Защищено: Гапанюк Ю.Е.	Демонстрация: Гапанюк Ю.Е.
"__"____________2022 г.	"__"____________2022 г.

Отчет по лабораторной работе № 4 по курсу Технологии машинного обучения ГУИМЦ

Тема работы: " Линейные модели, SVM и деревья решений. "

16
(количество листов)
Вариант № **3**

ИСПОЛНИТЕЛЬ:

студент группы ИУ5Ц-82Б ______________________
(подпись)

Чиварзин А.Е.

"__"____________2022 г.

Москва, МГТУ - 2022

Цель лабораторной работы

Изучение линейных моделей, SVM и деревьев решений

Задание

1. Выберите набор данных (датасет) для решения задачи классификации или регрессии.
2. В случае необходимости проведите удаление или заполнение пропусков и кодирование категориальных признаков.
3. С использованием метода `train_test_split` разделите выборку на обучающую и тестовую.
4. Обучите следующие модели:
   - одну из линейных моделей (линейную или полиномиальную регрессию при решении задачи регрессии, логистическую регрессию при решении задачи классификации);
   - SVM;
   - дерево решений.
5. Оцените качество моделей с помощью двух подходящих для задачи метрик. Сравните качество полученных моделей.
6. Постройте график, показывающий важность признаков в дереве решений.
7. Визуализируйте дерево решений или выведите правила дерева решений в текстовом виде.

Ход лабораторной работы

Текстовое описание набора данных

В качестве набора данных используется dataset рейтингов университетов мира на основании трёх рейтингов. Датасет доступен по адресу: https://www.kaggle.com/mylesoneill/world-university-rankings

Из набора данных будет рассматриваться только файл `cwurData.csv` .

Описание столбцов:

- `world_rank` - мировой рейтинг университета
- `institution` - название университета
- `country` - страна, в которой расположен университет
- `national_rank` - рейтинг университета в стране его нахождения
- `quality_of_education` - рейтинг качества образования
- `quality_of_faculty` - рейтинг качества профессорско-преподавательского состава
- `publications` - рейтинг публикаций
- `infuence` - рейтинг влияния
- `citations` - количество студентов в университете
- `broad_impact` - рейтинг за широкое влияние (предоставлен только за 2014 и 2015 гг. Остальное - пропуски)
- `patents` - рейтинг за патенты
- `score` - общий балл, используемый для определения мирового рейтинга
- `year` - год рейтинга (с 2012 по 2015 год)

Основные характеристики набора данных

Подключаем все необходимые библиотеки

In [1]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib
import matplotlib_inline
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
%matplotlib inline
sns.set(style="ticks")
from io import StringIO
```

Подключаем Dataset

In [2]:
```
data = pd.read_csv('cwurData.csv', sep=",")
```

Размер набора данных

In [3]:
```
data.shape
```

Out[3]:
```
(2200, 14)
```

Типы колонок

In [4]:
```
data.dtypes
```

Out[4]:
```
world_rank                int64
institution              object
country                  object
national_rank             int64
quality_of_education      int64
alumni_employment         int64
quality_of_faculty        int64
publications              int64
influence                 int64
citations                 int64
broad_impact            float64
patents                   int64
score                   float64
year                      int64
dtype: object
```

Проверяем, есть ли пропущенные значения

In [5]:
```
data.isnull().sum()
```

Out[5]:
```
world_rank                0
institution               0
country                   0
national_rank             0
quality_of_education      0
alumni_employment         0
quality_of_faculty        0
publications              0
influence                 0
citations                 0
broad_impact            200
patents                   0
score                     0
year                      0
dtype: int64
```

Первые 5 строк датасета

In [6]:
```
data.head()
```

Out[6]:

	world_rank	institution	country	national_rank	quality_of_education	alumni_employment	quality_of_faculty	publications	influence
0	1	Harvard University	USA	1	7	9	1	1	1
1	2	Massachusetts Institute of Technology	USA	2	9	17	3	12	4
2	3	Stanford University	USA	3	17	11	5	4	2
3	4	University of Cambridge	United Kingdom	1	10	24	4	16	16
4	5	California Institute of Technology	USA	4	2	29	7	37	22

In [7]:
```
total_count = data.shape[0]
print('Всего строк: {}'.format(total_count))
```

```
Всего строк: 2200
```

Процент пропусков в `broad_impact`

In [8]:
```
(200 / 2200) * 100
```

Out[8]:
```
9.090909090909092
```

Настройка отображения графиков

In [9]:
```
# Задание формата графиков для сохранения высокого качества PNG
from IPython.display import set_matplotlib_formats
matplotlib_inline.backend_inline.set_matplotlib_formats("retina")
# Задание ширины графиков, чтобы они помещались на A4
pd.set_option("display.width", 70)
```

Обработка пропусков данных

Очистка строк

Можно очистить строки, содержащие пропуски. При этом останутся данные только за 2014 и 2015 гг (см. описание датасета)

In [10]:
```
# Удаление строк, содержащих пустые значения
data_no_null = data.dropna(axis=0, how='any')
(data.shape, data_no_null.shape)
```

Out[10]:
```
((2200, 14), (2000, 14))
```

Выведем первые 11 строк, чтобы убедиться, что данные в `national_rank` числовые (Jupyter Lab в предпросмотре CSV показывает не совсем верно)

In [11]:
```
data_no_null.head(11)
```

Out[11]:

	world_rank	institution	country	national_rank	quality_of_education	alumni_employment	quality_of_faculty	publications	influenc
200	1	Harvard University	USA	1	1	1	1	1	
201	2	Stanford University	USA	2	11	2	4	5	
202	3	Massachusetts Institute of Technology	USA	3	3	11	2	15	
203	4	University of Cambridge	United Kingdom	1	2	10	5	10	
204	5	University of Oxford	United Kingdom	2	7	12	10	11	1
205	6	Columbia University	USA	4	13	8	9	14	1
206	7	University of California, Berkeley	USA	5	4	22	6	7	
207	8	University of Chicago	USA	6	10	14	8	17	1
208	9	Princeton University	USA	7	5	16	3	70	2
209	10	Yale University	USA	8	9	25	11	18	
210	11	Cornell University	USA	9	12	18	19	23	1

In [12]:
```
total_count = data_no_null.shape[0]
print('Всего строк: {}'.format(total_count))
```

```
Всего строк: 2000
```

Кодирование категориальных признаков

Преобразуем названия стран, городов, ... в числовые зеачения (label encoding)

In [13]:
```
from sklearn.preprocessing import LabelEncoder, OneHotEncoder
```

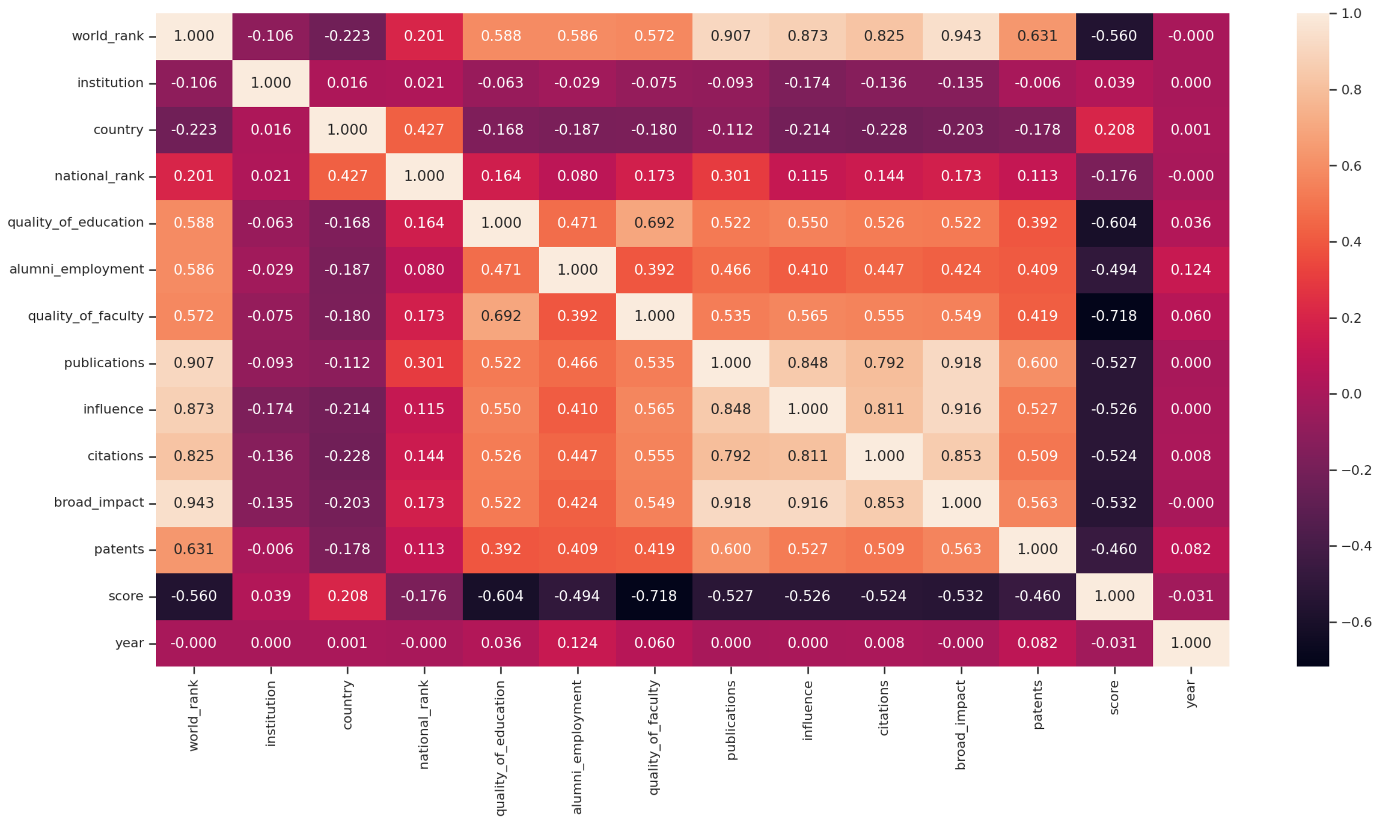
In [14]:
```
le = LabelEncoder()
    # "institution"
le.fit(data_no_null.institution.drop_duplicates())
data_no_null.institution = le.transform(data_no_null.institution)
    # "country"
le.fit(data_no_null["country"].drop_duplicates())
data_no_null["country"] = le.transform(data_no_null["country"])
```

```
/tmp/ipykernel_143/4210865855.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#re
turning-a-view-versus-a-copy
  data_no_null.institution = le.transform(data_no_null.institution)
/tmp/ipykernel_143/4210865855.py:7: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#re
turning-a-view-versus-a-copy
  data_no_null["country"] = le.transform(data_no_null["country"])
```

Построим кореляционную матрицу

In [15]:
```
ig, ax = plt.subplots(figsize=(20,10))
sns.heatmap(data_no_null.corr(method='pearson'), ax=ax, annot=True, fmt='.3f')
```

Out[15]:
```
<AxesSubplot:>
```



	world_rank	institution	country	national_rank	quality_of_education	alumni_employment	quality_of_faculty	publications	influence	citations	broad_impact	patents	score	year
world_rank	1.000	-0.106	-0.223	0.201	0.588	0.586	0.572	0.907	0.873	0.825	0.943	0.631	-0.560	-0.000
institution	-0.106	1.000	0.016	0.021	-0.063	-0.029	-0.075	-0.093	-0.174	-0.136	-0.135	-0.006	0.039	0.000
country	-0.223	0.016	1.000	0.427	-0.168	-0.187	-0.180	-0.112	-0.214	-0.228	-0.203	-0.178	0.208	0.001
national_rank	0.201	0.021	0.427	1.000	0.164	0.080	0.173	0.301	0.115	0.144	0.173	0.113	-0.176	-0.000
quality_of_education	0.588	-0.063	-0.168	0.164	1.000	0.471	0.692	0.522	0.550	0.526	0.522	0.392	-0.604	0.036
alumni_employment	0.586	-0.029	-0.187	0.080	0.471	1.000	0.392	0.466	0.410	0.447	0.424	0.409	-0.494	0.124
quality_of_faculty	0.572	-0.075	-0.180	0.173	0.692	0.392	1.000	0.535	0.565	0.555	0.549	0.419	-0.718	0.060
publications	0.907	-0.093	-0.112	0.301	0.522	0.466	0.535	1.000	0.848	0.792	0.918	0.600	-0.527	0.000
influence	0.873	-0.174	-0.214	0.115	0.550	0.410	0.565	0.848	1.000	0.811	0.916	0.527	-0.526	0.000
citations	0.825	-0.136	-0.228	0.144	0.526	0.447	0.555	0.792	0.811	1.000	0.853	0.509	-0.524	0.008
broad_impact	0.943	-0.135	-0.203	0.173	0.522	0.424	0.549	0.918	0.916	0.853	1.000	0.563	-0.532	-0.000
patents	0.631	-0.006	-0.178	0.113	0.392	0.409	0.419	0.600	0.527	0.509	0.563	1.000	-0.460	0.082
score	-0.560	0.039	0.208	-0.176	-0.604	-0.494	-0.718	-0.527	-0.526	-0.524	-0.532	-0.460	1.000	-0.031
year	-0.000	0.000	0.001	-0.000	0.036	0.124	0.060	0.000	0.000	0.008	-0.000	0.082	-0.031	1.000

Предсказание целевого признака

Предскажем значение целевого признака `world_rank` по `broad_impact` и `publications`, поскольку их значения кореляции ближе всего к 1

Разбиение выборки на обучающую и тестовую

In [16]:
```
X = data_no_null[["broad_impact", "publications"]]
Y = data_no_null["world_rank"]
print('Входные данные:\n\n', X.head(), '\n\nВыходные данные:\n\n', Y.head())
```

```
Входные данные:

      broad_impact  publications
200          1.0             1
201          4.0             5
202          2.0            15
203         13.0            10
204         12.0            11

Выходные данные:

 200    1
201    2
202    3
203    4
204    5
Name: world_rank, dtype: int64
```

Разделим выборку на обучающую и тестовую

In [17]:
```
X_train,  X_test,  Y_train,  Y_test = train_test_split(X,  Y, random_state = 2022, test_size = 0.1)
```

Входные параметры обучающей выборки

In [18]:
```
X_train.head()
```

Out[18]:

	broad_impact	publications
2164	932.0	875
1710	590.0	576
428	164.0	200
1389	164.0	233
2089	932.0	675

Входные параметры тестовой выборки

In [19]:
```
X_test.head()
```

Out[19]:

	broad_impact	publications
1218	14.0	3
1495	265.0	236
843	703.0	943
2042	850.0	803
1869	606.0	701

Выходные параметры обучающей выборки

In [20]:
```
Y_train.head()
```

Out[20]:
```
2164    965
1710    511
428     229
1389    190
2089    890
Name: world_rank, dtype: int64
```

Выходные параметры тестовой выборки

In [21]:
```
Y_test.head()
```

Out[21]:
```
1218     19
1495    296
843     644
2042    843
1869    670
Name: world_rank, dtype: int64
```

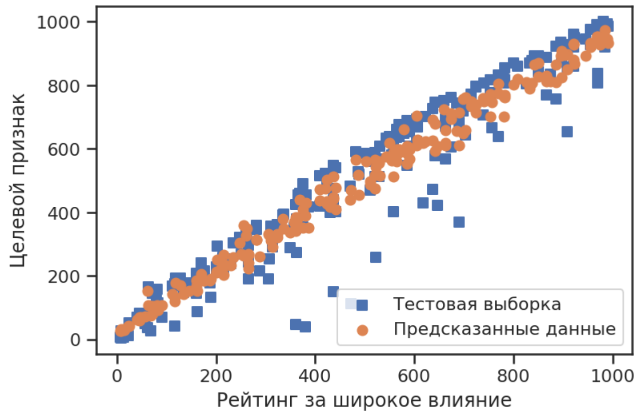
Построение линейной регрессии

In [22]:
```
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_absolute_error, mean_squared_error,  median_absolute_error, r2_score
```

In [23]:
```
Lin_Reg = LinearRegression().fit(X_train, Y_train)
lr_y_pred = Lin_Reg.predict(X_test)
```

Возьмем тот параметр, чья корреляция ближе всего к единице, т.е. `broad_impact`

In [40]:
```
plt.scatter(X_test["broad_impact"], Y_test,    marker = 's', label = 'Тестовая выборка')
plt.scatter(X_test["broad_impact"], lr_y_pred, marker = 'o', label = 'Предсказанные данные')
plt.legend (loc = 'lower right')
plt.xlabel ('Рейтинг за широкое влияние')
plt.ylabel ('Целевой признак')
plt.show()
```



In [25]:
```
from sklearn.metrics import mean_absolute_error, mean_squared_error,  median_absolute_error, r2_score
```

In [26]:
```
print('Средняя абсолютная ошибка:',   mean_absolute_error(Y_test, lr_y_pred))
print('Средняя квадратичная ошибка:', mean_squared_error(Y_test, lr_y_pred))
print('Median absolute error:',       median_absolute_error(Y_test, lr_y_pred))
print('Коэффициент детерминации:',    r2_score(Y_test, lr_y_pred))
```

```
Средняя абсолютная ошибка: 54.70203008487861
Средняя квадратичная ошибка: 6228.270901286782
Median absolute error: 42.05433711920929
Коэффициент детерминации: 0.9234584275958889
```

SVM

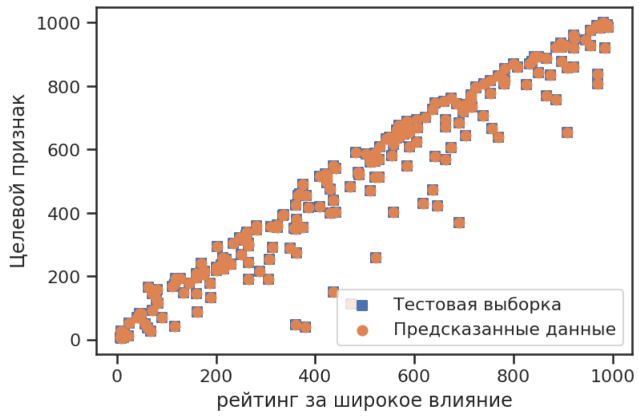
In [27]:
```
from sklearn.svm import SVC , LinearSVC
from sklearn.datasets import make_blobs
```

In [28]:
```
svc = SVC(kernel='linear')
svc.fit(X_train,Y_train)
```

Out[28]:
```
SVC(kernel='linear')
```

In [29]:
```
pred_y = svc.predict(X_test)
```

In [41]:
```
plt.scatter(X_test["broad_impact"], Y_test, marker = 's', label = 'Тестовая выборка')
plt.scatter(X_test["broad_impact"], pred_y, marker = 'o', label = 'Предсказанные данные')
plt.legend (loc = 'lower right')
plt.xlabel ('рейтинг за широкое влияние')
plt.ylabel ('Целевой признак')
plt.show()
```



In [31]:
```
print('Средняя абсолютная ошибка:',   mean_absolute_error(Y_test, pred_y))
print('Средняя квадратичная ошибка:', mean_squared_error(Y_test, pred_y))
print('Median absolute error:',       median_absolute_error(Y_test, pred_y))
print('Коэффициент детерминации:',    r2_score(Y_test, pred_y))
```

```
Средняя абсолютная ошибка: 57.19
Средняя квадратичная ошибка: 9379.4
Median absolute error: 27.0
Коэффициент детерминации: 0.8847330124868531
```

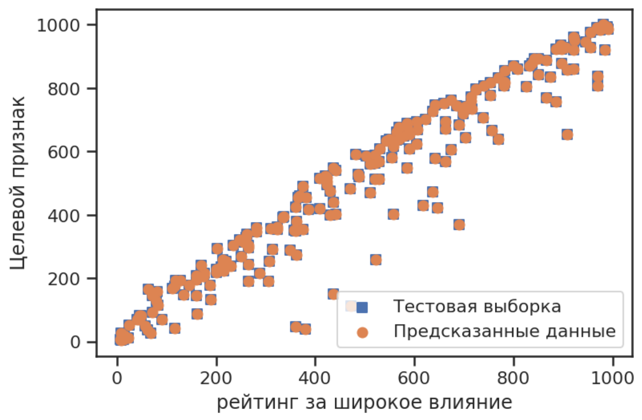
Дерево (Tree)

In [32]:
```
from sklearn.tree import DecisionTreeClassifier, DecisionTreeRegressor, export_graphviz
from sklearn.tree import export_graphviz
from sklearn import tree
import re
from IPython.core.display import HTML
from sklearn.tree import export_text
import graphviz
from IPython.display import Image
import pydotplus
```

Обучим дерево на всех признаках

In [33]:
```
reg = tree.DecisionTreeRegressor()
reg = reg.fit(X_test, Y_test)
```

In [42]:
```
pred_y = reg.predict(X_test)
plt.scatter(X_test["broad_impact"], Y_test,    marker = 's', label = 'Тестовая выборка')
plt.scatter(X_test["broad_impact"], pred_y, marker = 'o', label = 'Предсказанные данные')
plt.legend (loc = 'lower right')
plt.xlabel ('рейтинг за широкое влияние')
plt.ylabel ('Целевой признак')
plt.show()
```



Дерево в текстовом виде

In [35]:
```
tree_rules = export_text(reg, feature_names=list(X.columns))
HTML('<pre>' + tree_rules + '</pre>')
```

Out[35]:
```
|--- broad_impact <= 477.00
|   |--- broad_impact <= 201.50
|   |   |--- publications <= 105.00
|   |   |   |--- publications <= 24.50
|   |   |   |   |--- publications <= 23.50
|   |   |   |   |   |--- publications <= 5.00
|   |   |   |   |   |   |--- value: [19.00]
|   |   |   |   |   |--- publications >  5.00
|   |   |   |   |   |   |--- broad_impact <= 18.00
|   |   |   |   |   |   |   |--- broad_impact <= 8.00
|   |   |   |   |   |   |   |   |--- value: [7.00]
|   |   |   |   |   |   |   |--- broad_impact >  8.00
|   |   |   |   |   |   |   |   |--- publications <= 10.50
|   |   |   |   |   |   |   |   |   |--- value: [5.00]
|   |   |   |   |   |   |   |   |--- publications >  10.50
|   |   |   |   |   |   |   |   |   |--- value: [6.00]
|   |   |   |   |   |   |--- broad_impact >  18.00
|   |   |   |   |   |   |   |--- value: [11.00]
|   |   |   |   |--- publications >  23.50
|   |   |   |   |   |--- value: [27.00]
|   |   |   |--- publications >  24.50
|   |   |   |   |--- broad_impact <= 69.50
|   |   |   |   |   |--- broad_impact <= 52.00
|   |   |   |   |   |   |--- publications <= 30.00
|   |   |   |   |   |   |   |--- value: [53.00]
|   |   |   |   |   |   |--- publications >  30.00
|   |   |   |   |   |   |   |--- broad_impact <= 43.50
|   |   |   |   |   |   |   |   |--- value: [69.00]
|   |   |   |   |   |   |   |--- broad_impact >  43.50
|   |   |   |   |   |   |   |   |--- publications <= 65.50
|   |   |   |   |   |   |   |   |   |--- value: [82.00]
|   |   |   |   |   |   |   |   |   |--- value: [82.00]
|   |   |   |   |   |   |   |   |--- publications >  65.50
|   |   |   |   |   |   |   |   |   |--- value: [70.00]
|   |   |   |   |   |--- broad_impact >  52.00
|   |   |   |   |   |   |--- publications <= 46.50
|   |   |   |   |   |   |   |--- value: [28.00]
|   |   |   |   |   |   |--- publications >  46.50
|   |   |   |   |   |   |   |--- value: [51.00]
|   |   |   |   |--- broad_impact >  69.50
|   |   |   |   |   |--- publications <= 73.00
|   |   |   |   |   |   |--- broad_impact <= 75.00
|   |   |   |   |   |   |   |--- value: [93.00]
|   |   |   |   |   |   |--- broad_impact >  75.00
|   |   |   |   |   |   |   |--- publications <= 66.00
|   |   |   |   |   |   |   |   |--- value: [116.00]
|   |   |   |   |   |   |   |--- publications >  66.00
|   |   |   |   |   |   |   |   |--- value: [127.00]
|   |   |   |   |   |--- publications >  73.00
|   |   |   |   |   |   |--- broad_impact <= 139.00
|   |   |   |   |   |   |   |--- broad_impact <= 103.50
|   |   |   |   |   |   |   |   |--- value: [70.00]
|   |   |   |   |   |   |   |--- broad_impact >  103.50
|   |   |   |   |   |   |   |   |--- value: [43.00]
|   |   |   |   |   |   |--- broad_impact >  139.00
|   |   |   |   |   |   |   |--- publications <= 82.50
|   |   |   |   |   |   |   |   |--- value: [87.00]
|   |   |   |   |   |   |   |--- publications >  82.50
|   |   |   |   |   |   |   |   |--- value: [145.00]
|   |   |--- publications >  105.00
|   |   |   |--- broad_impact <= 63.00
|   |   |   |   |--- value: [37.00]
|   |   |   |--- broad_impact >  63.00
|   |   |   |   |--- publications <= 155.50
|   |   |   |   |   |--- publications <= 138.50
|   |   |   |   |   |   |--- publications <= 120.50
|   |   |   |   |   |   |   |--- publications <= 115.00
|   |   |   |   |   |   |   |   |--- value: [147.00]
|   |   |   |   |   |   |   |--- publications >  115.00
|   |   |   |   |   |   |   |   |--- value: [157.00]
|   |   |   |   |   |   |--- publications >  120.50
|   |   |   |   |   |   |   |--- publications <= 133.00
|   |   |   |   |   |   |   |   |--- broad_impact <= 130.50
|   |   |   |   |   |   |   |   |   |--- value: [175.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  130.50
|   |   |   |   |   |   |   |   |   |--- publications <= 127.00
|   |   |   |   |   |   |   |   |   |   |--- value: [178.00]
|   |   |   |   |   |   |   |   |   |--- publications >  127.00
|   |   |   |   |   |   |   |   |   |   |--- value: [179.00]
|   |   |   |   |   |   |   |--- publications >  133.00
|   |   |   |   |   |   |   |   |--- value: [208.00]
|   |   |   |   |   |--- publications >  138.50
|   |   |   |   |   |   |--- publications <= 145.00
|   |   |   |   |   |   |   |--- value: [146.00]
|   |   |   |   |   |   |--- publications >  145.00
|   |   |   |   |   |   |   |--- value: [133.00]
|   |   |   |   |--- publications >  155.50
|   |   |   |   |   |--- broad_impact <= 165.50
|   |   |   |   |   |   |--- publications <= 190.50
|   |   |   |   |   |   |   |--- publications <= 173.00
|   |   |   |   |   |   |   |   |--- value: [165.00]
|   |   |   |   |   |   |   |--- publications >  173.00
|   |   |   |   |   |   |   |   |--- value: [168.00]
|   |   |   |   |   |   |--- publications >  190.50
|   |   |   |   |   |   |   |--- publications <= 220.50
|   |   |   |   |   |   |   |   |--- value: [197.00]
|   |   |   |   |   |   |   |--- publications >  220.50
|   |   |   |   |   |   |   |   |--- publications <= 262.50
|   |   |   |   |   |   |   |   |   |--- value: [194.00]
|   |   |   |   |   |   |   |   |--- publications >  262.50
|   |   |   |   |   |   |   |   |   |--- value: [193.00]
|   |   |   |   |   |--- broad_impact >  165.50
|   |   |   |   |   |   |--- publications <= 202.50
|   |   |   |   |   |   |   |--- broad_impact <= 175.00
|   |   |   |   |   |   |   |   |--- value: [205.00]
|   |   |   |   |   |   |   |--- broad_impact >  175.00
|   |   |   |   |   |   |   |   |--- broad_impact <= 188.00
|   |   |   |   |   |   |   |   |   |--- value: [216.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  188.00
|   |   |   |   |   |   |   |   |   |--- value: [219.00]
|   |   |   |   |   |   |--- publications >  202.50
|   |   |   |   |   |   |   |--- broad_impact <= 185.00
|   |   |   |   |   |   |   |   |--- value: [240.00]
|   |   |   |   |   |   |   |--- broad_impact >  185.00
|   |   |   |   |   |   |   |   |--- value: [229.00]
|   |--- broad_impact >  201.50
|   |   |--- broad_impact <= 380.50
|   |   |   |--- publications <= 399.00
|   |   |   |   |--- publications <= 382.00
|   |   |   |   |   |--- publications <= 277.00
|   |   |   |   |   |   |--- broad_impact <= 368.00
|   |   |   |   |   |   |   |--- broad_impact <= 355.00
|   |   |   |   |   |   |   |   |--- publications <= 197.50
|   |   |   |   |   |   |   |   |   |--- publications <= 100.00
|   |   |   |   |   |   |   |   |   |   |--- value: [191.00]
|   |   |   |   |   |   |   |   |   |--- publications >  100.00
|   |   |   |   |   |   |   |   |   |   |--- broad_impact <= 276.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |   |--- broad_impact >  276.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [217.00]
|   |   |   |   |   |   |   |   |--- publications >  197.50
|   |   |   |   |   |   |   |   |   |--- broad_impact <= 253.50
|   |   |   |   |   |   |   |   |   |   |--- broad_impact <= 212.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [237.00]
|   |   |   |   |   |   |   |   |   |   |--- broad_impact >  212.00
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |   |   |--- broad_impact >  253.50
|   |   |   |   |   |   |   |   |   |   |--- broad_impact <= 260.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [313.00]
|   |   |   |   |   |   |   |   |   |   |--- broad_impact >  260.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 3
|   |   |   |   |   |   |   |--- broad_impact >  355.00
|   |   |   |   |   |   |   |   |--- value: [48.00]
|   |   |   |   |   |   |--- broad_impact >  368.00
|   |   |   |   |   |   |   |--- value: [354.00]
|   |   |   |   |   |--- publications >  277.00
|   |   |   |   |   |   |--- broad_impact <= 309.50
|   |   |   |   |   |   |   |--- broad_impact <= 293.50
|   |   |   |   |   |   |   |   |--- broad_impact <= 257.50
|   |   |   |   |   |   |   |   |   |--- publications <= 350.50
|   |   |   |   |   |   |   |   |   |   |--- broad_impact <= 218.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [293.00]
|   |   |   |   |   |   |   |   |   |   |--- broad_impact >  218.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [303.00]
|   |   |   |   |   |   |   |   |   |--- publications >  350.50
|   |   |   |   |   |   |   |   |   |   |--- value: [234.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  257.50
|   |   |   |   |   |   |   |   |   |--- publications <= 368.50
|   |   |   |   |   |   |   |   |   |   |--- value: [359.00]
|   |   |   |   |   |   |   |   |   |--- publications >  368.50
|   |   |   |   |   |   |   |   |   |   |--- value: [346.00]
|   |   |   |   |   |   |   |--- broad_impact >  293.50
|   |   |   |   |   |   |   |   |--- publications <= 363.50
|   |   |   |   |   |   |   |   |   |--- value: [253.00]
|   |   |   |   |   |   |   |   |--- publications >  363.50
|   |   |   |   |   |   |   |   |   |--- value: [190.00]
|   |   |   |   |   |   |--- broad_impact >  309.50
|   |   |   |   |   |   |   |--- publications <= 364.50
|   |   |   |   |   |   |   |   |--- publications <= 328.50
|   |   |   |   |   |   |   |   |   |--- broad_impact <= 342.50
|   |   |   |   |   |   |   |   |   |   |--- publications <= 303.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- publications >  303.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [355.00]
|   |   |   |   |   |   |   |   |   |--- broad_impact >  342.50
|   |   |   |   |   |   |   |   |   |   |--- value: [349.00]
|   |   |   |   |   |   |   |   |--- publications >  328.50
|   |   |   |   |   |   |   |   |   |--- publications <= 346.50
|   |   |   |   |   |   |   |   |   |   |--- value: [380.00]
|   |   |   |   |   |   |   |   |   |--- publications >  346.50
|   |   |   |   |   |   |   |   |   |   |--- value: [395.00]
|   |   |   |   |   |   |   |--- publications >  364.50
|   |   |   |   |   |   |   |   |--- publications <= 371.50
|   |   |   |   |   |   |   |   |   |--- value: [275.00]
|   |   |   |   |   |   |   |   |--- publications >  371.50
|   |   |   |   |   |   |   |   |   |--- value: [353.00]
|   |   |   |   |   |   |   |   |   |--- value: [353.00]
|   |   |   |   |--- publications >  382.00
|   |   |   |   |   |--- value: [40.00]
|   |   |   |--- publications >  399.00
|   |   |   |   |--- broad_impact <= 348.00
|   |   |   |   |   |--- broad_impact <= 298.50
|   |   |   |   |   |   |--- broad_impact <= 258.00
|   |   |   |   |   |   |   |--- broad_impact <= 251.50
|   |   |   |   |   |   |   |   |--- value: [321.00]
|   |   |   |   |   |   |   |--- broad_impact >  251.50
|   |   |   |   |   |   |   |   |--- value: [317.00]
|   |   |   |   |   |   |--- broad_impact >  258.00
|   |   |   |   |   |   |   |--- publications <= 516.00
|   |   |   |   |   |   |   |   |--- value: [329.00]
|   |   |   |   |   |   |   |--- publications >  516.00
|   |   |   |   |   |   |   |   |--- value: [340.00]
|   |   |   |   |   |--- broad_impact >  298.50
|   |   |   |   |   |   |--- value: [392.00]
|   |   |   |   |--- broad_impact >  348.00
|   |   |   |   |   |--- broad_impact <= 363.50
|   |   |   |   |   |   |--- value: [425.00]
|   |   |   |   |   |--- broad_impact >  363.50
|   |   |   |   |   |   |--- broad_impact <= 372.00
|   |   |   |   |   |   |   |--- publications <= 509.50
|   |   |   |   |   |   |   |   |--- value: [456.00]
|   |   |   |   |   |   |   |--- publications >  509.50
|   |   |   |   |   |   |   |   |--- value: [461.00]
|   |   |   |   |   |   |--- broad_impact >  372.00
|   |   |   |   |   |   |   |--- value: [491.00]
|   |   |--- broad_impact >  380.50
|   |   |   |--- broad_impact <= 471.50
|   |   |   |   |--- publications <= 551.00
|   |   |   |   |   |--- publications <= 455.50
|   |   |   |   |   |   |--- publications <= 321.00
|   |   |   |   |   |   |   |--- publications <= 265.00
|   |   |   |   |   |   |   |   |--- value: [418.00]
|   |   |   |   |   |   |   |--- publications >  265.00
|   |   |   |   |   |   |   |   |--- value: [402.00]
|   |   |   |   |   |   |--- publications >  321.00
|   |   |   |   |   |   |   |--- broad_impact <= 427.00
|   |   |   |   |   |   |   |   |--- publications <= 436.00
|   |   |   |   |   |   |   |   |   |--- value: [495.00]
|   |   |   |   |   |   |   |   |--- publications >  436.00
|   |   |   |   |   |   |   |   |   |--- value: [505.00]
|   |   |   |   |   |   |   |--- broad_impact >  427.00
|   |   |   |   |   |   |   |   |--- publications <= 386.00
|   |   |   |   |   |   |   |   |   |--- publications <= 351.50
|   |   |   |   |   |   |   |   |   |   |--- value: [484.00]
|   |   |   |   |   |   |   |   |   |--- publications >  351.50
|   |   |   |   |   |   |   |   |   |   |--- value: [474.00]
|   |   |   |   |   |   |   |   |--- publications >  386.00
|   |   |   |   |   |   |   |   |   |--- broad_impact <= 433.50
|   |   |   |   |   |   |   |   |   |   |--- value: [400.00]
|   |   |   |   |   |   |   |   |   |--- broad_impact >  433.50
|   |   |   |   |   |   |   |   |   |   |--- value: [441.00]
|   |   |   |   |   |--- publications >  455.50
|   |   |   |   |   |   |--- publications <= 477.50
|   |   |   |   |   |   |   |--- value: [150.00]
|   |   |   |   |   |   |--- publications >  477.50
|   |   |   |   |   |   |   |--- publications <= 518.50
|   |   |   |   |   |   |   |   |--- value: [419.00]
|   |   |   |   |   |   |   |--- publications >  518.50
|   |   |   |   |   |   |   |   |--- value: [454.00]
|   |   |   |   |--- publications >  551.00
|   |   |   |   |   |--- broad_impact <= 430.50
|   |   |   |   |   |   |--- publications <= 621.00
|   |   |   |   |   |   |   |--- value: [524.00]
|   |   |   |   |   |   |--- publications >  621.00
|   |   |   |   |   |   |   |--- broad_impact <= 416.50
|   |   |   |   |   |   |   |   |--- value: [516.00]
|   |   |   |   |   |   |   |--- broad_impact >  416.50
|   |   |   |   |   |   |   |   |--- value: [519.00]
|   |   |   |   |   |--- broad_impact >  430.50
|   |   |   |   |   |   |--- broad_impact <= 439.50
|   |   |   |   |   |   |   |--- value: [547.00]
|   |   |   |   |   |   |--- broad_impact >  439.50
|   |   |   |   |   |   |   |--- value: [541.00]
|   |   |   |--- broad_impact >  471.50
|   |   |   |   |--- value: [114.00]
|--- broad_impact >  477.00
|   |--- broad_impact <= 709.00
|   |   |--- publications <= 626.50
|   |   |   |--- broad_impact <= 694.50
|   |   |   |   |--- publications <= 592.50
|   |   |   |   |   |--- publications <= 458.00
|   |   |   |   |   |   |--- broad_impact <= 539.00
|   |   |   |   |   |   |   |--- publications <= 434.50
|   |   |   |   |   |   |   |   |--- broad_impact <= 499.50
|   |   |   |   |   |   |   |   |   |--- value: [520.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  499.50
|   |   |   |   |   |   |   |   |   |--- broad_impact <= 515.50
|   |   |   |   |   |   |   |   |   |   |--- value: [562.00]
|   |   |   |   |   |   |   |   |   |--- broad_impact >  515.50
|   |   |   |   |   |   |   |   |   |   |--- value: [563.00]
|   |   |   |   |   |   |   |--- publications >  434.50
|   |   |   |   |   |   |   |   |--- value: [469.00]
|   |   |   |   |   |   |--- broad_impact >  539.00
|   |   |   |   |   |   |   |--- publications <= 390.50
|   |   |   |   |   |   |   |   |--- value: [401.00]
|   |   |   |   |   |   |   |--- publications >  390.50
|   |   |   |   |   |   |   |   |--- value: [370.00]
|   |   |   |   |   |--- publications >  458.00
|   |   |   |   |   |   |--- publications <= 510.00
|   |   |   |   |   |   |   |--- publications <= 505.50
|   |   |   |   |   |   |   |   |--- broad_impact <= 652.50
|   |   |   |   |   |   |   |   |   |--- broad_impact <= 558.00
|   |   |   |   |   |   |   |   |   |   |--- broad_impact <= 525.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [589.00]
|   |   |   |   |   |   |   |   |   |   |--- broad_impact >  525.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [608.00]
|   |   |   |   |   |   |   |   |   |--- broad_impact >  558.00
|   |   |   |   |   |   |   |   |   |   |--- publications <= 463.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [548.00]
|   |   |   |   |   |   |   |   |   |   |--- publications >  463.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [579.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  652.50
|   |   |   |   |   |   |   |   |   |--- publications <= 488.00
|   |   |   |   |   |   |   |   |   |   |--- value: [672.00]
|   |   |   |   |   |   |   |   |   |--- publications >  488.00
|   |   |   |   |   |   |   |   |   |   |--- value: [568.00]
|   |   |   |   |   |   |   |--- publications >  505.50
|   |   |   |   |   |   |   |   |--- value: [422.00]
|   |   |   |   |   |   |--- publications >  510.00
|   |   |   |   |   |   |   |--- broad_impact <= 638.00
|   |   |   |   |   |   |   |   |--- broad_impact <= 559.50
|   |   |   |   |   |   |   |   |   |--- value: [581.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  559.50
|   |   |   |   |   |   |   |   |   |--- publications <= 567.50
|   |   |   |   |   |   |   |   |   |   |--- publications <= 528.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [654.00]
|   |   |   |   |   |   |   |   |   |   |--- publications >  528.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [637.00]
|   |   |   |   |   |   |   |   |   |--- publications >  567.50
|   |   |   |   |   |   |   |   |   |   |--- value: [678.00]
|   |   |   |   |   |   |   |--- broad_impact >  638.00
|   |   |   |   |   |   |   |   |--- value: [745.00]
|   |   |   |   |--- publications >  592.50
|   |   |   |   |   |--- publications <= 596.50
|   |   |   |   |   |   |--- broad_impact <= 504.50
|   |   |   |   |   |   |   |--- value: [529.00]
|   |   |   |   |   |   |--- broad_impact >  504.50
|   |   |   |   |   |   |   |--- value: [258.00]
|   |   |   |   |   |--- publications >  596.50
|   |   |   |   |   |   |--- broad_impact <= 573.50
|   |   |   |   |   |   |   |--- value: [568.00]
|   |   |   |   |   |   |--- broad_impact >  573.50
|   |   |   |   |   |   |   |--- broad_impact <= 627.50
|   |   |   |   |   |   |   |   |--- value: [429.00]
|   |   |   |   |   |   |   |--- broad_impact >  627.50
|   |   |   |   |   |   |   |   |--- value: [473.00]
|   |   |   |--- broad_impact >  694.50
|   |   |   |   |--- broad_impact <= 701.00
|   |   |   |   |   |--- value: [729.00]
|   |   |   |   |--- broad_impact >  701.00
|   |   |   |   |   |--- value: [741.00]
|   |   |--- publications >  626.50
|   |   |   |--- broad_impact <= 536.00
|   |   |   |   |--- publications <= 699.00
|   |   |   |   |   |--- publications <= 664.00
|   |   |   |   |   |   |--- value: [512.00]
|   |   |   |   |   |--- publications >  664.00
|   |   |   |   |   |   |--- value: [513.00]
|   |   |   |   |--- publications >  699.00
|   |   |   |   |   |--- publications <= 754.50
|   |   |   |   |   |   |--- value: [585.00]
|   |   |   |   |   |--- publications >  754.50
|   |   |   |   |   |   |--- value: [590.00]
|   |   |   |--- broad_impact >  536.00
|   |   |   |   |--- broad_impact <= 614.00
|   |   |   |   |   |--- publications <= 628.00
|   |   |   |   |   |   |--- value: [608.00]
|   |   |   |   |   |--- publications >  628.00
|   |   |   |   |   |   |--- broad_impact <= 561.50
|   |   |   |   |   |   |   |--- broad_impact <= 553.50
|   |   |   |   |   |   |   |   |--- publications <= 740.00
|   |   |   |   |   |   |   |   |   |--- value: [633.00]
|   |   |   |   |   |   |   |   |--- publications >  740.00
|   |   |   |   |   |   |   |   |   |--- value: [639.00]
|   |   |   |   |   |   |   |--- broad_impact >  553.50
|   |   |   |   |   |   |   |   |--- value: [616.00]
|   |   |   |   |   |   |--- broad_impact >  561.50
|   |   |   |   |   |   |   |--- publications <= 943.00
|   |   |   |   |   |   |   |   |--- broad_impact <= 582.00
|   |   |   |   |   |   |   |   |   |--- publications <= 662.50
|   |   |   |   |   |   |   |   |   |   |--- value: [638.00]
|   |   |   |   |   |   |   |   |   |--- publications >  662.50
|   |   |   |   |   |   |   |   |   |   |--- publications <= 686.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [676.00]
|   |   |   |   |   |   |   |   |   |   |--- publications >  686.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |--- broad_impact >  582.00
|   |   |   |   |   |   |   |   |   |--- publications <= 630.50
|   |   |   |   |   |   |   |   |   |   |--- value: [660.00]
|   |   |   |   |   |   |   |   |   |--- publications >  630.50
|   |   |   |   |   |   |   |   |   |   |--- broad_impact <= 605.50
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |   |--- broad_impact >  605.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [670.00]
|   |   |   |   |   |   |   |--- publications >  943.00
|   |   |   |   |   |   |   |   |--- value: [623.00]
|   |   |   |   |--- broad_impact >  614.00
|   |   |   |   |   |--- broad_impact <= 661.00
|   |   |   |   |   |   |--- publications <= 715.00
|   |   |   |   |   |   |   |--- value: [701.00]
|   |   |   |   |   |   |--- publications >  715.00
|   |   |   |   |   |   |   |--- broad_impact <= 639.50
|   |   |   |   |   |   |   |   |--- value: [728.00]
|   |   |   |   |   |   |   |--- broad_impact >  639.50
|   |   |   |   |   |   |   |   |--- publications <= 856.00
|   |   |   |   |   |   |   |   |   |--- value: [748.00]
|   |   |   |   |   |   |   |   |--- publications >  856.00
|   |   |   |   |   |   |   |   |   |--- value: [752.00]
|   |   |   |   |   |--- broad_impact >  661.00
|   |   |   |   |   |   |--- publications <= 780.00
|   |   |   |   |   |   |   |--- broad_impact <= 669.00
|   |   |   |   |   |   |   |   |--- value: [693.00]
|   |   |   |   |   |   |   |--- broad_impact >  669.00
|   |   |   |   |   |   |   |   |--- value: [762.00]
|   |   |   |   |   |   |--- publications >  780.00
|   |   |   |   |   |   |   |--- broad_impact <= 682.50
|   |   |   |   |   |   |   |   |--- value: [607.00]
|   |   |   |   |   |   |   |--- broad_impact >  682.50
|   |   |   |   |   |   |   |   |--- publications <= 938.50
|   |   |   |   |   |   |   |   |   |--- publications <= 867.00
|   |   |   |   |   |   |   |   |   |   |--- value: [684.00]
|   |   |   |   |   |   |   |   |   |--- publications >  867.00
|   |   |   |   |   |   |   |   |   |   |--- value: [719.00]
|   |   |   |   |   |   |   |   |--- publications >  938.50
|   |   |   |   |   |   |   |   |   |--- value: [644.00]
|   |--- broad_impact >  709.00
|   |   |--- broad_impact <= 915.00
|   |   |   |--- broad_impact <= 769.50
|   |   |   |   |--- broad_impact <= 755.00
|   |   |   |   |   |--- broad_impact <= 740.00
|   |   |   |   |   |   |--- publications <= 803.50
|   |   |   |   |   |   |   |--- publications <= 753.50
|   |   |   |   |   |   |   |   |--- value: [797.00]
|   |   |   |   |   |   |   |--- publications >  753.50
|   |   |   |   |   |   |   |   |--- value: [795.00]
|   |   |   |   |   |   |--- publications >  803.50
|   |   |   |   |   |   |   |--- broad_impact <= 715.50
|   |   |   |   |   |   |   |   |--- publications <= 838.50
|   |   |   |   |   |   |   |   |   |--- value: [773.00]
|   |   |   |   |   |   |   |   |--- publications >  838.50
|   |   |   |   |   |   |   |   |   |--- value: [759.00]
|   |   |   |   |   |   |   |--- broad_impact >  715.50
|   |   |   |   |   |   |   |   |--- broad_impact <= 727.50
|   |   |   |   |   |   |   |   |   |--- value: [735.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  727.50
|   |   |   |   |   |   |   |   |   |--- value: [707.00]
|   |   |   |   |   |--- broad_impact >  740.00
|   |   |   |   |   |   |--- publications <= 686.50
|   |   |   |   |   |   |   |--- value: [776.00]
|   |   |   |   |   |   |--- publications >  686.50
|   |   |   |   |   |   |   |--- broad_impact <= 747.50
|   |   |   |   |   |   |   |   |--- value: [808.00]
|   |   |   |   |   |   |   |--- broad_impact >  747.50
|   |   |   |   |   |   |   |   |--- value: [818.00]
|   |   |   |   |--- broad_impact >  755.00
|   |   |   |   |   |--- broad_impact <= 762.50
|   |   |   |   |   |   |--- value: [667.00]
|   |   |   |   |   |--- broad_impact >  762.50
|   |   |   |   |   |   |--- value: [639.00]
|   |   |   |--- broad_impact >  769.50
|   |   |   |   |--- publications <= 824.00
|   |   |   |   |   |--- broad_impact <= 903.00
|   |   |   |   |   |   |--- publications <= 651.00
|   |   |   |   |   |   |   |--- broad_impact <= 833.50
|   |   |   |   |   |   |   |   |--- value: [807.00]
|   |   |   |   |   |   |   |--- broad_impact >  833.50
|   |   |   |   |   |   |   |   |--- value: [756.00]
|   |   |   |   |   |   |--- publications >  651.00
|   |   |   |   |   |   |   |--- publications <= 760.50
|   |   |   |   |   |   |   |   |--- broad_impact <= 807.50
|   |   |   |   |   |   |   |   |   |--- publications <= 750.00
|   |   |   |   |   |   |   |   |   |   |--- publications <= 732.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [818.00]
|   |   |   |   |   |   |   |   |   |   |--- publications >  732.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [819.00]
|   |   |   |   |   |   |   |   |   |--- publications >  750.00
|   |   |   |   |   |   |   |   |   |   |--- value: [855.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  807.50
|   |   |   |   |   |   |   |   |   |--- broad_impact <= 870.50
|   |   |   |   |   |   |   |   |   |   |--- publications <= 699.00
|   |   |   |   |   |   |   |   |   |   |   |--- value: [889.00]
|   |   |   |   |   |   |   |   |   |   |--- publications >  699.00
|   |   |   |   |   |   |   |   |   |   |   |--- truncated branch of depth 2
|   |   |   |   |   |   |   |   |   |--- broad_impact >  870.50
|   |   |   |   |   |   |   |   |   |   |--- publications <= 670.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [878.00]
|   |   |   |   |   |   |   |   |   |   |--- publications >  670.50
|   |   |   |   |   |   |   |   |   |   |   |--- value: [834.00]
|   |   |   |   |   |   |   |--- publications >  760.50
|   |   |   |   |   |   |   |   |--- publications <= 799.50
|   |   |   |   |   |   |   |   |   |--- broad_impact <= 846.50
|   |   |   |   |   |   |   |   |   |   |--- value: [804.00]
|   |   |   |   |   |   |   |   |   |--- broad_impact >  846.50
|   |   |   |   |   |   |   |   |   |   |--- value: [770.00]
|   |   |   |   |   |   |   |   |--- publications >  799.50
|   |   |   |   |   |   |   |   |   |--- publications <= 806.50
|   |   |   |   |   |   |   |   |   |   |--- value: [843.00]
|   |   |   |   |   |   |   |   |   |--- publications >  806.50
|   |   |   |   |   |   |   |   |   |   |--- value: [833.00]
|   |   |   |   |   |--- broad_impact >  903.00
|   |   |   |   |   |   |--- value: [653.00]
|   |   |   |   |--- publications >  824.00
|   |   |   |   |   |--- broad_impact <= 868.00
|   |   |   |   |   |   |--- publications <= 919.50
|   |   |   |   |   |   |   |--- broad_impact <= 804.50
|   |   |   |   |   |   |   |   |--- value: [871.00]
|   |   |   |   |   |   |   |--- broad_impact >  804.50
|   |   |   |   |   |   |   |   |--- value: [861.00]
|   |   |   |   |   |   |--- publications >  919.50
|   |   |   |   |   |   |   |--- value: [892.00]
|   |   |   |   |   |--- broad_impact >  868.00
|   |   |   |   |   |   |--- broad_impact <= 907.50
|   |   |   |   |   |   |   |--- broad_impact <= 891.00
|   |   |   |   |   |   |   |   |--- value: [923.00]
|   |   |   |   |   |   |   |--- broad_impact >  891.00
|   |   |   |   |   |   |   |   |--- broad_impact <= 896.50
|   |   |   |   |   |   |   |   |   |--- value: [935.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  896.50
|   |   |   |   |   |   |   |   |   |--- publications <= 946.50
|   |   |   |   |   |   |   |   |   |   |--- value: [929.00]
|   |   |   |   |   |   |   |   |   |--- publications >  946.50
|   |   |   |   |   |   |   |   |   |   |--- value: [924.00]
|   |   |   |   |   |   |--- broad_impact >  907.50
|   |   |   |   |   |   |   |--- value: [858.00]
|   |   |--- broad_impact >  915.00
|   |   |   |--- broad_impact <= 972.50
|   |   |   |   |--- broad_impact <= 969.50
|   |   |   |   |   |--- broad_impact <= 922.00
|   |   |   |   |   |   |--- publications <= 993.50
|   |   |   |   |   |   |   |--- publications <= 898.00
|   |   |   |   |   |   |   |   |--- value: [920.00]
|   |   |   |   |   |   |   |--- publications >  898.00
|   |   |   |   |   |   |   |   |--- value: [860.00]
|   |   |   |   |   |   |--- publications >  993.50
|   |   |   |   |   |   |   |--- value: [962.00]
|   |   |   |   |   |--- broad_impact >  922.00
|   |   |   |   |   |   |--- publications <= 894.00
|   |   |   |   |   |   |   |--- broad_impact <= 951.00
|   |   |   |   |   |   |   |   |--- broad_impact <= 934.50
|   |   |   |   |   |   |   |   |   |--- value: [950.00]
|   |   |   |   |   |   |   |   |--- broad_impact >  934.50
|   |   |   |   |   |   |   |   |   |--- value: [946.00]
|   |   |   |   |   |   |   |--- broad_impact >  951.00
|   |   |   |   |   |   |   |   |--- value: [928.00]
|   |   |   |   |   |   |--- publications >  894.00
|   |   |   |   |   |   |   |--- broad_impact <= 962.50
|   |   |   |   |   |   |   |   |--- value: [975.00]
|   |   |   |   |   |   |   |--- broad_impact >  962.50
|   |   |   |   |   |   |   |   |--- value: [992.00]
|   |   |   |   |--- broad_impact >  969.50
|   |   |   |   |   |--- publications <= 936.00
|   |   |   |   |   |   |--- value: [837.00]
|   |   |   |   |   |--- publications >  936.00
|   |   |   |   |   |   |--- value: [807.00]
|   |   |   |--- broad_impact >  972.50
|   |   |   |   |--- publications <= 945.00
|   |   |   |   |   |--- broad_impact <= 978.00
|   |   |   |   |   |   |--- publications <= 873.50
|   |   |   |   |   |   |   |--- value: [986.00]
|   |   |   |   |   |   |--- publications >  873.50
|   |   |   |   |   |   |   |--- value: [983.00]
|   |   |   |   |   |--- broad_impact >  978.00
|   |   |   |   |   |   |--- publications <= 840.00
|   |   |   |   |   |   |   |--- value: [985.00]
|   |   |   |   |   |   |--- publications >  840.00
|   |   |   |   |   |   |   |--- broad_impact <= 985.00
|   |   |   |   |   |   |   |   |--- value: [1000.00]
|   |   |   |   |   |   |   |--- broad_impact >  985.00
|   |   |   |   |   |   |   |   |--- value: [994.00]
|   |   |   |   |--- publications >  945.00
|   |   |   |   |   |--- value: [920.00]
```

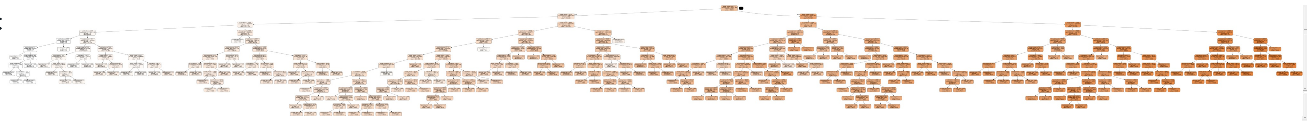
Визуализация дерева

In [36]:
```python
# Визуализация дерева
def get_png_tree(tree_model_param, feature_names_param):
    dot_data = StringIO()
    export_graphviz(tree_model_param, out_file=dot_data, feature_names=feature_names_param,
                    filled=True, rounded=True, special_characters=True)
    graph = pydotplus.graph_from_dot_data(dot_data.getvalue())
```

```
        return graph.create_png()
```

In [37]:
```
Image(get_png_tree(reg, X.columns), height='100%')
```

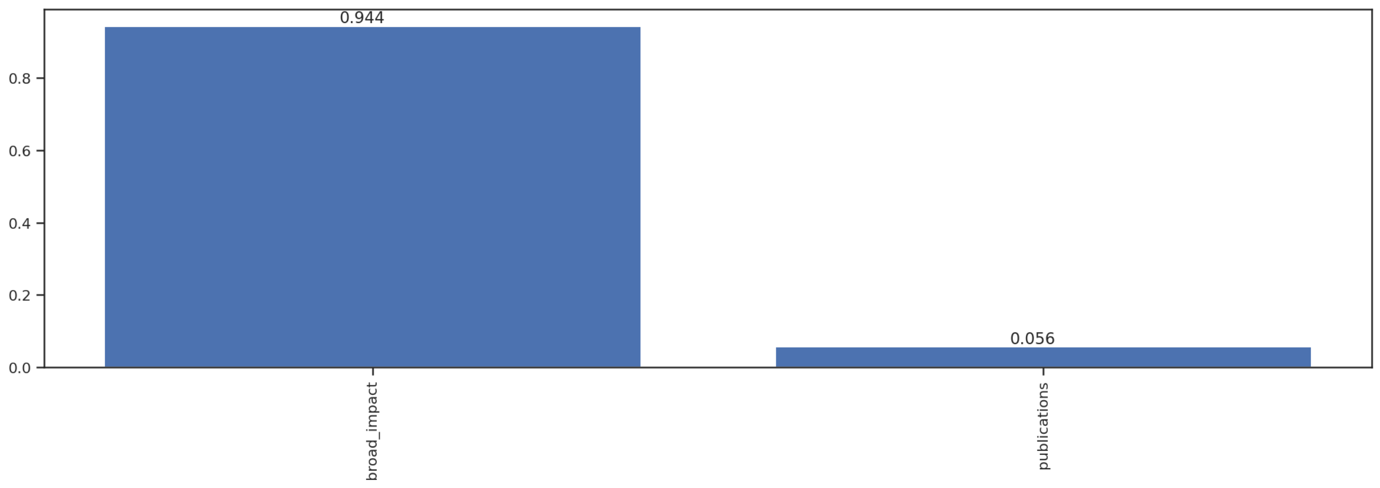
Out[37]:



Важность признаков в дереве

In [38]:
```
from operator import itemgetter

def draw_feature_importances(tree_model, X_dataset, figsize=(18,5)):
    """
    Вывод важности признаков в виде графика
    """
    # Сортировка значений важности признаков по убыванию
    list_to_sort = list(zip(X_dataset.columns.values, tree_model.feature_importances_))
    sorted_list = sorted(list_to_sort, key=itemgetter(1), reverse = True)
    # Названия признаков
    labels = [x for x,_ in sorted_list]
    # Важности признаков
    data = [x for _,x in sorted_list]
    # Вывод графика
    fig, ax = plt.subplots(figsize=figsize)
    ind = np.arange(len(labels))
    plt.bar(ind, data)
    plt.xticks(ind, labels, rotation='vertical')
    # Вывод значений
    for a,b in zip(ind, data):
        plt.text(a-0.05, b+0.01, str(round(b,3)))
    plt.show()
    return labels, data
```

In [39]:
```
boston_tree_regr_fl, boston_tree_regr_fd = draw_feature_importances(reg, X)
```



In [ ]: