In [1]:
```
import warnings
warnings.filterwarnings('ignore')

# Import the numpy and pandas package

import numpy as np
import pandas as pd

# Data Visualisation

import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:
```
housing = pd.DataFrame(pd.read_csv("Housing.csv"))
```

In [3]:
```
# Check the head of the dataset
housing.head()
```

Out[3]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	p
0	13300000	7420	4	2	3	yes	no	no	no	yes	2	
1	12250000	8960	4	4	4	yes	no	no	no	yes	3	
2	12250000	9960	3	2	2	yes	no	yes	no	no	2	
3	12215000	7500	4	2	2	yes	no	yes	no	yes	3	
4	11410000	7420	4	1	2	yes	yes	yes	no	yes	2	

In [4]:
```
housing.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 545 entries, 0 to 544
Data columns (total 13 columns):
 #   Column            Non-Null Count  Dtype 
---  ------            --------------  ----- 
 0   price             545 non-null    int64 
 1   area              545 non-null    int64 
 2   bedrooms          545 non-null    int64 
 3   bathrooms         545 non-null    int64 
 4   stories           545 non-null    int64 
 5   mainroad          545 non-null    object
 6   guestroom         545 non-null    object
 7   basement          545 non-null    object
 8   hotwaterheating   545 non-null    object
 9   airconditioning   545 non-null    object
 10  parking           545 non-null    int64 
 11  prefarea          545 non-null    object
 12  furnishingstatus  545 non-null    object
dtypes: int64(6), object(7)
memory usage: 55.5+ KB
```

In [5]:
```
housing.describe()
```

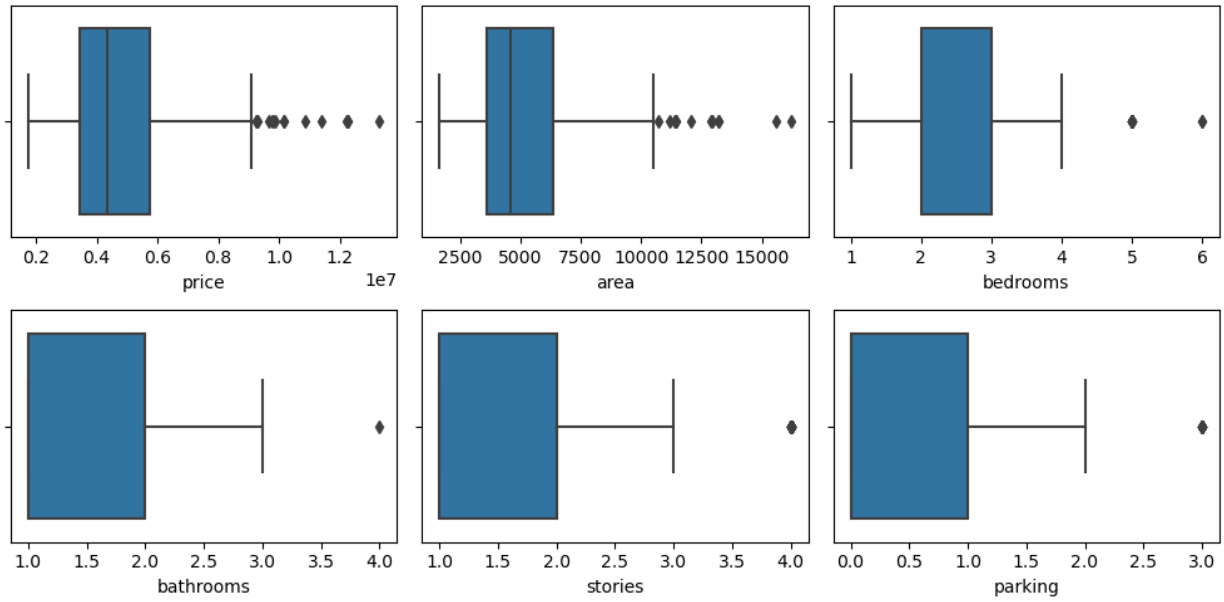
Out[5]:

	price	area	bedrooms	bathrooms	stories	parking
count	5.450000e+02	545.000000	545.000000	545.000000	545.000000	545.000000
mean	4.766729e+06	5150.541284	2.965138	1.286239	1.805505	0.693578
std	1.870440e+06	2170.141023	0.738064	0.502470	0.867492	0.861586
min	1.750000e+06	1650.000000	1.000000	1.000000	1.000000	0.000000
25%	3.430000e+06	3600.000000	2.000000	1.000000	1.000000	0.000000
50%	4.340000e+06	4600.000000	3.000000	1.000000	2.000000	0.000000
75%	5.740000e+06	6360.000000	3.000000	2.000000	2.000000	1.000000
max	1.330000e+07	16200.000000	6.000000	4.000000	4.000000	3.000000

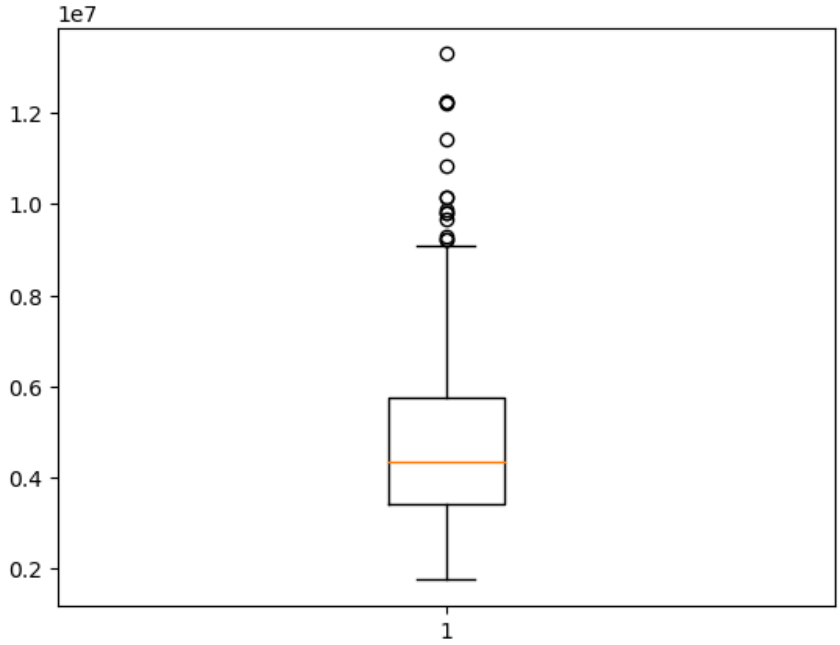
In [6]:
```
# Checking Null values
housing.isnull().sum()*100/housing.shape[0]
```

Out[6]:
```
price             0.0
area              0.0
bedrooms          0.0
bathrooms         0.0
stories           0.0
mainroad          0.0
guestroom         0.0
basement          0.0
hotwaterheating   0.0
airconditioning   0.0
parking           0.0
prefarea          0.0
furnishingstatus  0.0
dtype: float64
```

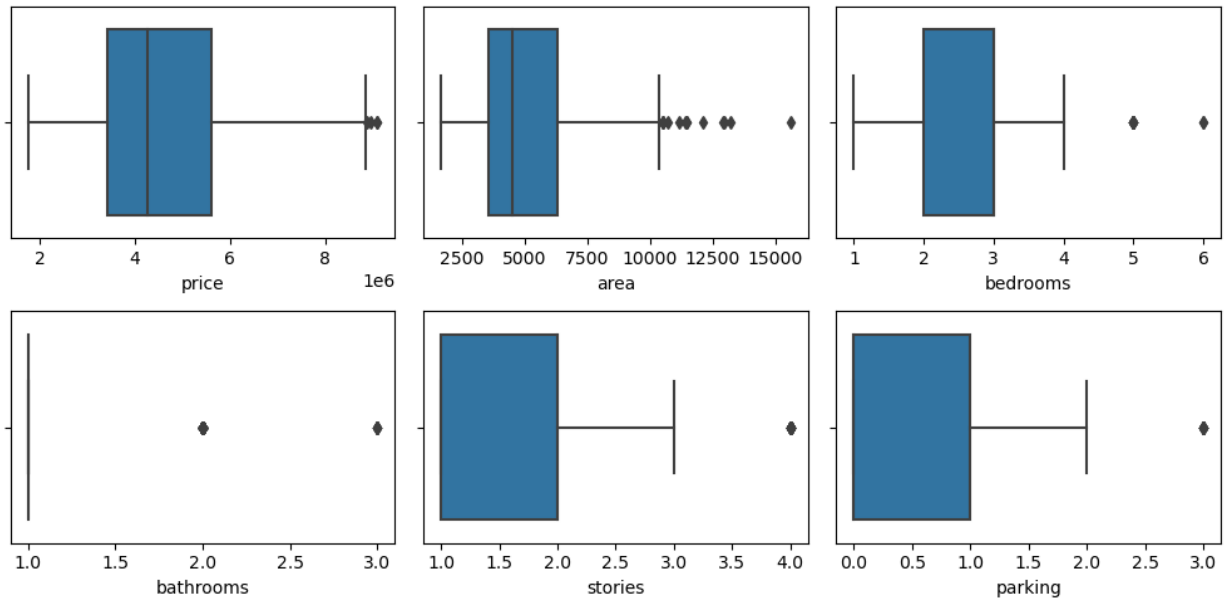
In [7]:
```
# Outlier Analysis
fig, axs = plt.subplots(2,3, figsize = (10,5))
plt1 = sns.boxplot(housing['price'], ax = axs[0,0])
plt2 = sns.boxplot(housing['area'], ax = axs[0,1])
plt3 = sns.boxplot(housing['bedrooms'], ax = axs[0,2])
plt1 = sns.boxplot(housing['bathrooms'], ax = axs[1,0])
plt2 = sns.boxplot(housing['stories'], ax = axs[1,1])
plt3 = sns.boxplot(housing['parking'], ax = axs[1,2])

plt.tight_layout()
```



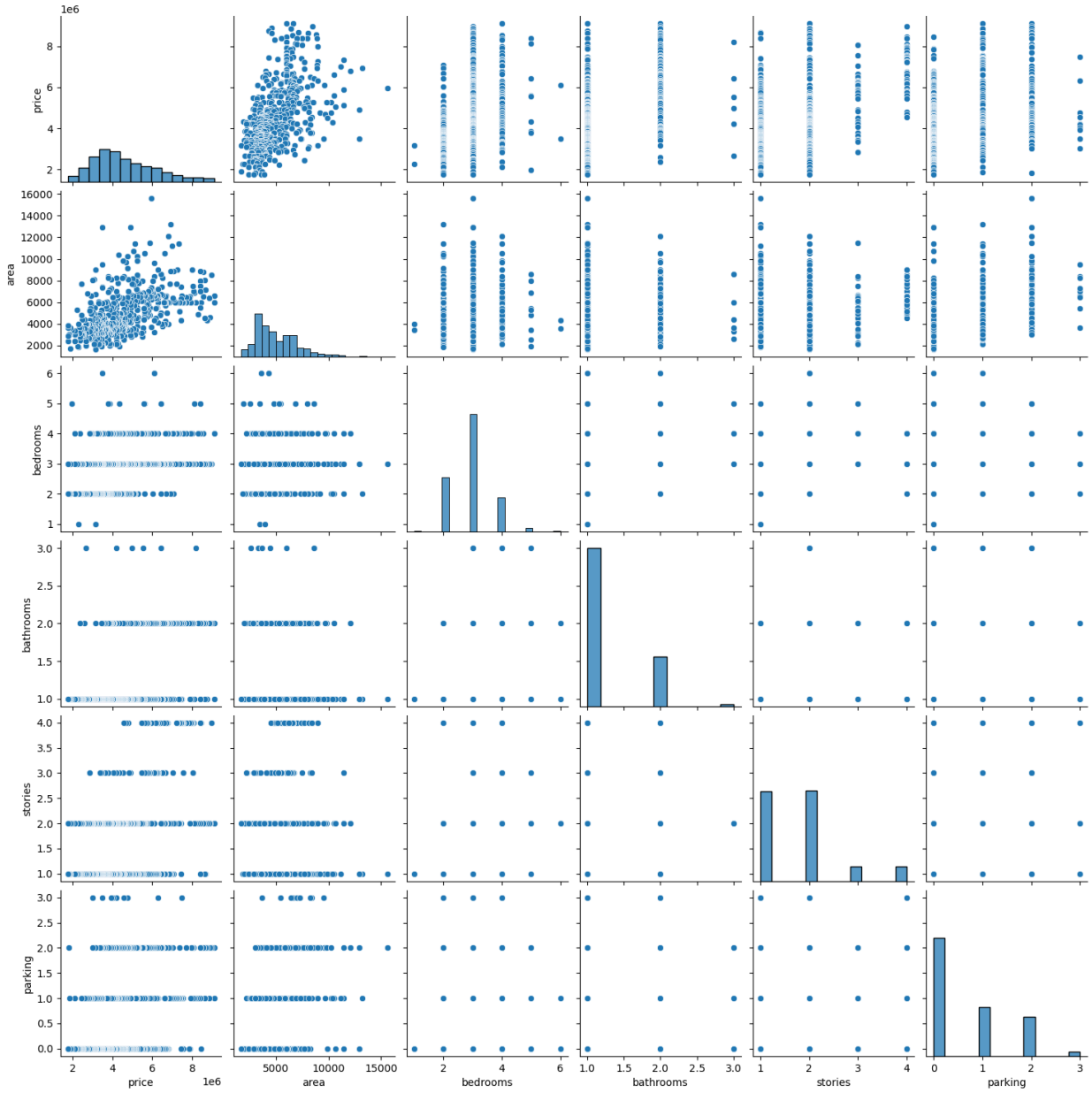
In [8]:
```
# outlier treatment for price
plt.boxplot(housing.price)
Q1 = housing.price.quantile(0.25)
Q3 = housing.price.quantile(0.75)
IQR = Q3 - Q1
housing = housing[(housing.price >= Q1 - 1.5*IQR) & (housing.price <= Q3 + 1.5*IQR)]
```



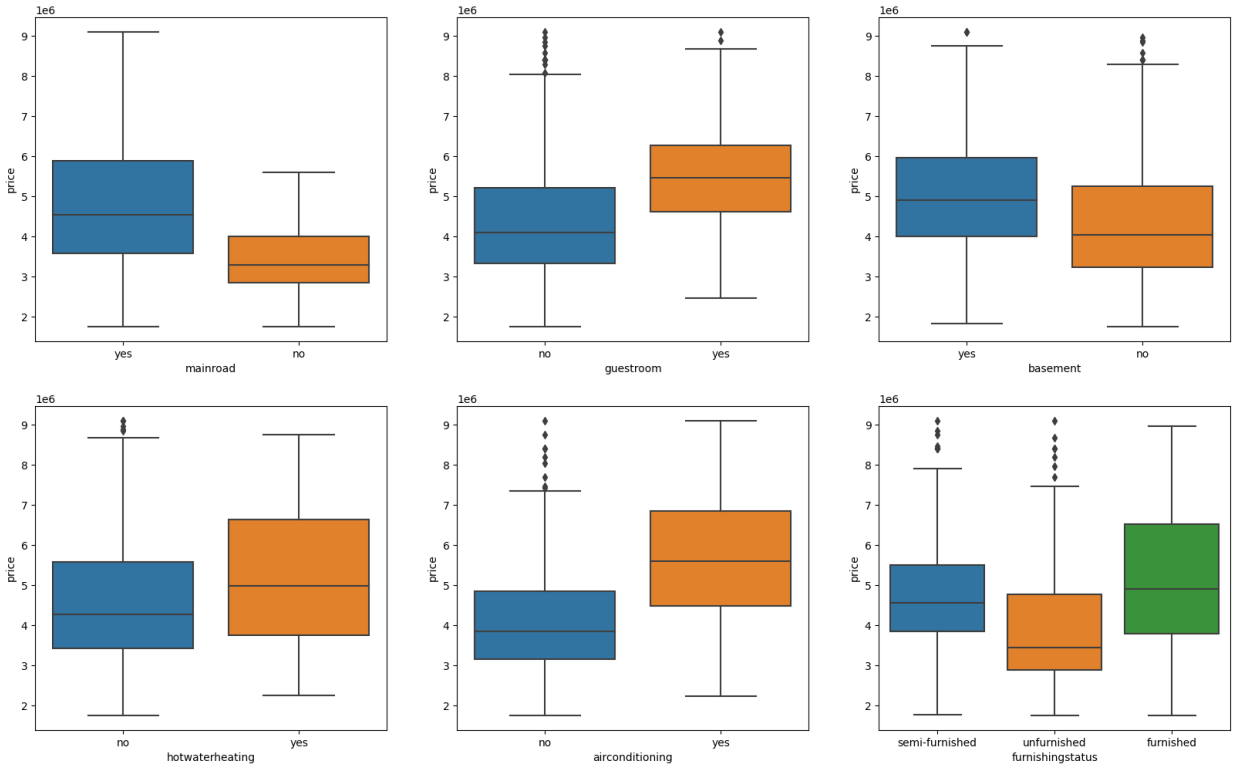
In [9]:
```
# Outlier Analysis
fig, axs = plt.subplots(2,3, figsize = (10,5))
plt1 = sns.boxplot(housing['price'], ax = axs[0,0])
plt2 = sns.boxplot(housing['area'], ax = axs[0,1])
plt3 = sns.boxplot(housing['bedrooms'], ax = axs[0,2])
plt1 = sns.boxplot(housing['bathrooms'], ax = axs[1,0])
plt2 = sns.boxplot(housing['stories'], ax = axs[1,1])
plt3 = sns.boxplot(housing['parking'], ax = axs[1,2])

plt.tight_layout()
```



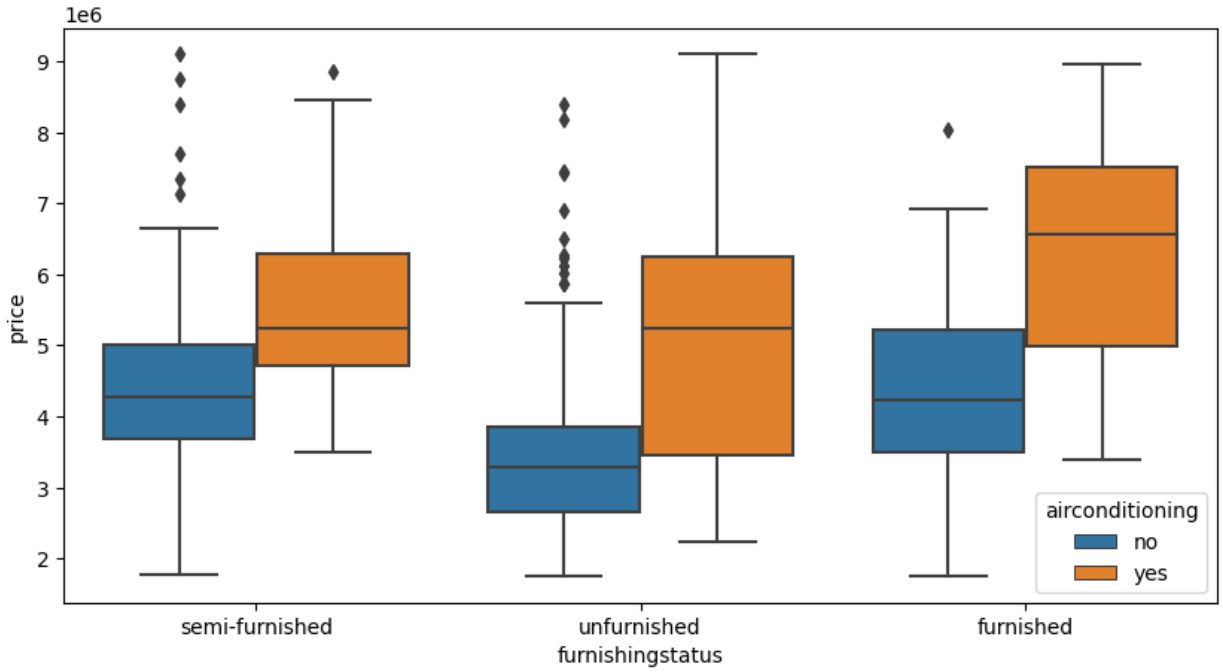
In [10]:
```
1 sns.pairplot(housing)
2 plt.show()
```



In [11]:
```
plt.figure(figsize=(20, 12))
plt.subplot(2,3,1)
sns.boxplot(x = 'mainroad', y = 'price', data = housing)
plt.subplot(2,3,2)
sns.boxplot(x = 'guestroom', y = 'price', data = housing)
plt.subplot(2,3,3)
sns.boxplot(x = 'basement', y = 'price', data = housing)
plt.subplot(2,3,4)
sns.boxplot(x = 'hotwaterheating', y = 'price', data = housing)
plt.subplot(2,3,5)
sns.boxplot(x = 'airconditioning', y = 'price', data = housing)
plt.subplot(2,3,6)
sns.boxplot(x = 'furnishingstatus', y = 'price', data = housing)
plt.show()
```



In [12]:
```
plt.figure(figsize = (10, 5))
sns.boxplot(x = 'furnishingstatus', y = 'price', hue = 'airconditioning', data = housing)
plt.show()
```



In [13]:
```
# List of variables to map

varlist =  ['mainroad', 'guestroom', 'basement', 'hotwaterheating', 'airconditioning', 'prefarea']

# Defining the map function
def binary_map(x):
    return x.map({'yes': 1, "no": 0})

# Applying the function to the housing list
housing[varlist] = housing[varlist].apply(binary_map)
```

In [14]:
```
housing.head()
```

Out[14]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	p
15	9100000	6000	4	1	2	1	0	1	0	0	2	
16	9100000	6600	4	2	2	1	1	1	0	1	1	
17	8960000	8500	3	2	4	1	0	0	0	1	2	
18	8890000	4600	3	2	2	1	1	0	0	1	2	
19	8855000	6420	3	2	2	1	0	0	0	1	1	

In [18]:
```
# Get the dummy variables for the feature 'furnishingstatus' and store it in a new variable - 'statu
status = pd.get_dummies(housing['furnishingstatus'])
```

In [20]:
```
# Let's drop the first column from status df using 'drop_first = True'

status = pd.get_dummies(housing['furnishingstatus'], drop_first = True)
```

In [21]:
```
# Add the results to the original housing dataframe

housing = pd.concat([housing, status], axis = 1)
```

In [22]:
```
# Now let's see the head of our dataframe.

housing.head()
```

Out[22]:

ea	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	prefarea	furnishing
00	4	1	2	1	0	1	0	0	2	0	semi-fu
00	4	2	2	1	1	1	0	1	1	1	unfu
00	3	2	4	1	0	0	0	1	2	0	fu
00	3	2	2	1	1	0	0	1	2	0	fu
20	3	2	2	1	0	0	0	1	1	1	semi-fu

In [23]:
```
# Drop 'furnishingstatus' as we have created the dummies for it

housing.drop(['furnishingstatus'], axis = 1, inplace = True)
```

In [24]:
```
housing.head()
```

Out[24]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	parking	p
15	9100000	6000	4	1	2	1	0	1	0	0	2	
16	9100000	6600	4	2	2	1	1	1	0	1	1	
17	8960000	8500	3	2	4	1	0	0	0	1	2	
18	8890000	4600	3	2	2	1	1	0	0	1	2	
19	8855000	6420	3	2	2	1	0	0	0	1	1	

In [25]:
```
from sklearn.model_selection import train_test_split

# We specify this so that the train and test data set always have the same rows, respectively
np.random.seed(0)
df_train, df_test = train_test_split(housing, train_size = 0.7, test_size = 0.3, random_state = 100
```

In [26]:
```
from sklearn.preprocessing import MinMaxScaler
```

In [27]:
```
scaler = MinMaxScaler()
```

In [28]:
```
# Apply scaler() to all the columns except the 'yes-no' and 'dummy' variables
num_vars = ['area', 'bedrooms', 'bathrooms', 'stories', 'parking','price']

df_train[num_vars] = scaler.fit_transform(df_train[num_vars])
```

In [29]:
```
df_train.head()
```

Out[29]:

	price	area	bedrooms	bathrooms	stories	mainroad	guestroom	basement	hotwaterheating	airconditioning	pa
48	0.776190	0.189964	0.4	0.5	0.333333	1	0	1	0	0	0.33
465	0.176190	0.154122	0.2	0.0	0.000000	1	0	0	0	0	0.0(
144	0.523810	0.218638	0.6	0.0	0.333333	1	1	1	0	1	0.33
395	0.238095	0.139785	1.0	0.0	0.333333	1	0	0	0	0	0.33
254	0.371429	0.205018	0.6	0.0	0.333333	1	0	0	0	1	0.66

In [31]:
```
y_train = df_train.pop('price')
X_train = df_train
```

In [33]:
```
# Importing RFE and LinearRegression
from sklearn.feature_selection import RFE
from sklearn.linear_model import LinearRegression
```

In [34]:
```
# Running RFE with the output number of the variable equal to 10
lm = LinearRegression()
lm.fit(X_train, y_train)
```

Out[34]:
```
LinearRegression()
```

In [36]:
```
from sklearn.feature_selection import RFE

# Create your linear model (lm) - for example, a Linear Regression model
# lm = LinearRegression()  # Replace this with the actual linear model you are using

# Create an instance of RFE with your linear model and the number of features to select (6 in this c
rfe = RFE(estimator=lm, n_features_to_select=6)

# Fit RFE to your training data (X_train and y_train)
rfe = rfe.fit(X_train, y_train)

```

In [37]:
```
list(zip(X_train.columns,rfe.support_,rfe.ranking_))

```

Out[37]:
```
[('area', True, 1),
 ('bedrooms', False, 7),
 ('bathrooms', True, 1),
 ('stories', True, 1),
 ('mainroad', False, 5),
 ('guestroom', False, 6),
 ('basement', False, 4),
 ('hotwaterheating', True, 1),
 ('airconditioning', True, 1),
 ('parking', False, 2),
 ('prefarea', True, 1),
 ('semi-furnished', False, 8),
 ('unfurnished', False, 3)]
```

In [38]:
```
col = X_train.columns[rfe.support_]
col
```

Out[38]:
```
Index(['area', 'bathrooms', 'stories', 'hotwaterheating', 'airconditioning',
       'prefarea'],
      dtype='object')
```

In [39]:
```
X_train.columns[~rfe.support_]
```

Out[39]:
```
Index(['bedrooms', 'mainroad', 'guestroom', 'basement', 'parking',
       'semi-furnished', 'unfurnished'],
      dtype='object')
```

In [40]:
```
# Creating X_test dataframe with RFE selected variables
X_train_rfe = X_train[col]
# Adding a constant variable
import statsmodels.api as sm
X_train_rfe = sm.add_constant(X_train_rfe)
lm = sm.OLS(y_train,X_train_rfe).fit()
```

In [41]:
```
#Let's see the summary of our linear model
print(lm.summary())
```

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                  price   R-squared:                       0.599
Model:                            OLS   Adj. R-squared:                  0.593
Method:                 Least Squares   F-statistic:                     90.72
Date:                Wed, 25 Oct 2023   Prob (F-statistic):           3.19e-69
Time:                        23:45:54   Log-Likelihood:                218.90
No. Observations:                 371   AIC:                            -423.8
Df Residuals:                     364   BIC:                            -396.4
Df Model:                           6
Covariance Type:            nonrobust
==================================================================================
                     coef    std err          t      P>|t|      [0.025      0.975]
----------------------------------------------------------------------------------
const              0.1123      0.015      7.357      0.000       0.082       0.142
area               0.5111      0.052      9.905      0.000       0.410       0.613
bathrooms          0.2483      0.033      7.557      0.000       0.184       0.313
stories            0.2033      0.027      7.489      0.000       0.150       0.257
hotwaterheating    0.1277      0.033      3.832      0.000       0.062       0.193
airconditioning    0.1128      0.016      6.897      0.000       0.081       0.145
prefarea           0.1190      0.018      6.657      0.000       0.084       0.154
==============================================================================
Omnibus:                       71.471   Durbin-Watson:                   2.040
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              153.315
Skew:                           0.996   Prob(JB):                     5.11e-34
Kurtosis:                       5.439   Cond. No.                         8.72
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

In [42]:
```
# Calculate the VIFs for the model
from statsmodels.stats.outliers_influence import variance_inflation_factor
```

In [43]:
```
vif = pd.DataFrame()
X = X_train_rfe
vif['Features'] = X.columns
vif['VIF'] = [variance_inflation_factor(X.values, i) for i in range(X.shape[1])]
vif['VIF'] = round(vif['VIF'], 2)
vif = vif.sort_values(by = "VIF", ascending = False)
vif
```

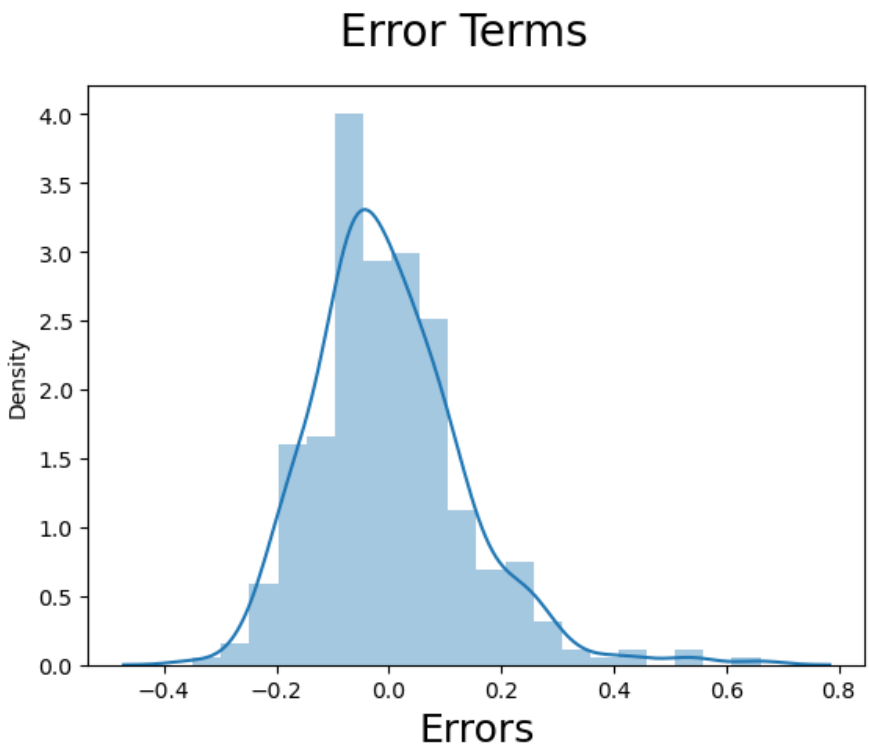
Out[43]:

	Features	VIF
0	const	4.72
5	airconditioning	1.16
3	stories	1.15
1	area	1.11
2	bathrooms	1.11
6	prefarea	1.07
4	hotwaterheating	1.04

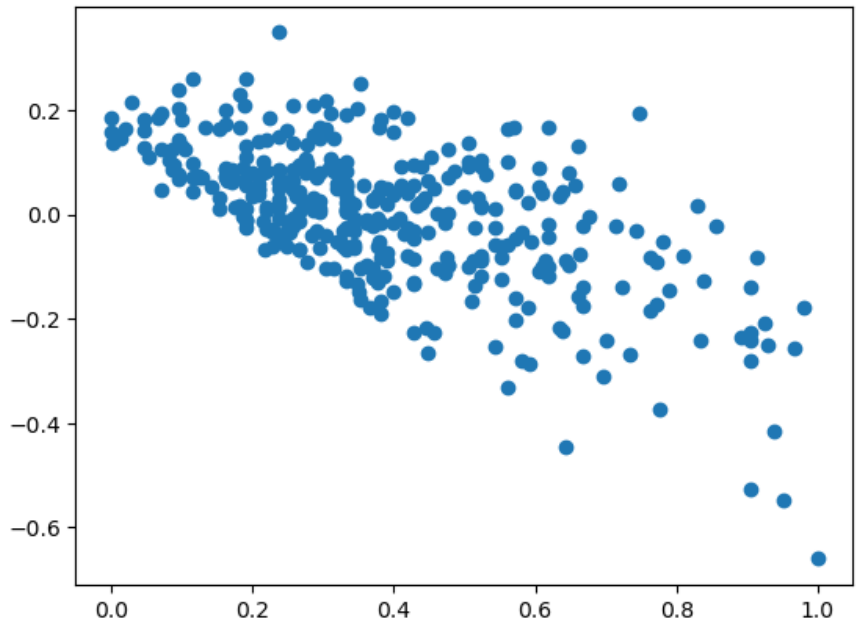
In [44]:
```
y_train_price = lm.predict(X_train_rfe)
res = (y_train_price - y_train)
# Importing the required libraries for plots.
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

In [45]:
```
# Plot the histogram of the error terms
fig = plt.figure()
sns.distplot((y_train - y_train_price), bins = 20)
fig.suptitle('Error Terms', fontsize = 20)                  # Plot heading
plt.xlabel('Errors', fontsize = 18)
```

Out[45]: Text(0.5, 0, 'Errors')



In [46]:
```
plt.scatter(y_train,res)
plt.show()
```



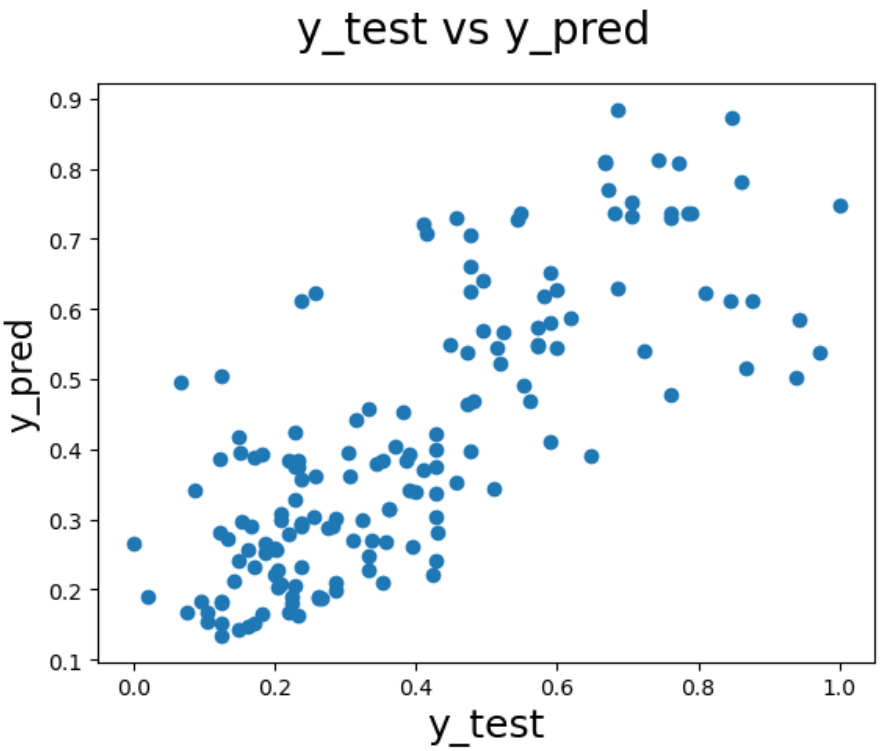
In [47]:
```
num_vars = ['area','stories', 'bathrooms', 'airconditioning', 'prefarea','parking','price']
df_test[num_vars] = scaler.fit_transform(df_test[num_vars])
```

In [48]:
```
y_test = df_test.pop('price')
X_test = df_test
# Adding constant variable to test dataframe
X_test = sm.add_constant(X_test)
# Now let's use our model to make predictions.
# Creating X_test_new dataframe by dropping variables from X_test
X_test_rfe = X_test[X_train_rfe.columns]
# Making predictions
y_pred = lm.predict(X_test_rfe)
from sklearn.metrics import r2_score
r2_score(y_test, y_pred)
```

Out[48]: 0.5832154960181066

In [49]:
```
# Plotting y_test and y_pred to understand the spread.
fig = plt.figure()
plt.scatter(y_test,y_pred)
fig.suptitle('y_test vs y_pred', fontsize=20)              # Plot heading
plt.xlabel('y_test', fontsize=18)                          # X-label
plt.ylabel('y_pred', fontsize=16)
```

Out[49]: Text(0, 0.5, 'y_pred')



In [ ]:
```
1
```