AirBnB Sydney Price Forecasting

In [129…

```
# Packages
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
warnings.filterwarnings('ignore')
# this is to clear the warnings from this page, usually we should leave th
```

In [130…

```
# Plot settings
sns.set_context('notebook') # optimises figures for notebook display
sns.set_style('ticks') # set default plot style
colours = ['#4E79A7','#F28E2C','#E15759','#76B7B2','#59A14F',
          '#EDC949','#AF7AA1','#FF9DA7','#9C755F','#BAB0AB']
sns.set_palette(colours) # set custom color scheme
%matplotlib inline
plt.rcParams['figure.figsize'] = (9, 6)
```

In [131…

```
train = pd.read_csv('train.csv')
test = pd.read_csv('test.csv')
```

EDA

In [132…

```
#Below function drops the $ and other symbols from price, etc. and renders
```

In [133…

```
def fixsymbols(d):
    if d is train:
        d[['price','host_response_rate','host_acceptance_rate']]=d[['price
        d['price'] = d['price'].astype(float)
    elif d is test:
        d[['host_response_rate','host_acceptance_rate']]=d[['host_response_
    else:
        print('Invalid data set.')
```

In [134…

```
fixsymbols(train)
fixsymbols(test)
```

In [135…

```
print(train['price'].skew())
print(train['price'].kurtosis())
```

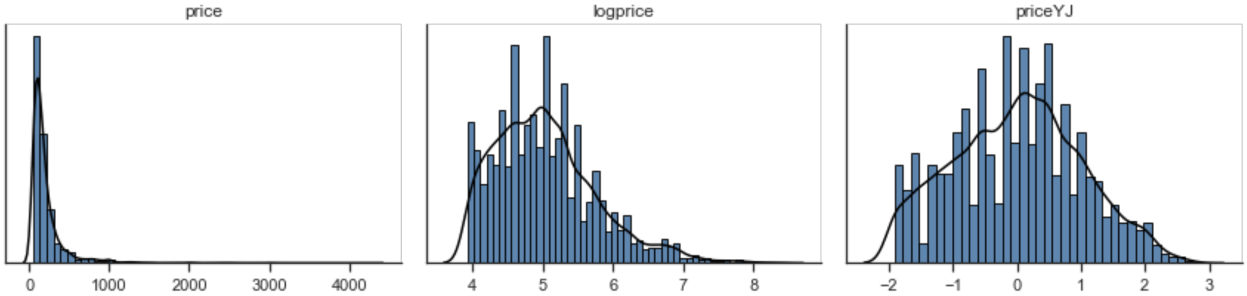
```
5.7035509554419335
52.62609840971898
```

In [136…

```
#Taking the log and YJ of price and comparing these.
```

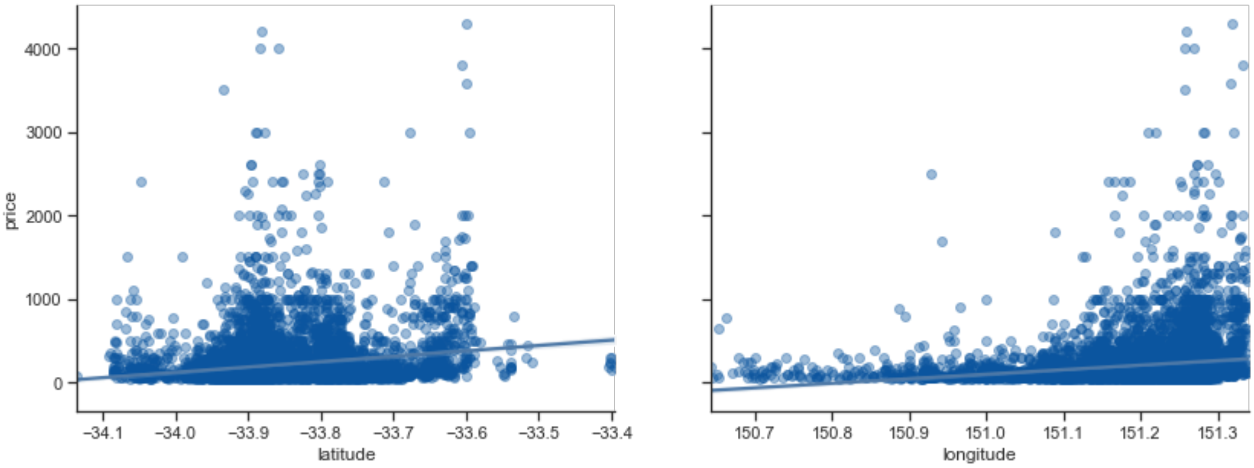
In [137…

```
from sklearn.preprocessing import PowerTransformer

train['logprice'] = np.log(train['price'])

yjp = PowerTransformer(method='yeo-johnson') # YJ is the default, this func
train['priceYJ'] = yjp.fit_transform(train[['price']])

from statlearning import plot_dists
plot_dists(train[['price','logprice','priceYJ']])
plt.show()
```



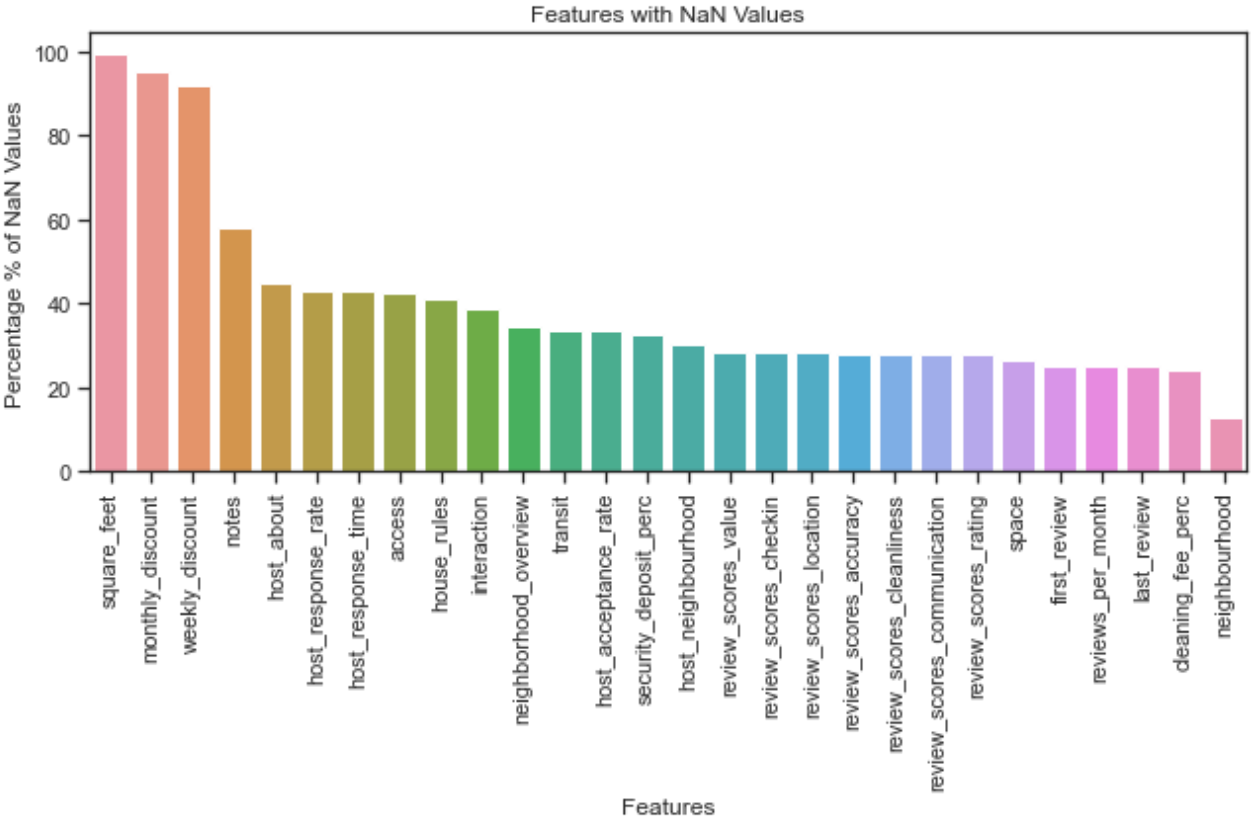
In [138…

```
g = sns.pairplot(train, kind='reg', x_vars=['latitude','longitude'],y_vars=
                   plot_kws={'scatter_kws' :{'color': sns.color_palette('Bl
g.fig.set_size_inches(13,5)
```



In [139…

```
#Find all features with NaN values
NaN_values = train.isnull().sum().sort_values(ascending=False)[:28]

fig, ax = plt.subplots(1,1, figsize = (9, 6))
sns.barplot(x=NaN_values.index, y=NaN_values/train.shape[0]*100)
plt.xticks(rotation='90')
plt.xlabel('Features')
plt.ylabel('Percentage % of NaN Values')
plt.title('Features with NaN Values')
plt.tight_layout()
plt.savefig('NaNValues.png')
```



In [140…

```
#The below code creates an array imputequantvars which shows all the quant
#The array imputeobjvars shows all the non-quantitative variables that nee
```

In [141…

```
imputevars = train.isnull().sum().sort_values(ascending=False)[train.isnul

imputequantvars = []
imputeobjvars = []
for i in imputevars:
    if train.dtypes[i] != object:
        imputequantvars.append(i)
    if train.dtypes[i] == object:
        imputeobjvars.append(i)
```

Feature Engineering

Data Mining

In [142…

```
# Just an idea
# Best hosts could be considered as the ones that maximise revenue (no.vis
# There is no visitor count but there is a number of reviews.
# I read somewhere that airbnb thinks that 70% of visits leave a review
# revenue per month of listing as new listings won't have as many reviews i
train['revenue_per_month'] = train['price']*(train['reviews_per_month']/0.
train = train[train.revenue_per_month.notna()]
```

Imputing 'object' type variables

In [143…

```
imputeobjvars
#These all need imputing. Below we will make a variable that records wheth
#fills blanks with 'blank'
```

Out[143…

```
['notes',
 'host_about',
 'host_response_rate',
 'host_response_time',
 'access',
 'house_rules',
 'interaction',
 'neighborhood_overview',
 'transit',
 'host_acceptance_rate',
 'host_neighbourhood',
 'space',
 'first_review',
 'last_review',
 'neighbourhood',
 'zipcode',
 'host_location',
 'city']
```

In [144…

```
#HOST RESPONSE RATE is not an object! It is actually an int.

#we will fill it with zeros because a NA response rate probably means no r
train.host_response_rate.fillna(0,inplace=True)
train.host_response_rate = train.host_response_rate.astype(int)

test.host_response_rate.fillna(0,inplace=True)
test.host_response_rate = test.host_response_rate.astype(int)
```

In [145…

```
pd.unique(train.host_response_time)
```

Out[145…

```
array(['within a few hours', 'within an hour', nan, 'within a day',
       'a few days or more'], dtype=object)
```

In [146…

```
#HOST RESPONSE TIME is an ordinal variable

train.host_response_time.fillna(0,inplace=True)
train.host_response_time = np.where(train.host_response_time=='a few days o
train.host_response_time = np.where(train.host_response_time=='within a day
train.host_response_time = np.where(train.host_response_time=='within a few
train.host_response_time = np.where(train.host_response_time=='within an ho

train.host_response_time = train.host_response_time.astype(int)

#HOST RESPONSE TIME is an ordinal variable

test.host_response_time.fillna(0,inplace=True)
test.host_response_time = np.where(test.host_response_time=='a few days or
test.host_response_time = np.where(test.host_response_time=='within a day'
test.host_response_time = np.where(test.host_response_time=='within a few h
test.host_response_time = np.where(test.host_response_time=='within an hour

test.host_response_time = test.host_response_time.astype(int)
```

In [147…

```
train.host_acceptance_rate_blank = np.where(train.host_acceptance_rate.isna
train.host_acceptance_rate = train.host_acceptance_rate.fillna(0)
train.host_acceptance_rate = train.host_acceptance_rate.astype(int)

test.host_acceptance_rate_blank = np.where(test.host_acceptance_rate.isna(
test.host_acceptance_rate = test.host_acceptance_rate.fillna(0)
test.host_acceptance_rate = test.host_acceptance_rate.astype(int)
```

In [148…

```
#First Review and Last Review are dates. I will make a variable showing the
```

In [149…

```
train.first_review.fillna('2000-01-01',inplace=True)
test.first_review.fillna('2000-01-01',inplace=True)
```

In [150…

```
train.first_review = pd.to_datetime(train.first_review)
test.first_review = pd.to_datetime(test.first_review)
```

In [151…

```
train.last_review.fillna('2000-01-01',inplace=True)
test.last_review.fillna('2000-01-01',inplace=True)
```

In [152…

```
train.last_review = pd.to_datetime(train.last_review)
test.last_review = pd.to_datetime(test.last_review)
```

In [153…

```
train.reviewtimegap = train.last_review - train.first_review
test.reviewtimegap = test.last_review - test.first_review
```

In [154…

```
train.reviewtimegap=train.reviewtimegap.astype(int)
test.reviewtimegap=test.reviewtimegap.astype(int)
```

In [155…

```
#The below function makes a variable for each object variable that still r
#and has NA values.
```

In [156…

```
imputeobjvars
```

Out[156…

```
['notes',
 'host_about',
 'host_response_rate',
 'host_response_time',
 'access',
 'house_rules',
 'interaction',
 'neighborhood_overview',
 'transit',
 'host_acceptance_rate',
 'host_neighbourhood',
 'space',
 'first_review',
 'last_review',
 'neighbourhood',
 'zipcode',
 'host_location',
 'city']
```

In [157…

```
imputeobjvars = np.delete(imputeobjvars,[2,3,9,12,13])
```

In [158…

```
def imputeobjs(d):
    for i in imputeobjvars:
        if d is train or d is test:
            d[i+'_blank'] = ''
            d[i+'_blank'] = np.where(d[i].isna()==True,1,0)
            d[i] = np.where(d[i].isna()==True,'Blank',d.name.values)
```

In [159…

```
imputeobjs(train)
imputeobjs(test)
```

Imputing quantitative variables logically

In [160…

```
imputequantvars
```

Out[160…

```
['square_feet',
 'monthly_discount',
 'weekly_discount',
 'security_deposit_perc',
 'review_scores_value',
 'review_scores_checkin',
 'review_scores_location',
 'review_scores_accuracy',
 'review_scores_cleanliness',
 'review_scores_communication',
 'review_scores_rating',
 'reviews_per_month',
 'cleaning_fee_perc',
 'beds',
 'bedrooms',
 'bathrooms']
```

In [161…

```
#I have an idea -- maybe places with square feet listed have higher value?
#Let's impute all NAs as 0 and add a dummy for this.

#For all the above quant variables except for beds, bedrooms and bathrooms
```

In [162…

```
imputequantvars = imputequantvars[:-3]
```

In [163…

```
#Below is a function that will impute all the ones I want.
```

In [164…

```
def imputequants(d):
    for i in imputequantvars:
        if d is train or d is test:
            d[i+'_blank'] = np.where(d[i].isna()==True,1,0)
            d[i] = d[i].fillna(0)
            d[i] = d[i].astype(int)
```

In [165…

```
imputequants(train)
imputequants(test)
```

Making new dummy variables

Neighbourhood binning

In [166…

```
# Fill neighbourhood NaN
train['neighbourhood_cleansed']=train['neighbourhood_cleansed'].fillna(tra

# This code bins very low frequency neighbourhoods into an 'Other' field –
series = pd.value_counts(train.neighbourhood_cleansed)
```

In [167…

```
mask = (series/series.sum() * 100).lt(0.03)
# # To replace df['column'] use np.where I.e
train['neighbourhood_cleansed'] = np.where(train['neighbourhood_cleansed']
```

In [168…

```
# Average price of neighbourhood ranked - starting to make sense
# We should bin based on this but need to consider how this will effect th
bins = train.groupby("neighbourhood_cleansed").mean()['price'].sort_values
```

In [169…

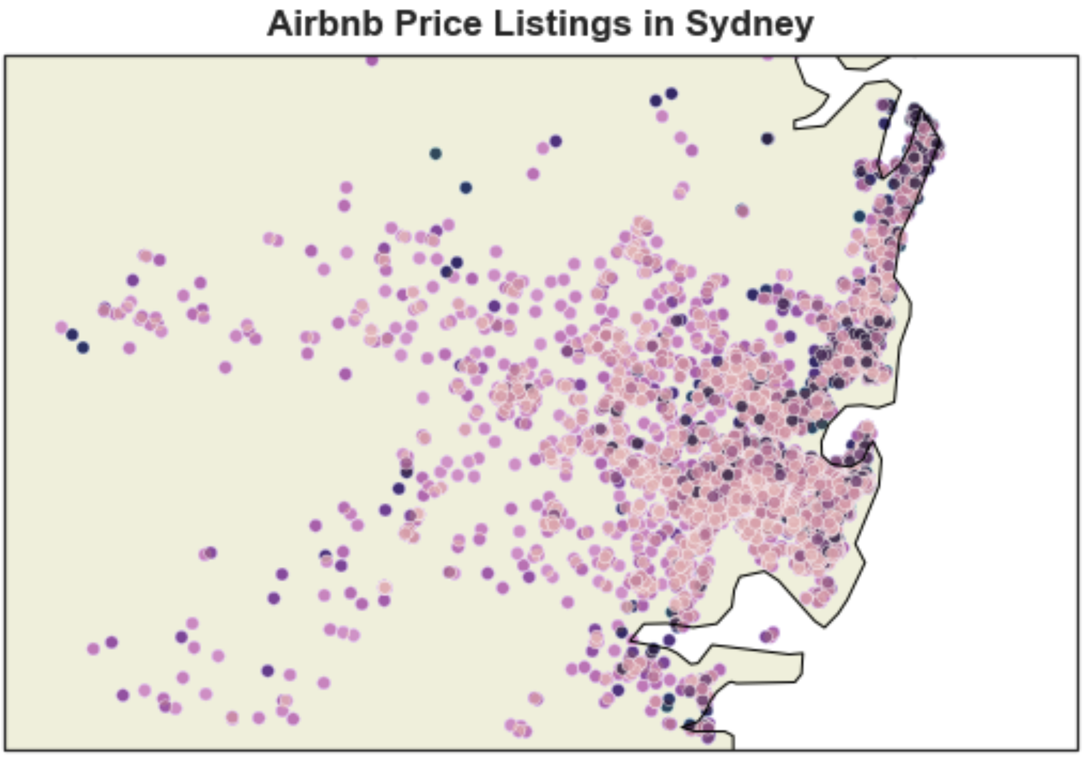
```
bins
```

Out[169…

```
neighbourhood_cleansed
Pittwater            8.0
Mosman               5.0
Hunters Hill         5.0
Manly                5.0
Warringah            5.0
Waverley             4.0
Sutherland Shire     4.0
Lane Cove            4.0
Woollahra            4.0
Leichhardt           4.0
North Sydney         3.0
The Hills Shire      3.0
Randwick             3.0
City Of Kogarah      3.0
Willoughby           3.0
Sydney               3.0
Penrith              3.0
Canada Bay           3.0
Liverpool            3.0
Hurstville           3.0
Hornsby              2.0
Strathfield          2.0
Auburn               2.0
Rockdale             2.0
Fairfield            2.0
Ashfield             2.0
Marrickville         2.0
Camden               2.0
Ku-Ring-Gai          2.0
Ryde                 2.0
Parramatta           2.0
Campbelltown         2.0
Canterbury           2.0
Botany Bay           2.0
Bankstown            2.0
Burwood              2.0
Holroyd              1.0
Blacktown            1.0
Name: price, dtype: float64
```

In [170…

```
import matplotlib.pyplot as plt
import cartopy.crs as ccrs
import cartopy.feature as cfeature
from matplotlib.offsetbox import AnchoredText


def main():
    ax = plt.axes(projection=ccrs.PlateCarree())
    ax.set_extent([151.45,150.6,-34.1,-33.55])


#     # Put a background image on for nice sea rendering.
#     ax.stock_img()

    # Create a feature for States/Admin 1 regions at 1:50m from Natural Ea
    states_provinces = cfeature.NaturalEarthFeature(
        category='cultural',
        name='admin_1_states_provinces_lines',
        scale='50m',
        facecolor='none')

    SOURCE = 'Natural Earth'
    LICENSE = 'public domain'

    ax.add_feature(cfeature.LAND)
    ax.add_feature(cfeature.COASTLINE)
    ax.add_feature(states_provinces, edgecolor='gray')

    # Get latitude and longitude for each data point
    x, y = (train['longitude'].to_numpy(), train['latitude'].to_numpy())

#     # Scatter plot as heat map
    ax.scatter(x,y,c=(train['price']),
           edgecolors='none', cmap=plt.get_cmap('rainbow'), alpha=1)

    sns.scatterplot(x='longitude', y='latitude',hue='price', hue_norm=(0,45
    plt.legend([],[], frameon=False)

#     # Add a text annotation for the license information to the
#     # the bottom right corner.
#     text = AnchoredText(r'$\mathcircled{{c}}$ {}; license: {}'
#                         ''.format(SOURCE, LICENSE),
#                         loc=4, prop={'size': 12}, frameon=True)
#     ax.add_artist(text)
    plt.title('Airbnb Price Listings in Sydney', fontsize=17, y=1.01, fontw
    plt.show()

if __name__ == '__main__':
    main()
```



In [171…

```
pd.unique(train.neighbourhood_cleansed)

def neighbourhoodbins(d):
    if d is train or d is test:

        d['neighbourhood_cleansed']=d['neighbourhood_cleansed'].fillna(d['
        series = pd.value_counts(d.neighbourhood_cleansed)

        mask = (series/series.sum() * 100).lt(0.03)
        d['neighbourhood_cleansed'] = np.where(d['neighbourhood_cleansed']

        for i in range(len(bins.index)):
            d.neighbourhood_cleansed = np.where(d.neighbourhood_cleansed==
```

In [172…

```
neighbourhoodbins(train)
neighbourhoodbins(test)

train.neighbourhood_cleansed = train.neighbourhood_cleansed.astype(float)
test.neighbourhood_cleansed = test.neighbourhood_cleansed.astype(float)
```

Here we carefully consider which categorical variables to include as dummies...

What do the most expensive places have in their summary?

In [173…

```
train = pd.get_dummies(train,columns=['cancellation_policy','requires_lice
```

In [174…

```
test = pd.get_dummies(test,columns=['cancellation_policy','requires_license
```

Amenity dummies

In [175…

```
#Below we define a function for rendering train and test amenity dummies.
```

In [176…

```
#This simply adds up all the amenities to generate a score.

def amenityscore(d):

    amenitieslist = []

    for i in range(len(d.amenities.values)):
        k = d.amenities.values[i].replace('{','').replace('}','').replace(
        for j in range(len(k)):
            if k[j] not in amenitieslist:
                amenitieslist.append(k[j])

    if d is train or d is test:
        d['amenityscore'] = 0
        for i in amenitieslist:
            d['amenityscore'] += np.where(d.amenities.str.contains(i,case=F
        d['amenityscore'] += np.where(d.summary.str.contains('beach',case=F
    else:
        print('Invalid entry, type train or test into the function.')
```

In [177…

```
amenityscore(train)
amenityscore(test)
```

In [178…

```
#AND/OR make a dummy for each amenity

def amenitify(d):

    amenitieslist = []

    for i in range(len(d.amenities.values)):
        k = d.amenities.values[i].replace('{','').replace('}','').replace(
        for j in range(len(k)):
            if k[j] not in amenitieslist:
                amenitieslist.append(k[j])

    if d is train or d is test:
        for i in amenitieslist:
            d[i] = np.where(d.amenities.str.contains(i,case=False),1,0)
        d['beach'] = np.where(d.summary.str.contains('beach',case=False),1
    else:
        print('Invalid entry, type train or test into the function.')
```

In [179…

```
amenitify(train)
amenitify(test)
```

In [180…

```
train['bedroomsXaccommodates'] = train['bedrooms']*train['accommodates']
```

In [181…

```
test['bedroomsXaccommodates'] = test['bedrooms']*test['accommodates']
```

In [182…

```
train['bedroomsXbathrooms'] = train['bedrooms']*train['bathrooms']
```

In [183…

```
test['bedroomsXbathrooms'] = test['bedrooms']*test['bathrooms']
```

In [184…

```
train['hotlatitude'] = np.where(((train['latitude']<-33.85)&(train['latitu
```

In [185…

```
test['hotlatitude'] = np.where(((test['latitude']<-33.85)&(test['latitude'
```

In [186…

```
train['hotlongitude'] = np.where((train['longitude']>151.2),1,0)
```

In [187…

```
test['hotlongitude'] = np.where((test['longitude']>151.2),1,0)
```

In [188…

```
train['hotlatXhotlong'] = train['hotlatitude']*train['hotlongitude']
test['hotlatXhotlong'] = test['hotlatitude']*test['hotlongitude']
```

In [189…

```
abs(train.corr()['logprice']).sort_values(ascending=False)[3:30].drop('reve
```

Out[189…

```
accommodates                                    0.679780
bedrooms                                        0.664572
bedroomsXaccommodates                           0.642417
bedroomsXbathrooms                              0.629077
beds                                            0.619002
room_type_Private room                          0.580205
bathrooms                                       0.428830
guests_included                                 0.357145
neighbourhood_cleansed                          0.304222
Family/kid friendly                             0.270347
TV                                              0.240464
amenityscore                                    0.238698
cancellation_policy_strict_14_with_grace_period    0.235938
security_deposit_perc_blank                     0.232616
longitude                                       0.228388
calculated_host_listings_count_private_rooms    0.217966
Crib                                            0.214264
Children’s books and toys                       0.212197
extra_people_perc                               0.208919
Dishwasher                                      0.205740
Indoor fireplace                                0.205426
cleaning_fee_perc_blank                         0.203889
High chair                                      0.202068
hotlongitude                                    0.195786
Heating                                         0.190258
property_type_House                             0.188856
Name: logprice, dtype: float64
```

In [190…

```
train.isna().sum().sort_values()
```

Out[190…

```
name                      0
Baby bath                 0
Baby monitor              0
Barbecue utensils         0
Game console              0
                         ..
bedrooms                  3
bathrooms                 3
bedroomsXaccommodates     3
bedroomsXbathrooms        6
beds                     22
Length: 344, dtype: int64
```

In [191…

```
features = train.columns.values
```

In [192…

```
features = np.delete(features,np.where(features=='priceYJ'))
features = np.delete(features,np.where(features=='price'))
```

In [193…

```
features = np.delete(features,np.where(features=='revenue_per_month'))
```

In [194…

```
#AND/OR make a dummy for each verification mode

def verify(d):

    verifylist = []

    for i in range(len(d.host_verifications.values)):
        k = d.host_verifications.values[i].replace('"','').replace("'",'')
        for j in range(len(k)):
            if k[j] not in verifylist:
                verifylist.append(k[j])
    #return print(verifylist)
    if d is train or d is test:
        for i in verifylist:
            d[i] = np.where(d.host_verifications.str.contains(i,case=False
    else:
        print('Invalid entry, type train or test into the function.')
```

In [195…

```
verify(train)
verify(test)
```

In [196…

```
train.host_since = pd.to_datetime(train.host_since)
test.host_since = pd.to_datetime(test.host_since)
```

In [197…

```
train['hostlife']=train.host_since.max()-train.host_since
test['hostlife']=test.host_since.max()-test.host_since
```

In [198…

```
train.host_since.fillna('2000-01-01',inplace=True)
test.host_since.fillna('2000-01-01',inplace=True)
```

In [199…

```
train.hostlife=train.hostlife.astype(int)
test.hostlife=test.hostlife.astype(int)
```

In [200…

```
from sklearn.model_selection import train_test_split
X_train, X_val, y_train, y_val = train_test_split(train[features], train['
```

In [201…

```
fullxtrain = train[np.delete(features,np.where(features=='logprice'))]
fullytrain = train['logprice']
```

In [204…

```
from pandas_profiling import ProfileReport
print('Warning: Pandas Profiling can take several minutes.')
optimise = str(input('Would you like to profile? Answer \'C\' to continue.

if optimise.lower() == 'c':
    profile = ProfileReport(train, minimal=True)
    profile.to_widgets()
else:
    print('Profiling cancelled')
```

```
Warning: Pandas Profiling can take several minutes.

Profiling cancelled
```

Modelling

In [205…

```
#One model must be a linear model. We will use an Elastic Net here.
```

In [206…

```
from sklearn.experimental import enable_iterative_imputer
from sklearn.impute import IterativeImputer

imp =  IterativeImputer()
imp.fit(X_train[imputequantvars])
X_train[imputequantvars] = imp.transform(X_train[imputequantvars])
X_val[imputequantvars] = imp.transform(X_val[imputequantvars])
```

Should we be fitting the imputer to the test?

In [207…

```
#imp.fit(test[imputequantvars])
test[imputequantvars] = imp.transform(test[imputequantvars])
```

In [208…

```
fullxtrain[imputequantvars] = imp.fit_transform(fullxtrain[imputequantvars
```

In [209…

```
#Fixing variable skewness
```

In [210…

```
skews = ['square_feet','weekly_discount','minimum_nights','minimum_minimum_
```

In [211…

```
yj = PowerTransformer(method='yeo-johnson')

X_train[skews]  = yj.fit_transform(X_train[skews])
X_val[skews] = yj.transform(X_val[skews])
test[skews] = yj.transform(test[skews])
```

In [212…

```
#Dropping training outliers
```

In [213…

```
fullxtrain[skews]  = yj.fit_transform(fullxtrain[skews])
```

Outliers

In [214…

```
quantitativevariables = []
for i in features:
    if train.dtypes[i] == int or train.dtypes[i] == float and i != 'logpric
        quantitativevariables.append(i)
```

In [215…

```
X_train = X_train.fillna(0)
X_val = X_val.fillna(0)
```

In [216…

```
fullxtrain = fullxtrain.fillna(0)
```

In [217…

```
test = test.fillna(0)
```

In [218…

```
from sklearn.linear_model import LinearRegression

ols = LinearRegression()
ols.fit(X_train[quantitativevariables], y_train)

y_fitted = ols.predict(X_train[quantitativevariables])
e = y_train - y_fitted

#e.reset_index(drop=True,inplace=True)

outliers = e.abs().sort_values().iloc[-10:] # retrieves the indexes for th
```

In [219…

```
outlierlist = outliers.index.values
```

In [220…

```
for i in outlierlist:
    X_train['outlier'] = np.where(X_train.index==i,1,0)
    fullxtrain['outlier'] = np.where(fullxtrain.index==i,1,0)
```

Elastic Net

In [221…

```
features = abs(train.corr()['logprice']).sort_values(ascending=False)[3:].
```

In [222…

```
features=np.delete(features,np.where(features=='property_type_Castle')) #c
features=np.delete(features,np.where(features=='revenue_per_month')) #cast
```

In [223…

```
badfeatures = ['Nespresso machine', 'Natural gas barbeque', 'Sonos sound s
#These features don't exist in the test and so will be deleted.
for i in badfeatures:
    features=np.delete(features,np.where(features==i)) # is causing it to
morebadfeatures = [' zhima_selfie', ' sent_id', ' reviews', ' manual_onlin
for i in morebadfeatures:
    features=np.delete(features,np.where(features==i)) # is causing it to
```

In [224…

```
from sklearn.preprocessing import RobustScaler
scaler = RobustScaler() #scaling

X_train_scaled = scaler.fit_transform(X_train[features])
X_train = pd.DataFrame(X_train_scaled)

X_val_scaled = scaler.transform(X_val[features])
X_val = pd.DataFrame(X_val_scaled)
```

In [225…

```
test_scaled = scaler.transform(test[features])
test = pd.DataFrame(test_scaled)
```

In [226…

```
fullxtrain = pd.DataFrame(scaler.fit_transform(fullxtrain[features]))
```

In [227…

```
from sklearn.linear_model import ElasticNetCV
enet_cv = ElasticNetCV(l1_ratio=[0.01,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8
enet_cv.fit(X_train,np.ravel(y_train))
```

Out[227…

```
ElasticNetCV(cv=5,
             l1_ratio=[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8,
0.9,
                       0.95, 0.99, 1])
```

In [228…

```
enet_cv.l1_ratio_
```

Out[228…

```
1.0
```

In [229…

```
enet_cv.alpha_
```

Out[229…

```
0.0028861641656963383
```

In [230…

```
from sklearn.linear_model import ElasticNet
enet = ElasticNet(alpha = enet_cv.alpha_, l1_ratio = enet_cv.l1_ratio_)
```

In [231…

```
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
kf=KFold(5)
scores = cross_val_score(enet, X_val, y_val, cv=kf, scoring = 'neg_mean_squ

# print the score for each fold
print(np.sqrt(-scores).round(4))
print((sum(np.sqrt(-scores))/len(np.sqrt(-scores))).round(4))
print('RMSE score for Elastic Net model')
```

```
[0.3353 0.335  0.3753 0.3212 0.3308]
0.3395
RMSE score for Elastic Net model
```

In [232…

```
enet.fit(X_train,y_train)
```

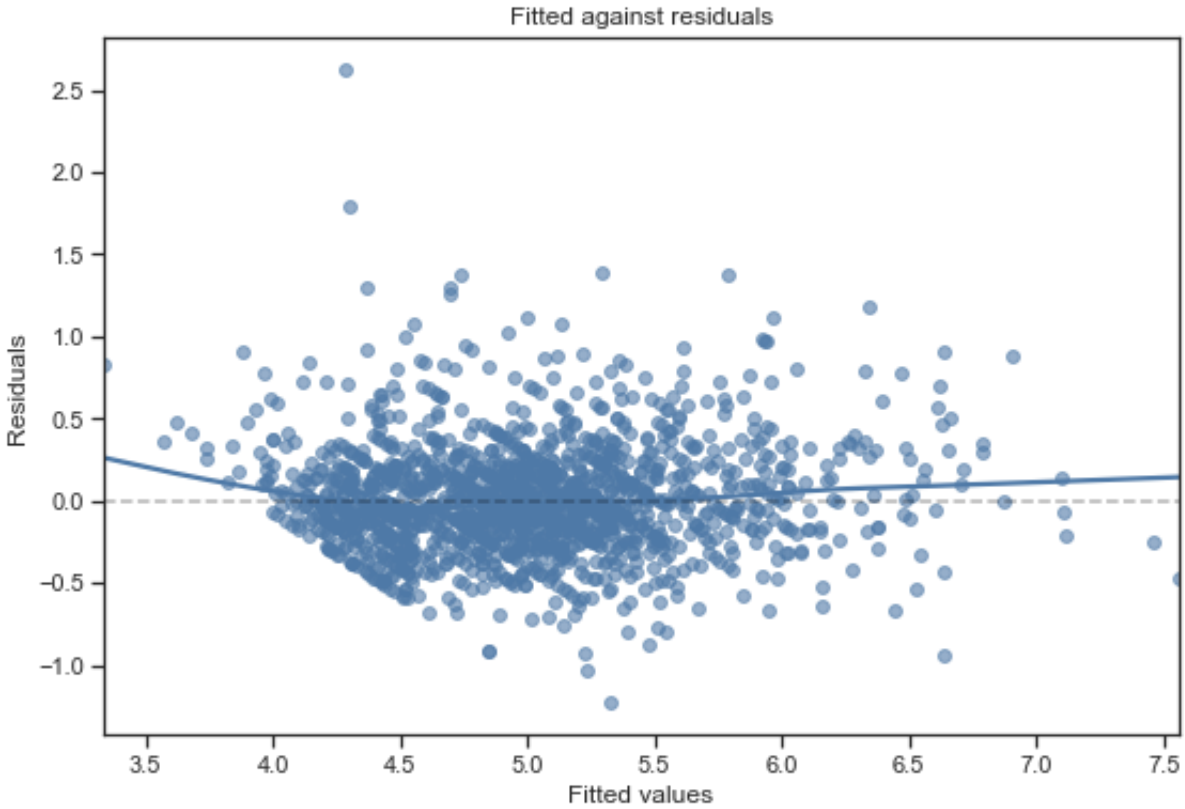
Out[232…

```
ElasticNet(alpha=0.0028861641656963383, l1_ratio=1.0)
```

In [233…

```
#interpretable fitted and resid
# fitted = np.exp(enet_cv.predict(X_val))
# resid = np.exp(y_val) - np.exp(enet_cv.predict(X_val))
fitted = enet.predict(X_val)
resid = y_val - enet.predict(X_val)

fig, ax= plt.subplots()
sns.regplot(fitted, resid, lowess=True, ax=ax, scatter_kws={'s': 35, 'alpha
ax.set_xlabel('Fitted values',  {'fontsize': 12})
ax.set_ylabel('Residuals', {'fontsize': 12})
ax.set_title('Fitted against residuals')
plt.axhline(color='Black', alpha=0.3, linestyle='--')
#EXOGENEITY plot
```

```
Out[233… <matplotlib.lines.Line2D at 0x7fa75d552a90>
```



```
In [234… elasticnetvars = pd.DataFrame(enet.coef_.round(3), index = features).T.wher
```

```
In [235… enetselect = elasticnetvars.iloc[0][elasticnetvars.iloc[0].values==True].in
```

```
In [236… np.where(elasticnetvars==True)[1]
```

```
Out[236… array([  0,   1,   2,   3,   4,   5,   6,   7,   8,   9,  10,  11,  12,
              13,  14,  18,  19,  20,  21,  23,  24,  25,  26,  28,  30,  31,
              32,  35,  40,  41,  42,  44,  45,  46,  47,  48,  54,  55,  62,
              67,  73,  75,  76,  85,  88,  90,  94,  95,  97, 104, 105, 108,
             109, 110, 124, 127, 131, 132, 134, 139, 140, 151, 165, 169, 179,
             190, 198, 205, 237, 239, 240, 254, 277, 278, 291])
```

```
In [237… len(enetselect)
```

```
Out[237… 75
```

```
In [238… enetselect
```

Out[238…

```
array(['accommodates', 'bedrooms', 'bedroomsXaccommodates',
       'bedroomsXbathrooms', 'beds', 'room_type_Private room',
       'bathrooms', 'guests_included', 'neighbourhood_cleansed',
       'Family/kid friendly', 'TV', 'amenityscore',
       'cancellation_policy_strict_14_with_grace_period',
       'security_deposit_perc_blank', 'longitude', 'extra_people_perc',
       'Dishwasher', 'Indoor fireplace', 'cleaning_fee_perc_blank',
       'hotlongitude', 'Heating', 'property_type_House', 'Cable TV',
       'Air conditioning', 'calculated_host_listings_count_entire_homes',
       'BBQ grill', 'latitude', 'host_listings_count', 'Smoking allowed',
       'Lock on bedroom door', 'Iron', 'hotlatXhotlong', 'Dryer',
       'Coffee maker', 'Pool', 'availability_365',
       'property_type_Apartment', 'Hair dryer', 'Fire extinguisher',
       'hotlatitude', 'house_rules_blank', 'Beachfront',
       'Dishes and silverware', 'First aid kit', 'notes_blank',
       'Microwave', 'host_id', 'Waterfront', 'Refrigerator',
       'host_about_blank', 'Long term stays allowed',
       'instant_bookable_t', 'availability_90',
       'host_neighbourhood_blank', 'Shampoo', 'maximum_minimum_nights',
       'availability_60', 'Free street parking', 'review_scores_rating',
       'review_scores_cleanliness', 'review_scores_location',
       'availability_30', 'weekly_discount', 'review_scores_accuracy',
       'Luggage dropoff allowed', 'number_of_reviews',
       'neighbourhood_blank',
       'calculated_host_listings_count_shared_rooms',
       'number_of_reviews_ltm', 'security_deposit_perc',
       'reviews_per_month', 'Elevator', 'Single level home',
       'cleaning_fee_perc', 'review_scores_value'], dtype=object)
```

In [284…

```
enet.fit(fullxtrain,fullytrain)
```

Out[284…

```
ElasticNet(alpha=0.0028861641656963383, l1_ratio=1.0)
```

In [285…

```
#predictions = yjp.inverse_transform(enet_cv.predict(test).reshape(-1,1))
predictions = np.round(np.exp(enet.predict(test)),2)
```

In [286…

```
np.isnan(predictions).sum()
```

Out[286…

```
0
```

In [287…

```
np.where(np.isnan(predictions)==True)
```

Out[287…

```
(array([], dtype=int64),)
```

In [288…

```
my_submission = pd.DataFrame({'id': test.index, 'price': predictions.ravel
my_submission.to_csv('submission.csv', index=False)
```

In [243…

```
enet_cv.coef_[enet_cv.coef_!=0]
```

Out[243…

```
array([ 1.44101122e-01,  1.33250452e-01, -3.63349653e-02,  7.62526235e-02,
        7.89937619e-03, -4.62849608e-01, -8.67279493e-03,  3.59084154e-03,
        2.79606144e-02,  1.13285401e-02,  3.49333742e-02,  1.38981100e-02,
        5.74739564e-02, -6.25050203e-02,  5.69165200e-02, -3.61235687e-02,
        4.49792524e-02,  3.95572228e-02, -1.51207761e-01,  2.71031709e-02,
        3.70857132e-03,  3.05443821e-02,  3.82751428e-02,  5.61184064e-02,
        2.57758917e-03,  2.06895770e-02,  5.29086845e-03, -9.75963371e-04,
       -6.02527570e-17, -2.01244156e-04, -2.69296742e-02, -1.81601914e-02,
        6.27051737e-03,  5.46134718e-02,  2.32771247e-02,  2.15145981e-02,
        3.26408718e-02,  4.75552807e-02, -3.30615022e-03,  8.53249431e-03,
        7.89389960e-04,  3.70736376e-02, -8.78994205e-04,  2.28625361e-02,
       -2.09412839e-03,  2.25209107e-02, -2.33080230e-02, -1.80473587e-02,
       -4.01637091e-03,  2.11709825e-02, -8.86795927e-03, -7.84073334e-04,
       -6.79814700e-03, -1.19586848e-02,  2.44962485e-02, -2.27897114e-02,
        1.58971823e-02,  2.26631857e-02,  9.63520488e-03, -5.21827781e-02,
        1.55270433e-02,  2.12183522e-02,  1.29973704e-02,  1.53444661e-02,
       -2.83860097e-04,  2.58545088e-02, -5.06790468e-03, -1.52544624e-02,
       -6.02676655e-03, -7.23949640e-02, -1.47508899e-02, -1.16252369e-02,
       -1.40113283e-02, -1.62804439e-02,  2.58939789e-02, -1.55885321e-04,
       -6.43101485e-03, -2.10552470e-01, -4.16602526e-02])
```

Ordinary Least Squares

We will take the same variables selected above as the L1 ratio = 1, meaning that LASSO has selected these variables and not Ridge.

In [244…

```
OLSfeatures = np.where(elasticnetvars==True)[1]
```

In [245…

```
ols = LinearRegression()
ols.fit(X_train[OLSfeatures], y_train)
```

Out[245…

```
LinearRegression()
```

In [246…

```
kf=KFold(5)
scores = cross_val_score(ols, X_val[OLSfeatures], y_val, cv=kf, scoring =

# print the score for each fold
print(np.sqrt(-scores).round(4))
print((sum(np.sqrt(-scores))/len(np.sqrt(-scores))).round(4))
print('RMSE score for Ordinary Least Squares model')
```

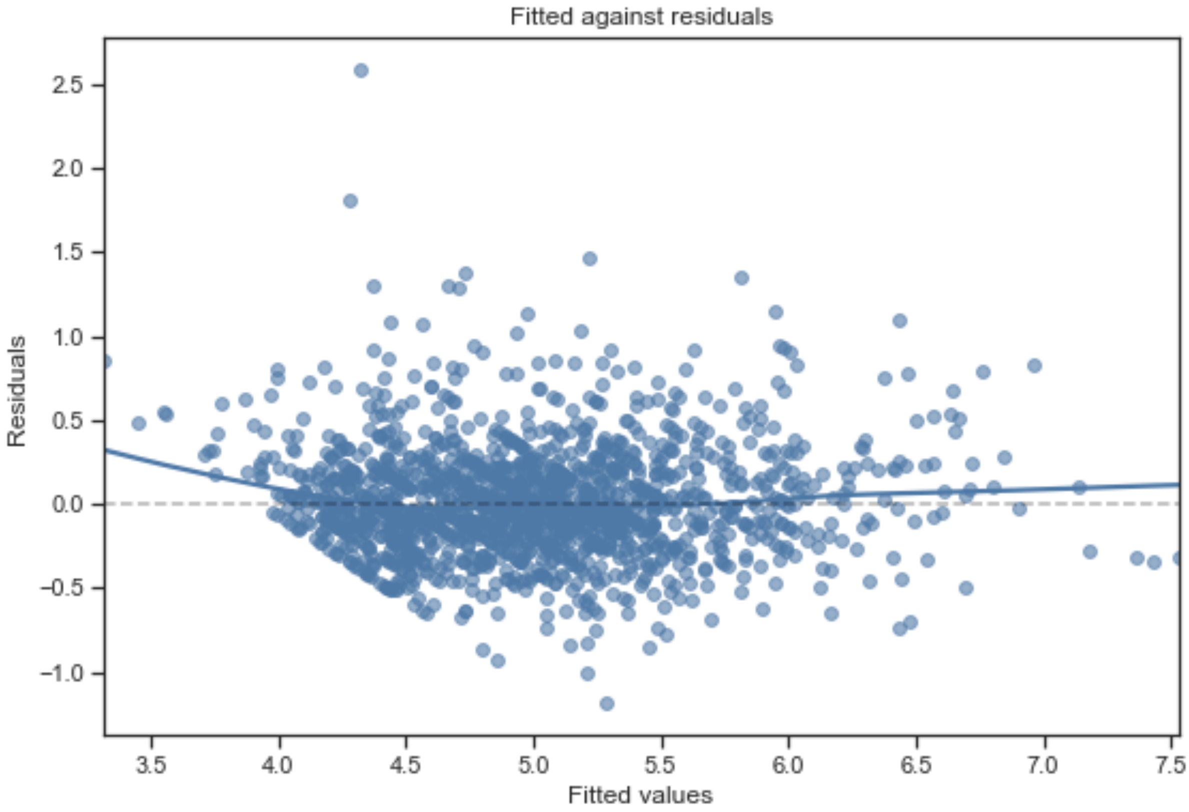
```
[0.3428 0.3355 0.3764 0.3237 0.3318]
0.342
RMSE score for Ordinary Least Squares model
```

In [247…

```
fitted = ols.predict(X_val[OLSfeatures])
resid = y_val - ols.predict(X_val[OLSfeatures])

fig, ax= plt.subplots()
sns.regplot(fitted, resid, lowess=True, ax=ax, scatter_kws={'s': 35, 'alpha
ax.set_xlabel('Fitted values',  {'fontsize': 12})
ax.set_ylabel('Residuals', {'fontsize': 12})
ax.set_title('Fitted against residuals')
plt.axhline(color='Black', alpha=0.3, linestyle='--')
#EXOGENEITY plot
```

Out[247…

```
<matplotlib.lines.Line2D at 0x7fa75d552650>
```



Ridge

We will take the same variables selected before as the L1 ratio = 1, meaning that LASSO has selected these variables and not Ridge.

In [248…

```
OLSfeatures = np.where(elasticnetvars==True)[1]
```

In [249…

```
from sklearn.linear_model import RidgeCV
ridge_cv = RidgeCV(alphas=np.arange(150,300)*0.1, cv=5)
ridge_cv.fit(X_train[OLSfeatures],np.ravel(y_train))
```

Out[249…

```
RidgeCV(alphas=array([15. , 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8,
15.9, 16. ,
       16.1, 16.2, 16.3, 16.4, 16.5, 16.6, 16.7, 16.8, 16.9, 17. , 17.1,
       17.2, 17.3, 17.4, 17.5, 17.6, 17.7, 17.8, 17.9, 18. , 18.1, 18.2,
       18.3, 18.4, 18.5, 18.6, 18.7, 18.8, 18.9, 19. , 19.1, 19.2, 19.3,
       19.4, 19.5, 19.6, 19.7, 19.8, 19.9, 20. , 20.1, 20.2, 20.3, 20.4,
       20.5, 20.6, 20.7, 20.8, 20.9, 21. , 21.1, 21.2, 21.3, 21.4, 21.5,
       21.6,...
       22.7, 22.8, 22.9, 23. , 23.1, 23.2, 23.3, 23.4, 23.5, 23.6, 23.7,
       23.8, 23.9, 24. , 24.1, 24.2, 24.3, 24.4, 24.5, 24.6, 24.7, 24.8,
       24.9, 25. , 25.1, 25.2, 25.3, 25.4, 25.5, 25.6, 25.7, 25.8, 25.9,
       26. , 26.1, 26.2, 26.3, 26.4, 26.5, 26.6, 26.7, 26.8, 26.9, 27. ,
       27.1, 27.2, 27.3, 27.4, 27.5, 27.6, 27.7, 27.8, 27.9, 28. , 28.1,
       28.2, 28.3, 28.4, 28.5, 28.6, 28.7, 28.8, 28.9, 29. , 29.1, 29.2,
       29.3, 29.4, 29.5, 29.6, 29.7, 29.8, 29.9]),
        cv=5)
```

In [250…

```
ridge_cv.alpha_
```

Out[250…

```
22.700000000000003
```

In [251…

```
from sklearn.linear_model import Ridge
ridge = Ridge(alpha=ridge_cv.alpha_)
```

In [252…

```
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
kf=KFold(5)
scores = cross_val_score(ridge, X_val[OLSfeatures], y_val, cv=kf, scoring =

# print the score for each fold
print(np.sqrt(-scores).round(4))
print((sum(np.sqrt(-scores))/len(np.sqrt(-scores))).round(4))
print('RMSE score for Ridge model')
```

```
[0.3375 0.3352 0.3756 0.3229 0.3317]
0.3406
RMSE score for Ridge model
```

XGBoost

Bayesian hyperparameter optimisation for XGB

In [253…

```
from skopt.space import Real, Categorical, Integer
from skopt import BayesSearchCV
```

In [254…

```
from xgboost import XGBRegressor

model = XGBRegressor()

search_space = {
    'reg_lambda': Real(1e-10, 1e12, 'log-uniform'),
    'learning_rate': Real(0.005, 0.1),
    'n_estimators' : Integer(100, 5000),
    'max_depth' : Integer(2, 8),
    'subsample' : Real(0.5, 1.0),
    'colsample_bytree' : Real(0.25, 1.0),
}

xgb_opt =  BayesSearchCV(model, search_space, cv = 5,  n_iter= 8, scoring =
```

In [255…

```
#Thinking about making this as a warning.

print('Warning: Optimising and fitting XGBoost will take at least 40 minute
optimise = str(input('Would you like to optimise and fit XGBoost? Answer \

if optimise.lower() == 'c':
    model = xgb_opt.fit(X_train, y_train)
    xgb_opt.best_params_
```

```
Warning: Optimising and fitting XGBoost will take at least 40 minutes.
```

In [256…

```
xgb_opt.best_params_
```

Out[256…

```
OrderedDict([('colsample_bytree', 0.6585666723543374),
             ('learning_rate', 0.02100437221055008),
             ('max_depth', 4),
             ('n_estimators', 2583),
             ('reg_lambda', 1.2994805179302653e-08),
             ('subsample', 0.6757498243587916)])
```

In [257…

```
#Why run the same 40 minute optimiser over and over? These are the best pa

xgboost = xgb_opt.best_estimator_
```

In [258…

```
score = cross_val_score(xgboost, X_val, y_val, cv=kf, scoring = 'neg_mean_s
print("xgboost: {:.4f} ({:.4f})".format(score.mean(), score.std()))
print(np.sqrt(-score)) #scores for each fold
```

```
xgboost: -0.0979 (0.0122)
[0.28633611 0.3105886  0.34594802 0.31012361 0.30812311]
```

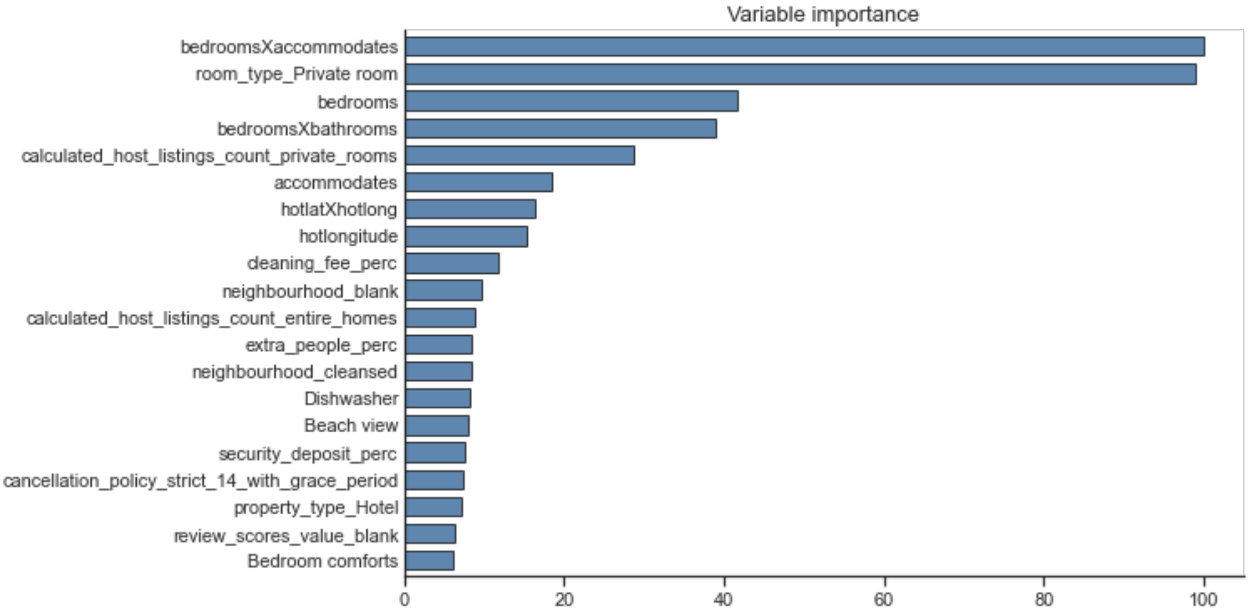
In [259…

```
print(np.mean(np.sqrt(-score)))
```

```
0.3122238920801711
```

In [260…

```
from statlearning import plot_feature_importance
plot_feature_importance(xgb_opt.best_estimator_, labels=features)
plt.show()
```



In [280…

```
testxgb = xgboost.fit(fullxtrain, fullytrain)
```

In [282…

```
#predictions = yjp.inverse_transform(enet_cv.predict(test).reshape(-1,1))
predictions = np.round(np.exp(testxgb.predict(test)),2)
```

In [283…

```
my_submission = pd.DataFrame({'id': test.index, 'price': predictions.ravel
my_submission.to_csv('submission.csv', index=False)
```

LightGBM

In [263…

```
import lightgbm as lgb
```

In [264…

```
model = lgb.LGBMRegressor(objective='regression')

search_space = {
    'learning_rate': Real(0.005,0.1), # uniform distribution between 0.005
    'n_estimators' : Integer(100, 2501), # discrete uniform distribution be
    'num_leaves' : Integer(2, 65), # discrete uniform distribution between
    'subsample' : Real(0.5, 1), # uniform distribution between 0.5 and 1
}


lbst = BayesSearchCV(model, search_space, n_iter = 32, cv = 5, n_jobs=-1, 
lbst.fit(X_train, y_train)


print('Best parameters found by Bayes search:', lbst.best_params_, '\n')
```

```
Best parameters found by Bayes search: OrderedDict([('learning_rate', 0.088
38008753245956), ('n_estimators', 963), ('num_leaves', 4), ('subsample', 0.
7854148780763127)])
```

In [265…

```
lgb = lbst.best_estimator_
```

In [266…

```
score = cross_val_score(lgb, X_val, y_val, cv=kf, scoring = 'neg_mean_squar
print("LightGBM: {:.4f} ({:.4f})".format(score.mean(), score.std()))
print(np.sqrt(-score)) #scores for each fold
```

```
LightGBM: -0.1008 (0.0141)
[0.29353705 0.3197337  0.35638825 0.30437453 0.31011024]
```

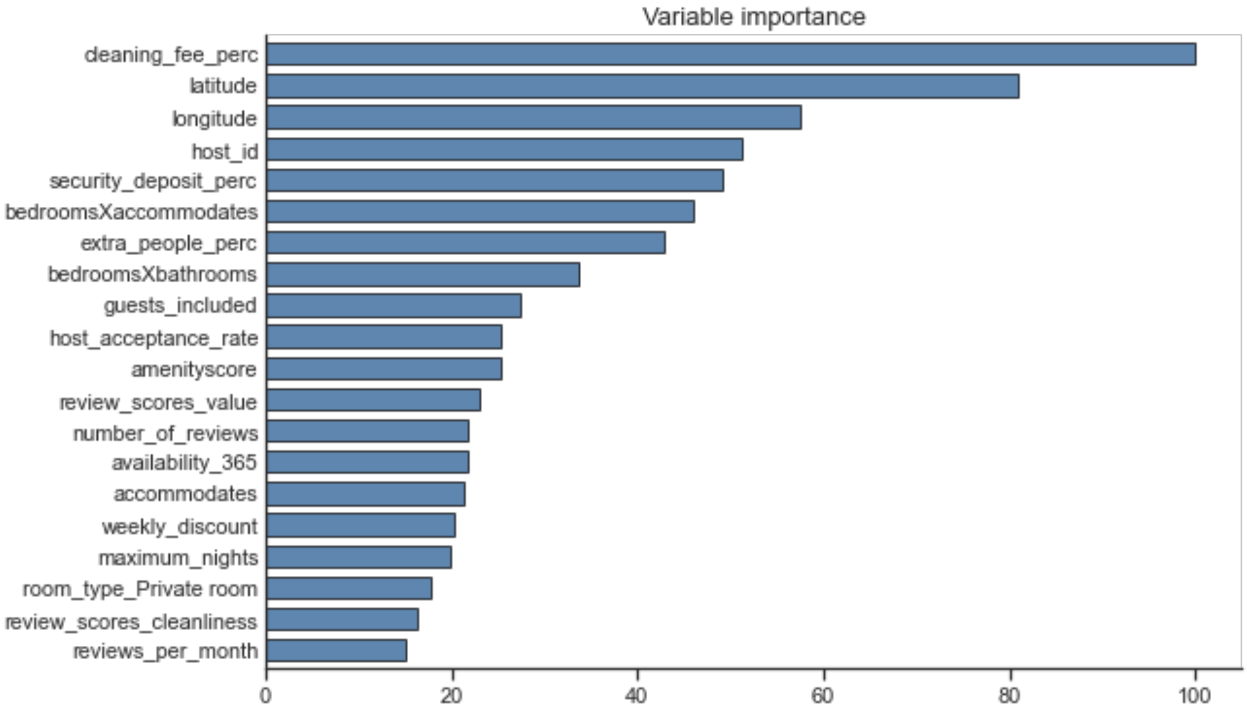
In [267…

```
print(np.mean(np.sqrt(-score)))
```

```
0.31682875376343217
```

In [268…

```
from statlearning import plot_feature_importance
plot_feature_importance(lgb, labels=features)
plt.show()
```



In [269…

```
#predictions = np.round(yj.inverse_transform(enet_cv.predict(test).reshape
predictions = np.round(np.exp(lgb.predict(test)),2)
```

In [270…

```
my_submission = pd.DataFrame({'id': test.index, 'price': predictions})
my_submission.to_csv('submission.csv', index=False)
```

Model Stacking

In [271…

```
stack_train = X_train.values
stack_val = X_val.values
stack_y_val = y_val.values
stack_y_train = y_train.values
```

In [272…

```
from mlxtend.regressor import StackingCVRegressor

stack = StackingCVRegressor(regressors=[lgb, enet, xgboost], meta_regresso
                            cv=5, use_features_in_secondary=True)
#modelstack = stack.fit(stack_train, stack_y_train)
```

In [274…

```
score = cross_val_score(stack, stack_val, stack_y_val, cv=kf, scoring = 'ne
print("stack: {:.4f} ({:.4f})".format(score.mean(), score.std()))
print(np.sqrt(-score)) #scores for each fold
```

```
stack: -0.0962 (0.0141)
[0.28539588 0.31069724 0.35016403 0.2986285  0.30231729]
```

In [275…

```
print(np.round(np.sqrt(-score),4))
```

```
[0.2854 0.3107 0.3502 0.2986 0.3023]
```

In [276…

```
np.mean(np.sqrt(-score))
```

Out[276…

```
0.30944058692793924
```

In [277…

```
teststack = stack.fit(fullxtrain, fullytrain)
```

In [278…

```
stacktest=test.values
predictions = np.round(np.exp(teststack.predict(stacktest)),2)
```

In [279…

```
my_submission = pd.DataFrame({'id': test.index, 'price': predictions.ravel
my_submission.to_csv('submission.csv', index=False)
```

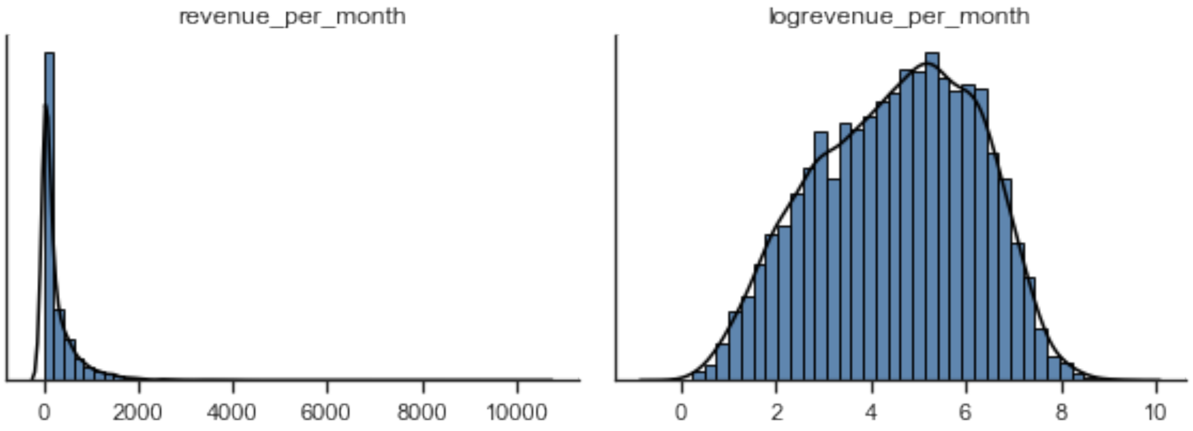
Data Mining

In [366…

```
train['logrevenue_per_month'] = np.log(train['revenue_per_month'])
```

In [367…

```
from statlearning import plot_dists
plot_dists(train[['revenue_per_month','logrevenue_per_month']])
plt.show()
```



In [332…

```
#These are the values for the data mining
```

In [368…

```
features = train.columns.values
```

In [369…

```
features = np.delete(features,np.where(features=='priceYJ'))
features = np.delete(features,np.where(features=='logprice'))
```

In [370…

```
features = np.delete(features,np.where(features=='revenue_per_month'))
features = np.delete(features,np.where(features=='logrevenue_per_month'))
```

In [371…

```
from sklearn.model_selection import train_test_split
X_tr_mine, X_val_mine, y_tr_mine, y_val_mine = train_test_split(train[featu
```

In [372…

```
from sklearn.experimental import enable_iterative_imputer
from sklearn.impute import IterativeImputer

imp =  IterativeImputer()
imp.fit(X_tr_mine[imputequantvars])
X_tr_mine[imputequantvars] = imp.transform(X_tr_mine[imputequantvars])
X_val_mine[imputequantvars] = imp.transform(X_val_mine[imputequantvars])
```

Should we be fitting the imputer to the test?

In [373…

```
#Fixing variable skewness
```

In [374…

```
skews = ['square_feet','weekly_discount','minimum_nights','minimum_minimum_
```

In [375…

```
yj = PowerTransformer(method='yeo-johnson')

X_tr_mine[skews]  = yj.fit_transform(X_tr_mine[skews])
X_val_mine[skews] = yj.transform(X_val_mine[skews])
```

Outliers

In [376…

```
quantitativevariables = []
for i in features:
    if train.dtypes[i] == int or train.dtypes[i] == float and i!='revenue_p
        quantitativevariables.append(i)
```

In [377…

```
X_tr_mine = X_tr_mine.fillna(0)
X_val_mine = X_val_mine.fillna(0)
```

In [378…

```
from sklearn.linear_model import LinearRegression

ols = LinearRegression()
ols.fit(X_tr_mine[quantitativevariables], y_tr_mine)

y_fitted = ols.predict(X_tr_mine[quantitativevariables])
e = y_train - y_fitted

#e.reset_index(drop=True,inplace=True)

outliers = e.abs().sort_values().iloc[-10:] # retrieves the indexes for th
```

In [379…

```
outlierlist = outliers.index.values
```

In [380…

```
for i in outlierlist:
    X_tr_mine['outlier'] = np.where(X_tr_mine.index==i,1,0)
```

In [381…

```
features = abs(train.corr()['logrevenue_per_month']).sort_values(ascending
```

In [382…

```
features=np.delete(features,np.where(features=='priceYJ'))
features=np.delete(features,np.where(features=='revenue_per_month'))
features=np.delete(features,np.where(features=='logprice')) #price is stil
```

In [383…

```
badfeatures = ['Nespresso machine', 'Natural gas barbeque', 'Sonos sound sy
#These features don't exist in the test and so will be deleted.
for i in badfeatures:
    features=np.delete(features,np.where(features==i)) # is causing it to
morebadfeatures = [' zhima_selfie', ' sent_id', ' reviews', ' manual_online
for i in morebadfeatures:
    features=np.delete(features,np.where(features==i)) # is causing it to
```

In [384…

```
from sklearn.preprocessing import RobustScaler
scaler = RobustScaler() #scaling

X_train_scaled = scaler.fit_transform(X_tr_mine[features])
X_tr_mine = pd.DataFrame(X_train_scaled)

X_val_scaled = scaler.transform(X_val_mine[features])
X_val_mine = pd.DataFrame(X_val_scaled)
```

In [385…

```
from sklearn.linear_model import ElasticNetCV
enet_cv = ElasticNetCV(l1_ratio=[0.01,0.05,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8
enet_cv.fit(X_tr_mine,np.ravel(y_tr_mine))
```

Out[385…

```
ElasticNetCV(cv=5,
             l1_ratio=[0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8,
0.9,
                       0.95, 0.99, 1])
```

In [386…

```
enet_cv.l1_ratio_
```

Out[386…

```
1.0
```

In [387…

```
enet_cv.alpha_
```

Out[387…

```
0.004718791204316187
```

In [388…

```
from sklearn.linear_model import ElasticNet
enetmine = ElasticNet(alpha = enet_cv.alpha_, l1_ratio = enet_cv.l1_ratio_
```

In [389…

```
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
kf=KFold(5)
scores = cross_val_score(enetmine, X_val_mine, y_val_mine, cv=kf, scoring

# print the score for each fold
print(np.sqrt(-scores).round(4))
print((sum(np.sqrt(-scores))/len(np.sqrt(-scores))).round(4))
print('RMSE score for Elastic Net model')
```

```
[0.8116 0.7935 0.6941 0.7883 0.8011]
0.7777
RMSE score for Elastic Net model
```

In [390…

```
enetmine.fit(X_tr_mine,y_tr_mine)
```

Out[390…

```
ElasticNet(alpha=0.004718791204316187, l1_ratio=1.0)
```

In [395…

```
coeffs = enetmine.coef_
```

In [396…

```
d = {'Coefficient': coeffs.round(4)}

coeffmatrix = pd.DataFrame(data=d,index=features)
```

In [397…

```
coeffmatrix.sort_values(by='Coefficient',ascending=False)
```

Out[397…

	Coefficient
host_acceptance_rate	0.9741
reviews_per_month	0.4042
host_response_rate	0.3783
price	0.2116
accommodates	0.1893
...	...
cleaning_fee_perc_blank	-0.1234
minimum_minimum_nights	-0.1458
Family/kid friendly	-0.1494
Internet	-0.1539
room_type_Private room	-0.3606

317 rows × 1 columns

In [398…

```
coeffmatrix.to_csv('coeffmatrix.csv', index=True)
```