминации: ", r2_score(y, dec_predict))
```

```
Метрики для линейной модели:

Средняя абсолютная ошибка:  0.048356176421919375
Средняя квадратичная ошибка:  0.004400575179962326
Коэффициент детерминации:  0.77865169967127


Метрики для SVM-модели:

Средняя абсолютная ошибка:  0.048000840719299075
Средняя квадратичная ошибка:  0.004531621770186015
Коэффициент детерминации:  0.7720600749804865


Метрики для Decision Tree:

Средняя абсолютная ошибка:  0.034978833333333334
Средняя квадратичная ошибка:  0.0017660232051282055
Коэффициент детерминации:  0.9111692861023747
```

Подбор гиперпараметров. Кросс-валидация

In [31]:

```
from sklearn.model_selection import cross_validate
```

In [32]:

```
scoring = {'mean': 'neg_mean_absolute_error', 'square': 'neg_mean_squared_error', 'r2': 'r2'}
```

In [33]:

```
scores_regr = cross_validate(BayesianRidge(fit_intercept=True),
                             x.reshape(-1, 1), y, cv=3, scoring=scoring)
scores_regr
```

Out[33]:

```
{'fit_time': array([0.00099945, 0.00099969, 0.0019958 ]),
 'score_time': array([0.0019989 , 0.00200224, 0.00099802]),
 'test_mean': array([-0.06390867, -0.04166959, -0.0434577 ]),
 'test_square': array([-0.00805285, -0.00264878, -0.00341377]),
 'test_r2': array([0.69147165, 0.77100056, 0.83635644])}
```

In [34]:

```
scores_svm = cross_validate(LinearSVR(C=1.0, max_iter=10000),
                           x.reshape(-1, 1), y, cv=3, scoring=scoring)
scores_svm
```

Out[34]:

```
{'fit_time': array([0.04097629, 0.0369761 , 0.03497982]),
 'score_time': array([0.00100136, 0.00101209, 0.00099945]),
 'test_mean': array([-0.06527236, -0.03968679, -0.04267425]),
 'test_square': array([-0.00838947, -0.00241486, -0.00330504]),
 'test_r2': array([0.67857482, 0.79122418, 0.84156854])}
```

In [36]:

```
scores_dec = cross_validate(DecisionTreeRegressor(random_state=1, max_depth=3),
                           data, data["Chance of Admit "], cv=5, scoring=scoring)
scores_dec
```

Out[36]:

```
{'fit_time': array([0.00599432, 0.00499773, 0.00599909, 0.00599551, 0.00599694]),
 'score_time': array([0.00599647, 0.00499654, 0.0070045 , 0.00299644, 0.00499654]),
 'test_mean': array([-0.01947024, -0.01658337, -0.01743311, -0.01960369, -0.01780489]),
 'test_square': array([-0.00070725, -0.00038489, -0.00040677, -0.00058168, -0.00045542]),
 'test_r2': array([0.97674954, 0.97437313, 0.96746869, 0.96943965, 0.97486837])}
```

In [37]:

```
print("Метрики для линейной модели:\n")
print("Средняя абсолютная ошибка: ", np.mean(scores_regr['test_mean']))
print("Средняя квадратичная ошибка: ", np.mean(scores_regr['test_square']))
print("Коэффициент детерминации: ", np.mean(scores_regr['test_r2']))

print("\n\nМетрики для SVM-модели:\n")
print("Средняя абсолютная ошибка: ", np.mean(scores_svm['test_mean']))
print("Средняя квадратичная ошибка: ", np.mean(scores_svm['test_square']))
print("Коэффициент детерминации: ", np.mean(scores_svm['test_r2']))


print("\n\nМетрики для Decision Tree:\n")
print("Средняя абсолютная ошибка: ", np.mean(scores_dec['test_mean']))
print("Средняя квадратичная ошибка: ", np.mean(scores_dec['test_square']))
print("Коэффициент детерминации: ", np.mean(scores_dec['test_r2']))
```

```
Метрики для линейной модели:

Средняя абсолютная ошибка:  -0.049678655143161145
Средняя квадратичная ошибка:  -0.004705132163926633
Коэффициент детерминации:  0.7662762176604807


Метрики для SVM-модели:

Средняя абсолютная ошибка:  -0.04921113136081001
Средняя квадратичная ошибка:  -0.0047031212018939636
Коэффициент детерминации:  0.7704558470118542


Метрики для Decision Tree:

Средняя абсолютная ошибка:  -0.018179061248257487
Средняя квадратичная ошибка:  -0.0005072017860681037
Коэффициент детерминации:  0.9725798741030808
```

Оптимизация с помощью решетчатого поиска

In [38]:

```
from sklearn.model_selection import GridSearchCV
```

In [39]:

```
n_range = np.array(range(1,10,1))
tuned_parameters = [{'max_depth': n_range}]
tuned_parameters
```

Out[39]:

```
[{'max_depth': array([1, 2, 3, 4, 5, 6, 7, 8, 9])}]
```

In [40]:

```
%%time
clf_gs = GridSearchCV(DecisionTreeRegressor(), tuned_parameters, cv=5, scoring='r2')
clf_gs.fit(x.reshape(-1, 1), y)
```

```
Wall time: 97 ms
```

Out[40]:

```
GridSearchCV(cv=5, estimator=DecisionTreeRegressor(),
             param_grid=[{'max_depth': array([1, 2, 3, 4, 5, 6, 7, 8, 9])}],
             scoring='r2')
```

In [41]:

```
# Лучшая модель
clf_gs.best_estimator_
```

Out[41]:

```
DecisionTreeRegressor(max_depth=4)
```

In [42]:

```
clf_gs.best_score_
```

Out[42]:

```
0.7749073093532586
```

In [43]:

```
clf_gs.best_params_
```

Out[43]:

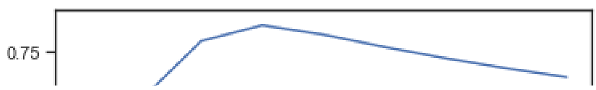
```
{'max_depth': 4}
```

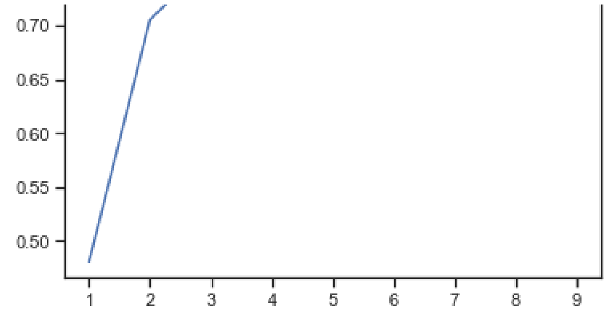
In [44]:

```
plt.plot(n_range, clf_gs.cv_results_['mean_test_score'])
```

Out[44]:

```
[<matplotlib.lines.Line2D at 0x17de5da9ef0>]
```





Оптимизация SVM

In [45]:

```
param_grid = {'C': [0.1,1, 10, 100], 'epsilon': [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0]}
```

In [46]:

```
grid = GridSearchCV(LinearSVR(),param_grid,refit=True,verbose=2)
grid.fit(x.reshape(-1, 1),y)
```

```
Fitting 5 folds for each of 40 candidates, totalling 200 fits
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.1 ..............................................
[CV] ............................... C=0.1, epsilon=0.1, total=   0.0s
[CV] C=0.1, epsilon=0.2 ..............................................
[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
[CV] C=0.1, epsilon=0.2 ..............................................
[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
[CV] C=0.1, epsilon=0.2 ..............................................
[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
[CV] C=0.1, epsilon=0.2 ..............................................
[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
[CV] C=0.1, epsilon=0.2 ..............................................
[CV] ............................... C=0.1, epsilon=0.2, total=   0.0s
[CV] C=0.1, epsilon=0.3 ..............................................
[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
[CV] C=0.1, epsilon=0.3 ..............................................
[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
[CV] C=0.1, epsilon=0.3 ..............................................
[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
[CV] C=0.1, epsilon=0.3 ..............................................
[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
[CV] C=0.1, epsilon=0.3 ..............................................
[CV] ............................... C=0.1, epsilon=0.3, total=   0.0s
[CV] C=0.1, epsilon=0.4 ..............................................
[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.4 ..............................................
[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.4 ..............................................
[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.4 ..............................................
[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.4 ..............................................
[CV] ............................... C=0.1, epsilon=0.4, total=   0.0s
[CV] C=0.1, epsilon=0.5 ..............................................
[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
[CV] C=0.1, epsilon=0.5 ..............................................
[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
[CV] C=0.1, epsilon=0.5 ..............................................
[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
[CV] C=0.1, epsilon=0.5 ..............................................
[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
[CV] C=0.1, epsilon=0.5 ..............................................
```

```
[CV] C=0.1, epsilon=0.5 ..............................................
[CV] ............................... C=0.1, epsilon=0.5, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
[CV] C=0.1, epsilon=0.6 ..............................................
[CV] ............................... C=0.1, epsilon=0.6, total=   0.0s
[CV] C=0.1, epsilon=0.7 ..............................................
[CV] ............................... C=0.1, epsilon=0.7, total=   0.0s
[CV] C=0.1, epsilon=0.7 ..............................................
[CV] ............................... C=0.1, epsilon=0.7, total=   0.0s
[CV] C=0.1, epsilon=0.7 ..............................................
[CV] ............................... C=0.1, epsilon=0.7, total=   0.0s
[CV] C=0.1, epsilon=0.7 ..............................................
[CV] ............................... C=0.1, epsilon=0.7, total=   0.0s
[CV] C=0.1, epsilon=0.7 ..............................................
[CV] ............................... C=0.1, epsilon=0.7, total=   0.0s
[CV] C=0.1, epsilon=0.8 ..............................................
[CV] ............................... C=0.1, epsilon=0.8, total=   0.0s
[CV] C=0.1, epsilon=0.8 ..............................................
[CV] ............................... C=0.1, epsilon=0.8, total=   0.0s
[CV] C=0.1, epsilon=0.8 ..............................................
[CV] ............................... C=0.1, epsilon=0.8, total=   0.0s
[CV] C=0.1, epsilon=0.8 ..............................................
[CV] ............................... C=0.1, epsilon=0.8, total=   0.0s
[CV] C=0.1, epsilon=0.8 ..............................................
[CV] ............................... C=0.1, epsilon=0.8, total=   0.0s
[CV] C=0.1, epsilon=0.9 ..............................................
[CV] ............................... C=0.1, epsilon=0.9, total=   0.0s
[CV] C=0.1, epsilon=0.9 ..............................................
[CV] ............................... C=0.1, epsilon=0.9, total=   0.0s
[CV] C=0.1, epsilon=0.9 ..............................................
[CV] ............................... C=0.1, epsilon=0.9, total=   0.0s
[CV] C=0.1, epsilon=0.9 ..............................................
[CV] ............................... C=0.1, epsilon=0.9, total=   0.0s
[CV] C=0.1, epsilon=0.9 ..............................................
[CV] ............................... C=0.1, epsilon=0.9, total=   0.0s
[CV] C=0.1, epsilon=1.0 ..............................................
[CV] ............................... C=0.1, epsilon=1.0, total=   0.0s
[CV] C=0.1, epsilon=1.0 ..............................................
[CV] ............................... C=0.1, epsilon=1.0, total=   0.0s
[CV] C=0.1, epsilon=1.0 ..............................................
[CV] ............................... C=0.1, epsilon=1.0, total=   0.0s
[CV] C=0.1, epsilon=1.0 ..............................................
[CV] ............................... C=0.1, epsilon=1.0, total=   0.0s
[CV] C=0.1, epsilon=1.0 ..............................................
[CV] ............................... C=0.1, epsilon=1.0, total=   0.0s
[CV] C=1, epsilon=0.1 ................................................
[CV] ................................. C=1, epsilon=0.1, total=   0.0s
[CV] C=1, epsilon=0.1 ................................................
[CV] ................................. C=1, epsilon=0.1, total=   0.0s
[CV] C=1, epsilon=0.1 ................................................
[CV] ................................. C=1, epsilon=0.1, total=   0.0s
[CV] C=1, epsilon=0.1 ................................................
[CV] ................................. C=1, epsilon=0.1, total=   0.0s
[CV] C=1, epsilon=0.1 ................................................
[CV] ................................. C=1, epsilon=0.1, total=   0.0s
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
```

```
[CV] C=1, epsilon=0.2 ................................................
[CV] ................................. C=1, epsilon=0.2, total=   0.0s
[CV] C=1, epsilon=0.2 ................................................
[CV] ................................. C=1, epsilon=0.2, total=   0.0s
[CV] C=1, epsilon=0.2 ................................................
[CV] ................................. C=1, epsilon=0.2, total=   0.0s
[CV] C=1, epsilon=0.2 ................................................
[CV] ................................. C=1, epsilon=0.2, total=   0.0s
[CV] C=1, epsilon=0.2 ................................................
[CV] ................................. C=1, epsilon=0.2, total=   0.0s
[CV] C=1, epsilon=0.3
```

```
[CV] C=1, epsilon=0.3 ................................................
[CV] ................................. C=1, epsilon=0.3, total=   0.0s
[CV] C=1, epsilon=0.3 ................................................
[CV] ................................. C=1, epsilon=0.3, total=   0.0s
[CV] C=1, epsilon=0.3 ................................................
[CV] ................................. C=1, epsilon=0.3, total=   0.0s
[CV] C=1, epsilon=0.3 ................................................
[CV] ................................. C=1, epsilon=0.3, total=   0.0s
[CV] C=1, epsilon=0.3 ................................................
[CV] ................................. C=1, epsilon=0.3, total=   0.0s
[CV] C=1, epsilon=0.4 ................................................
[CV] ................................. C=1, epsilon=0.4, total=   0.0s
[CV] C=1, epsilon=0.4 ................................................
[CV] ................................. C=1, epsilon=0.4, total=   0.0s
[CV] C=1, epsilon=0.4 ................................................
[CV] ................................. C=1, epsilon=0.4, total=   0.0s
[CV] C=1, epsilon=0.4 ................................................
[CV] ................................. C=1, epsilon=0.4, total=   0.0s
[CV] C=1, epsilon=0.4 ................................................
[CV] ................................. C=1, epsilon=0.4, total=   0.0s
[CV] C=1, epsilon=0.5 ................................................
[CV] ................................. C=1, epsilon=0.5, total=   0.0s
[CV] C=1, epsilon=0.5 ................................................
[CV] ................................. C=1, epsilon=0.5, total=   0.0s
[CV] C=1, epsilon=0.5 ................................................
[CV] ................................. C=1, epsilon=0.5, total=   0.0s
[CV] C=1, epsilon=0.5 ................................................
[CV] ................................. C=1, epsilon=0.5, total=   0.0s
[CV] C=1, epsilon=0.5 ................................................
[CV] ................................. C=1, epsilon=0.5, total=   0.0s
[CV] C=1, epsilon=0.6 ................................................
[CV] ................................. C=1, epsilon=0.6, total=   0.0s
[CV] C=1, epsilon=0.6 ................................................
[CV] ................................. C=1, epsilon=0.6, total=   0.0s
[CV] C=1, epsilon=0.6 ................................................
[CV] ................................. C=1, epsilon=0.6, total=   0.0s
[CV] C=1, epsilon=0.6 ................................................
[CV] ................................. C=1, epsilon=0.6, total=   0.0s
[CV] C=1, epsilon=0.6 ................................................
[CV] ................................. C=1, epsilon=0.6, total=   0.0s
[CV] C=1, epsilon=0.7 ................................................
[CV] ................................. C=1, epsilon=0.7, total=   0.0s
[CV] C=1, epsilon=0.7 ................................................
[CV] ................................. C=1, epsilon=0.7, total=   0.0s
[CV] C=1, epsilon=0.7 ................................................
[CV] ................................. C=1, epsilon=0.7, total=   0.0s
[CV] C=1, epsilon=0.7 ................................................
[CV] ................................. C=1, epsilon=0.7, total=   0.0s
[CV] C=1, epsilon=0.7 ................................................
[CV] ................................. C=1, epsilon=0.7, total=   0.0s
[CV] C=1, epsilon=0.8 ................................................
[CV] ................................. C=1, epsilon=0.8, total=   0.0s
[CV] C=1, epsilon=0.8 ................................................
[CV] ................................. C=1, epsilon=0.8, total=   0.0s
[CV] C=1, epsilon=0.8 ................................................
[CV] ................................. C=1, epsilon=0.8, total=   0.0s
[CV] C=1, epsilon=0.8 ................................................
[CV] ................................. C=1, epsilon=0.8, total=   0.0s
[CV] C=1, epsilon=0.8 ................................................
[CV] ................................. C=1, epsilon=0.8, total=   0.0s
[CV] C=1, epsilon=0.9 ................................................
[CV] ................................. C=1, epsilon=0.9, total=   0.0s
[CV] C=1, epsilon=0.9 ................................................
[CV] ................................. C=1, epsilon=0.9, total=   0.0s
[CV] C=1, epsilon=0.9 ................................................
[CV] ................................. C=1, epsilon=0.9, total=   0.0s
[CV] C=1, epsilon=0.9 ................................................
[CV] ................................. C=1, epsilon=0.9, total=   0.0s
[CV] C=1, epsilon=0.9 ................................................
[CV] ................................. C=1, epsilon=0.9, total=   0.0s
[CV] C=1, epsilon=1.0 ................................................
[CV] ................................. C=1, epsilon=1.0, total=   0.0s
[CV] C=1, epsilon=1.0 ................................................
[CV] ................................. C=1, epsilon=1.0, total=   0.0s
[CV] C=1, epsilon=1.0 ................................................
[CV] ................................. C=1, epsilon=1.0, total=   0.0s
[CV] C=1, epsilon=1.0 ................................................
[CV] ................................. C=1, epsilon=1.0, total=   0.0s
```

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[CV] ................................. C=1, epsilon=1.0, total=   0.0s
[CV] C=1, epsilon=1.0 ................................................
[CV] ................................. C=1, epsilon=1.0, total=   0.0s
[CV] C=10, epsilon=0.1 ...............................................
[CV] ................................ C=10, epsilon=0.1, total=   0.0s
[CV] C=10, epsilon=0.1 ...............................................
[CV] ................................ C=10, epsilon=0.1, total=   0.0s
[CV] C=10, epsilon=0.1 ...............................................
[CV] ................................ C=10, epsilon=0.1, total=   0.0s
[CV] C=10, epsilon=0.1 ...............................................
[CV] ................................ C=10, epsilon=0.1, total=   0.0s
[CV] C=10, epsilon=0.1 ...............................................
[CV] ................................ C=10, epsilon=0.1, total=   0.0s
[CV] C=10, epsilon=0.2 ...............................................
[CV] ................................ C=10, epsilon=0.2, total=   0.0s
[CV] C=10, epsilon=0.2 ...............................................
[CV] ................................ C=10, epsilon=0.2, total=   0.0s
[CV] C=10, epsilon=0.2 ...............................................
[CV] ................................ C=10, epsilon=0.2, total=   0.0s
[CV] C=10, epsilon=0.2 ...............................................
[CV] ................................ C=10, epsilon=0.2, total=   0.0s
[CV] C=10, epsilon=0.2 ...............................................
[CV] ................................ C=10, epsilon=0.2, total=   0.0s
[CV] C=10, epsilon=0.3 ...............................................
[CV] ................................ C=10, epsilon=0.3, total=   0.0s
[CV] C=10, epsilon=0.3 ...............................................
[CV] ................................ C=10, epsilon=0.3, total=   0.0s
[CV] C=10, epsilon=0.3 ...............................................
[CV] ................................ C=10, epsilon=0.3, total=   0.0s
[CV] C=10, epsilon=0.3 ...............................................
[CV] ................................ C=10, epsilon=0.3, total=   0.0s
[CV] C=10, epsilon=0.3 ...............................................
[CV] ................................ C=10, epsilon=0.3, total=   0.0s
[CV] C=10, epsilon=0.4 ...............................................
[CV] ................................ C=10, epsilon=0.4, total=   0.0s
[CV] C=10, epsilon=0.4 ...............................................
[CV] ................................ C=10, epsilon=0.4, total=   0.0s
[CV] C=10, epsilon=0.4 ...............................................
[CV] ................................ C=10, epsilon=0.4, total=   0.0s
[CV] C=10, epsilon=0.4 ...............................................
[CV] ................................ C=10, epsilon=0.4, total=   0.0s
[CV] C=10, epsilon=0.4 ...............................................
[CV] ................................ C=10, epsilon=0.4, total=   0.0s
[CV] C=10, epsilon=0.5 ...............................................
[CV] ................................ C=10, epsilon=0.5, total=   0.0s
[CV] C=10, epsilon=0.5 ...............................................
[CV] ................................ C=10, epsilon=0.5, total=   0.0s
[CV] C=10, epsilon=0.5 ...............................................
[CV] ................................ C=10, epsilon=0.5, total=   0.0s
[CV] C=10, epsilon=0.5 ...............................................
[CV] ................................ C=10, epsilon=0.5, total=   0.0s
[CV] C=10, epsilon=0.5 ...............................................
[CV] ................................ C=10, epsilon=0.5, total=   0.0s
[CV] C=10, epsilon=0.6 ...............................................
[CV] ................................ C=10, epsilon=0.6, total=   0.0s
[CV] C=10, epsilon=0.6 ...............................................
[CV] ................................ C=10, epsilon=0.6, total=   0.0s
[CV] C=10, epsilon=0.6 ...............................................
[CV] ................................ C=10, epsilon=0.6, total=   0.0s
[CV] C=10, epsilon=0.6 ...............................................
[CV] ................................ C=10, epsilon=0.6, total=   0.0s
[CV] C=10, epsilon=0.6 ...............................................
[CV] ................................ C=10, epsilon=0.6, total=   0.0s
[CV] C=10, epsilon=0.7 ...............................................
[CV] ................................ C=10, epsilon=0.7, total=   0.0s
[CV] C=10, epsilon=0.7 ...............................................
[CV] ................................ C=10, epsilon=0.7, total=   0.0s
[CV] C=10, epsilon=0.7 ...............................................
[CV] ................................ C=10, epsilon=0.7, total=   0.0s
[CV] C=10, epsilon=0.7 ...............................................
[CV] ................................ C=10, epsilon=0.7, total=   0.0s
[CV] C=10, epsilon=0.7 ...............................................
[CV] ................................ C=10, epsilon=0.7, total=   0.0s
[CV] C=10, epsilon=0.8 ...............................................
[CV] ................................ C=10, epsilon=0.8, total=   0.0s
[CV] C=10, epsilon=0.8 ...............................................
[CV] ................................ C=10, epsilon=0.8, total=   0.0s
```

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[CV] C=10, epsilon=0.8 ...............................................
[CV] ................................ C=10, epsilon=0.8, total=   0.0s
[CV] C=10, epsilon=0.8 ...............................................
[CV] ................................ C=10, epsilon=0.8, total=   0.0s
[CV] C=10, epsilon=0.8 ...............................................
[CV] ................................ C=10, epsilon=0.8, total=   0.0s
[CV] C=10, epsilon=0.9 ...............................................
[CV] ................................ C=10, epsilon=0.9, total=   0.0s
[CV] C=10, epsilon=0.9 ...............................................
[CV] ................................ C=10, epsilon=0.9, total=   0.0s
[CV] C=10, epsilon=0.9 ...............................................
[CV] ................................ C=10, epsilon=0.9, total=   0.0s
[CV] C=10, epsilon=0.9 ...............................................
[CV] ................................ C=10, epsilon=0.9, total=   0.0s
[CV] C=10, epsilon=0.9 ...............................................
[CV] ................................ C=10, epsilon=0.9, total=   0.0s
[CV] C=10, epsilon=1.0 ...............................................
[CV] ................................ C=10, epsilon=1.0, total=   0.0s
[CV] C=10, epsilon=1.0 ...............................................
[CV] ................................ C=10, epsilon=1.0, total=   0.0s
[CV] C=10, epsilon=1.0 ...............................................
[CV] ................................ C=10, epsilon=1.0, total=   0.0s
[CV] C=10, epsilon=1.0 ...............................................
[CV] ................................ C=10, epsilon=1.0, total=   0.0s
[CV] C=10, epsilon=1.0 ...............................................
[CV] ................................ C=10, epsilon=1.0, total=   0.0s
[CV] C=100, epsilon=0.1 ..............................................
[CV] ............................... C=100, epsilon=0.1, total=   0.0s
[CV] C=100, epsilon=0.1 ..............................................
[CV] ............................... C=100, epsilon=0.1, total=   0.0s
[CV] C=100, epsilon=0.1 ..............................................
[CV] ............................... C=100, epsilon=0.1, total=   0.0s
[CV] C=100, epsilon=0.1 ..............................................
[CV] ............................... C=100, epsilon=0.1, total=   0.0s
[CV] C=100, epsilon=0.1 ..............................................
[CV] ............................... C=100, epsilon=0.1, total=   0.0s
[CV] C=100, epsilon=0.2 ..............................................
[CV] ............................... C=100, epsilon=0.2, total=   0.0s
[CV] C=100, epsilon=0.2 ..............................................
[CV] ............................... C=100, epsilon=0.2, total=   0.0s
[CV] C=100, epsilon=0.2 ..............................................
[CV] ............................... C=100, epsilon=0.2, total=   0.0s
[CV] C=100, epsilon=0.2 ..............................................
[CV] ............................... C=100, epsilon=0.2, total=   0.0s
[CV] C=100, epsilon=0.2 ..............................................
[CV] ............................... C=100, epsilon=0.2, total=   0.0s
[CV] C=100, epsilon=0.3 ..............................................
[CV] ............................... C=100, epsilon=0.3, total=   0.0s
[CV] C=100, epsilon=0.3 ..............................................
[CV] ............................... C=100, epsilon=0.3, total=   0.0s
[CV] C=100, epsilon=0.3 ..............................................
[CV] ............................... C=100, epsilon=0.3, total=   0.0s
[CV] C=100, epsilon=0.3 ..............................................
[CV] ............................... C=100, epsilon=0.3, total=   0.0s
[CV] C=100, epsilon=0.3 ..............................................
[CV] ............................... C=100, epsilon=0.3, total=   0.0s
[CV] C=100, epsilon=0.4 ..............................................
[CV] ............................... C=100, epsilon=0.4, total=   0.0s
[CV] C=100, epsilon=0.4 ..............................................
[CV] ............................... C=100, epsilon=0.4, total=   0.0s
[CV] C=100, epsilon=0.4 ..............................................
[CV] ............................... C=100, epsilon=0.4, total=   0.0s
[CV] C=100, epsilon=0.4 ..............................................
[CV] ............................... C=100, epsilon=0.4, total=   0.0s
[CV] C=100, epsilon=0.4 ..............................................
[CV] ............................... C=100, epsilon=0.4, total=   0.0s
[CV] C=100, epsilon=0.5 ..............................................
[CV] ............................... C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.5 ..............................................
[CV] ............................... C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.5 ..............................................
[CV] ............................... C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.5 ..............................................
[CV] ............................... C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.5 ..............................................
[CV] ............................... C=100, epsilon=0.5, total=   0.0s
[CV] C=100, epsilon=0.6 ..............................................
```

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[CV] ............................... C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.6 ...............................................
[CV] ............................... C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.6 ...............................................
[CV] ............................... C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.6 ...............................................
[CV] ............................... C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.6 ...............................................
[CV] ............................... C=100, epsilon=0.6, total=   0.0s
[CV] C=100, epsilon=0.7 ...............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.7 ...............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.7 ...............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.7 ...............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.7 ...............................................
[CV] ............................... C=100, epsilon=0.7, total=   0.0s
[CV] C=100, epsilon=0.8 ...............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.8 ...............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.8 ...............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.8 ...............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.8 ...............................................
[CV] ............................... C=100, epsilon=0.8, total=   0.0s
[CV] C=100, epsilon=0.9 ...............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=0.9 ...............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=0.9 ...............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=0.9 ...............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=0.9 ...............................................
[CV] ............................... C=100, epsilon=0.9, total=   0.0s
[CV] C=100, epsilon=1.0 ...............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s
[CV] C=100, epsilon=1.0 ...............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s
[CV] C=100, epsilon=1.0 ...............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s
[CV] C=100, epsilon=1.0 ...............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s
[CV] C=100, epsilon=1.0 ...............................................
[CV] ............................... C=100, epsilon=1.0, total=   0.0s
```

```
[Parallel(n_jobs=1)]: Done 200 out of 200 | elapsed:    0.7s finished
```

Out[46]:

```
GridSearchCV(estimator=LinearSVR(),
             param_grid={'C': [0.1, 1, 10, 100],
                         'epsilon': [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8,
                                     0.9, 1.0]},
             verbose=2)
```

In [47]:

```
grid.best_estimator_
```

Out[47]:

```
LinearSVR(C=10, epsilon=0.1)
```

In [48]:

```
grid.best_score_
```

Out[48]:

```
0.6827159871789266
```

In [49]:

```
grid.best_params_
```

Out[49]:

```
{'C': 10, 'epsilon': 0.1}
```

In [50]:

```
parameters = {"alpha_1": np.logspace(-13,-5,10),
              "alpha_2": np.logspace(-9,-3,10),
              "lambda_1": np.logspace(-10,-5,10),
              "lambda_2": np.logspace(-11,-4,10)}

grid_regr = GridSearchCV(BayesianRidge(), parameters, cv=3, n_jobs=-1)
grid_regr.fit(x.reshape(-1, 1), y)
```

Out[50]:

```
GridSearchCV(cv=3, estimator=BayesianRidge(), n_jobs=-1,
             param_grid={'alpha_1': array([1.00000000e-13, 7.74263683e-13, 5.99484250e-12, 4.641588
83e-11,
       3.59381366e-10, 2.78255940e-09, 2.15443469e-08, 1.66810054e-07,
       1.29154967e-06, 1.00000000e-05]),
                         'alpha_2': array([1.00000000e-09, 4.64158883e-09, 2.15443469e-08,
1.00000000e-07,
       4.64158883e-07, 2.15443469e-06, 1.000000...
       2.15443469e-04, 1.00000000e-03]),
                         'lambda_1': array([1.00000000e-10, 3.59381366e-10, 1.29154967e-09,
4.64158883e-09,
       1.66810054e-08, 5.99484250e-08, 2.15443469e-07, 7.74263683e-07,
       2.78255940e-06, 1.00000000e-05]),
                         'lambda_2': array([1.00000000e-11, 5.99484250e-11, 3.59381366e-10,
2.15443469e-09,
       1.29154967e-08, 7.74263683e-08, 4.64158883e-07, 2.78255940e-06,
       1.66810054e-05, 1.00000000e-04])})
```

In [51]:

```
grid_regr.best_estimator_
```

Out[51]:

```
BayesianRidge(alpha_1=1e-13, alpha_2=0.001, lambda_1=1e-05, lambda_2=1e-11)
```

In [52]:

```
grid_regr.best_score_
```

Out[52]:

```
0.7662762307971316
```

In [53]:

```
grid_regr.best_params_
```

Out[53]:

```
{'alpha_1': 1e-13, 'alpha_2': 0.001, 'lambda_1': 1e-05, 'lambda_2': 1e-11}
```

In [55]:

```
reg = BayesianRidge(fit_intercept=True, alpha_1=1e-05, alpha_2=1e-09, lambda_1=1e-10, lambda_2=0.00
01).fit(x.reshape(-1, 1), y.reshape(-1, 1))
y_tt = reg.predict(x.reshape(-1, 1))

lin_SVR = LinearSVR(C=1.0, max_iter=10000, epsilon=1.0)
```

```
lin_SVR = LinearSVR(C=1.0, max_iter=10000, epsilon=1.0)
lin_SVR.fit(x.reshape(-1, 1), y)
predict = lin_SVR.predict(x.reshape(-1, 1))

dec_tree = DecisionTreeRegressor(random_state=1, max_depth=3)
dec_tree.fit(data, data["Chance of Admit "])
dec_predict = dec_tree.predict(data)
```

In [190]:

```
print("Метрики для линейной модели:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, y_tt))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, y_tt))
print("Коэффициент детерминации: ", r2_score(y, y_tt))

print("\n\nМетрики для SVM-модели:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, predict))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, predict))
print("Коэффициент детерминации: ", r2_score(y, predict))


print("\n\nМетрики для Decision Tree:\n")
print("Средняя абсолютная ошибка: ", mean_absolute_error(y, dec_predict))
print("Средняя квадратичная ошибка: ", mean_squared_error(y, dec_predict))
print("Коэффициент детерминации: ", r2_score(y, dec_predict))
```

```
Метрики для линейной модели:

Средняя абсолютная ошибка:  2.5508292802546
Средняя квадратичная ошибка:  10.512794897173503
Коэффициент детерминации:  0.6118698089221382


Метрики для SVM-модели:

Средняя абсолютная ошибка:  2.5996867264932724
Средняя квадратичная ошибка:  11.18839596468356
Коэффициент детерминации:  0.586926758668624


Метрики для Decision Tree:

Средняя абсолютная ошибка:  0.7095532407407409
Средняя квадратичная ошибка:  0.7222188657407407
Коэффициент детерминации:  0.9733358303760538
```

После подбора параметров модели показали лучший результат, чем без подбора.