Exploratory data analysis (EDA) of apartments data

Libraries and settings

In [1]:
```
# Libraries
import os
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import statsmodels.api as sm
import pylab as py

# seaborn graphics settings
sns.set(color_codes=True)

# Ignore warnings
import warnings
warnings.filterwarnings("ignore")

# Show current working directory
print(os.getcwd())
```

```
C:\Users\mmfis\Downloads
```

Univariate non-graphical exploratory data analysis (EDA)

Importing the enriched apartment data

In [2]:
```
# Read and select variables
df_orig = pd.read_csv("apartments_data_enriched.csv")[['web-scraper-order',
                                                       'address_raw',
                                                       'lat',
                                                       'lon',
                                                       'bfs_number',
                                                       'bfs_name',
                                                       'rooms',
                                                       'area',
                                                       'luxurious',
                                                       'price',
                                                       'price_per_m2',
                                                       'pop',
                                                       'pop_dens',
                                                       'emp',
                                                       'frg_pct',
                                                       'mean_taxable_income']]

# Remove duplicates
df_orig = df_orig.drop_duplicates()
df_orig.head(5)

# Remove missing values
```

```
df_orig = df_orig.dropna()
df_orig.head(5)
```

Out[2]:

	web-scraper-order	address_raw	lat	lon	bfs_number	bfs_name	rooms	area	luxuri
0	1693998201-1	Neuhusstrasse 6, 8630 Rüti ZH, ZH	47.252171	8.845797	118	Rüti (ZH)	3.0	49.0	
1	1693998233-172	Widacherstrasse 5, 8630 Rüti ZH, ZH	47.252087	8.854919	118	Rüti (ZH)	3.0	111.0	
2	1693998256-331	Widenweg 14, 8630 Rüti ZH, ZH	47.253670	8.853993	118	Rüti (ZH)	3.0	58.0	
3	1693998265-381	Rain 1, 8630 Rüti ZH, ZH	47.259834	8.851705	118	Rüti (ZH)	4.0	118.0	
4	1693998276-419	Bachtelstrasse 24b, 8630 Rüti ZH, ZH	47.266113	8.866872	118	Rüti (ZH)	3.0	66.0	

Quantiles original values

In [3]:
```
df_orig[['price','rooms', 'area', 'price_per_m2', 'pop_dens']].quantile(q=[0.05, 0.
```

Out[3]:

	price	rooms	area	price_per_m2	pop_dens
0.05	1337.00	1.00	26.00	17.90	336.03
0.10	1492.50	1.50	41.50	20.02	525.66
0.25	1842.25	2.50	63.00	23.30	1044.63
0.50	2391.00	3.50	86.00	27.95	1662.60
0.75	3056.75	4.50	108.75	38.12	4778.99
0.90	3960.00	4.75	140.50	52.78	4778.99
0.95	4957.50	5.50	163.75	67.33	4778.99

Filter apartments

In [4]:
```
# Filter apartments (replace '<= 5000' by the respective operator and quantile)
df = df_orig.loc[df_orig['pop_dens'] <= 5000]
```

Shape (number of rows and colums)

In [5]:
```
# Number of rows and columns
print(df.shape)
```

```
(786, 16)
```

Data types

In [6]:
```
df.dtypes
```

Out[6]:
```
web-scraper-order       object
address_raw             object
lat                    float64
lon                    float64
bfs_number               int64
bfs_name                object
rooms                  float64
area                   float64
luxurious                int64
price                  float64
price_per_m2           float64
pop                      int64
pop_dens               float64
emp                    float64
frg_pct                float64
mean_taxable_income    float64
dtype: object
```

Summary statistics of numeric variables

In [7]:
```
df.describe()
```

Out[7]:

	lat	lon	bfs_number	rooms	area	luxurious	price	pric
count	786.000000	786.000000	786.000000	786.000000	786.000000	786.000000	786.000000	7
mean	47.407331	8.600386	186.862595	3.421756	92.426209	0.012723	2649.339695	
std	0.085343	0.117298	81.404652	1.304543	75.786527	0.112146	1289.074423	
min	47.195290	8.367652	1.000000	1.000000	8.000000	0.000000	10.000000	
25%	47.361061	8.518511	121.000000	2.500000	63.000000	0.000000	1842.250000	
50%	47.395105	8.562069	230.000000	3.500000	86.000000	0.000000	2391.000000	
75%	47.481115	8.710458	261.000000	4.500000	108.750000	0.000000	3056.750000	
max	47.693893	8.915933	298.000000	8.500000	1633.000000	1.000000	9950.000000	1

Statistical measures (min, max, std, mean, median, count) for selected variables

In [8]:
```
# Price
print('Price:',
      'Count:', round(df.price.count(), 1),
      'Min:', round(df.price.min(), 1),
      'Max:', round(df.price.max(), 1),
      'Mean:', round(df.price.mean(), 1),
      'Median:', round(df.price.median(), 1),
      'Std:', round(df.price.std(), 1))

# Area
print('Area:',
      'Count:', round(df.area.count(), 1),
      'Min:', round(df.area.min(), 1),
      'Max:', round(df.area.max(), 1),
      'Mean:', round(df.area.mean(), 1),
```

```
      'Median:', round(df.area.median(), 1),
      'Std:', round(df.area.std(), 1))
```

```
Price: Count: 786 Min: 10.0 Max: 9950.0 Mean: 2649.3 Median: 2391.0 Std: 1289.1
Area: Count: 786 Min: 8.0 Max: 1633.0 Mean: 92.4 Median: 86.0 Std: 75.8
```

Skewness

In [9]:
```
df[['price','rooms', 'area']].skew()
```

Out[9]:
```
price     2.093405
rooms     0.209733
area     12.529695
dtype: float64
```

Kurtosis

In [10]:
```
df[['price','rooms', 'area']].kurtosis()
```

Out[10]:
```
price      6.668070
rooms      0.085123
area     232.607355
dtype: float64
```

Extreme values

In [11]:
```
# Low costs apartments
df[df['price_per_m2'] <= 10]
```

Out[11]:

	web-scraper-order	address_raw	lat	lon	bfs_number	bfs_name	rooms	area
183	1693998317-653	8001 Zürich, ZH	47.374966	8.543989	261	Zürich	4.5	137.0
198	1693998326-702	Hohenbühlstrasse 7, 8032 Zürich, ZH	47.366306	8.551867	261	Zürich	5.5	183.0
404	1693998205-39	Binzigerstrasse 52, 8707 Uetikon am See, ZH	47.267185	8.689932	159	Uetikon am See	6.5	300.0
511	1693998369-926	Dorfstrasse 2, 8309 Nürensdorf, ZH	47.458389	8.638629	64	Nürensdorf	6.5	863.0
584	1693998289-482	Lärchenstrasse 6, 8442 Hettlingen, ZH	47.547836	8.717198	221	Hettlingen	6.0	1633.0
762	1693998280-447	Grabenwiese 2, 8484 Weisslingen, ZH	47.426781	8.767586	180	Weisslingen	6.5	585.0

In [12]:
```
# Very expansive apartments
df[df['price_per_m2'] >= 100]
```

Out[12]:

	web-scraper-order	address_raw	lat	lon	bfs_number	bfs_name	rooms	area	luxurio
11	1693998201-16	Wolframplatz 1, 8045 Zürich, ZH	47.362282	8.522193	261	Zürich	2.0	32.0	
20	1693998214-82	Baurstrasse 29, 8008 Zürich, ZH	47.355923	8.554498	261	Zürich	1.5	30.0	
21	1693998214-83	Baurstrasse 29, 8008 Zürich, ZH	47.355923	8.554498	261	Zürich	1.5	25.0	
107	1693998280-434	Neugasse 40, 8005 Zürich, ZH	47.382469	8.530180	261	Zürich	1.0	11.0	
154	1693998305-585	Steinstrasse 35, 8003 Zürich, ZH	47.366997	8.520324	261	Zürich	1.0	15.0	
171	1693998309-621	Baurstrasse 29, 8008 Zürich, ZH	47.355923	8.554498	261	Zürich	1.5	30.0	
185	1693998317-658	8004 Zürich, ZH	47.380417	8.525352	261	Zürich	1.0	10.0	

Get a list of categories of categorical variable

In [13]:
```
np.array(pd.Categorical(df['bfs_name']).categories)
```

Out[13]:
```
array(['Adliswil', 'Aeugst am Albis', 'Affoltern am Albis', 'Altikon',
       'Andelfingen', 'Bachenbülach', 'Bassersdorf', 'Bauma',
       'Bonstetten', 'Brütten', 'Bülach', 'Dielsdorf', 'Dietikon',
       'Dietlikon', 'Dättlikon', 'Dübendorf', 'Dürnten', 'Egg', 'Eglisau',
       'Elsau', 'Embrach', 'Fehraltorf', 'Feuerthalen',
       'Freienstein-Teufen', 'Fällanden', 'Glattfelden', 'Gossau (ZH)',
       'Greifensee', 'Hausen am Albis', 'Hedingen', 'Herrliberg',
       'Hettlingen', 'Hinwil', 'Hittnau', 'Hochfelden', 'Hombrechtikon',
       'Höri', 'Hüttikon', 'Kloten', 'Knonau', 'Küsnacht (ZH)',
       'Langnau am Albis', 'Laufen-Uhwiesen', 'Lindau', 'Lufingen',
       'Maur', 'Meilen', 'Mettmenstetten', 'Männedorf', 'Mönchaltorf',
       'Neerach', 'Neftenbach', 'Niederglatt', 'Niederhasli',
       'Niederweningen', 'Nürensdorf', 'Oberengstringen', 'Oberglatt',
       'Obfelden', 'Oetwil am See', 'Oetwil an der Limmat', 'Opfikon',
       'Ossingen', 'Pfungen', 'Pfäffikon', 'Regensdorf', 'Rheinau',
       'Richterswil', 'Rickenbach (ZH)', 'Rorbas', 'Russikon', 'Rümlang',
       'Rüschlikon', 'Rüti (ZH)', 'Schlatt (ZH)', 'Schlieren',
       'Schwerzenbach', 'Seuzach', 'Stadel', 'Stallikon', 'Steinmaur',
       'Stäfa', 'Thalwil', 'Trüllikon', 'Uetikon am See', 'Uitikon',
       'Urdorf', 'Uster', 'Volketswil', 'Wald (ZH)', 'Wallisellen',
       'Wangen-Brüttisellen', 'Weiach', 'Weiningen (ZH)', 'Weisslingen',
       'Wettswil am Albis', 'Wetzikon (ZH)', 'Wiesendangen', 'Wila',
       'Winkel', 'Winterthur', 'Zell (ZH)', 'Zollikon', 'Zürich'],
      dtype=object)
```

Multivariate non-graphical exploratory data analysis (EDA)

Cross-tabulation

In [14]:
```
pd.crosstab(df['luxurious'], df['rooms'])
```

Out[14]:

rooms	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.5
luxurious															
0	52	36	39	135	44	200	28	164	3	53	3	13	2	3	1
1	0	0	0	6	0	3	0	0	0	0	0	1	0	0	0

Pivot tables

In [15]:
```
# Using pivot_table to reshape the data and calculate means
pd.pivot_table(df[['rooms', 'price', 'price_per_m2', 'area', 'luxurious']],
               index=['rooms', 'luxurious'],
               values=['price', 'price_per_m2', 'area'],
               aggfunc=(np.mean, 'count'))
```

Out[15]:

		area		price		price_per_m2	
		count	mean	count	mean	count	mean
rooms	luxurious						
1.0	0	52	32.057692	52	1306.346154	52	50.168077
1.5	0	36	35.333333	36	2110.166667	36	65.455000
2.0	0	39	54.589744	39	2155.846154	39	42.528462
2.5	0	135	66.800000	135	2382.755556	135	37.010000
	1	6	72.166667	6	3339.500000	6	45.978333
3.0	0	44	68.159091	44	1964.022727	44	28.677955
3.5	0	200	89.770000	200	2648.980000	200	29.494700
	1	3	101.666667	3	6036.666667	3	59.826667
4.0	0	28	98.464286	28	2852.357143	28	29.646429
4.5	0	164	115.060976	164	3067.847561	164	26.332622
5.0	0	3	108.000000	3	2881.666667	3	26.376667
5.5	0	53	153.811321	53	3523.094340	53	23.143396
6.0	0	3	667.666667	3	3833.333333	3	15.706667
6.5	0	13	253.000000	13	4077.461538	13	21.676154
	1	1	300.000000	1	11.000000	1	0.040000
7.0	0	2	175.000000	2	6350.000000	2	36.325000
7.5	0	3	205.000000	3	4765.000000	3	23.273333
8.5	0	1	210.000000	1	8500.000000	1	40.480000

Correlation matrix

In [16]:
```
corr = df[['rooms',
           'area',
           'price',
           'price_per_m2',
           'pop_dens',
           'frg_pct']].cov().corr()
corr
```

Out[16]:

	rooms	area	price	price_per_m2	pop_dens	frg_pct
rooms	1.000000	0.994278	0.489308	-0.529276	-0.635035	-0.717159
area	0.994278	1.000000	0.554403	-0.460172	-0.569562	-0.657421
price	0.489308	0.554403	1.000000	0.480956	0.362619	0.256582
price_per_m2	-0.529276	-0.460172	0.480956	1.000000	0.991165	0.970554
pop_dens	-0.635035	-0.569562	0.362619	0.991165	1.000000	0.993760
frg_pct	-0.717159	-0.657421	0.256582	0.970554	0.993760	1.000000

Covariance matrix

In [17]:
```
cov = df[['rooms',
          'area',
          'price',
          'price_per_m2',
          'pop_dens',
          'frg_pct']].cov()
cov
```

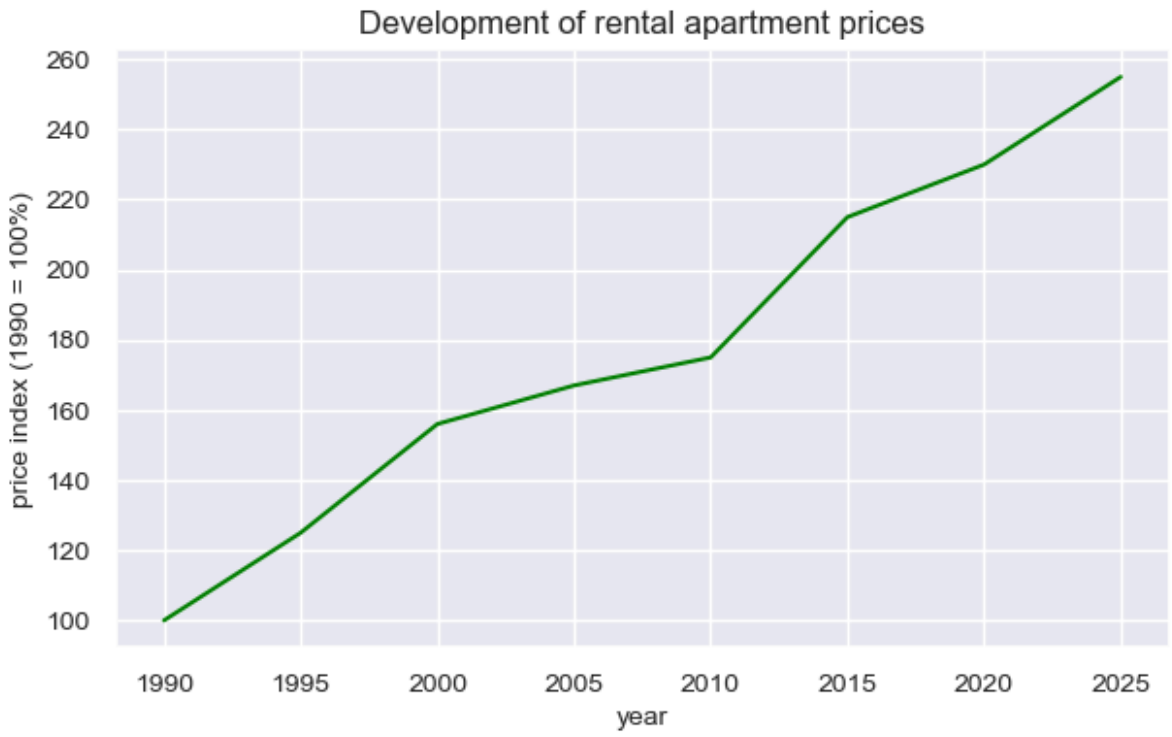
Out[17]:

	rooms	area	price	price_per_m2	pop_dens	frg_pct
rooms	1.701832	53.983072	7.535699e+02	-10.918122	-7.421349e+02	-2.844866
area	53.983072	5743.597733	3.395904e+04	-432.361623	-2.592857e+04	-138.172149
price	753.569925	33959.041022	1.661713e+06	5774.838303	6.157488e+05	794.060532
price_per_m2	-10.918122	-432.361623	5.774838e+03	293.839203	1.750019e+04	43.945653
pop_dens	-742.134930	-25928.569102	6.157488e+05	17500.189962	3.055641e+06	8736.395054
frg_pct	-2.844866	-138.172149	7.940605e+02	43.945653	8.736395e+03	57.638648

Univariate graphical exploratory data analysis (EDA)

Line chart (matplotlib)

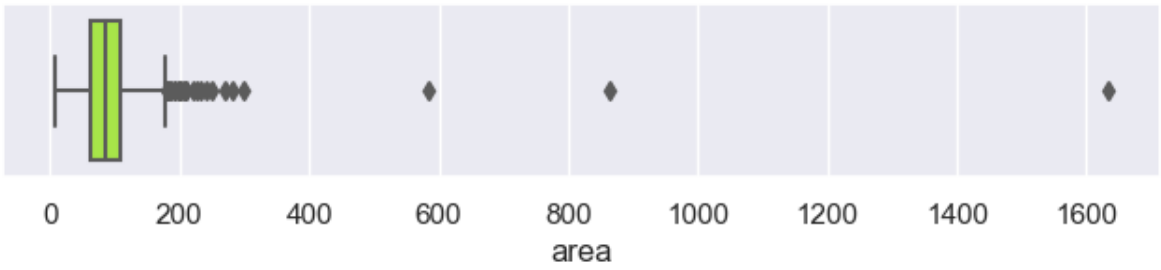
In [18]:
```
# Generate some useful values (time series)
x = [1990, 1995, 2000, 2005, 2010, 2015, 2020, 2025]
y = [100, 125, 156, 167, 175, 215, 230, 255]

# Create figure
fig = plt.figure(figsize=(7,4))
plt.plot(x, y, color="green")
plt.title('Development of rental apartment prices', fontsize=12)
plt.xlabel('year', fontsize=10)
plt.ylabel('price index (1990 = 100%)', fontsize=10)
plt.xticks(fontsize=10)
plt.yticks(fontsize=10)

plt.show()
```



Boxplot (seaborn)

In [19]:
```
plt.figure(figsize=(8,1.2))
plt.ticklabel_format(style='plain')
sns.boxplot(x=df['area'], color="greenyellow")
```

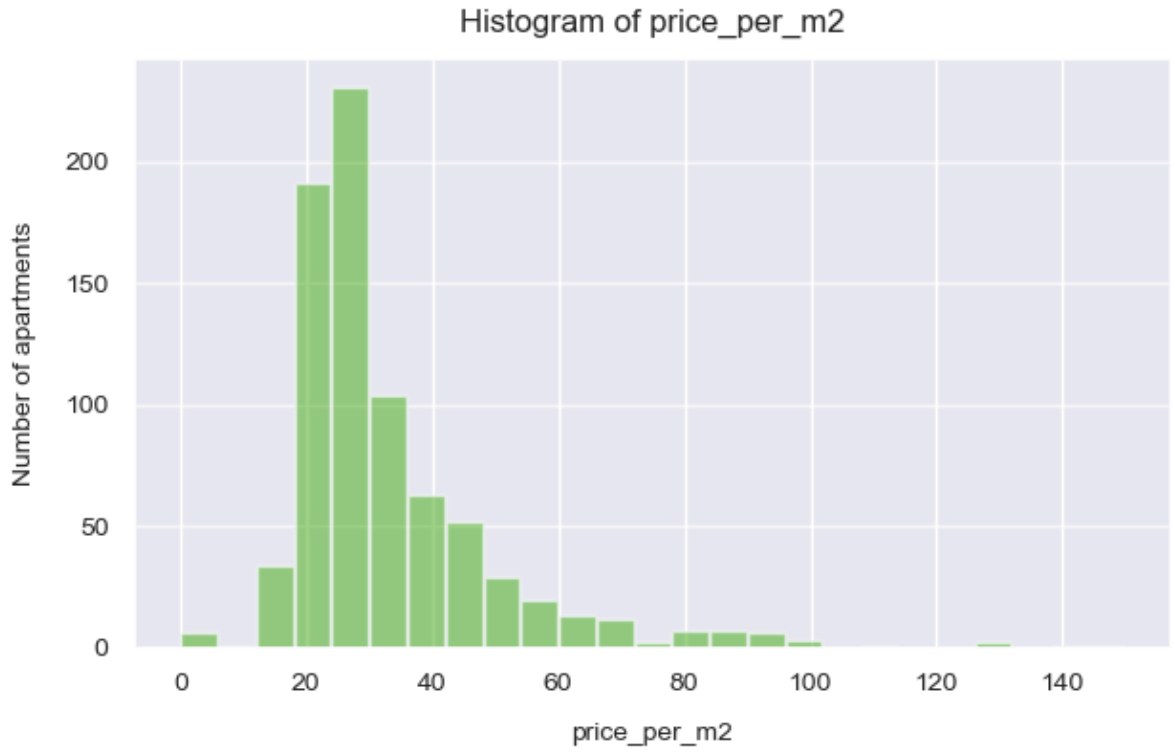
Out[19]:
```
<Axes: xlabel='area'>
```



Histogram (matplotlib)

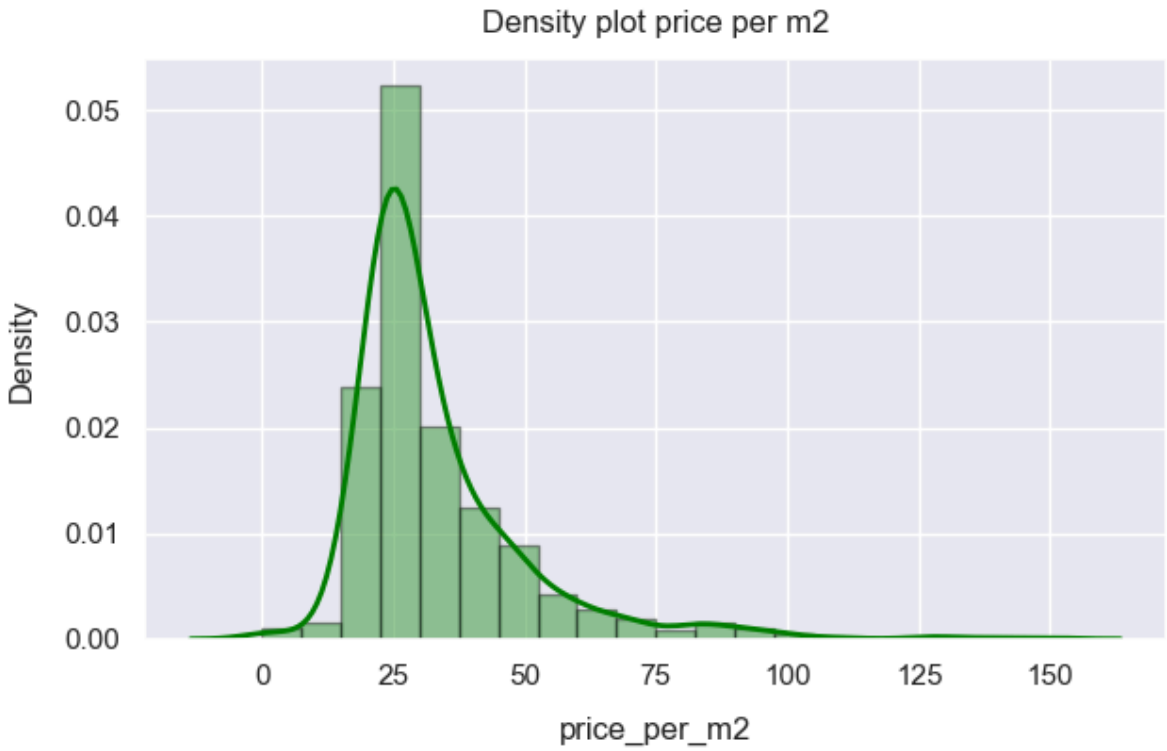
In [20]:
```
import matplotlib.pyplot as plt
import numpy as np

# Plot Histogram
fig = plt.figure( figsize=(7,4))

plt.xticks(fontsize=14, rotation=0)
plt.yticks(fontsize=14, rotation=0)

n, bins, patches = plt.hist(x=df['price_per_m2'],
                            bins=25,
                            color='#42AD12',
                            alpha=0.5,
                            rwidth=0.95
                    )
plt.grid(True)
plt.ticklabel_format(style='plain')
```

```
plt.grid(axis='y', alpha=0.75)

# Set labels
plt.xlabel('price_per_m2', fontsize=10, labelpad=10)
plt.ylabel('Number of apartments', fontsize=10, labelpad=10)
plt.title('Histogram of price_per_m2', fontsize=12, pad=10)

# Set fontsize of tick labels
plt.xticks(fontsize = 10)
plt.yticks(fontsize = 10)

plt.show()
```



Density plot (seaborn)

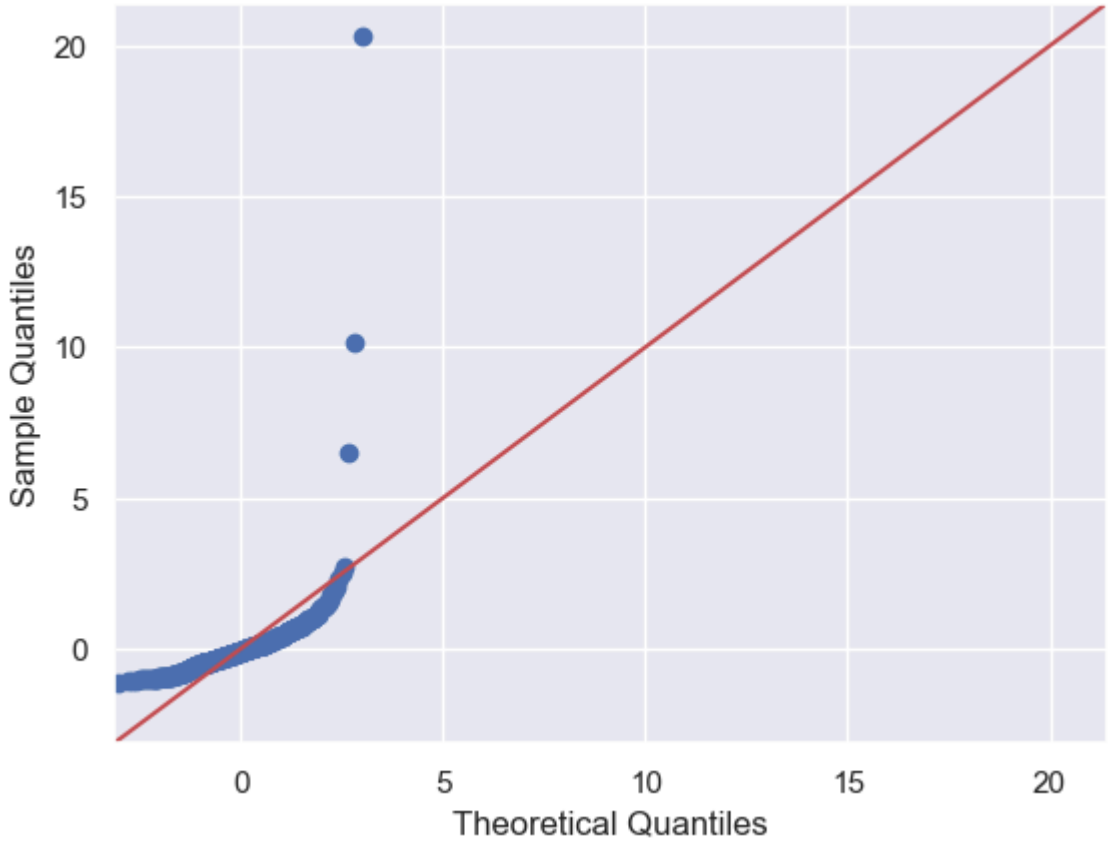
In [21]:
```
plt.figure(figsize=(7,4))
sns.distplot(df['price_per_m2'],
             hist=True,
             kde=True,
             bins=20,
             color = 'green',
             hist_kws={'edgecolor':'black'},
             kde_kws={'linewidth': 2},
            )
plt.title('Density plot price per m2', fontsize=12, pad=10)
plt.xlabel('price_per_m2', fontsize=12, labelpad=10)
plt.ylabel('Density', fontsize=12, labelpad=10)
plt.grid(True)
plt.show()
```



Quantile-Quantile (QQ-) plot

In [22]:
```
# Variable (standardized)
x = 'area'
df_qq = df
df_qq['var'] = (df[x]-df[x].mean()) / df[x].std()
print(df_qq.sort_values('var')[['area', 'var']])

# Plot
sm.qqplot(df_qq['var'], line ='45')
py.show()
```

```
       area        var
682     8.0  -1.114000
185    10.0  -1.087610
107    11.0  -1.074415
190    14.0  -1.034830
52     15.0  -1.021636
..      ...        ...
445   282.0   2.501418
404   300.0   2.738927
762   585.0   6.499490
511   863.0  10.167688
584  1633.0  20.327806

[786 rows x 2 columns]
```

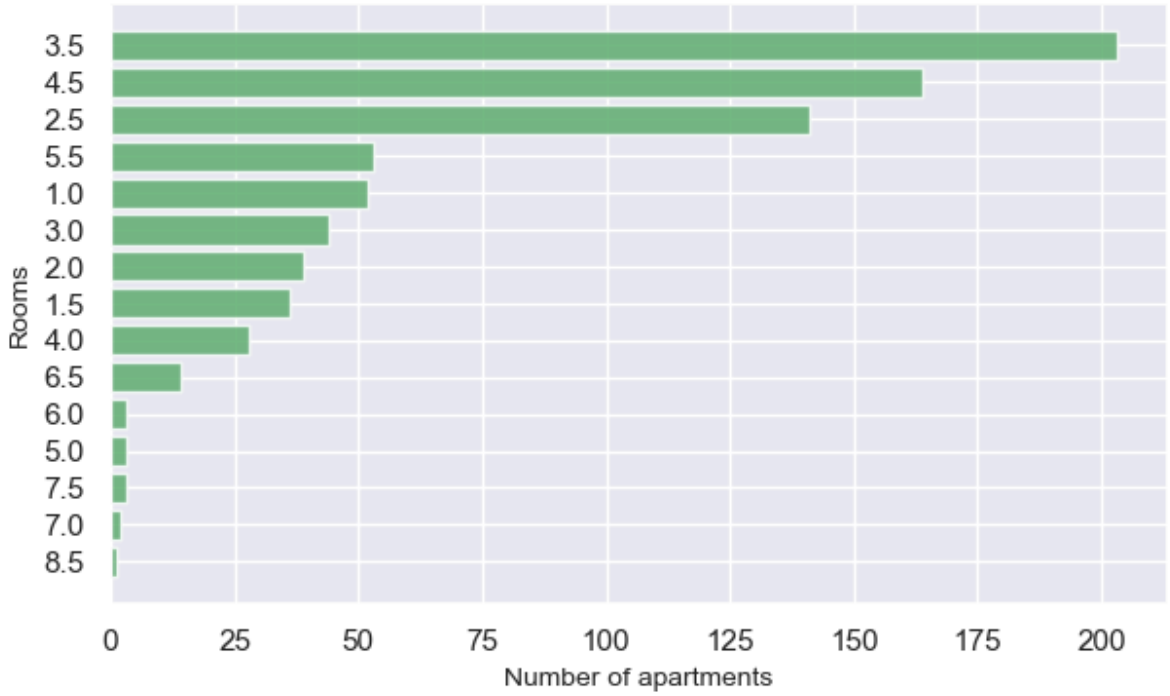


Barchart (matplotlib)

In [23]:
```
# Group data by rooms (only the topmost 15 values are shown)
df_bar = df['rooms'].value_counts().nlargest(15).sort_values(ascending=True)

# Values for barchart
napart = list(df_bar.values)
index = list(df_bar.index.values)
index
```

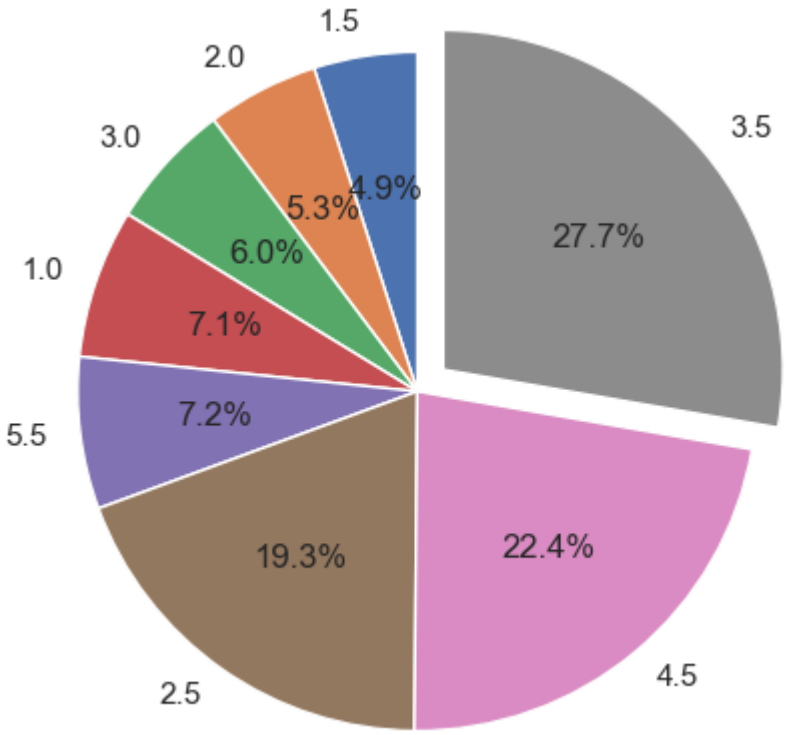
Out[23]:
```
[8.5, 7.0, 7.5, 5.0, 6.0, 6.5, 4.0, 1.5, 2.0, 3.0, 1.0, 5.5, 2.5, 4.5, 3.5]
```

In [24]:
```
# Group data by rooms (only the topmost 15 values are shown)
df_bar = df['rooms'].value_counts().nlargest(15).sort_values(ascending=True)

# Values for barchart
napart = list(df_bar.values)
index = list(df_bar.index.values)
y_pos = np.arange(len(index))

# Figure
fig, ax = plt.subplots(figsize=(7,4))
ax.barh(y_pos, napart, align='center', color='g', alpha=0.8)
ax.set_yticks(y_pos, index)
ax.set_xlabel('Number of apartments', fontsize=10)
ax.set_ylabel('Rooms', fontsize=10)

# Show graph
plt.show()
```



Piechart (matplotlib)

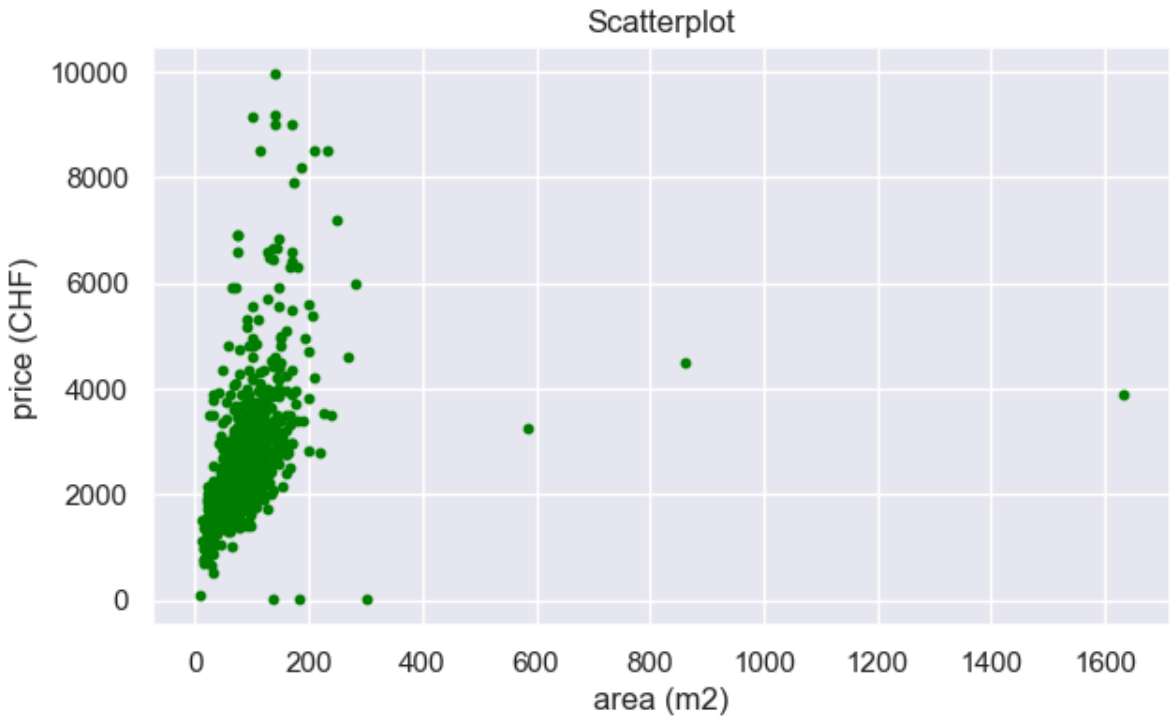
In [25]:
```
# Group data by rooms (only the 8 most frequently occurencies by rooms)
df_bar = df.rooms.value_counts().nlargest(8).sort_values(ascending=True)

# Simple bar chart
sizes = list(df_bar.values)
labels = list(df_bar.index.values)
explode = (0, 0, 0, 0, 0.0, 0, 0, 0.1) # increases distance of pieces

fig1, ax1 = plt.subplots(figsize=(5,5))
ax1.pie(sizes,
        labels=labels,
        explode=explode,
        autopct='%1.1f%%',
        shadow=False,
        startangle=90)
ax1.axis('equal')  # ensures that pie is drawn as a circle.

plt.show()
```



Multivariate graphical exploratory data analysis (EDA)

Scatterplot (matplotlib)

In [26]:
```
plt.figure(figsize=(7,4))
plt.scatter(df['area'],
            df['price'],
            color="green",
            alpha=1.0,
            s=10)
plt.title('Scatterplot', fontsize=12)
plt.xlabel('area (m2)')
plt.ylabel('price (CHF)')
plt.show()
```

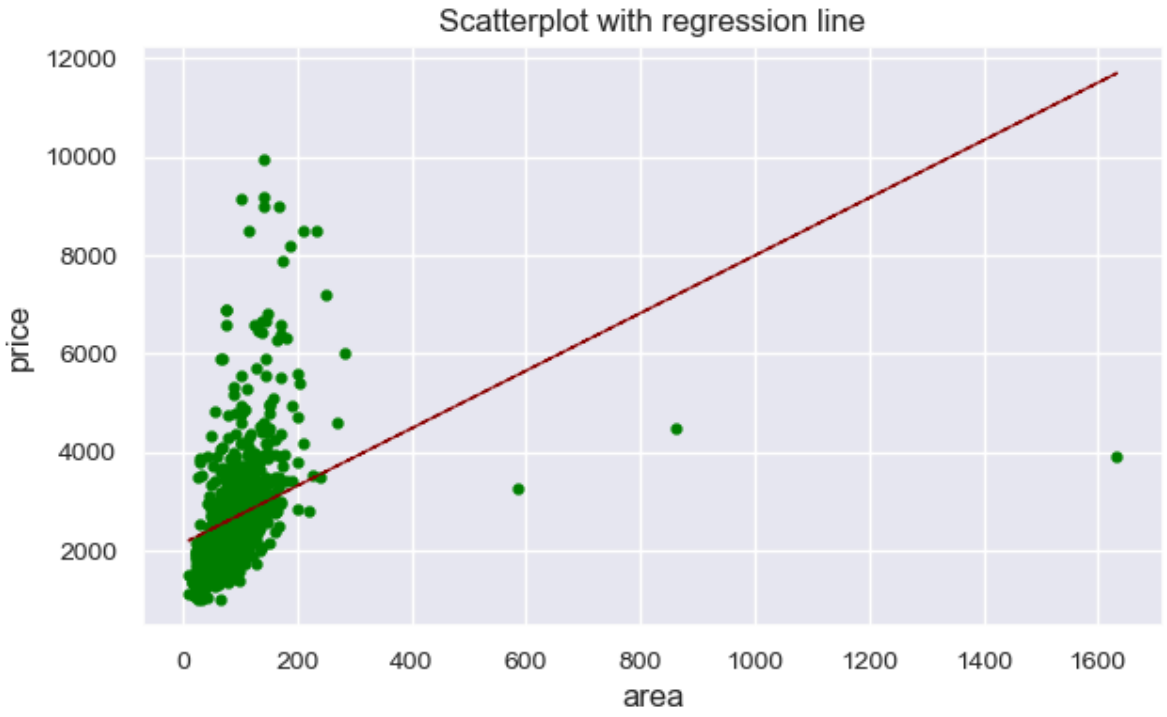


Scatterplot (matplotlib) with regression line

In [27]:

```
# Subset
df_sub = df.loc[(df.price >= 1000)]
print(df_sub.shape)

# Scatterplot
plt.figure(figsize=(7,4))
plt.plot(df_sub.area,
         df_sub.price,
         'o',
         markersize=3.5,
         color="green")

# Regression line (b = slope, a=intercept)
b, a = np.polyfit(df_sub.area, df_sub.price, 1)
print(b)
print(a)

# Plot regression line
plt.plot(df_sub.area,
         b*df_sub.area + a,
         linewidth=1,
         linestyle='dashed',
         color='darkred')

# Add title and axes labels
plt.title('Scatterplot with regression line', fontsize=12)
plt.ylabel('price', fontsize=12)
plt.xlabel('area', fontsize=12)

# Set fontsize of tick labels
plt.xticks(fontsize = 10)
plt.yticks(fontsize = 10)

plt.show()
```

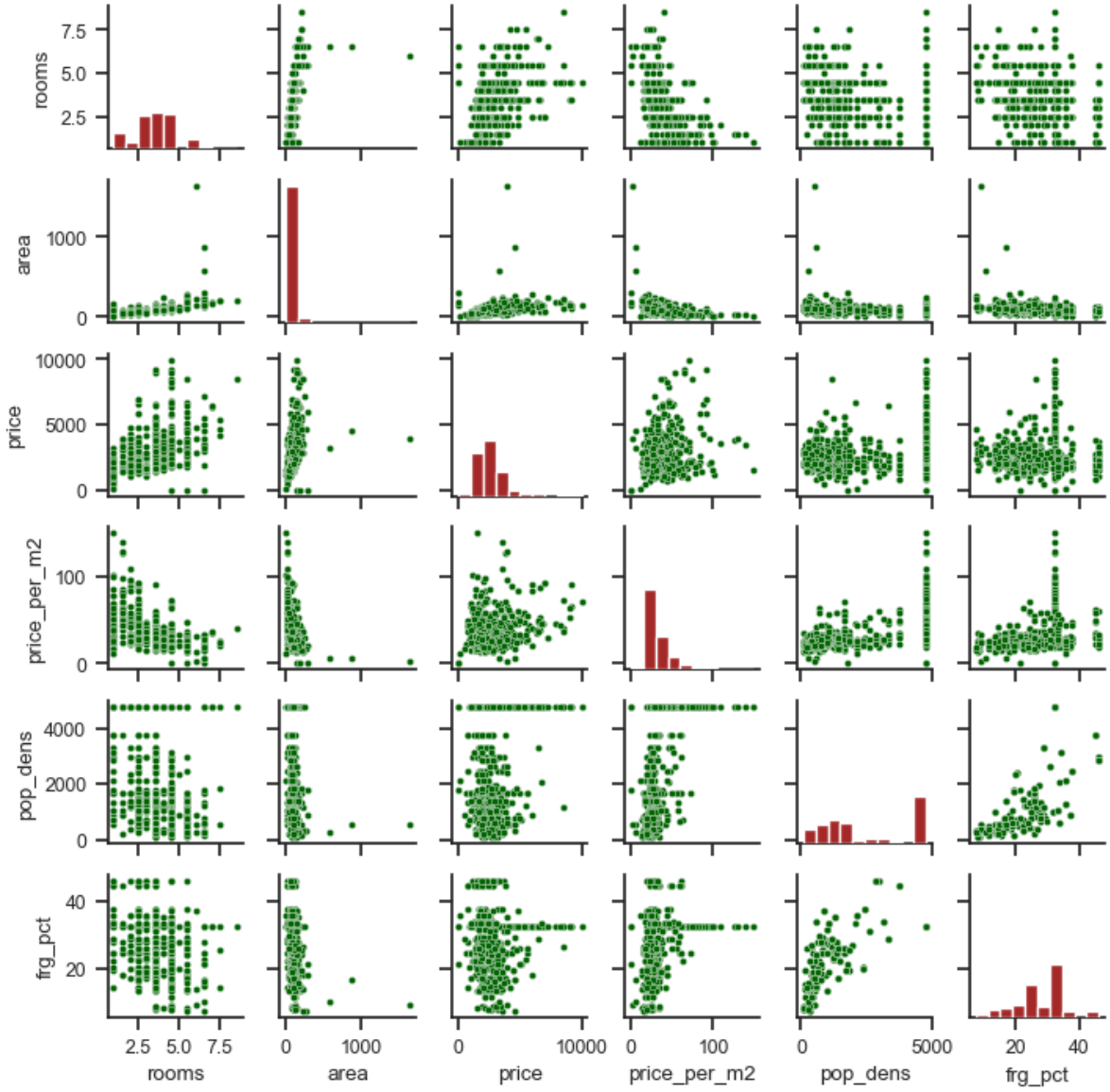
```
(769, 17)
5.842687833767073
2149.0487159317886
```



Scatterplot-matrix (seaborn)

In [28]:
```
sns.set(style="ticks", font_scale=0.8)
g = sns.PairGrid(df[['rooms',
                     'area',
                     'price',
                     'price_per_m2',
                     'pop_dens',
                     'frg_pct']],
                 height=1.2,
                 aspect=1)
g.map_upper(sns.scatterplot,color='darkgreen', s=10)
g.map_lower(sns.scatterplot, color='darkgreen', s=10)
g.map_diag(plt.hist, color='brown')
```

Out[28]:
```
<seaborn.axisgrid.PairGrid at 0x1d0382c7a50>
```



Hexagonal binning plot (matplotlib)

In [29]:

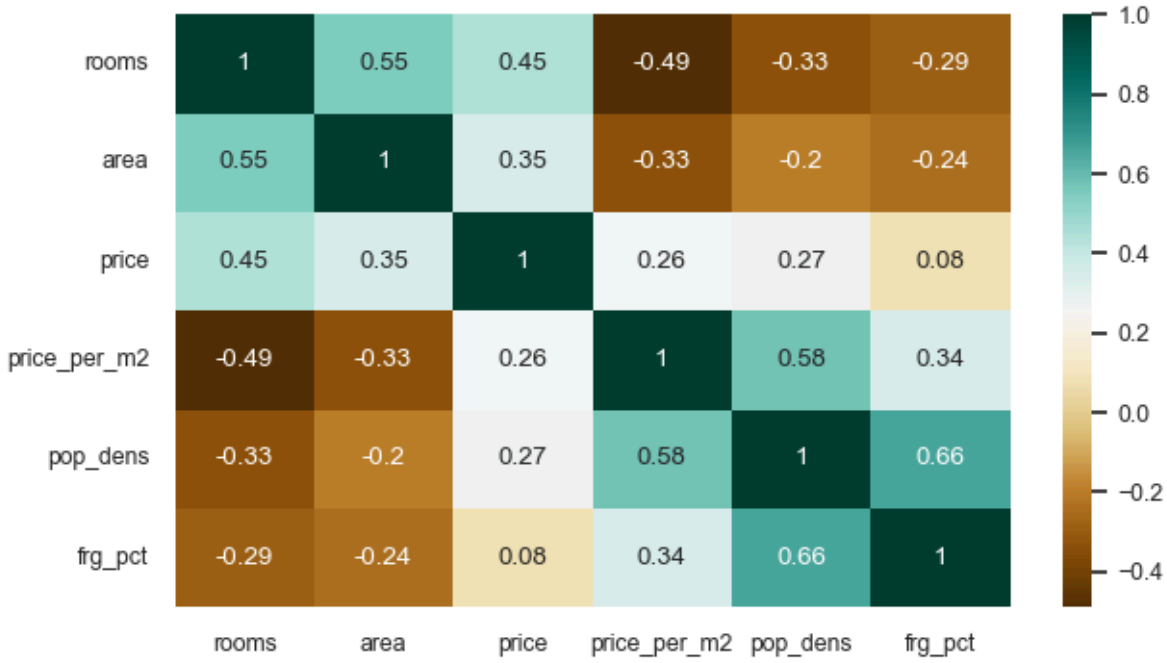
```
# Subset
df_sub = df.loc[(df.price <= 6000) & (df.area <= 200)]
print(df_sub.shape)

# Plot
fig = plt.figure( figsize=(7,4) )
plt.hexbin(df_sub.area, df_sub.price, gridsize=30, cmap='Greens')

# Set Labels
plt.xlabel('area', fontsize=12, labelpad=10)
plt.ylabel('price', fontsize=12, labelpad=10)
plt.title('Two-dimensional histogram of price versus area', fontsize=12, pad=10)

cb = plt.colorbar(label='count in bin')
cb.set_label('counts in bin')
```

```
(751, 17)
```

Correlation heatmap (seaborn)

In [30]:
```
# Set font size for plot
sns.set(font_scale=0.8)

# Create correlation matrix as the basis for the heatmap
plt.figure(figsize=(7,4))
corr = df[['rooms',
                      'area',
                      'price',
                      'price_per_m2',
                      'pop_dens',
                      'frg_pct']].corr().round(2)

# Plot heatmap
sns.heatmap(corr,
            cmap="BrBG",
            annot=True)
```

Out[30]:
```
<Axes: >
```



Bubble plot (seaborn)

In [31]:
```
# Subset of df
df_sub = df.loc[(df['rooms'] >= 2.5) & (df['rooms'] <= 4.5)]

plt.figure(figsize=(7,4))
plt.ticklabel_format(style='plain')
cmap = sns.cubehelix_palette(dark=.3, light=3, as_cmap=True)

ax = sns.scatterplot(x="area",
                     y="price",
                     size="rooms", # determines bubble size
                     hue="pop_dens",  # determines color
                     palette="Set2",
                     data=df_sub)

# Set title and axes
ax.set_title('Price vs area', fontsize = 12)
ax.set_xlabel('area', fontsize = 10)
ax.set_ylabel('price', fontsize = 10)
ax.legend([],[], frameon=False) # skip legend
```

Out[31]:
```
<matplotlib.legend.Legend at 0x1d038270450>
```

Jupyter notebook --footer info-- (please always provide this at the end of each submitted notebook)

In [32]:
```
import os
import platform
import socket
from platform import python_version
from datetime import datetime

print('-----------------------------------')
print(os.name.upper())
print(platform.system(), '|', platform.release())
print('Datetime:', datetime.now().strftime("%Y-%m-%d %H:%M:%S"))
print('Python Version:', python_version())
print('-----------------------------------')
```

```
-----------------------------------
NT
Windows | 10
Datetime: 2024-10-08 14:55:21
Python Version: 3.11.5
-----------------------------------
```

In [ ]: