Goal

1. Finding out which variable affects the rental price the most for three cities: Berlin, Monachium, Prague
2. Study diffirent algorithms used for regression analysis

Prereqs

1. Ensure input files are presented on Google disc. Source file listing_summary.csv should be there. Otherwise upload is directly to Colab filesystem. In this notebook I'm using files directly from my Google Drive. Please replace all path to source data with proper one (take value from copy path for source files)
2. Install shap library
3. Output files Some code produces images which are stored. If you interested to store them pernamently update the path to store them in your google driver or download them before ending work with notebook.

Source data

1. listings_berlin_11_2019.csv
2. listings_munich_11_2019.csv
3. listings_prague_11_2019.csv

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

```
Mounted at /content/drive
```

```
!pip install shap
```

```
Collecting shap
  Downloading shap-0.40.0-cp37-cp37m-manylinux2010_x86_64.whl (564 kB)
     |████████████████████████████████| 564 kB 26.1 MB/s
Requirement already satisfied: tqdm>4.25.0 in /usr/local/lib/python3.7/dist-packages (from shap) (4.62.3)
Requirement already satisfied: numba in /usr/local/lib/python3.7/dist-packages (from shap) (0.51.2)
Requirement already satisfied: packaging>20.9 in /usr/local/lib/python3.7/dist-packages (from shap) (21.3)
Requirement already satisfied: cloudpickle in /usr/local/lib/python3.7/dist-packages (from shap) (1.3.0)
Requirement already satisfied: scipy in /usr/local/lib/python3.7/dist-packages (from shap) (1.4.1)
Requirement already satisfied: numpy in /usr/local/lib/python3.7/dist-packages (from shap) (1.19.5)
Collecting slicer==0.0.7
  Downloading slicer-0.0.7-py3-none-any.whl (14 kB)
Requirement already satisfied: pandas in /usr/local/lib/python3.7/dist-packages (from shap) (1.1.5)
Requirement already satisfied: scikit-learn in /usr/local/lib/python3.7/dist-packages (from shap) (1.0.2)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /usr/local/lib/python3.7/dist-packages (from packaging>20.9->shap) (3.0.6
Requirement already satisfied: setuptools in /usr/local/lib/python3.7/dist-packages (from numba->shap) (57.4.0)
Requirement already satisfied: llvmlite<0.35,>=0.34.0.dev0 in /usr/local/lib/python3.7/dist-packages (from numba->shap) (0.34.0)
Requirement already satisfied: python-dateutil>=2.7.3 in /usr/local/lib/python3.7/dist-packages (from pandas->shap) (2.8.2)
Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.7/dist-packages (from pandas->shap) (2018.9)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.7/dist-packages (from python-dateutil>=2.7.3->pandas->shap) (1.15
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.7/dist-packages (from scikit-learn->shap) (1.1.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.7/dist-packages (from scikit-learn->shap) (3.0.0)
Installing collected packages: slicer, shap
Successfully installed shap-0.40.0 slicer-0.0.7
```

```
import pandas as pd # for data manipulation
import numpy as np  # fast n-dimensional arrays library
import statsmodels.formula.api as smf # for linear regresion
import seaborn as sns # for data visualization
import matplotlib.pyplot as plt # for data visualization
from sklearn import preprocessing # for preprocessing for LASSO algorithm
from sklearn.metrics import mean_squared_error # metric for comparing models
from sklearn import linear_model # for LASSO algorithm
import xgboost # for XGBoost algorithm
import shap # for visualization output from XGBoost
from PIL import Image # for images manipulation
```

```
/usr/local/lib/python3.7/dist-packages/statsmodels/tools/_testing.py:19: FutureWarning: pandas.util.testing is deprecated. Use the f
  import pandas.util.testing as tm
```

Lest save information about exact version of libraries used.

```
print("Version of libraries used")
print("pandas: " + pd.__version__)
print("numpy: " + np.__version__)
import statsmodels as lib
print("statsmodels: " + lib.__version__)
del lib
print("sns: " + sns.__version__)
import matplotlib as lib
```

```
print("matplotlib.pyplot: " + lib.__version__)
del lib
import sklearn as lib
print("sklearn: " + lib.__version__)
del lib
print("xgboost: " + xgboost.__version__)
print("shap: " + shap.__version__)
import PIL as lib
print("PIL: " + lib.__version__)
del lib
```

```
Version of libraries used
pandas: 1.1.5
numpy: 1.19.5
statsmodels: 0.10.2
sns: 0.11.2
matplotlib.pyplot: 3.2.2
sklearn: 1.0.2
xgboost: 0.90
shap: 0.40.0
PIL: 7.1.2
```

Read data and exploratory analysis

```
data = pd.read_csv('/content/drive/MyDrive/listings_berlin_11_2019.csv') # orginal berlin
```

```
data.head()
```

	id	listing_url	scrape_id	last_scraped	name	summary	space	description	experier
0	2015	https://www.airbnb.com/rooms/2015	20181107122246	2018-11-07	Berlin-Mitte Value! Quiet courtyard/very central	Great location! 30 of 75 sq meters. This wood...	A+++ location! This „Einliegerwohnung“ is an e...	Great location! 30 of 75 sq meters. This wood...	
1	2695	https://www.airbnb.com/rooms/2695	20181107122246	2018-11-07	Prenzlauer Berg close to Mauerpark	NaN	In the summertime we are spending most of our ...	In the summertime we are spending most of our ...	
2	3176	https://www.airbnb.com/rooms/3176	20181107122246	2018-11-07	Fabulous Flat in great Location	This beautiful first floor apartment is situa...	1st floor (68m2) apartment on Kollwitzplatz/ P...	This beautiful first floor apartment is situa...	
3	3309	https://www.airbnb.com/rooms/3309	20181107122246	2018-11-07	BerlinSpot Schöneberg near KaDeWe	First of all: I prefer short-notice bookings. ...	Your room is really big and has 26 sqm, is ver...	First of all: I prefer short-notice bookings. ...	
4	7071	https://www.airbnb.com/rooms/7071	20181107122246	2018-11-07	BrightRoom with sunny greenview!	Cozy and large room in the beautiful district ...	The BrightRoom is an approx. 20 sqm (215ft²), ...	Cozy and large room in the beautiful district ...	

5 rows × 96 columns

```
data2 = pd.read_csv('/content/drive/MyDrive/listings_munich_11_2019.csv') # monachium
```

```
Columns (43,61,62,94) have mixed types.Specify dtype option on import or set low_memory=False.
```

```
data3 = pd.read_csv('/content/drive/MyDrive/listings_prague_11_2019.csv') # prague
```

```
data3.head()
```

	id	listing_url	scrape_id	last_scraped	name	description	neighborhood_overview	
0	3884	https://www.airbnb.com/rooms/3884	20211218004437	2019-12-18	Enjoy/relax/hide Old Town Prague	The space for detailed info see ht...	Surpricing quiet atmosphere, the street is cl...	https://a0.n
1	23163	https://www.airbnb.com/rooms/23163	20211218004437	2019-12-18	Quiet 1BR directly in the Centre, Air-conditio...	Unique and elegant apartment rental in Prague,...	Check my guidebook for this apartment to disco...	https://a0.r
2	23169	https://www.airbnb.com/rooms/23169	20211218004437	2019-12-18	M302-Cozy Serviced Studio in Center	Masna studio offers a lot of space and privacy...	NaN	https://a0.r
3	26755	https://www.airbnb.com/rooms/26755	20211218004437	2019-12-18	Central Prague Old Town Top Floor	Big and beautiful new attic apartment in the v...	This apartment offers a fantastic location. Yo...	https://a0
4	27916	https://www.airbnb.com/rooms/27916	20211218004437	2019-12-18	Cosy & Quiet Studio - Romantic Stay in Zizkov	Our cozy studio is very well located in a quie...	Our neighborhood is quiet but still has a lot ...	https://a0.r

```
# Preprocessing - cast price as float
data.price = data.price.apply(lambda x: x.replace("$", ""))
data.price = data.price.apply(lambda x: x.replace(",", ""))
data.price = data.price.astype("float")
data.price.describe()
```

```
count    22552.000000
mean        67.143668
std        220.266210
min          0.000000
25%         30.000000
50%         45.000000
75%         70.000000
max       9000.000000
Name: price, dtype: float64
```

```
# Preprocessing - cast price as float
data2.price = data2.price.apply(lambda x: x.replace("$", ""))
data2.price = data2.price.apply(lambda x: x.replace(",", ""))
data2.price = data2.price.astype("float")
data2.price.describe()
```

```
count    11481.000000
mean       116.336469
std        168.078321
min          8.000000
25%         55.000000
50%         82.000000
75%        130.000000
max       9000.000000
Name: price, dtype: float64
```

```
# Preprocessing - cast price as float
data3.price = data3.price.apply(lambda x: x.replace("$", ""))
data3.price = data3.price.apply(lambda x: x.replace(",", ""))
data3.price = data3.price.astype("float")
data3.price.describe()
```

```
count    6.782000e+03
mean     9.016939e+03
std      1.282461e+05
min      0.000000e+00
25%      1.113250e+03
50%      1.705000e+03
75%      2.762750e+03
```

```
max      2.866213e+06
Name: price, dtype: float64
```

```
# Enrich data by calculate zip code relation to price
# amenities_len -> value for comparing number of amenities across offerts
# zip_count -> number of offerts in close location
# zip_price -> average price for offerts in the same location

temp_zipcode = data.zipcode.copy()
data['zipcode2'] = temp_zipcode.str.replace("\D+", "", ).copy()
data.zipcode2.fillna(0, inplace=True)
x_count = data.groupby('zipcode2')['id'].nunique()
x_mean = data.groupby('zipcode2')['price'].mean()

x_count_dict = x_count.to_dict()
x_mean_dict = x_mean.to_dict()

a1 = np.zeros((len(data), 6))
print(a1)
for i in range(0,len(data)):
    val = data.zipcode2[i]
    a1[i][0] = data.id[i]
    a1[i][1] = x_count_dict[val]
    a1[i][2] = x_mean_dict[val]
    a1[i][3] = val
    a1[i][4] = len(data.amenities[i])

data['amenities_len'] = a1[:,3]
data['zipcode_count'] = a1[:,1]
data['zipcode_price'] = a1[:,2]
print(data.head())
```

```
[[0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]
 ...
 [0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]]
    id                         listing_url  ...  zipcode_count zipcode_price
0  2015  https://www.airbnb.com/rooms/2015  ...          538.0     88.500000
1  2695  https://www.airbnb.com/rooms/2695  ...          703.0     80.765292
2  3176  https://www.airbnb.com/rooms/3176  ...          585.0     68.446154
3  3309  https://www.airbnb.com/rooms/3309  ...          183.0    112.234973
4  7071  https://www.airbnb.com/rooms/7071  ...          703.0     80.765292

[5 rows x 100 columns]
```

```
# Enrich data by calculate zip code relation to price
# amenities_len -> value for comparing number of amenities across offerts
# zip_count -> number of offerts in close location
# zip_price -> average price for offerts in the same location

temp_zipcode = data2.zipcode.copy()
data2['zipcode2'] = temp_zipcode.str.replace("\D+", "", ).copy()

data2.zipcode2.fillna(0, inplace=True)

x_count = data2.groupby('zipcode2')['id'].nunique()
x_mean = data2.groupby('zipcode2')['price'].mean()

x_count_dict = x_count.to_dict()
x_mean_dict = x_mean.to_dict()

a1 = np.zeros((len(data2), 6))
print(a1)
for i in range(0,len(data2)):
    val = data2.zipcode2[i]
    a1[i][0] = data2.id[i]
    a1[i][1] = x_count_dict[val]
    a1[i][2] = x_mean_dict[val]
    a1[i][3] = val
    a1[i][4] = len(data2.amenities[i])

data2['amenities_len'] = a1[:,3]
data2['zipcode_count'] = a1[:,1]
data2['zipcode_price'] = a1[:,2]
print(data2.head())
```

```
[[0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]
 ...
```

```
 [0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]]
       id                          listing_url  ...  zipcode_count zipcode_price
0   36720   https://www.airbnb.com/rooms/36720  ...          417.0    184.453237
1   97945   https://www.airbnb.com/rooms/97945  ...           50.0     84.460000
2  114695  https://www.airbnb.com/rooms/114695  ...           69.0    109.594203
3  127383  https://www.airbnb.com/rooms/127383  ...          201.0    124.527363
4  157808  https://www.airbnb.com/rooms/157808  ...          163.0    118.122699

[5 rows x 110 columns]
```

```
# Enrich data by calculate zip code relation to price
# amenities_len -> value for comparing number of amenities across offerts
# zip_count -> number of offerts in close location
# zip_price -> average price for offerts in the same location

temp_zipcode = data2.zipcode.copy()
data3['zipcode2'] = temp_zipcode.str.replace("\D+", "", ).copy()

data3.zipcode2.fillna(0, inplace=True)

x_count = data3.groupby('zipcode2')['id'].nunique()
x_mean = data3.groupby('zipcode2')['price'].mean()

x_count_dict = x_count.to_dict()
x_mean_dict = x_mean.to_dict()

a1 = np.zeros((len(data3), 6))
print(a1)
for i in range(0,len(data3)):
    val = data3.zipcode2[i]
    a1[i][0] = data3.id[i]
    a1[i][1] = x_count_dict[val]
    a1[i][2] = x_mean_dict[val]
    a1[i][3] = val
    a1[i][4] = len(data3.amenities[i])

data3['amenities_len'] = a1[:,3]
data3['zipcode_count'] = a1[:,1]
data3['zipcode_price'] = a1[:,2]
print(data3.head())
```

```
[[0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]
 ...
 [0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]
 [0. 0. 0. 0. 0. 0.]]
       id                          listing_url  ...  zipcode_count zipcode_price
0   3884   https://www.airbnb.com/rooms/3884  ...          362.0  18629.168508
1  23163  https://www.airbnb.com/rooms/23163  ...           41.0   2690.560976
2  23169  https://www.airbnb.com/rooms/23169  ...           50.0   2129.060000
3  26755  https://www.airbnb.com/rooms/26755  ...          169.0   2999.792899
4  27916  https://www.airbnb.com/rooms/27916  ...          137.0  23789.394161

[5 rows x 78 columns]
```

```
# Preprocessing - get rid of outliers
print("99.7% properties have a price lower than {0: .2f}".format(np.percentile(data.price, 99.7)))
data = data[(data.price <= np.percentile(data.price, 99.7)) & (data.price > 0)]
```

```
99.7% properties have a price lower than  550.00
```

```
# Preprocessing - get rid of outliers
print("99.7% properties have a price lower than {0: .2f}".format(np.percentile(data2.price, 99.7)))
data2 = data2[(data2.price <= np.percentile(data2.price, 99.7)) & (data2.price > 0)]
```

```
99.7% properties have a price lower than  999.00
```

```
# Preprocessing - get rid of outliers
print("99.7% properties have a price lower than {0: .2f}".format(np.percentile(data3.price, 99.7)))
data3 = data3[(data3.price <= np.percentile(data3.price, 99.7)) & (data3.price > 0)]
```

```
99.7% properties have a price lower than  61282.69
```

Visualizing the important characteristics of a dataset

```
cols = ['price', 'host_is_superhost', 'bedrooms', 'number_of_reviews', 'review_scores_rating', 'beds', 'bathrooms']
cols2 = ['accommodates', 'amenities_len', 'minimum_nights', 'zipcode_count', 'zipcode_price']
```

```
cols = cols + cols2
cols
```

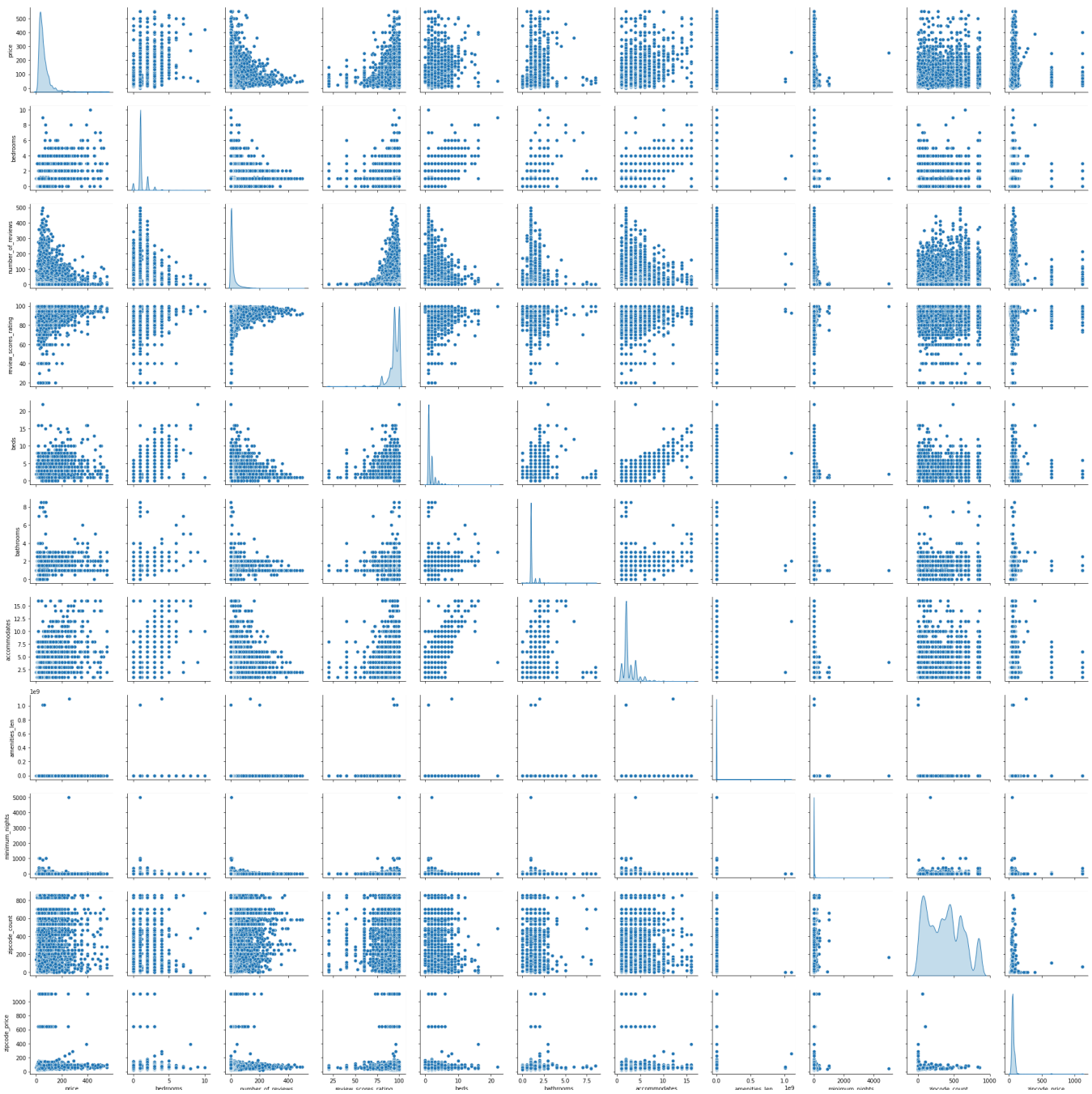
```
['price',
 'host_is_superhost',
 'bedrooms',
 'number_of_reviews',
 'review_scores_rating',
 'beds',
 'bathrooms',
 'accommodates',
 'amenities_len',
 'minimum_nights',
 'zipcode_count',
 'zipcode_price']
```

```
# Preprocessing - replace NaN values with mean from column
# With checking before and after replacement

print(data[cols].isna().sum())
print(data2[cols].isna().sum())
print(data3[cols].isna().sum())

data.fillna((data[cols].mean()), inplace=True)
data2.fillna((data2[cols].mean()), inplace=True)
data3.fillna((data3[cols].mean()), inplace=True)

# Why bathromes NaN not cleaned for Prague ?
data3['bathrooms'] = data3['bathrooms'].replace(np.nan, 0)

print(data[cols].isna().sum())
print(data2[cols].isna().sum())
print(data3[cols].isna().sum())
```

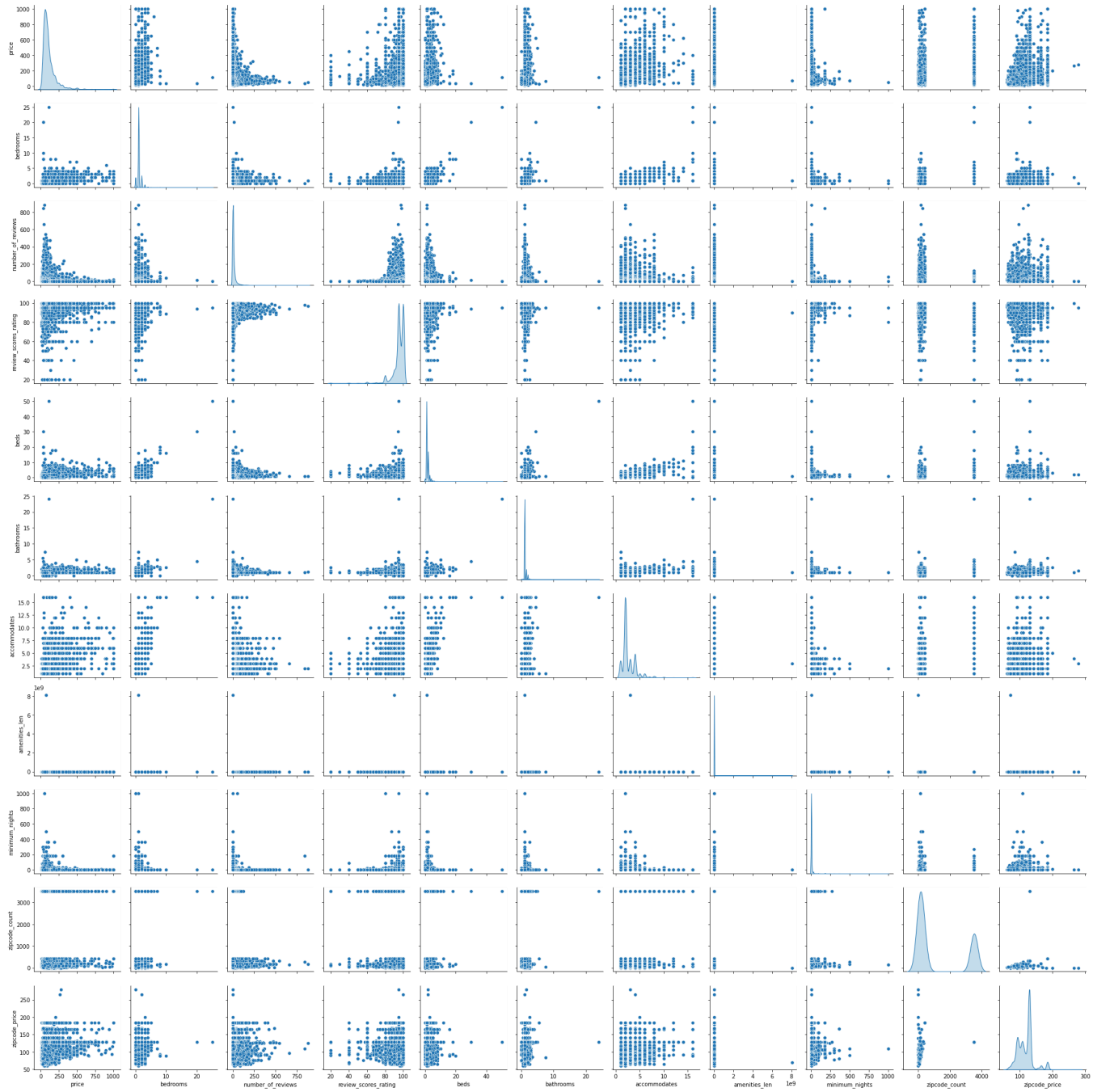
```
price                      0
host_is_superhost         25
bedrooms                  18
number_of_reviews          0
review_scores_rating    4349
beds                      39
bathrooms                 32
accommodates               0
amenities_len              0
minimum_nights             0
zipcode_count              0
zipcode_price              0
dtype: int64
price                      0
host_is_superhost         23
bedrooms                  30
number_of_reviews          0
review_scores_rating    2719
beds                      18
bathrooms                 21
accommodates               0
amenities_len              0
minimum_nights             0
zipcode_count              0
zipcode_price              0
dtype: int64
price                      0
host_is_superhost          0
bedrooms                 795
number_of_reviews          0
review_scores_rating     963
beds                     165
bathrooms               6752
accommodates               0
amenities_len              0
minimum_nights             0
zipcode_count              0
zipcode_price              0
dtype: int64
price                    0
host_is_superhost       25
bedrooms                 0
number_of_reviews        0
review_scores_rating     0
beds                     0
bathrooms                0
accommodates             0
amenities_len            0
minimum_nights           0
zipcode_count            0
zipcode_price            0
dtype: int64
```

```
price                   0
host_is_superhost      23
bedrooms                0
number_of_reviews       0
review_scores_rating    0
```

```
# Convert remaining columns to float type
data['number_of_reviews'] = data['number_of_reviews'].astype(float)
data['accommodates'] = data['accommodates'].astype(float)
data['amenities_len'] = data['amenities_len'].astype(float)
data['minimum_nights'] = data['minimum_nights'].astype(float)

data2['number_of_reviews'] = data2['number_of_reviews'].astype(float)
data2['accommodates'] = data2['accommodates'].astype(float)
data2['amenities_len'] = data2['amenities_len'].astype(float)
data2['minimum_nights'] = data2['minimum_nights'].astype(float)

data3['number_of_reviews'] = data3['number_of_reviews'].astype(float)
data3['accommodates'] = data3['accommodates'].astype(float)
data3['amenities_len'] = data3['amenities_len'].astype(float)
data3['minimum_nights'] = data3['minimum_nights'].astype(float)


set_of_data =[data, data2, data3]
set_of_city = ['berlin', 'monachium', 'praga']

sns.pairplot(data[cols], height=2.5, diag_kind='kde')
plt.tight_layout()
plt.savefig('berlin_matrix_pair_plot.png', dpi=300)

plt.show()
plt.clf() # Clean parirplot figure from sns
```



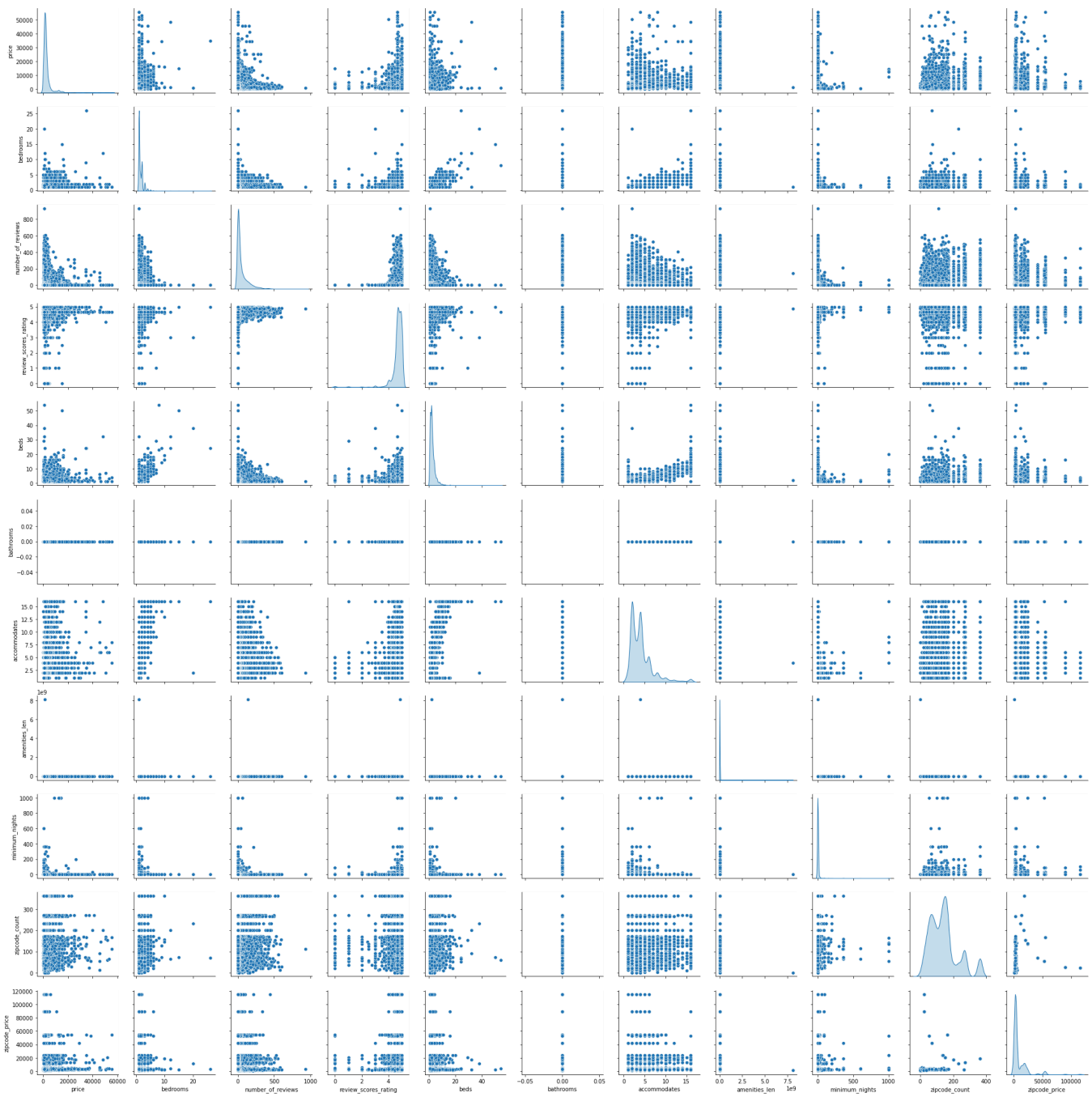

```
sns.pairplot(data2[cols], height=2.5, diag_kind='kde')
plt.tight_layout()
plt.savefig('monachium_matrix_pair_plot.png', dpi=300)

plt.show()
plt.clf() # Clean parirplot figure from sns
```



<Figure size 432x288 with 0 Axes>

```
sns.pairplot(data3[cols], height=2.5, diag_kind='kde')
plt.tight_layout()
plt.savefig('prague_matrix_pair_plot.png', dpi=300)
```

```
plt.show()
plt.clf() # Clean parirplot figure from sns
```




```
<Figure size 432x288 with 0 Axes>
```

```
print(data[cols].info())
```

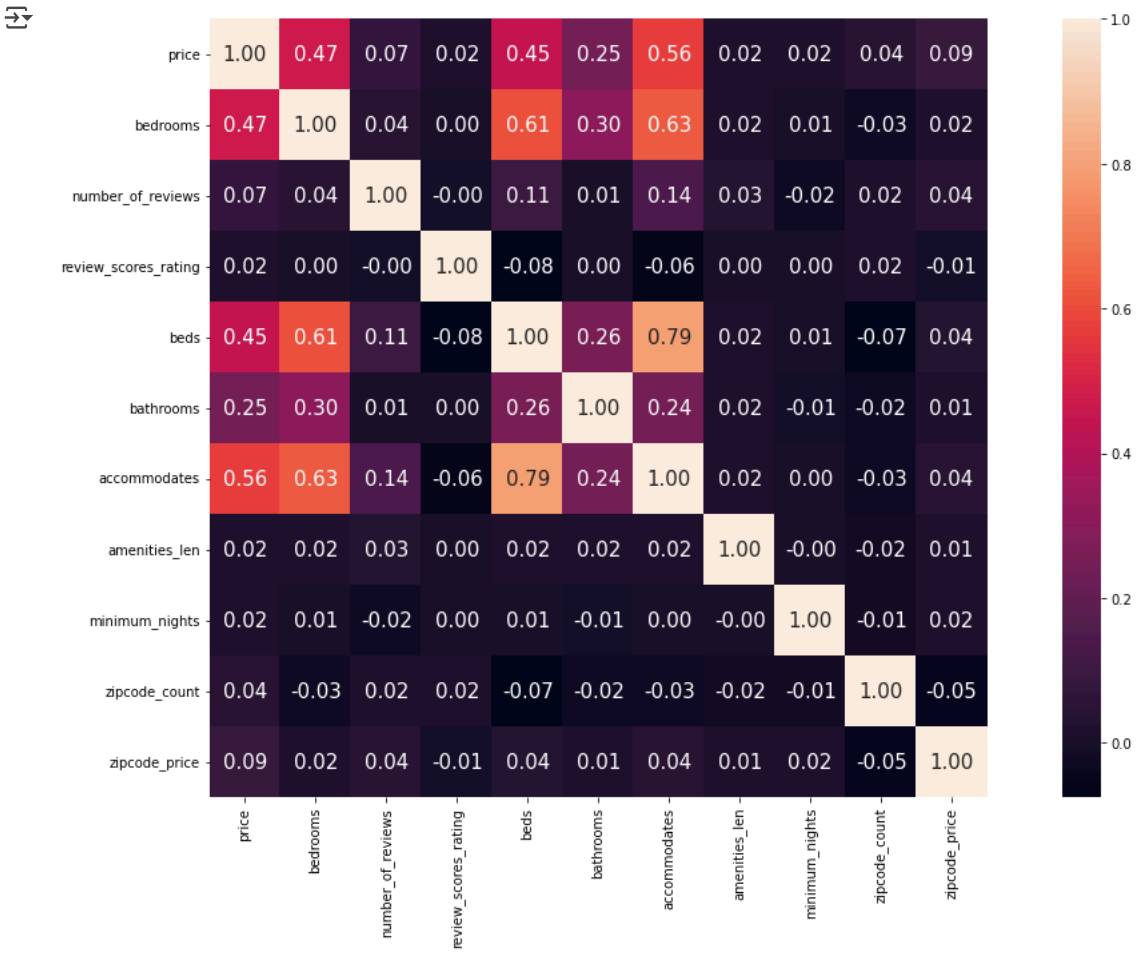
```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 22479 entries, 0 to 22551
Data columns (total 12 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   price                 22479 non-null  float64
 1   host_is_superhost     22454 non-null  object 
 2   bedrooms              22479 non-null  float64
 3   number_of_reviews     22479 non-null  float64
 4   review_scores_rating  22479 non-null  float64
 5   beds                  22479 non-null  float64
 6   bathrooms             22479 non-null  float64
 7   accommodates          22479 non-null  float64
 8   amenities_len         22479 non-null  float64
 9   minimum_nights        22479 non-null  float64
 10  zipcode_count         22479 non-null  float64
 11  zipcode_price         22479 non-null  float64
dtypes: float64(11), object(1)
memory usage: 2.2+ MB
None
```

```
# Preparing data to show in heatmap
print(data[cols].describe())
print(data[cols].info())
data[cols].values.T
print(cols)
print(data[cols].info())
cols_for_heatmap = cols.copy()
cols_for_heatmap.remove('host_is_superhost')
```

```
              price      bedrooms  ...  zipcode_count  zipcode_price
count  22479.000000  22479.000000  ...   22479.000000   22479.000000
mean      58.308021      1.158809  ...     371.533253      66.299797
std       45.678653      0.637756  ...     242.231660      62.961177
min        1.000000      0.000000  ...       1.000000      20.000000
25%       30.000000      1.000000  ...     146.000000      50.030000
50%       45.000000      1.000000  ...     371.000000      57.971477
75%       70.000000      1.000000  ...     574.000000      67.370370
max      550.000000     10.000000  ...     855.000000    1113.288136

[8 rows x 11 columns]
<class 'pandas.core.frame.DataFrame'>
Int64Index: 22479 entries, 0 to 22551
Data columns (total 12 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   price                 22479 non-null  float64
 1   host_is_superhost     22454 non-null  object 
 2   bedrooms              22479 non-null  float64
 3   number_of_reviews     22479 non-null  float64
 4   review_scores_rating  22479 non-null  float64
 5   beds                  22479 non-null  float64
 6   bathrooms             22479 non-null  float64
 7   accommodates          22479 non-null  float64
 8   amenities_len         22479 non-null  float64
 9   minimum_nights        22479 non-null  float64
 10  zipcode_count         22479 non-null  float64
 11  zipcode_price         22479 non-null  float64
dtypes: float64(11), object(1)
memory usage: 2.2+ MB
None
['price', 'host_is_superhost', 'bedrooms', 'number_of_reviews', 'review_scores_rating', 'beds', 'bathrooms', 'accommodates', 'amenit
<class 'pandas.core.frame.DataFrame'>
Int64Index: 22479 entries, 0 to 22551
Data columns (total 12 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   price                 22479 non-null  float64
 1   host_is_superhost     22454 non-null  object 
 2   bedrooms              22479 non-null  float64
 3   number_of_reviews     22479 non-null  float64
 4   review_scores_rating  22479 non-null  float64
 5   beds                  22479 non-null  float64
 6   bathrooms             22479 non-null  float64
 7   accommodates          22479 non-null  float64
 8   amenities_len         22479 non-null  float64
 9   minimum_nights        22479 non-null  float64
 10  zipcode_count         22479 non-null  float64
 11  zipcode_price         22479 non-null  float64
dtypes: float64(11), object(1)
memory usage: 2.2+ MB
None
```

```
cm = np.corrcoef(data[cols_for_heatmap].values.T)
```

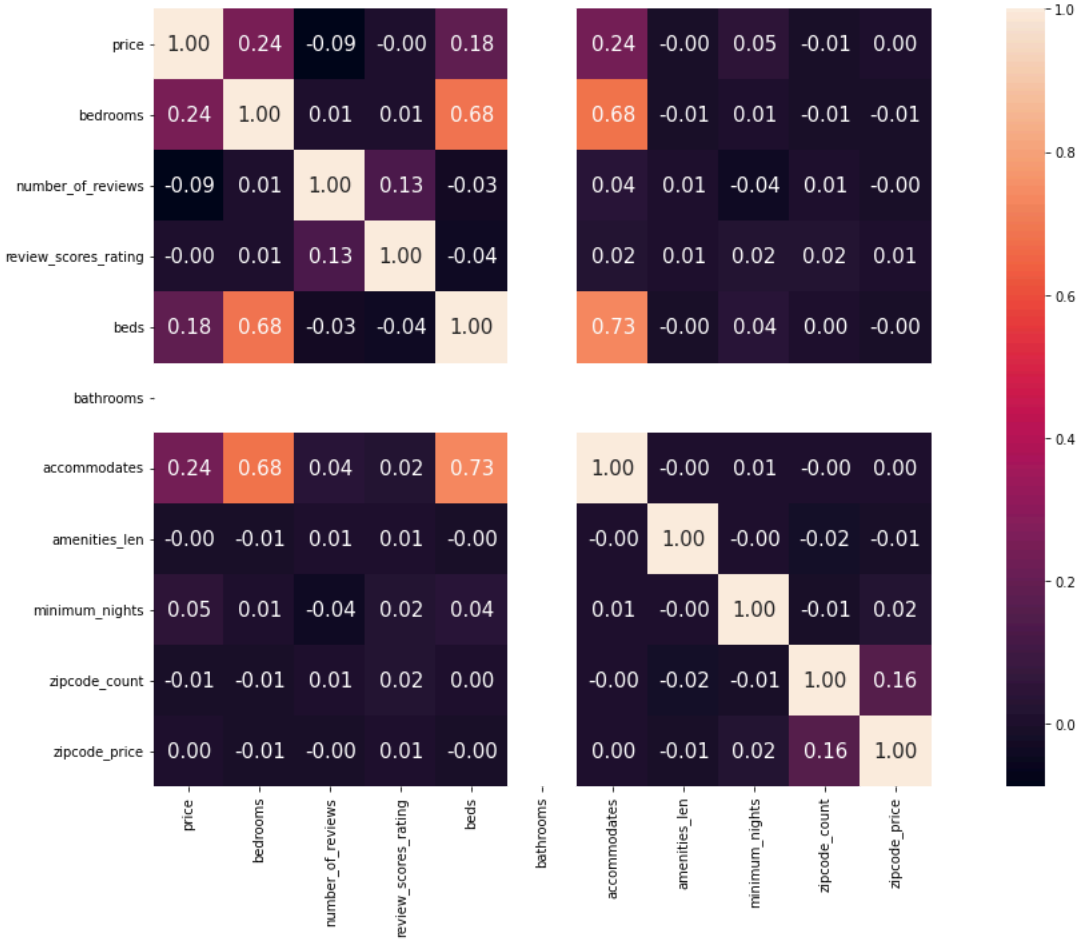
```
plt.figure(figsize = (16,10))
hm = sns.heatmap(cm,
                 cbar=True,
                 annot=True,
                 square=True,
                 fmt='.2f',
                 annot_kws={'size': 15},
                 yticklabels=cols_for_heatmap,
                 xticklabels=cols_for_heatmap)

plt.tight_layout()
plt.savefig('berlin_heatmap.png', dpi=300)
plt.show()
```




```
cm = np.corrcoef(data2[cols_for_heatmap].values.T)
plt.figure(figsize = (16,10))

hm = sns.heatmap(cm,
                 cbar=True,
                 annot=True,
                 square=True,
                 fmt='.2f',
                 annot_kws={'size': 15},
                 yticklabels=cols_for_heatmap,
                 xticklabels=cols_for_heatmap)

plt.tight_layout()
plt.savefig('monachium_heatmap.png', dpi=300)
plt.show()
```


```
cm = np.corrcoef(data3[cols_for_heatmap].values.T)
plt.figure(figsize = (16,10))

hm = sns.heatmap(cm,
                 cbar=True,
                 annot=True,
                 square=True,
                 fmt='.2f',
                 annot_kws={'size': 15},
                 yticklabels=cols_for_heatmap,
                 xticklabels=cols_for_heatmap)

plt.tight_layout()
plt.savefig('praga_heatmap.png', dpi=300)
plt.show()
```

```
invalid value encountered in true_divide
invalid value encountered in true_divide
```



Estimating the coefficient of a regression model via scikit-learn

Perform regression using classic methods -> linear regression and polynomial regression

```
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import PolynomialFeatures
from sklearn.metrics import r2_score
from sklearn.metrics import mean_squared_error
```

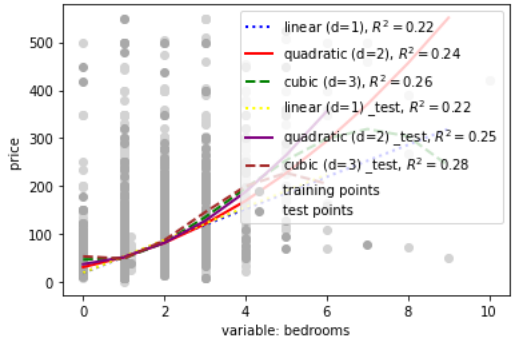
Modeling nonlinear relationships in the Housing Dataset

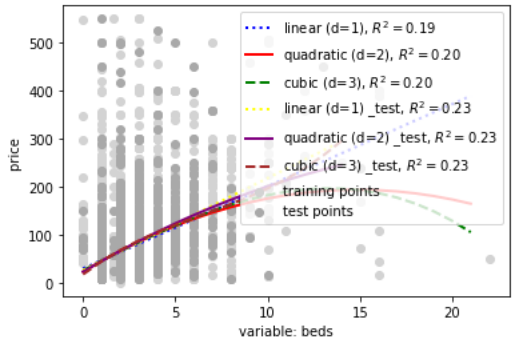
```
results = pd.DataFrame()

cols = [ 'bedrooms', 'beds', 'bathrooms', 'accommodates', 'number_of_reviews','review_scores_rating', 'zipcode_price', 'zipcode_count']

set_of_data =[data, data2]
# set_of_data =[data, data2,data3]
set_of_city = ['berlin', 'monachium']
# set_of_city = ['berlin', 'monachium', 'praga']

city = 'berlin'
j_index = 0
i_index =0
for j in set_of_data:
    print("Processing next city ")
    for i in cols:
        X = j[[i]].values
        y = j['price'].values



        X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)

        regr = LinearRegression()
```

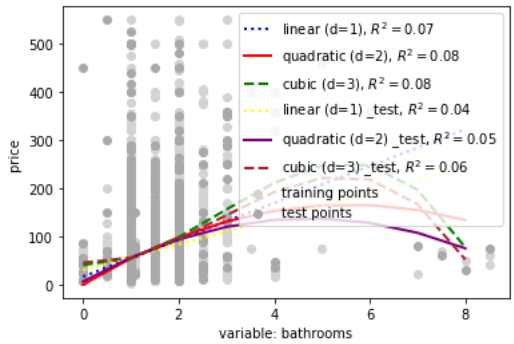
```
# create quadratic features
quadratic = PolynomialFeatures(degree=2)
cubic = PolynomialFeatures(degree=3)
X_quad_train = quadratic.fit_transform(X_train)
X_cubic_train = cubic.fit_transform(X_train)

quadratic = PolynomialFeatures(degree=2)
cubic = PolynomialFeatures(degree=3)
X_quad_test = quadratic.fit_transform(X_test)
X_cubic_test = cubic.fit_transform(X_test)


# fit features
X_fit_train = np.arange(X_train.min(), X_train.max(), 1)[:, np.newaxis]
X_fit_test = np.arange(X_test.min(), X_test.max(), 1)[:, np.newaxis]


regr = regr.fit(X_train, y_train)
y_lin_fit_train = regr.predict(X_fit_train)
y_train_pred = regr.predict(X_train)
linear_r2_train = r2_score(y_train, y_train_pred)
linear_mse_train =  mean_squared_error(y_train, y_train_pred)

regr = regr.fit(X_test, y_test)
y_lin_fit_test = regr.predict(X_fit_test)
y_test_pred = regr.predict(X_test)
linear_r2_test = r2_score(y_test, y_test_pred)
linear_mse_test = mean_squared_error(y_test, y_test_pred)


regr = regr.fit(X_quad_train, y_train)
y_quad_fit_train = regr.predict(quadratic.fit_transform(X_fit_train))
y_train_pred = regr.predict(X_quad_train)
quadratic_r2_train = r2_score(y_train, y_train_pred)
quadratic_mse_train = mean_squared_error(y_train, y_train_pred)

regr = regr.fit(X_quad_test, y_test)
y_quad_fit_test = regr.predict(quadratic.fit_transform(X_fit_test))
y_test_pred = regr.predict(X_quad_test)
quadratic_r2_test = r2_score(y_test, y_test_pred)
quadratic_mse_test = mean_squared_error(y_test, y_test_pred)

regr = regr.fit(X_cubic_train, y_train)
y_cubic_fit_train = regr.predict(cubic.fit_transform(X_fit_train))
y_train_pred = regr.predict(X_cubic_train)
cubic_r2_train = r2_score(y_train, y_train_pred)
cubic_mse_train = mean_squared_error(y_train, y_train_pred)

regr = regr.fit(X_cubic_test, y_test)
y_cubic_fit_test = regr.predict(cubic.fit_transform(X_fit_test))
y_test_pred = regr.predict(X_cubic_test)
cubic_r2_test = r2_score(y_test, y_test_pred)
cubic_mse_test = mean_squared_error(y_test, y_test_pred)


# plot results
plt.scatter(X_train, y_train, label='training points', color='lightgray')
plt.scatter(X_test, y_test, label='test points', color='darkgray')

plt.plot(X_fit_train, y_lin_fit_train,
         label='linear (d=1), $R^2=%.2f$' % linear_r2_train,
         color='blue',
         lw=2,
         linestyle=':')

plt.plot(X_fit_train, y_quad_fit_train,
         label='quadratic (d=2), $R^2=%.2f$' % quadratic_r2_train,
         color='red',
         lw=2,
         linestyle='-')

plt.plot(X_fit_train, y_cubic_fit_train,
         label='cubic (d=3), $R^2=%.2f$' % cubic_r2_train,
         color='green',
         lw=2,
         linestyle='--')

plt.plot(X_fit_test, y_lin_fit_test,
         label='linear (d=1) _test, $R^2=%.2f$' % linear_r2_test,
         color='yellow',
         lw=2,
         linestyle=':')
```

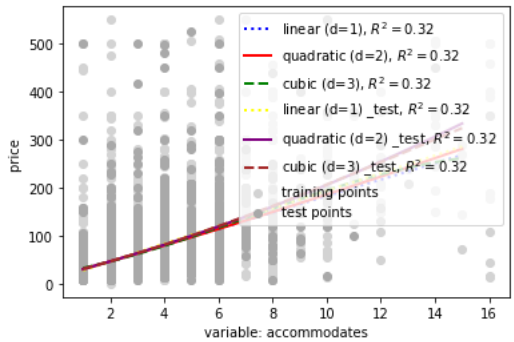
```
            plt.plot(X_fit_test, y_quad_fit_test,
                     label='quadratic (d=2) _test, $R^2=%.2f$' % quadratic_r2_test,
                     color='purple',
                     lw=2,
                     linestyle='-')

            plt.plot(X_fit_test, y_cubic_fit_test,
                     label='cubic (d=3) _test, $R^2=%.2f$' % cubic_r2_test,
                     color='brown',
                     lw=2,
                     linestyle='--')

            plt.xlabel('variable: ' + i)
            plt.ylabel('price ')
            plt.legend(loc='upper right')

            plt.figsize = (50,50)
            plt.title = "test_title"
            #plt.annotate(ha='center', va='bottom', xy=(0,0), size =15)

            #plt.ylim([25.0, 300])
            #plt.figure(figsize=(30,30))

            #plt.savefig('images/10_11.png', dpi=300)
            new_row_train = {'variable':i, 'data': set_of_city[j_index],
                             'linear_r2_train':round(linear_r2_train, 3), 'quadratic_r2_train':round(quadratic_r2_train, 3), 'cubic_r2_train'
                              'linear_mse_train':round(linear_mse_train, 3), 'quadratic_mse_train':round(quadratic_mse_train, 3), 'cubic_mse_
                             'linear_r2_test':round(linear_r2_test, 3), 'quadratic_r2_test':round(quadratic_r2_test, 3), 'cubic_r2_test':roun
                              'linear_mse_test':round(linear_mse_test, 3), 'quadratic_mse_test':round(quadratic_mse_test, 3), 'cubic_mse_test
                            }

            #new_row_test= {'zmienna':i, 'linear_r2':round(linear_r2_test, 3), 'quadratic_r2':round(quadratic_r2_test, 3), 'cubic_r2':round(c

            #print(new_row)
            results= results.append(new_row_train, ignore_index=True)
            #results= results.append(new_row_test, ignore_index=True)
            plt.savefig(f'{set_of_city[j_index]}_{i_index}_{i}.png', dpi=300)
            plt.show()
            i_index += 1
        j_index += 1
        i_index = 0
    print(results)
```

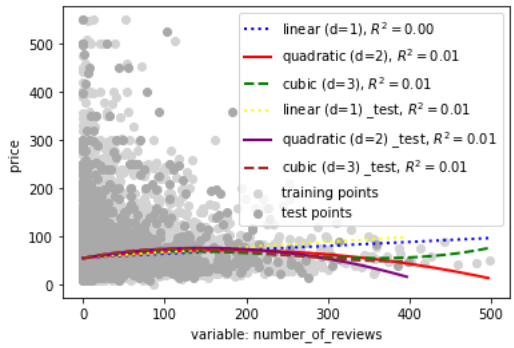
```
Processing next city
```

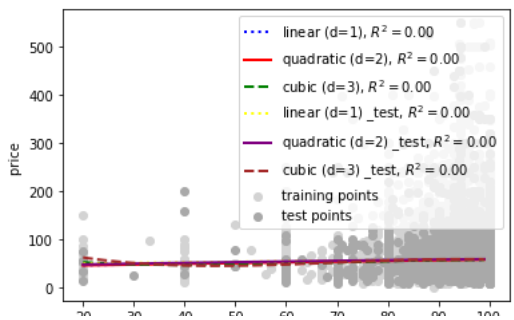


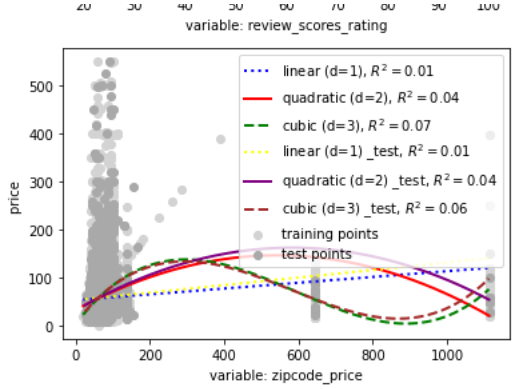


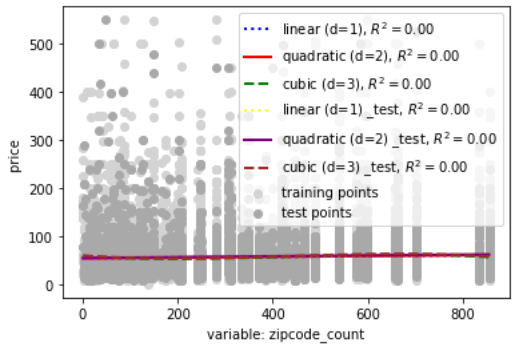




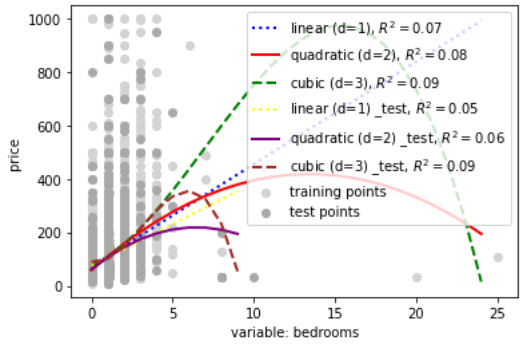


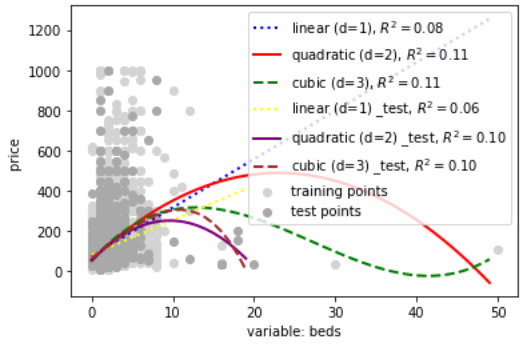


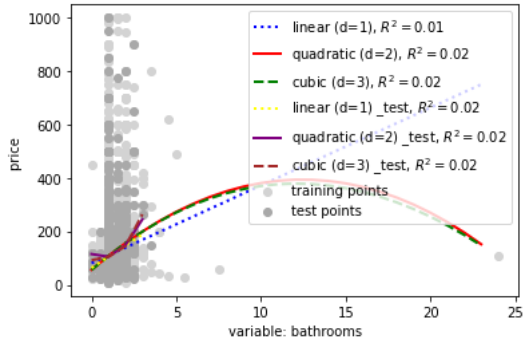


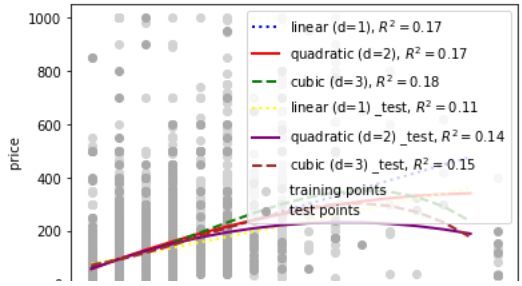


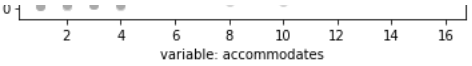

```
Processing next city
```

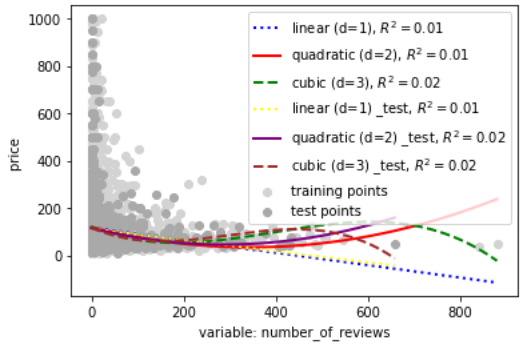


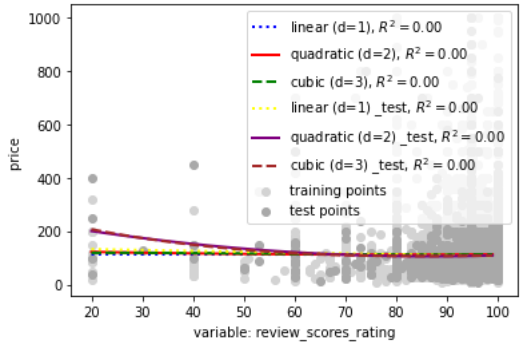


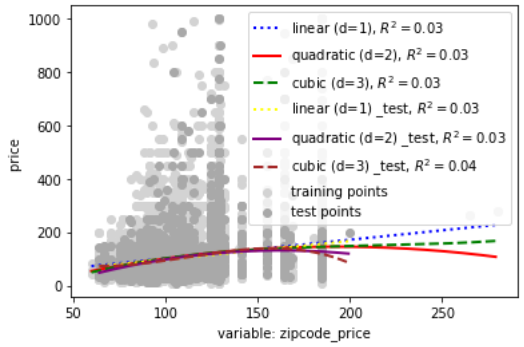


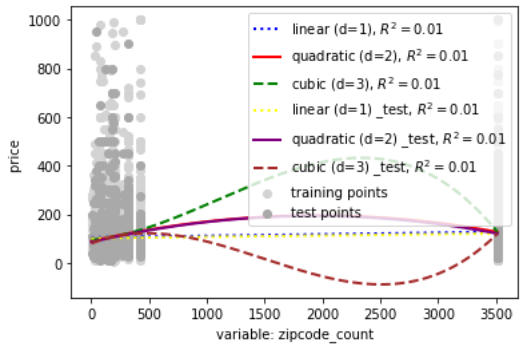












	cubic_mse_test	cubic_mse_train	...	quadratic_r2_train	variable
0	1609.698	1509.888	...	0.235	bedrooms
1	1719.490	1642.957	...	0.198	beds
2	2102.707	1877.084	...	0.078	bathrooms
3	1510.194	1396.725	...	0.317	accommodates
4	2208.443	2032.539	...	0.007	number_of_reviews
5	2235.045	2047.468	...	0.000	review_scores_rating
6	2091.493	1900.925	...	0.036	zipcode_price
7	2227.109	2040.034	...	0.002	zipcode_count
8	8047.125	9661.068	...	0.081	bedrooms
9	7959.417	9475.409	...	0.105	beds
10	8648.659	10421.267	...	0.020	bathrooms
11	7457.556	8688.268	...	0.174	accommodates
12	8651.100	10438.202	...	0.015	number_of_reviews
13	8798.822	10631.396	...	0.000	review_scores_rating
14	8508.041	10333.030	...	0.028	zipcode_price
15	8690.981	10476.602	...	0.014	zipcode_count

[16 rows x 14 columns]

```
data.replace({'host_is_superhost' : {'t' : True, 'f' : False}}, inplace=True)
data2.replace({'host_is_superhost' : {'t' : True, 'f' : False}}, inplace=True)
data3.replace({'host_is_superhost' : {'t' : True, 'f' : False}}, inplace=True)


str = 'bedrooms + beds + bathrooms + accommodates  + number_of_reviews + review_scores_rating + zipcode_price'
s1_1 = 'host_is_superhost + accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price + number_of_reviews + review_scor
s1_2 = 'host_is_superhost + accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price + number_of_reviews'
s1_3 = 'host_is_superhost + accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price'
s1_4 = 'host_is_superhost + accommodates + bedrooms + beds + bathrooms + zipcode_count'
s1_5 = 'host_is_superhost + accommodates + bedrooms + beds + bathrooms'
s1_6 = 'host_is_superhost + accommodates + bedrooms + beds'
s1_7 = 'host_is_superhost + accommodates + bedrooms'
s1_8 = 'host_is_superhost + accommodates'
s1_9 = 'host_is_superhost'

s2_1 = 'accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price + number_of_reviews + review_scores_rating'
s2_2 = 'accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price + number_of_reviews'
s2_3 = 'accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price'
s2_4 = 'accommodates + bedrooms + beds + bathrooms + zipcode_count'
s2_5 = 'accommodates + bedrooms + beds + bathrooms'
s2_6 = 'accommodates + bedrooms + beds'
s2_7 = 'accommodates + bedrooms'
s2_8 = 'accommodates'

s1_1 = 'host_is_superhost  bedrooms + beds + bathrooms + zipcode_count + zipcode_price + number_of_reviews + review_scores_rating'
s1_2 = 'host_is_superhost + accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price + number_of_reviews'
s1_3 = 'host_is_superhost + accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price'
s1_4 = 'host_is_superhost + accommodates + bedrooms + beds + bathrooms + zipcode_count'
s1_5 = 'host_is_superhost + accommodates + bedrooms + beds + bathrooms'
s1_6 = 'host_is_superhost + accommodates + bedrooms + beds'
s1_7 = 'host_is_superhost + accommodates + bedrooms'
s1_8 = 'host_is_superhost + accommodates'
s1_9 = 'host_is_superhost'


s2 = 'accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price + number_of_reviews + review_scores_rating'
s3 = 'accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price'
s3 = 'accommodates + bedrooms + beds + bathrooms + zipcode_price'
s4 = 'accommodates + bedrooms + beds'
s5 = 'accommodates + bedrooms'
s6 = 'bedrooms + beds'
s7 = 'accommodates + beds'
s8 = 'accommodates + zipcode_price'
s9 = 'accommodates + beds + zipcode_price'

tab = [s2, s3, s4, s5, s6, s7, s8, s9]
print(tab)

tab2 = ['accommodates','bedrooms','beds','bathrooms','zipcode_count','zipcode_price','host_is_superhost','number_of_reviews','review_sc
```

```
['accommodates + bedrooms + beds + bathrooms + zipcode_count + zipcode_price + number_of_reviews + review_scores_rating', 'accommoda
```

```
# https://scikit-learn.org/stable/auto_examples/linear_model/plot_lasso_coordinate_descent_path.html#sphx-glr-auto-examples-
# linear-model-plot-lasso-coordinate-descent-path-py

#'host_is_superhost +
with open("Output.txt", "w") as text_file:
    print(f"start", file=text_file)

set_of_data =[data, data2,data3]
set_of_city = ['berlin', 'monachium', 'praga']
city = 'berlin'
j_index = 0
i_index =1
for j in set_of_data:
    for i in tab:
        model = smf.ols('price ~ ' + i, data=j).fit()
        wynik = model.summary()
        print(wynik)
        with open("Output.txt", "a") as text_file:
            print(f"################miasto: {set_of_city[j_index]}", file=text_file)
            print(f"$$$$$$$$$ciąg zmiennych nr:{i_index} {i}", file=text_file)
            print(f"{wynik}", file=text_file)
            print("\n\n")
```

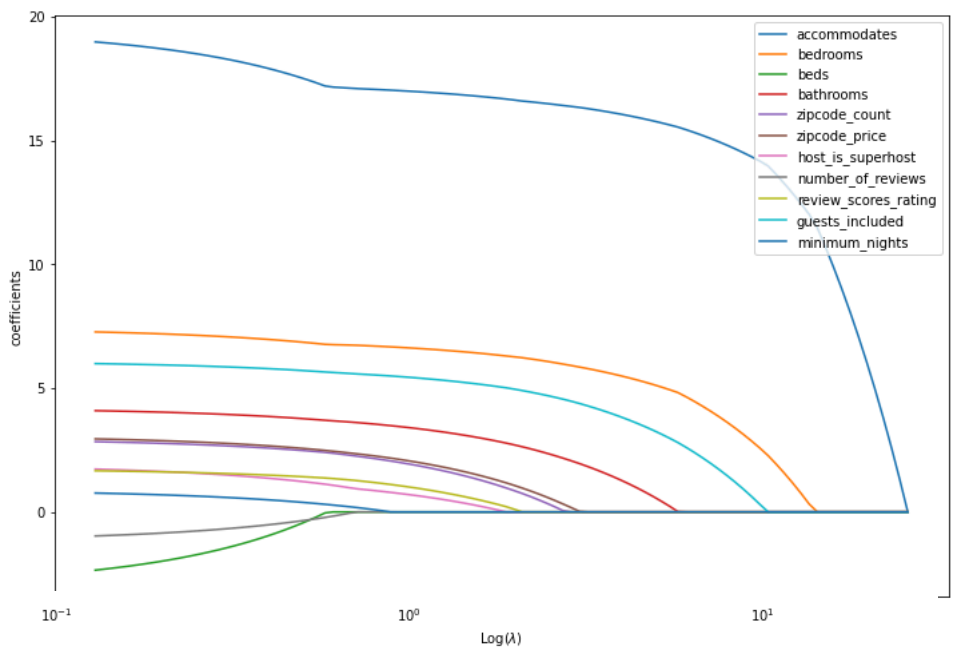
```
        i_index += 1
    j_index += 1
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  price   R-squared:                       0.360
Model:                            OLS   Adj. R-squared:                  0.359
Method:                 Least Squares   F-statistic:                     1577.
Date:                Fri, 21 Jan 2022   Prob (F-statistic):               0.00
Time:                        16:08:51   Log-Likelihood:            -1.1279e+05
No. Observations:               22479   AIC:                         2.256e+05
Df Residuals:                   22470   BIC:                         2.257e+05
Df Model:                           8
Covariance Type:            nonrobust
============================================================================================
                               coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------------------
Intercept                -42.7828      3.526    -12.132      0.000     -49.695     -35.871
accommodates              14.7067      0.283     52.045      0.000      14.153      15.261
bedrooms                  12.4222      0.515     24.127      0.000      11.413      13.431
beds                      -2.2904      0.355     -6.457      0.000      -2.986      -1.595
bathrooms                 13.7462      0.792     17.352      0.000      12.193      15.299
zipcode_count              0.0123      0.001     12.176      0.000       0.010       0.014
zipcode_price              0.0498      0.004     12.826      0.000       0.042       0.057
number_of_reviews         -0.0032      0.007     -0.470      0.639      -0.016       0.010
review_scores_rating       0.3058      0.036      8.552      0.000       0.236       0.376
==============================================================================
Omnibus:                    17436.228   Durbin-Watson:                   1.862
Prob(Omnibus):                  0.000   Jarque-Bera (JB):           726674.790
Skew:                           3.370   Prob(JB):                         0.00
Kurtosis:                      30.026   Cond. No.                     6.58e+03
==============================================================================

Warnings:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 6.58e+03. This might indicate that there are
strong multicollinearity or other numerical problems.
```

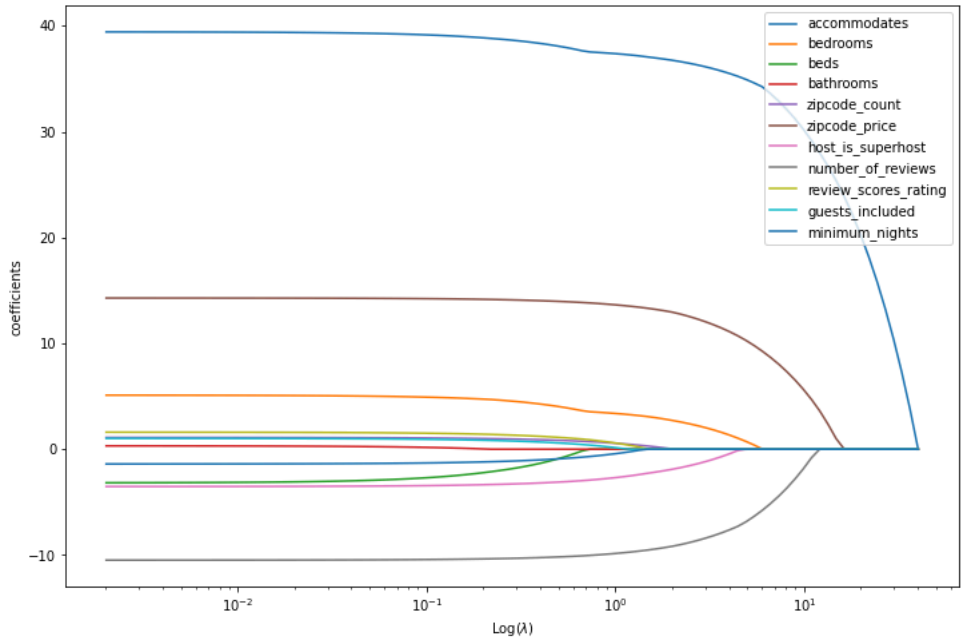
```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  price   R-squared:                       0.353
Model:                            OLS   Adj. R-squared:                  0.353
Method:                 Least Squares   F-statistic:                     2455.
Date:                Fri, 21 Jan 2022   Prob (F-statistic):               0.00
Time:                        16:08:51   Log-Likelihood:            -1.1290e+05
No. Observations:               22479   AIC:                         2.258e+05
Df Residuals:                   22473   BIC:                         2.259e+05
Df Model:                           5
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept     -8.9422      0.932     -9.591      0.000     -10.770      -7.115
accommodates  14.7502      0.282     52.259      0.000      14.197      15.303
bedrooms      12.7158      0.516     24.665      0.000      11.705      13.726
beds          -2.7492      0.355     -7.742      0.000      -3.445      -2.053
bathrooms     13.7580      0.796     17.287      0.000      12.198      15.318
zipcode_price  0.0472      0.004     12.115      0.000       0.040       0.055
==============================================================================
```

```
variables = ['accommodates','bedrooms','beds','bathrooms','zipcode_count','zipcode_price','host_is_superhost','number_of_reviews','revie


data_subset = data.loc[:, variables + ['price']]
data_subset.dropna(inplace=True)

X = data_subset.loc[:,variables]
X = preprocessing.scale(X)
y = np.array(data_subset.price)

alphas_lasso, coefs_lasso, _ = linear_model.lasso_path(X, y, eps=5e-3)

# Display results
plt.figure(figsize = (12,8))

for i in range(X.shape[1]):
    plt.plot(alphas_lasso, coefs_lasso[i], label = variables[i])

plt.xscale('log')
plt.xlabel('Log($\\lambda$)')
plt.ylabel('coefficients')
#plt.title('Lasso paths - Sklearn')
plt.legend()
plt.axis('tight')
```

```
plt.savefig('berlin_lasso.png', dpi=300)
```

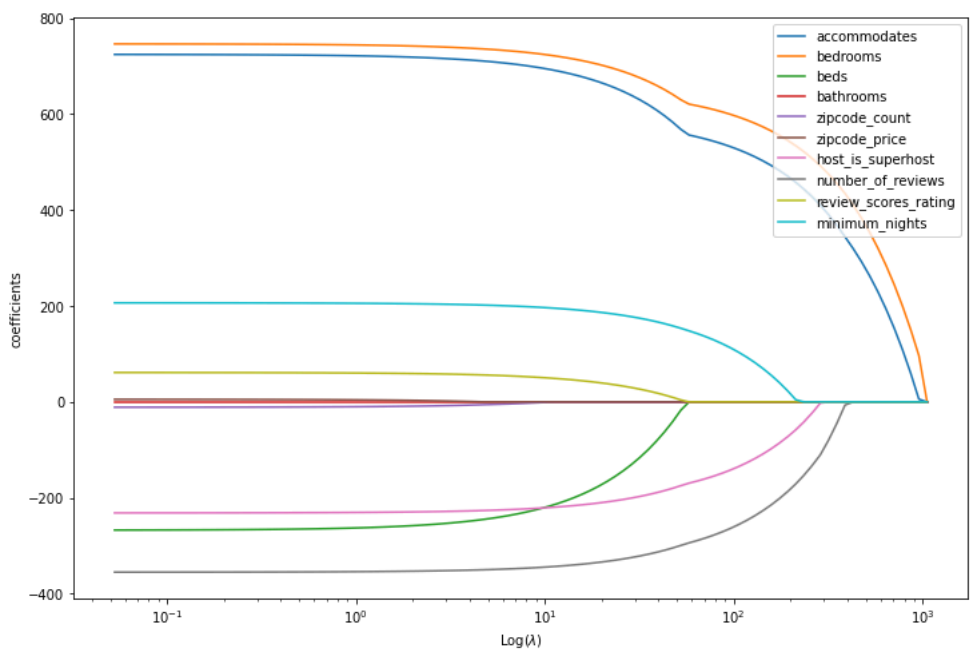



```
variables = ['accommodates','bedrooms','beds','bathrooms','zipcode_count','zipcode_price','host_is_superhost','number_of_reviews','review

data_subset = data2.loc[:, variables + ['price']]
data_subset.dropna(inplace=True)

X = data_subset.loc[:,variables]
X = preprocessing.scale(X)
y = np.array(data_subset.price)

alphas_lasso, coefs_lasso, _ = linear_model.lasso_path(X, y, eps=5e-5)

# Display results
plt.figure(figsize = (12,8))

for i in range(X.shape[1]):
    plt.plot(alphas_lasso, coefs_lasso[i], label = variables[i])

plt.xscale('log')
plt.xlabel('Log($\\lambda$)')
plt.ylabel('coefficients')
#plt.title('Lasso paths - Sklearn')
plt.legend()
plt.axis('tight')

plt.savefig('monachium_lasso.png', dpi=300)
```




```
variables = ['accommodates','bedrooms','beds','bathrooms','zipcode_count','zipcode_price','host_is_superhost','number_of_reviews','revie
```

```
data_subset = data3.loc[:, variables + ['price']]
data_subset.dropna(inplace=True)

X = data_subset.loc[:,variables]
X = preprocessing.scale(X)
y = np.array(data_subset.price)

alphas_lasso, coefs_lasso, _ = linear_model.lasso_path(X, y, eps=5e-5)

# Display results
plt.figure(figsize = (12,8))

for i in range(X.shape[1]):
    plt.plot(alphas_lasso, coefs_lasso[i], label = variables[i])

plt.xscale('log')
plt.xlabel('Log($\\lambda$)')
plt.ylabel('coefficients')
#plt.title('Lasso paths - Sklearn')
plt.legend()
plt.axis('tight')

plt.savefig('praga_lasso.png', dpi=300)
```




```
# XGBoost
```