title: House prices prediction

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Description

this paper will analyze House prices dataset and built model for regression prediction the sale price of house by following step below;

- Import essential package
- Collect Data
- Basic explore dataset and split data into train and test set
- cleaning missing data
- feature engineering
- category data encoding
  - order encoding
  - one hot encoding
- data transformation
- feature selection
  - constant feature
  - lasso
  - rfe
- model selection
- hyperparameter
- df_test prediction

Import essential package

In [256…

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
pd.set_option('display.max_columns',100)
import warnings
warnings.filterwarnings('ignore')
%matplotlib inline

from sklearn.cluster import KMeans
from feature_engine.encoding import OneHotEncoder
import scipy.stats as stats
from scipy.stats import skew
from sklearn.preprocessing import RobustScaler
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import LassoCV
from sklearn.model_selection import train_test_split
from sklearn.feature_selection import RFE
from sklearn.ensemble import GradientBoostingRegressor
```

```
from sklearn.ensemble import RandomForestRegressor
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import Ridge
from sklearn.metrics import mean_absolute_error,r2_score
from sklearn.model_selection import RandomizedSearchCV
from scipy.stats import loguniform
import joblib
```

Collect Data

In [256…

```
df_train=pd.read_csv('/Users/wittawatmuangkot/Downloads/house-prices-advanced-regression-t
df_test=pd.read_csv('/Users/wittawatmuangkot/Downloads/house-prices-advanced-regression-te
```

In [256…

```
print('df_train \nhave total rows: {} and total columns: {}'.format(df_train.shape[0],df_t
missing_col_train=[x for x in df_train.columns
            if df_train[x].isnull().any()]
print('Total missing values columns: {}'.format(len(missing_col_train)))
print('number of each data type\n')
dtypes_train = pd.DataFrame(df_train.dtypes)
print(dtypes_train.value_counts(),'\n')

print('df_test \nhave total rows: {} and total columns: {}'.format(df_test.shape[0],df_tes
missing_col_test=[x for x in df_test.columns
            if df_test[x].isnull().any()]
print('Total missing values columns: {}'.format(len(missing_col_test)))
print('number of each data type\n')
dtypes_test = pd.DataFrame(df_test.dtypes)
print(dtypes_test.value_counts())
```

```
df_train
have total rows: 1460 and total columns: 81
Total missing values columns: 19
number of each data type

object     43
int64      35
float64     3
dtype: int64

df_test
have total rows: 1459 and total columns: 80
Total missing values columns: 33
number of each data type

object     43
int64      26
float64    11
dtype: int64
```

After check the infomation of this dataset we found that there are missing values in some column and need to clean data before do the next process of model building. As this dataset has many feature train_df 81 columns and test_df 80 columns, so we need to do the feature selection that to select the low significance feature.

First remove ID columns that has no any unique values in columns that mean this columns not useful for our model prediction

In [257…

```
df_train=df_train.drop('Id',axis=1)
df_test=df_test.drop('Id',axis=1)
```

Split train_df data into train and test set using for evaluate model, using the test size 30% and train size for 70%

In [257…

```
X_train,X_test,y_train,y_test=train_test_split(df_train,df_train['SalePrice'],test_size=0.
```

In [257…

```
X_train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1022 entries, 135 to 1126
Data columns (total 80 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   MSSubClass     1022 non-null   int64  
 1   MSZoning       1022 non-null   object 
 2   LotFrontage    832 non-null    float64
 3   LotArea        1022 non-null   int64  
 4   Street         1022 non-null   object 
 5   Alley          66 non-null     object 
 6   LotShape       1022 non-null   object 
 7   LandContour    1022 non-null   object 
 8   Utilities      1022 non-null   object 
 9   LotConfig      1022 non-null   object 
 10  LandSlope      1022 non-null   object 
 11  Neighborhood   1022 non-null   object 
 12  Condition1     1022 non-null   object 
 13  Condition2     1022 non-null   object 
 14  BldgType       1022 non-null   object 
 15  HouseStyle     1022 non-null   object 
 16  OverallQual    1022 non-null   int64  
 17  OverallCond    1022 non-null   int64  
 18  YearBuilt      1022 non-null   int64  
 19  YearRemodAdd   1022 non-null   int64  
 20  RoofStyle      1022 non-null   object 
 21  RoofMatl       1022 non-null   object 
 22  Exterior1st    1022 non-null   object 
 23  Exterior2nd    1022 non-null   object 
 24  MasVnrType     1019 non-null   object 
 25  MasVnrArea     1019 non-null   float64
 26  ExterQual      1022 non-null   object 
 27  ExterCond      1022 non-null   object 
 28  Foundation     1022 non-null   object 
 29  BsmtQual       996 non-null    object 
 30  BsmtCond       996 non-null    object 
 31  BsmtExposure   996 non-null    object 
 32  BsmtFinType1   996 non-null    object 
 33  BsmtFinSF1     1022 non-null   int64  
 34  BsmtFinType2   996 non-null    object 
 35  BsmtFinSF2     1022 non-null   int64  
 36  BsmtUnfSF      1022 non-null   int64  
 37  TotalBsmtSF    1022 non-null   int64  
 38  Heating        1022 non-null   object 
 39  HeatingQC      1022 non-null   object 
 40  CentralAir     1022 non-null   object 
 41  Electrical     1021 non-null   object 
 42  1stFlrSF       1022 non-null   int64  
 43  2ndFlrSF       1022 non-null   int64  
 44  LowQualFinSF   1022 non-null   int64  
 45  GrLivArea      1022 non-null   int64  
```

```
 46  BsmtFullBath   1022 non-null   int64
 47  BsmtHalfBath   1022 non-null   int64
 48  FullBath       1022 non-null   int64
 49  HalfBath       1022 non-null   int64
 50  BedroomAbvGr   1022 non-null   int64
 51  KitchenAbvGr   1022 non-null   int64
 52  KitchenQual    1022 non-null   object
 53  TotRmsAbvGrd   1022 non-null   int64
 54  Functional     1022 non-null   object
 55  Fireplaces     1022 non-null   int64
 56  FireplaceQu    535 non-null    object
 57  GarageType     968 non-null    object
 58  GarageYrBlt    968 non-null    float64
 59  GarageFinish   968 non-null    object
 60  GarageCars     1022 non-null   int64
 61  GarageArea     1022 non-null   int64
 62  GarageQual     968 non-null    object
 63  GarageCond     968 non-null    object
 64  PavedDrive     1022 non-null   object
 65  WoodDeckSF     1022 non-null   int64
 66  OpenPorchSF    1022 non-null   int64
 67  EnclosedPorch  1022 non-null   int64
 68  3SsnPorch      1022 non-null   int64
 69  ScreenPorch    1022 non-null   int64
 70  PoolArea       1022 non-null   int64
 71  PoolQC         5 non-null      object
 72  Fence          202 non-null    object
 73  MiscFeature    40 non-null     object
 74  MiscVal        1022 non-null   int64
 75  MoSold         1022 non-null   int64
 76  YrSold         1022 non-null   int64
 77  SaleType       1022 non-null   object
 78  SaleCondition  1022 non-null   object
 79  SalePrice      1022 non-null   int64
dtypes: float64(3), int64(34), object(43)
memory usage: 646.7+ KB
```

In [257…

```
df_test.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1459 entries, 0 to 1458
Data columns (total 79 columns):
 #   Column         Non-Null Count  Dtype
---  ------         --------------  -----
 0   MSSubClass     1459 non-null   int64
 1   MSZoning       1455 non-null   object
 2   LotFrontage    1232 non-null   float64
 3   LotArea        1459 non-null   int64
 4   Street         1459 non-null   object
 5   Alley          107 non-null    object
 6   LotShape       1459 non-null   object
 7   LandContour    1459 non-null   object
 8   Utilities      1457 non-null   object
 9   LotConfig      1459 non-null   object
 10  LandSlope      1459 non-null   object
 11  Neighborhood   1459 non-null   object
 12  Condition1     1459 non-null   object
 13  Condition2     1459 non-null   object
 14  BldgType       1459 non-null   object
 15  HouseStyle     1459 non-null   object
 16  OverallQual    1459 non-null   int64
 17  OverallCond    1459 non-null   int64
 18  YearBuilt      1459 non-null   int64
 19  YearRemodAdd   1459 non-null   int64
 20  RoofStyle      1459 non-null   object
```

```
 21  RoofMatl       1459 non-null   object
 22  Exterior1st    1458 non-null   object
 23  Exterior2nd    1458 non-null   object
 24  MasVnrType     1443 non-null   object
 25  MasVnrArea     1444 non-null   float64
 26  ExterQual      1459 non-null   object
 27  ExterCond      1459 non-null   object
 28  Foundation     1459 non-null   object
 29  BsmtQual       1415 non-null   object
 30  BsmtCond       1414 non-null   object
 31  BsmtExposure   1415 non-null   object
 32  BsmtFinType1   1417 non-null   object
 33  BsmtFinSF1     1458 non-null   float64
 34  BsmtFinType2   1417 non-null   object
 35  BsmtFinSF2     1458 non-null   float64
 36  BsmtUnfSF      1458 non-null   float64
 37  TotalBsmtSF    1458 non-null   float64
 38  Heating        1459 non-null   object
 39  HeatingQC      1459 non-null   object
 40  CentralAir     1459 non-null   object
 41  Electrical     1459 non-null   object
 42  1stFlrSF       1459 non-null   int64
 43  2ndFlrSF       1459 non-null   int64
 44  LowQualFinSF   1459 non-null   int64
 45  GrLivArea      1459 non-null   int64
 46  BsmtFullBath   1457 non-null   float64
 47  BsmtHalfBath   1457 non-null   float64
 48  FullBath       1459 non-null   int64
 49  HalfBath       1459 non-null   int64
 50  BedroomAbvGr   1459 non-null   int64
 51  KitchenAbvGr   1459 non-null   int64
 52  KitchenQual    1458 non-null   object
 53  TotRmsAbvGrd   1459 non-null   int64
 54  Functional     1457 non-null   object
 55  Fireplaces     1459 non-null   int64
 56  FireplaceQu    729 non-null    object
 57  GarageType     1383 non-null   object
 58  GarageYrBlt    1381 non-null   float64
 59  GarageFinish   1381 non-null   object
 60  GarageCars     1458 non-null   float64
 61  GarageArea     1458 non-null   float64
 62  GarageQual     1381 non-null   object
 63  GarageCond     1381 non-null   object
 64  PavedDrive     1459 non-null   object
 65  WoodDeckSF     1459 non-null   int64
 66  OpenPorchSF    1459 non-null   int64
 67  EnclosedPorch  1459 non-null   int64
 68  3SsnPorch      1459 non-null   int64
 69  ScreenPorch    1459 non-null   int64
 70  PoolArea       1459 non-null   int64
 71  PoolQC         3 non-null      object
 72  Fence          290 non-null    object
 73  MiscFeature    51 non-null     object
 74  MiscVal        1459 non-null   int64
 75  MoSold         1459 non-null   int64
 76  YrSold         1459 non-null   int64
 77  SaleType       1458 non-null   object
 78  SaleCondition  1459 non-null   object
dtypes: float64(11), int64(25), object(43)
memory usage: 900.6+ KB
```

In [257…

```
discrete = []

for var in numeric_col:
    if len(df_train[var].unique()) < 20 and var not in year_col:
```

```
        print(var, ' values: ', df_train[var].unique())
        discrete.append(var)
print()
print('There are {} discrete variables'.format(len(discrete)))
```

```
MSSubClass  values:  [ 60  20  70  50 190  45  90 120  30  85  80 160  75 180  40]
OverallQual  values:  [ 7  6  8  5  9  4 10  3  1  2]
OverallCond  values:  [5 8 6 7 4 2 3 9 1]
BsmtFullBath  values:  [1 0 2 3]
BsmtHalfBath  values:  [0 1 2]
FullBath  values:  [2 1 3 0]
HalfBath  values:  [1 0 2]
BedroomAbvGr  values:  [3 4 1 2 0 5 6 8]
KitchenAbvGr  values:  [1 2 3 0]
TotRmsAbvGrd  values:  [ 8  6  7  9  5 11  4 10 12  3  2 14]
Fireplaces  values:  [0 1 2 3]
GarageCars  values:  [2 3 1 0 4]
PoolArea  values:  [  0 512 648 576 555 480 519 738]
MoSold  values:  [ 2  5  9 12 10  8 11  4  1  7  3  6]

There are 14 discrete variables
```

Feature name correction

Some columns name of this dataset start with numeric, so we need to replace with text, to prevent miss understand of programe when we call these columns

In [257…

```
X_train.rename(columns={'1stFlrSF':'FirstFlrSF','2ndFlrSF':'SecondFlrSF','3SsnPorch':'Thi
X_test.rename(columns={'1stFlrSF':'FirstFlrSF','2ndFlrSF':'SecondFlrSF','3SsnPorch':'Third
df_test.rename(columns={'1stFlrSF':'FirstFlrSF','2ndFlrSF':'SecondFlrSF','3SsnPorch':'Thi
```

Missing data check and Imputation

let start with checking the total number of missing columns in X_train dataset. to prevent overfiting in test dataset, we will Impute missing data refering missing values from the X_train and transform to test set

In [257…

```
miss_col=[a for a in X_train.columns
              if X_train[a].isnull().any()]
len(miss_col)
```

Out[257…

```
19
```

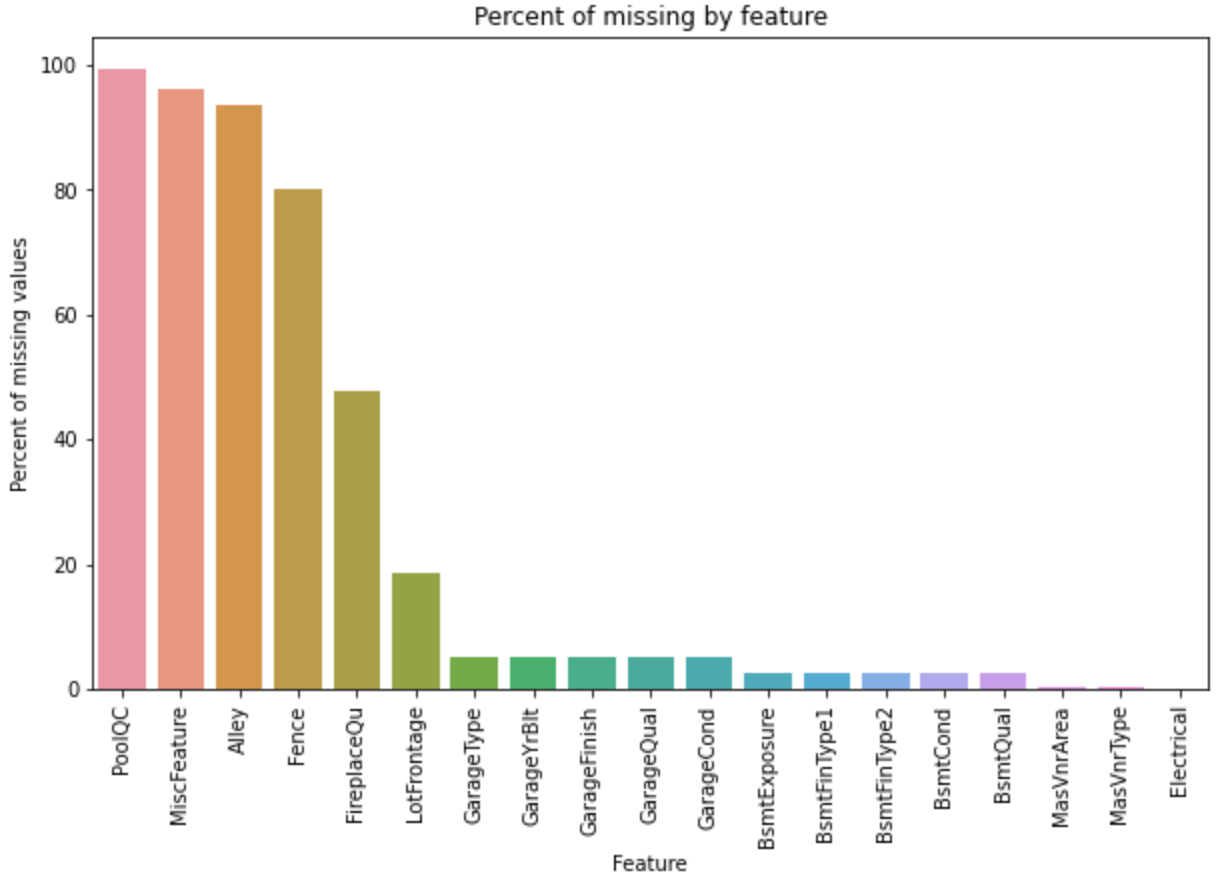
In [257…

```
def missing_table(data):
    miss_col=[a for a in data.columns
              if data[a].isnull().any()]
    missing=[]
    percent=[]
    for i in miss_col:
        miss=data[i].isnull().sum()
        percent_miss=(miss/data.shape[0])*100
        missing.append(miss)
        percent.append(percent_miss)

    miss_table=pd.DataFrame({'Col':miss_col,'missing':missing,'percent':percent}).sort_val
    plt.subplots(figsize=(10,6))
    sns.barplot(x=miss_table['Col'],y=miss_table['percent'])
    plt.xlabel('Feature')
    plt.ylabel('Percent of missing values')
    plt.title('Percent of missing by feature')
    plt.xticks(rotation='90')
```

```
    plt.show()
    return miss_table
```

In [257…

```
missing_table(X_train)
```



Out[257…

	Col	missing	percent
16	PoolQC	1017	99.510763
18	MiscFeature	982	96.086106
1	Alley	956	93.542074
17	Fence	820	80.234834
10	FireplaceQu	487	47.651663
0	LotFrontage	190	18.590998
11	GarageType	54	5.283757
12	GarageYrBlt	54	5.283757
13	GarageFinish	54	5.283757
14	GarageQual	54	5.283757
15	GarageCond	54	5.283757
6	BsmtExposure	26	2.544031
7	BsmtFinType1	26	2.544031
8	BsmtFinType2	26	2.544031
5	BsmtCond	26	2.544031
4	BsmtQual	26	2.544031
3	MasVnrArea	3	0.293542

	Col	missing	percent
2	MasVnrType	3	0.293542
9	Electrical	1	0.097847

As data of missing data show many of missing data, so we will separate into 2 group. one more than 5 precent and another less than 5 percent. and we will use impute missing values method depend on group and data type of each group.

- more than 5 percent of category columns will be imputed by 'None'
- more than 5 percent of numerical columns will be imputed by 0
- less than 5 percent of both category and numeric will be imputed by sampling imputaion method

In [257…
```
col_more_five=['PoolQC','MiscFeature','Alley','Fence','FireplaceQu','LotFrontage','GarageT
col_less_five=['BsmtExposure','BsmtFinType2','BsmtFinType1','BsmtCond','BsmtQual','MasVnrA
```

next separate each group into category and numerical group

In [258…
```
miss_more_five_cat=[c for c in X_train[col_more_five]
                    if X_train[c].dtypes == 'object']

miss_more_five_num=[n for n in X_train[col_more_five]
                   if X_train[n].dtypes in ['int','float']]

miss_less_five_cat=[a for a in X_train[col_less_five]
                    if X_train[a].dtypes == 'object']
miss_less_five_num=[b for b in X_train[col_less_five]
                    if X_train[b].dtypes in ['int','float']]
```

fill the missing in columns missing more than 5 precent both category and numerical group

In [258…
```
def fill_na(feature,data,fill_val):
    for i in feature:
        data[i]=data[i].fillna(fill_val,axis=0)
```

In [258…
```
fill_na(miss_more_five_cat,X_train,'None')
fill_na(miss_more_five_num,X_train,0)
fill_na(miss_more_five_cat,X_test,'None')
fill_na(miss_more_five_num,X_test,0)
```

impute missing data columns with value less than 5 percent by using sampling method in X_train dataset and transform to X_test set

In [258…
```
for feat in miss_less_five_cat:
        X_train[feat+'_imputed']=X_train[feat].copy()
        random_sample=X_train[feat].dropna().sample(X_train[feat].isnull().sum(),random_st
        random_sample.index=X_train[X_train[feat].isnull()].index
        X_train.loc[X_train[feat].isnull(),feat+'_imputed']=random_sample
```

In [258…
```
for feat in miss_less_five_num:
        X_train[feat+'_imputed']=X_train[feat].copy()
        random_sample=X_train[feat].dropna().sample(X_train[feat].isnull().sum(),random_st
        random_sample.index=X_train[X_train[feat].isnull()].index
        X_train.loc[X_train[feat].isnull(),feat+'_imputed']=random_sample
```

In [258…

```
for feat in miss_less_five_cat:
        X_test[feat+'_imputed']=X_test[feat].copy()
        random_sample=X_train[feat].dropna().sample(X_test[feat].isnull().sum(),random_sta
        random_sample.index=X_test[X_test[feat].isnull()].index
        X_test.loc[X_test[feat].isnull(),feat+'_imputed']=random_sample
```

In [258…

```
for feat in miss_less_five_num:
        X_test[feat+'_imputed']=X_test[feat].copy()
        random_sample=X_train[feat].dropna().sample(X_test[feat].isnull().sum(),random_sta
        random_sample.index=X_test[X_test[feat].isnull()].index
        X_test.loc[X_test[feat].isnull(),feat+'_imputed']=random_sample
```

In [258…

```
def categorical_distribution(df, variable_original, variable_imputed):

    tmp = pd.concat(
        [df[variable_original].value_counts() / len(df[variable_original].dropna()),
         df[variable_imputed].value_counts() / len(df)
        ],
        axis=1)


    tmp.columns = ['original', 'imputed']

    return tmp
```

In [258…

```
def distribute_plot_compare(df, variable, target):

    fig = plt.figure()
    ax = fig.add_subplot(111)

    for category in df[variable].dropna().unique():
        df[df[variable]==category][target].plot(kind='kde', ax=ax)


    lines, labels = ax.get_legend_handles_labels()
    labels = df[variable].dropna().unique()
    ax.legend(lines, labels, loc='best')

    plt.show()
```

as the comparision data and visualization below show that data was low distrub by using sampling imputation.

In [258…

```
categorical_distribution(X_train,'BsmtFinType1','BsmtFinType1_imputed')
```

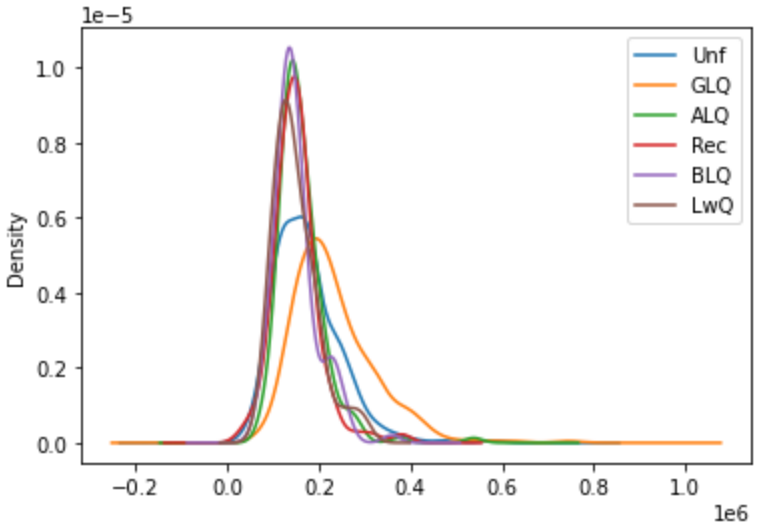
Out[258…

	original	imputed
Unf	0.300201	0.299413
GLQ	0.297189	0.298434
ALQ	0.156627	0.155577
BLQ	0.105422	0.105675
Rec	0.087349	0.086106
LwQ	0.053213	0.054795

now let's look at the distribution of the target within each variable category in original vs imputed columns, as we can set with no difference after we imputed with random sampling method

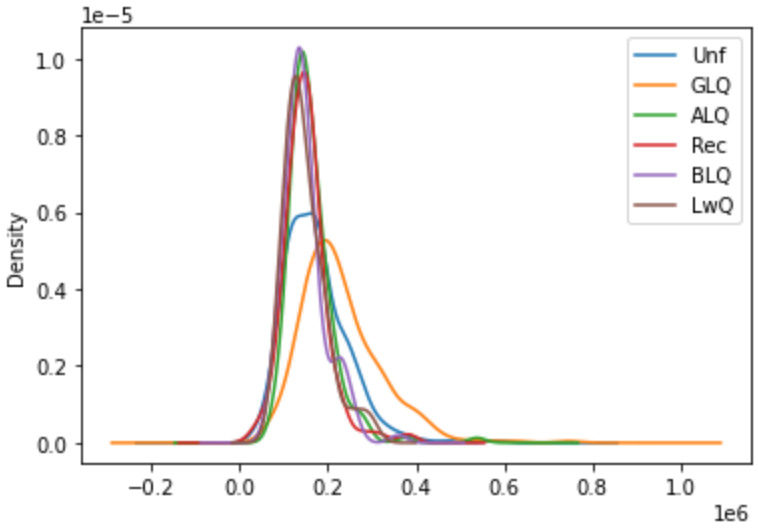
In [259…

```
distribute_plot_compare(X_train,'BsmtFinType1','SalePrice')
```



In [259…

```
distribute_plot_compare(X_train,'BsmtFinType1_imputed','SalePrice')
```



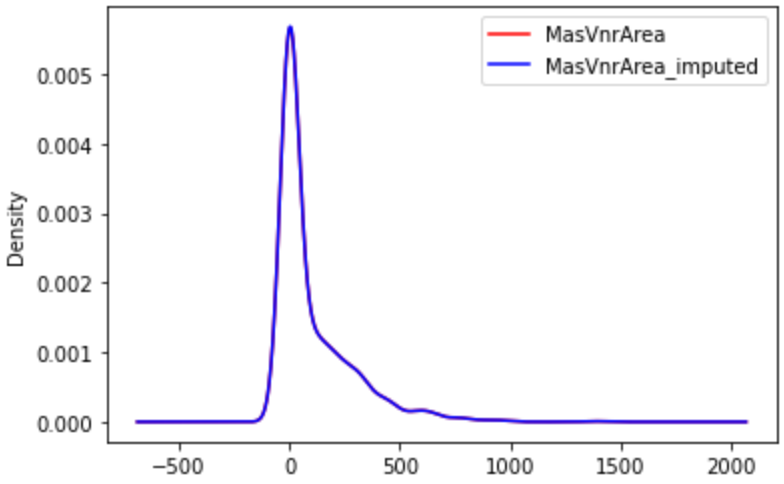
For imputed in numerical columns, we'll compare distribution original vs imputed columns. show with no difference

In [259…

```
fig = plt.figure()
ax = fig.add_subplot(111)

X_train['MasVnrArea'].plot(kind='kde', ax=ax,color='r')
X_train['MasVnrArea_imputed'].plot(kind='kde', ax=ax, color='b')

lines, labels = ax.get_legend_handles_labels()
ax.legend(lines, labels, loc='best')
```

Out[259…

```
<matplotlib.legend.Legend at 0x7fb5189244c0>
```



let drop original missing columns, we'll using the imputed columns only

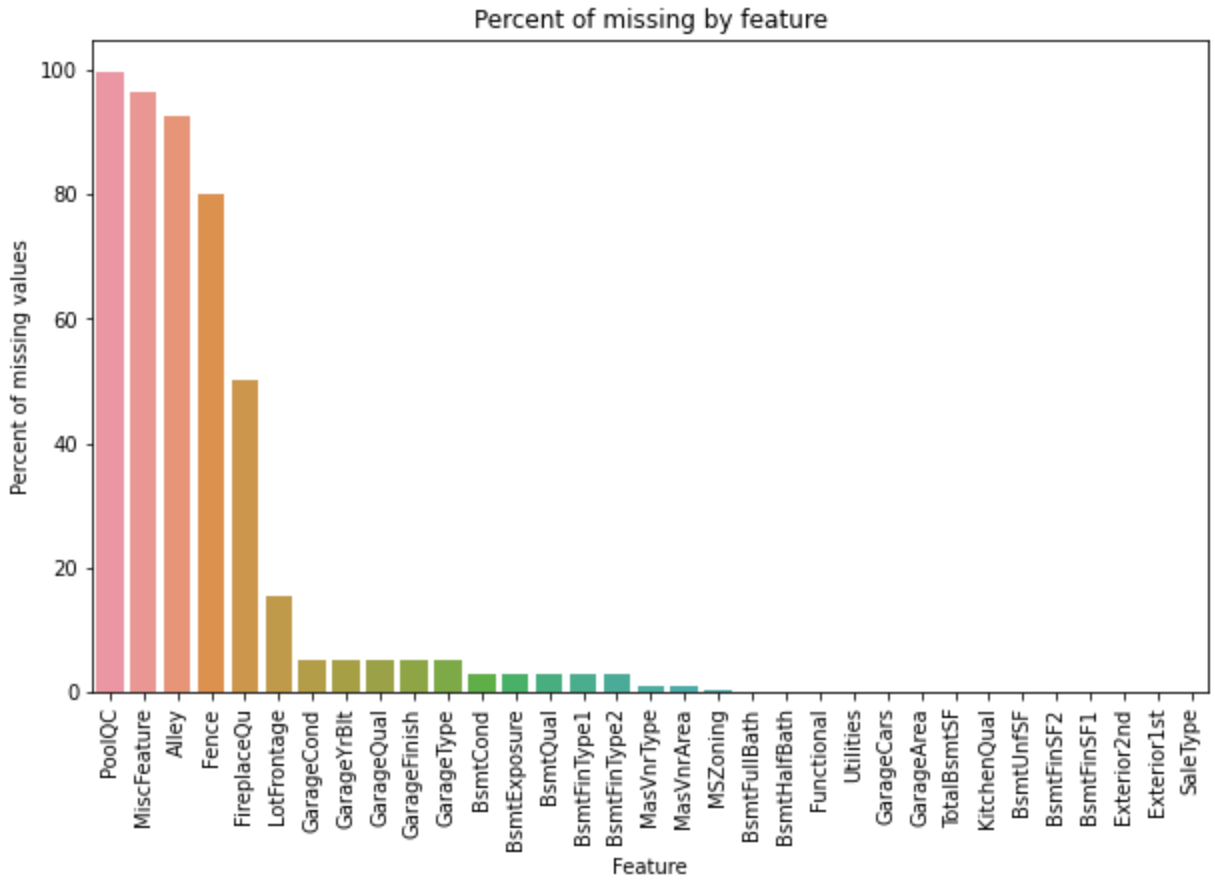
In [259…

```
X_train.drop(miss_less_five_cat,axis=1,inplace=True)
X_train.drop(miss_less_five_num,axis=1,inplace=True)
X_test.drop(miss_less_five_cat,axis=1,inplace=True)
X_test.drop(miss_less_five_num,axis=1,inplace=True)
```

Do the process of clean data for the df_test dataset

In [259…

```
missing_table(df_test)
```



Out[259…

	Col	missing	percent
29	PoolQC	1456	99.794380
31	MiscFeature	1408	96.504455

	Col	missing	percent
2	Alley	1352	92.666210
30	Fence	1169	80.123372
21	FireplaceQu	730	50.034270
1	LotFrontage	227	15.558602
28	GarageCond	78	5.346127
23	GarageYrBlt	78	5.346127
27	GarageQual	78	5.346127
24	GarageFinish	78	5.346127
22	GarageType	76	5.209047
9	BsmtCond	45	3.084304
10	BsmtExposure	44	3.015764
8	BsmtQual	44	3.015764
11	BsmtFinType1	42	2.878684
13	BsmtFinType2	42	2.878684
6	MasVnrType	16	1.096642
7	MasVnrArea	15	1.028101
0	MSZoning	4	0.274160
17	BsmtFullBath	2	0.137080
18	BsmtHalfBath	2	0.137080
20	Functional	2	0.137080
3	Utilities	2	0.137080
25	GarageCars	1	0.068540
26	GarageArea	1	0.068540
16	TotalBsmtSF	1	0.068540
19	KitchenQual	1	0.068540
15	BsmtUnfSF	1	0.068540
14	BsmtFinSF2	1	0.068540
12	BsmtFinSF1	1	0.068540
5	Exterior2nd	1	0.068540
4	Exterior1st	1	0.068540
32	SaleType	1	0.068540

In [259…

```
missing_morethan_five=['PoolQC','MiscFeature','Alley','Fence','FireplaceQu','LotFrontage',
missing_lessthan_five=['BsmtCond','BsmtExposure','BsmtQual','BsmtFinType1','BsmtFinType2',
```

In [259…

```
missing_morethan_five_cat=[c for c in df_test[missing_morethan_five]
                  if df_test[c].dtypes == 'object']

missing_morethan_five_num=[n for n in df_test[missing_morethan_five]
                  if df_test[n].dtypes in ['int','float']]
```

```
missing_lessthan_five_cat=[a for a in df_test[missing_lessthan_five]
                    if df_test[a].dtypes == 'object']
missing_lessthan_five_num=[b for b in df_test[missing_lessthan_five]
                    if df_test[b].dtypes in ['int','float']]
```

In [259…

```
fill_na(missing_morethan_five_cat,df_test,'None')
fill_na(missing_morethan_five_num,df_test,0)
```

In [259…

```
for feat in missing_lessthan_five_cat:
        df_test[feat+'_imputed']=df_test[feat].copy()
        random_sample=df_test[feat].dropna().sample(df_test[feat].isnull().sum(),random_st
        random_sample.index=df_test[df_test[feat].isnull()].index
        df_test.loc[df_test[feat].isnull(),feat+'_imputed']=random_sample
```

In [259…

```
for feat in missing_lessthan_five_num:
        df_test[feat+'_imputed']=df_test[feat].copy()
        random_sample=df_test[feat].dropna().sample(df_test[feat].isnull().sum(),random_st
        random_sample.index=df_test[df_test[feat].isnull()].index
        df_test.loc[df_test[feat].isnull(),feat+'_imputed']=random_sample
```

In [260…

```
categorical_distribution(df_test,'BsmtFinType2','BsmtFinType2_imputed')
```

Out[260…

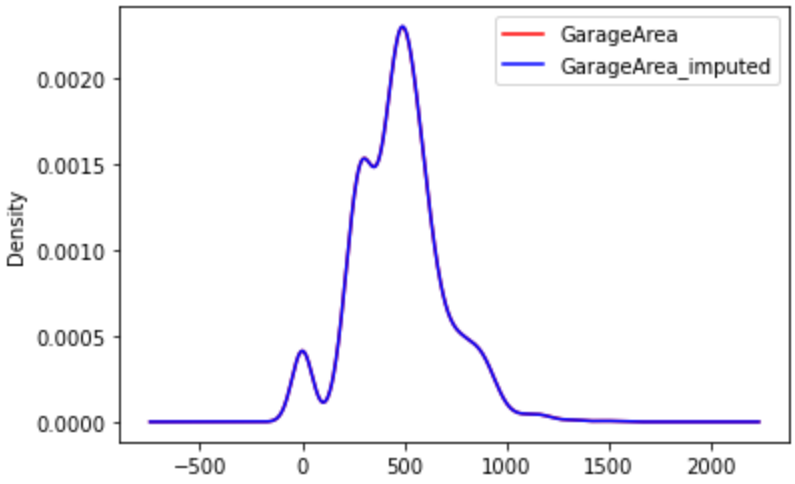
	original	imputed
Unf	0.872971	0.872515
Rec	0.035992	0.037012
LwQ	0.028934	0.028787
BLQ	0.024700	0.023989
ALQ	0.023289	0.023989
GLQ	0.014114	0.013708

In [260…

```
fig = plt.figure()
ax = fig.add_subplot(111)

df_test['GarageArea'].plot(kind='kde', ax=ax,color='r')
df_test['GarageArea_imputed'].plot(kind='kde', ax=ax, color='b')

lines, labels = ax.get_legend_handles_labels()
ax.legend(lines, labels, loc='best')
```

Out[260…

```
<matplotlib.legend.Legend at 0x7fb4fa8d8c40>
```



In [260…
```
df_test.drop(missing_lessthan_five_cat,axis=1,inplace=True)
df_test.drop(missing_lessthan_five_num,axis=1,inplace=True)
```

In [260…
```
X_train.columns=X_train.columns.str.replace("_imputed","")
X_test.columns=X_test.columns.str.replace("_imputed","")
df_test.columns=df_test.columns.str.replace("_imputed","")
```

Feature Engineering

refer to data description file of dataset, we will invent new feature by using interested feature. start with year feature

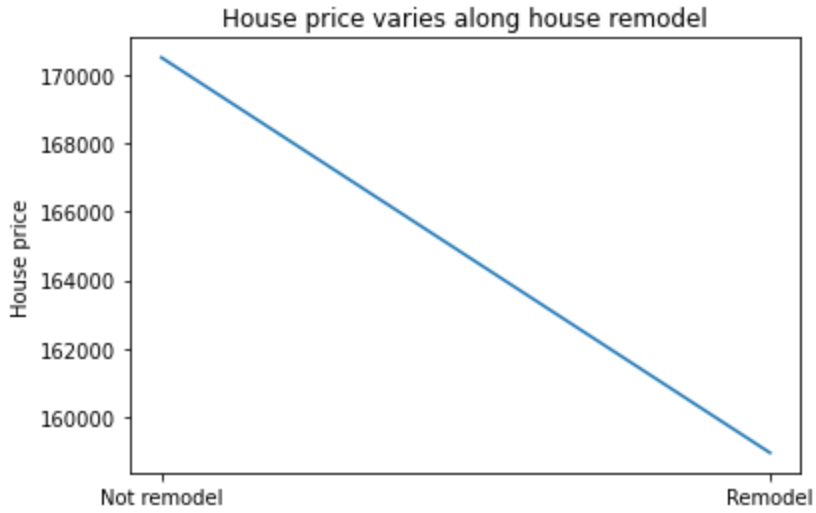
In [260…
```
X_train["Remodel"]=np.where(X_train['YearBuilt']==X_train['YearRemodAdd'],0,1)
X_train['Lotsize']=pd.cut(X_train['LotArea'],bins=4,right=False,labels=[0,1,2,3])
X_train['TotalSF'] = X_train['TotalBsmtSF'] + X_train['FirstFlrSF'] + X_train['SecondFlrSF
X_train['Housesize']=pd.cut(X_train['TotalSF'],bins=4,right=False,labels=[0,1,2,3])
X_train['TotalPerLot']=round(X_train['TotalSF']/X_train['LotArea'],2)
X_train['GroupYearBuilt']=pd.cut(X_train['YearBuilt'],bins=3,labels=[0,1,2])

X_test["Remodel"]=np.where(X_test['YearBuilt']==X_test['YearRemodAdd'],0,1)
X_test['Lotsize']=pd.cut(X_test['LotArea'],bins=4,right=False,labels=[0,1,2,3])
X_test['TotalSF'] = X_test['TotalBsmtSF'] + X_test['FirstFlrSF'] + X_test['SecondFlrSF']
X_test['Housesize']=pd.cut(X_test['TotalSF'],bins=4,right=False,labels=[0,1,2,3])
X_test['TotalPerLot']=round(X_test['TotalSF']/X_test['LotArea'],2)
X_test['GroupYearBuilt']=pd.cut(X_test['YearBuilt'],bins=3,labels=[0,1,2])

df_test["Remodel"]=np.where(df_test['YearBuilt']==df_test['YearRemodAdd'],0,1)
df_test['Lotsize']=pd.cut(df_test['LotArea'],bins=4,right=False,labels=[0,1,2,3])
df_test['TotalSF'] = df_test['TotalBsmtSF'] + df_test['FirstFlrSF'] + df_test['SecondFlrSF
df_test['Housesize']=pd.cut(df_test['TotalSF'],bins=4,right=False,labels=[0,1,2,3])
df_test['TotalPerLot']=round(df_test['TotalSF']/df_test['LotArea'],2)
df_test['GroupYearBuilt']=pd.cut(df_test['YearBuilt'],bins=3,labels=[0,1,2])
```

the chart above show that there are difference in price of house by group of year built and seem that the house with built in the most recent year has the trend to has more price than the older built year

Visualization median SalePrice in compare to the house with remodel and not remodel

In [260…
```
X_train.groupby('Remodel')['SalePrice'].median().plot()
plt.title('House price varies along house remodel')
```

```
plt.xlabel('')
plt.ylabel('House price')
plt.xticks([0,1],['Not remodel','Remodel'])
plt.show();
```



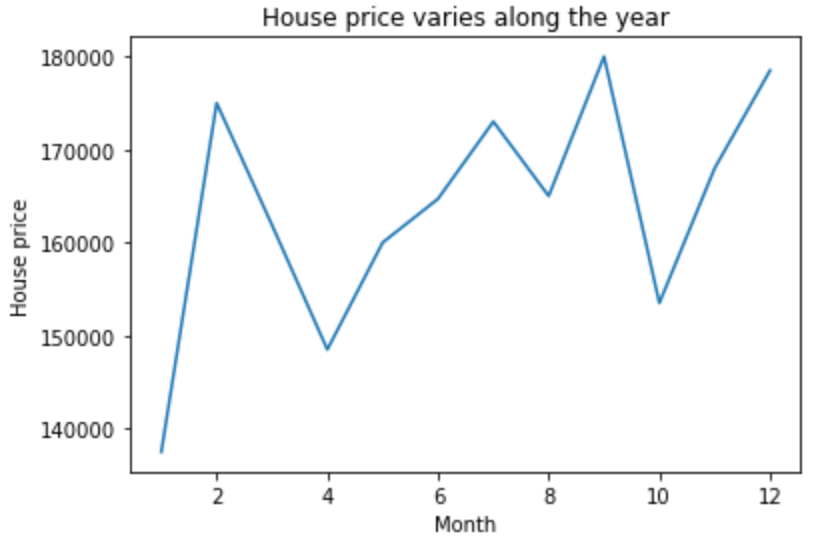
as the chart above notice that house with remodel has less prices than the house with no remodel

As the scatter plot above the price invert with age of house and age of garage, say that with more age got the low prices

Visaulization to see trand of sale prices in period of month, year and with sale condition

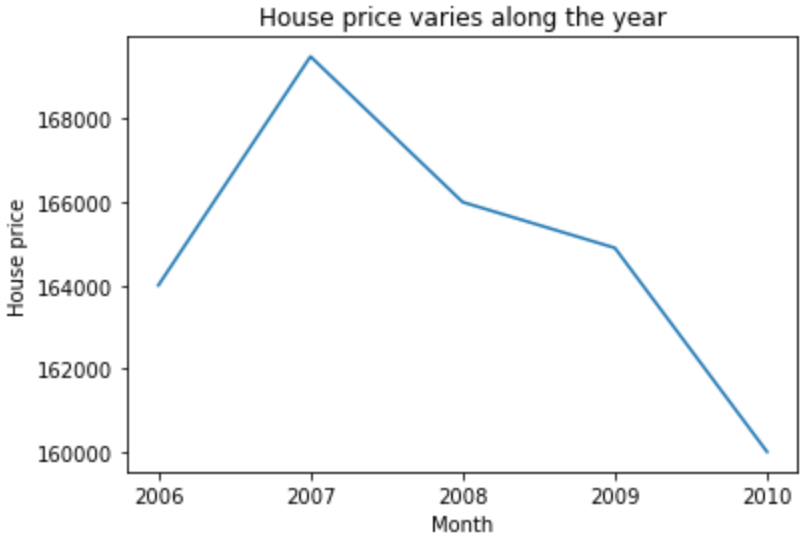
In [260…

```
X_train.groupby('MoSold')['SalePrice'].median().plot()
plt.title('House price varies along the year')
plt.xlabel('Month')
plt.ylabel('House price')
plt.show();
```



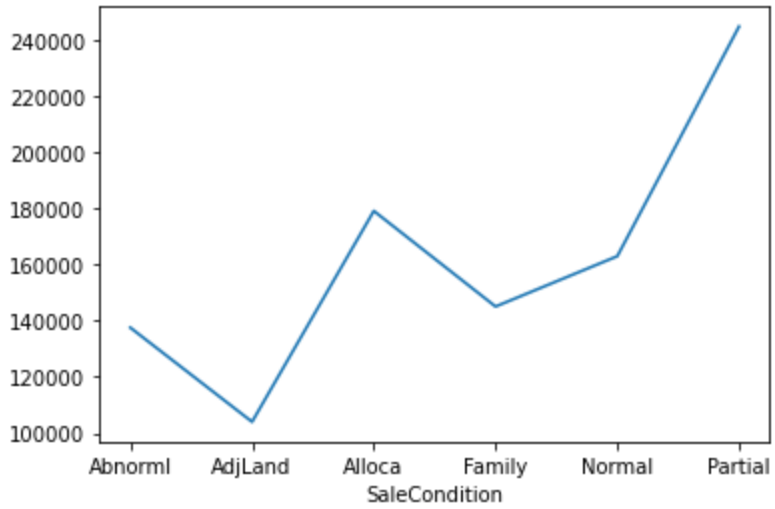
In [261…

```
X_train.groupby('YrSold')['SalePrice'].median().plot()
plt.title('House price varies along the year')
plt.xlabel('Month')
plt.ylabel('House price')
plt.xticks(np.arange(2006,2011,1))
plt.show();
```



In [261…

```
X_train.groupby('SaleCondition')['SalePrice'].median().plot()
plt.show()
```



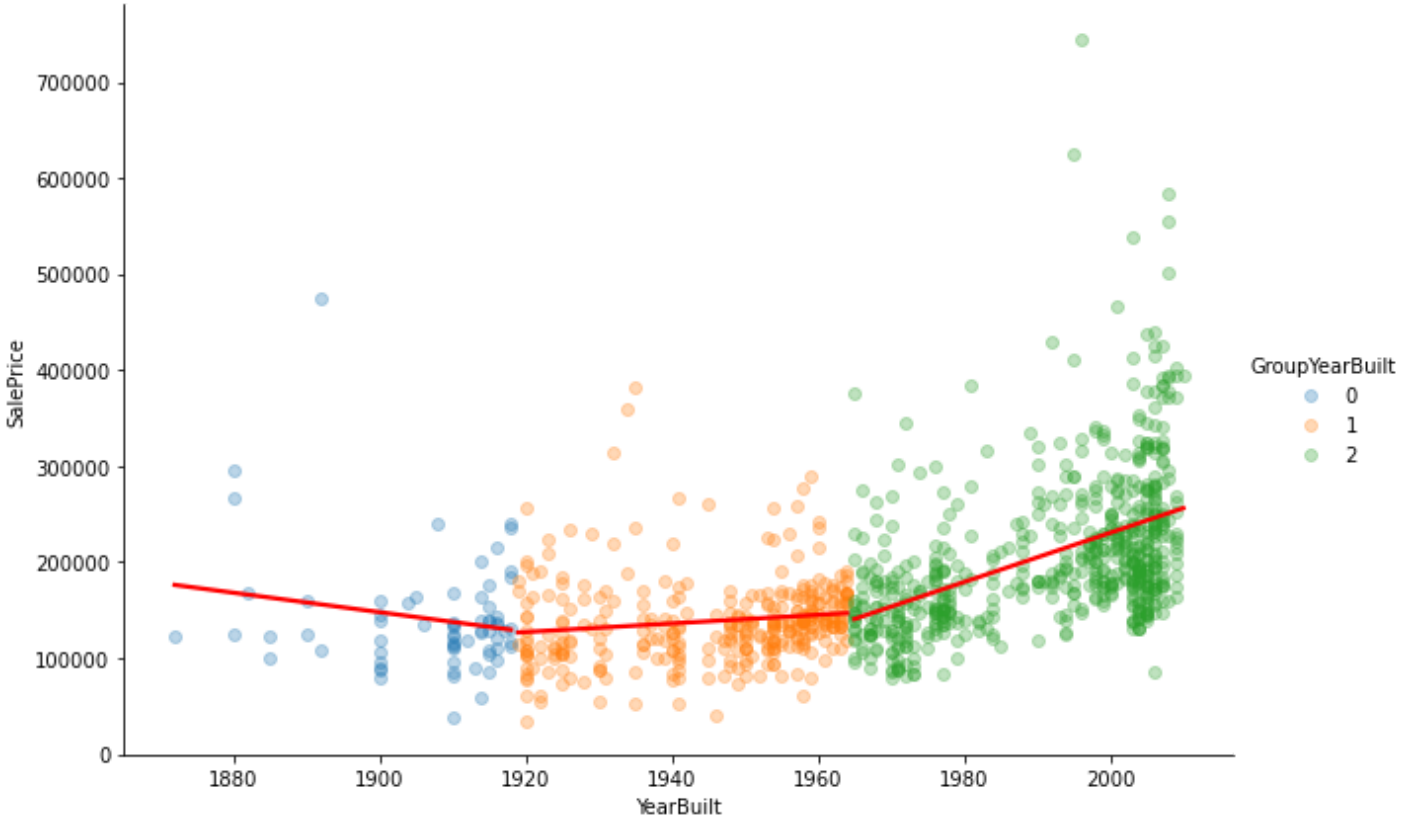
Visualization the relationship between the house price and each group of YearBuilt

In [261…

```
sns.lmplot(y='SalePrice',x='YearBuilt',hue='GroupYearBuilt',data=X_train,ci=False,scatter_
```

Out[261…

```
<seaborn.axisgrid.FacetGrid at 0x7fb4f9f9ea60>
```



as the result of grouping the yearbuilt we can fit the linear model into all range of data

Categorical Encoding

As the dataset has high cadinality and rare rebels in category feature. we will group some of category labels with low frequency less than 5 percent into rare group

first with showing the object columns with number of unique values less than 9 and find the label with low number of frequency less than 5 percent

In [261…

```
for col in X_train.columns:
    if X_train[col].dtypes == 'O':
        if X_train[col].nunique()<9:
            print(X_train.groupby(col)[col].count()/len(X_train))
            print()
```

```
MSZoning
C (all)    0.003914
FV         0.042074
RH         0.012720
RL         0.789628
RM         0.151663
Name: MSZoning, dtype: float64

Street
Grvl    0.003914
Pave    0.996086
Name: Street, dtype: float64

Alley
Grvl    0.041096
None    0.935421
Pave    0.023483
Name: Alley, dtype: float64

LotShape
```

```
IR1    0.336595
IR2    0.031311
IR3    0.007828
Reg    0.624266
Name: LotShape, dtype: float64

LandContour
Bnk    0.039139
HLS    0.029354
Low    0.023483
Lvl    0.908023
Name: LandContour, dtype: float64

Utilities
AllPub    0.999022
NoSeWa    0.000978
Name: Utilities, dtype: float64

LotConfig
Corner     0.194716
CulDSac    0.073386
FR2        0.034247
FR3        0.002935
Inside     0.694716
Name: LotConfig, dtype: float64

LandSlope
Gtl    0.944227
Mod    0.046967
Sev    0.008806
Name: LandSlope, dtype: float64

Condition2
Artery    0.001957
Feedr     0.002935
Norm      0.991194
PosN      0.001957
RRAe      0.000978
RRAn      0.000978
Name: Condition2, dtype: float64

BldgType
1Fam      0.834638
2fmCon    0.023483
Duplex    0.035225
Twnhs     0.028376
TwnhsE    0.078278
Name: BldgType, dtype: float64

HouseStyle
1.5Fin    0.101761
1.5Unf    0.010763
1Story    0.495108
2.5Fin    0.006849
2.5Unf    0.008806
2Story    0.309198
SFoyer    0.021526
SLvl      0.045988
Name: HouseStyle, dtype: float64

RoofStyle
Flat       0.010763
Gable      0.771037
Gambrel    0.008806
Hip        0.203523
Mansard    0.003914
```

```
Shed       0.001957
Name: RoofStyle, dtype: float64

RoofMatl
ClyTile    0.000978
CompShg    0.981409
Metal      0.000978
Roll       0.000978
Tar&Grv    0.008806
WdShake    0.002935
WdShngl    0.003914
Name: RoofMatl, dtype: float64

ExterQual
Ex    0.034247
Fa    0.009785
Gd    0.332681
TA    0.623288
Name: ExterQual, dtype: float64

ExterCond
Ex    0.001957
Fa    0.021526
Gd    0.098826
Po    0.000978
TA    0.876712
Name: ExterCond, dtype: float64

Foundation
BrkTil    0.100783
CBlock    0.427593
PConc     0.446184
Slab      0.017613
Stone     0.004892
Wood      0.002935
Name: Foundation, dtype: float64

Heating
Floor    0.000978
GasA     0.975538
GasW     0.014677
Grav     0.003914
OthW     0.001957
Wall     0.002935
Name: Heating, dtype: float64

HeatingQC
Ex    0.507828
Fa    0.036204
Gd    0.167319
Po    0.000978
TA    0.287671
Name: HeatingQC, dtype: float64

CentralAir
N    0.073386
Y    0.926614
Name: CentralAir, dtype: float64

KitchenQual
Ex    0.063601
Fa    0.029354
Gd    0.406067
TA    0.500978
Name: KitchenQual, dtype: float64
```

```
Functional
Maj1    0.008806
Maj2    0.003914
Min1    0.023483
Min2    0.024462
Mod     0.012720
Sev     0.000978
Typ     0.925636
Name: Functional, dtype: float64

FireplaceQu
Ex      0.017613
Fa      0.022505
Gd      0.255382
None    0.476517
Po      0.013699
TA      0.214286
Name: FireplaceQu, dtype: float64

GarageType
2Types     0.003914
Attchd     0.590998
Basment    0.013699
BuiltIn    0.062622
CarPort    0.006849
Detchd     0.269080
None       0.052838
Name: GarageType, dtype: float64

GarageFinish
Fin     0.246575
None    0.052838
RFn     0.285714
Unf     0.414873
Name: GarageFinish, dtype: float64

GarageQual
Ex      0.002935
Fa      0.031311
Gd      0.011742
None    0.052838
Po      0.000978
TA      0.900196
Name: GarageQual, dtype: float64

GarageCond
Ex      0.001957
Fa      0.025440
Gd      0.007828
None    0.052838
Po      0.002935
TA      0.909002
Name: GarageCond, dtype: float64

PavedDrive
N    0.062622
P    0.021526
Y    0.915851
Name: PavedDrive, dtype: float64

PoolQC
Ex      0.001957
Fa      0.000978
Gd      0.001957
None    0.995108
Name: PoolQC, dtype: float64
```

```
Fence
GdPrv    0.040117
GdWo     0.040117
MnPrv    0.109589
MnWw     0.007828
None     0.802348
Name: Fence, dtype: float64

MiscFeature
Gar2    0.000978
None    0.960861
Othr    0.000978
Shed    0.036204
TenC    0.000978
Name: MiscFeature, dtype: float64

SaleCondition
Abnorml    0.066536
AdjLand    0.003914
Alloca     0.004892
Family     0.016634
Normal     0.824853
Partial    0.083170
Name: SaleCondition, dtype: float64

BsmtExposure
Av    0.150685
Gd    0.096869
Mn    0.081213
No    0.671233
Name: BsmtExposure, dtype: float64

BsmtFinType2
ALQ    0.016634
BLQ    0.016634
GLQ    0.007828
LwQ    0.030333
Rec    0.040117
Unf    0.888454
Name: BsmtFinType2, dtype: float64

BsmtFinType1
ALQ    0.155577
BLQ    0.105675
GLQ    0.298434
LwQ    0.054795
Rec    0.086106
Unf    0.299413
Name: BsmtFinType1, dtype: float64

BsmtCond
Fa    0.034247
Gd    0.045988
Po    0.000978
TA    0.918787
Name: BsmtCond, dtype: float64

BsmtQual
Ex    0.087084
Fa    0.027397
Gd    0.435421
TA    0.450098
Name: BsmtQual, dtype: float64

MasVnrType
```

```
BrkCmn      0.011742
BrkFace     0.321918
None        0.577299
Stone       0.089041
Name: MasVnrType, dtype: float64

Electrical
FuseA    0.058708
FuseF    0.022505
FuseP    0.002935
SBrkr    0.915851
Name: Electrical, dtype: float64
```

In [261…

```
few_label=['MSZoning','Alley','LotShape','LandContour','LotConfig','LandSlope','Condition2
```

Group the labels with low frequency into the Rare group

In [261…

```
def find_non_rare_labels(df, variable, tolerance):

    temp = df.groupby([variable])[variable].count() / len(df)

    non_rare = [x for x in temp.loc[temp>tolerance].index.values]

    return non_rare

def rare_encoding(X_train, X_test, df_test, variable, tolerance):

    X_train = X_train.copy()
    X_test = X_test.copy()
    df_test=df_test.copy()


    frequent_cat = find_non_rare_labels(X_train, variable, tolerance)


    X_train[variable] = np.where(X_train[variable].isin(
        frequent_cat), X_train[variable], 'Rare')

    X_test[variable] = np.where(X_test[variable].isin(
        frequent_cat), X_test[variable], 'Rare')

    df_test[variable] = np.where(df_test[variable].isin(
        frequent_cat), df_test[variable], 'Rare')

    return X_train, X_test, df_test
```

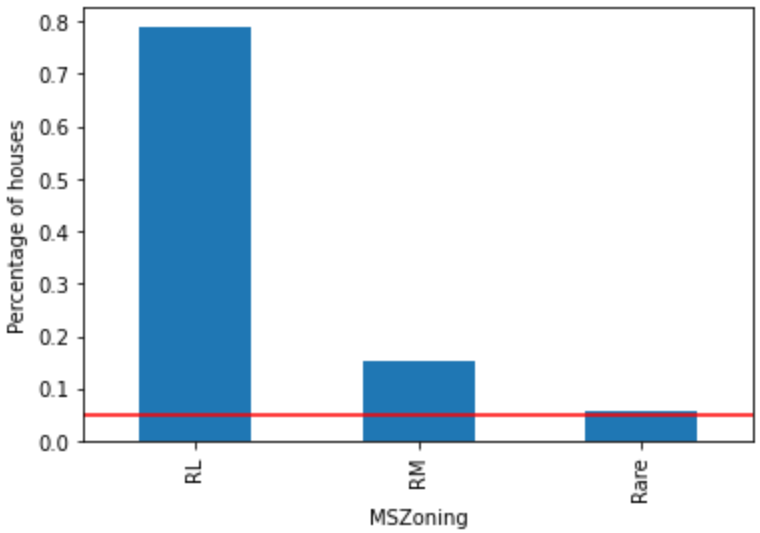
In [261…

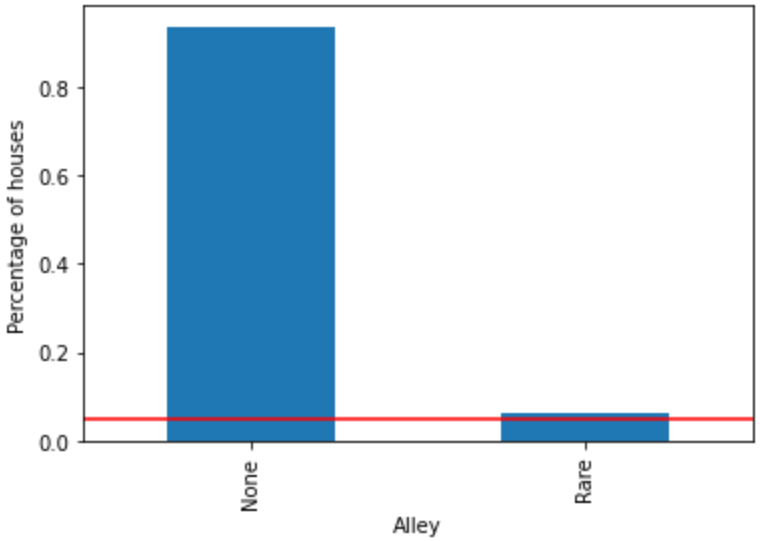
```
for variable in few_label:

    X_train, X_test, df_test = rare_encoding(X_train, X_test, df_test, variable, 0.05)
```

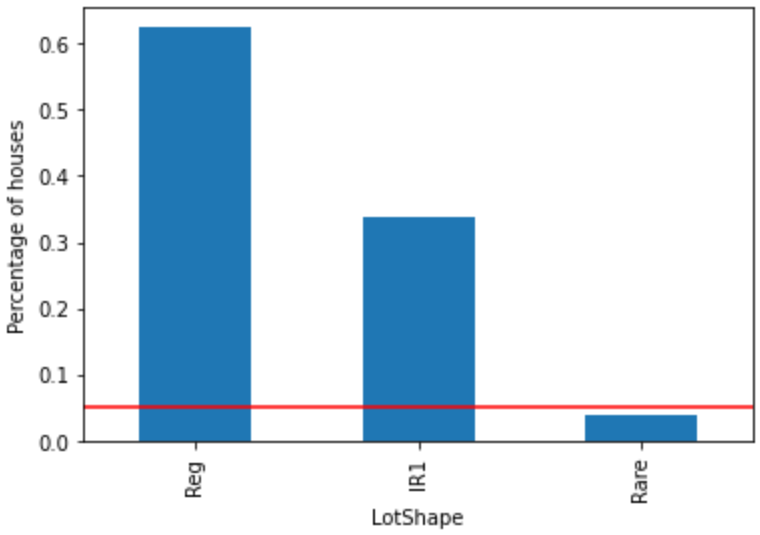
In [261…

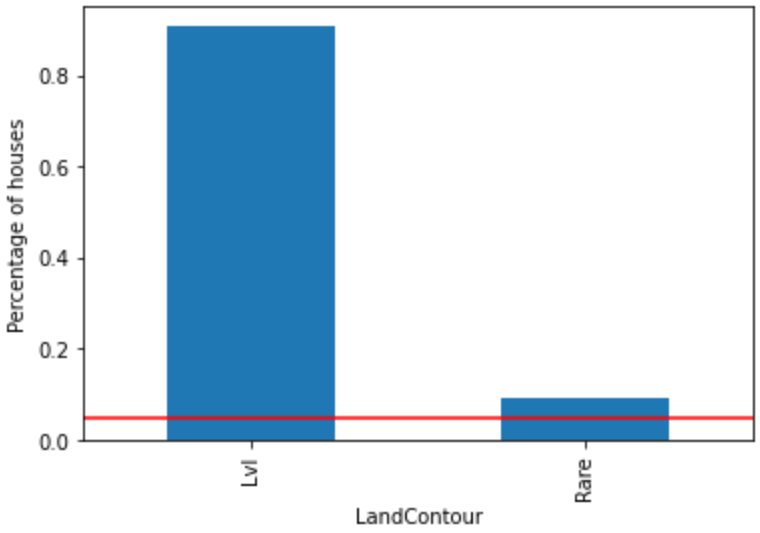
```
for col in few_label:

    temp_df = pd.Series(X_train[col].value_counts() / len(X_train) )


    fig = temp_df.sort_values(ascending=False).plot.bar()
    fig.set_xlabel(col)


    fig.axhline(y=0.05, color='red')
```

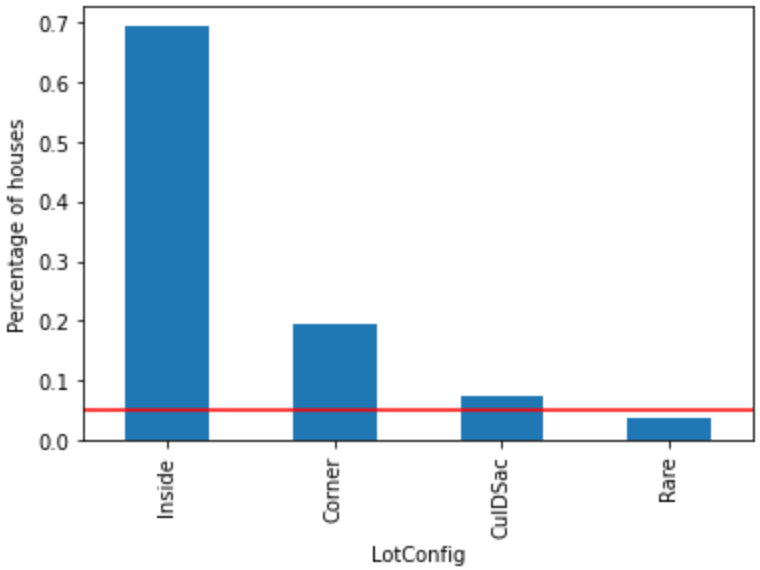
```
    fig.set_ylabel('Percentage of houses')
    plt.show()
```

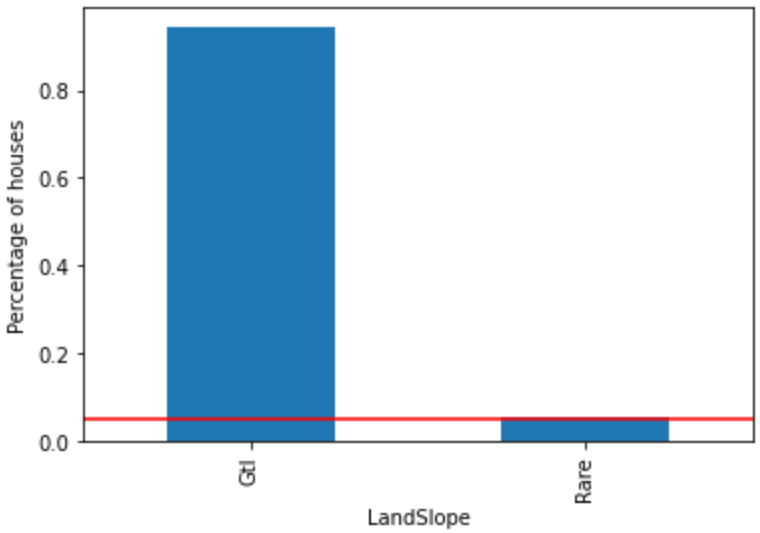


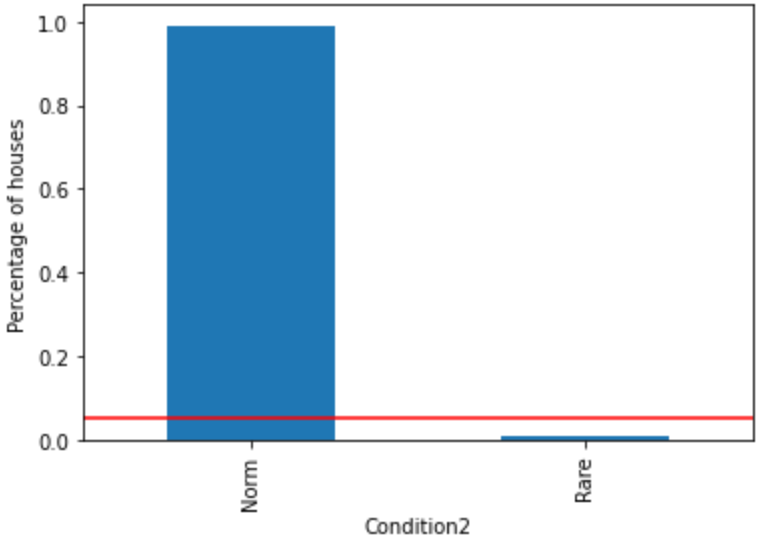


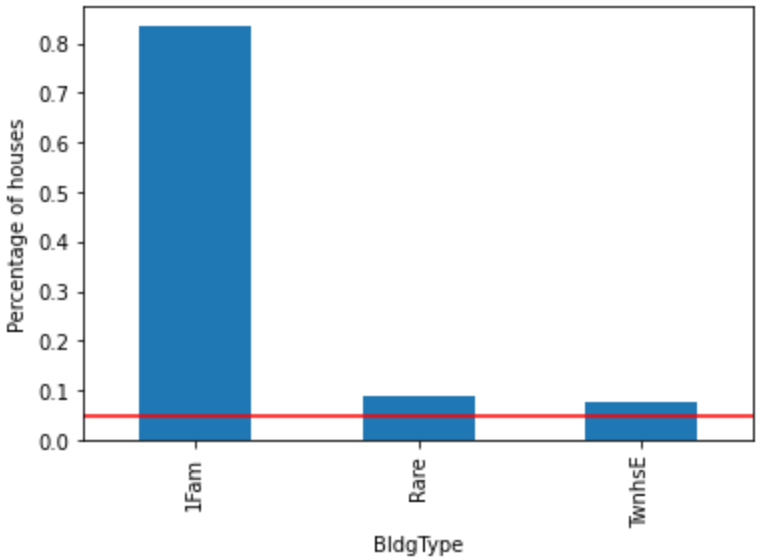


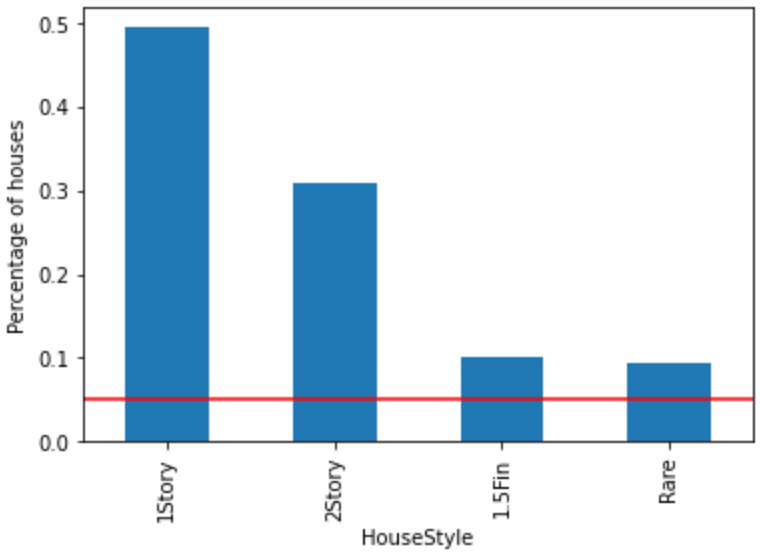

Percentage of houses
0.0
0.2
0.4
0.6
0.8
Lvl
Rare
LandContour

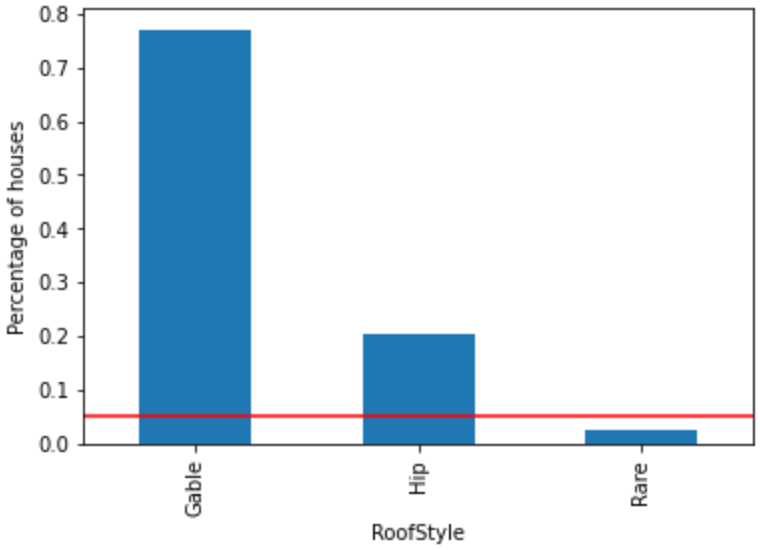

Percentage of houses
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Inside
Corner
CulDSac
Rare
LotConfig

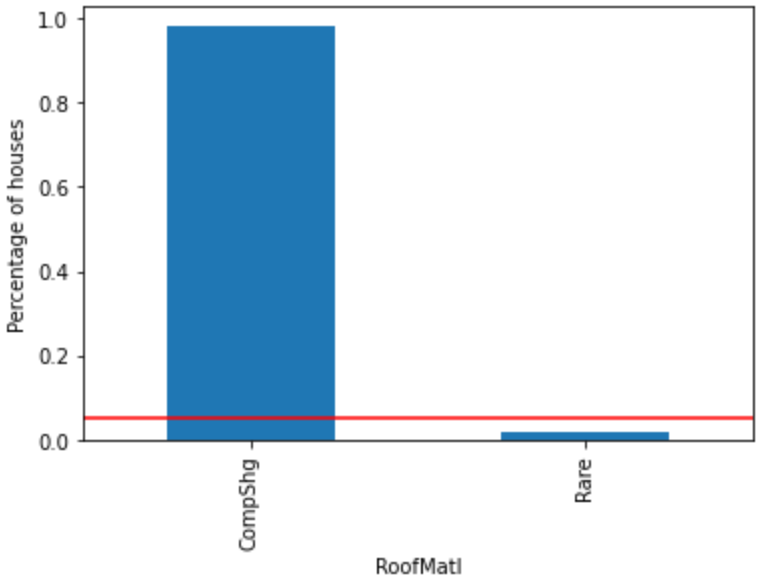

Percentage of houses
0.0
0.2
0.4
0.6
0.8
Gtl
Rare
LandSlope

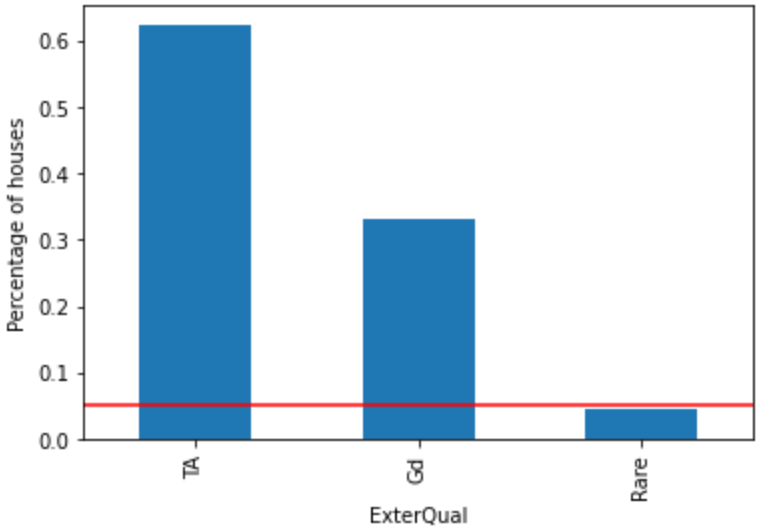

Percentage of houses
1.0
0.8
0.6
0.4
0.2
0.0
Norm
Rare
Condition2

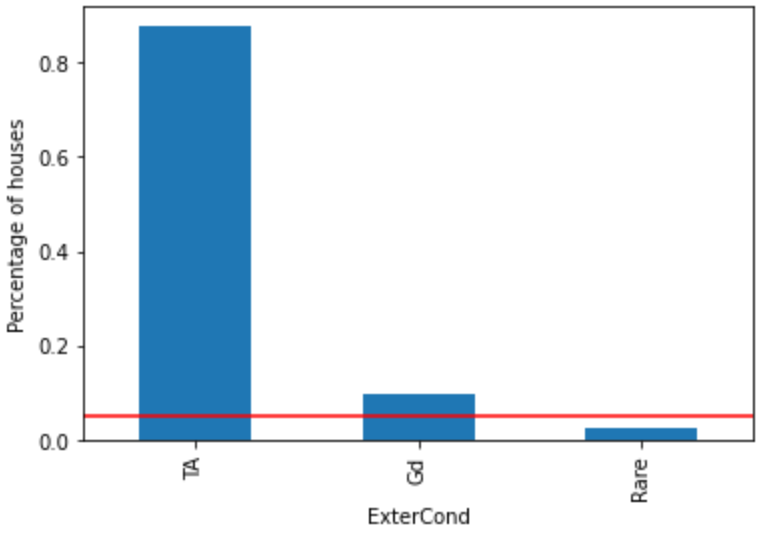

Percentage of houses
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1Fam
Rare
TwnhsE
BldgType

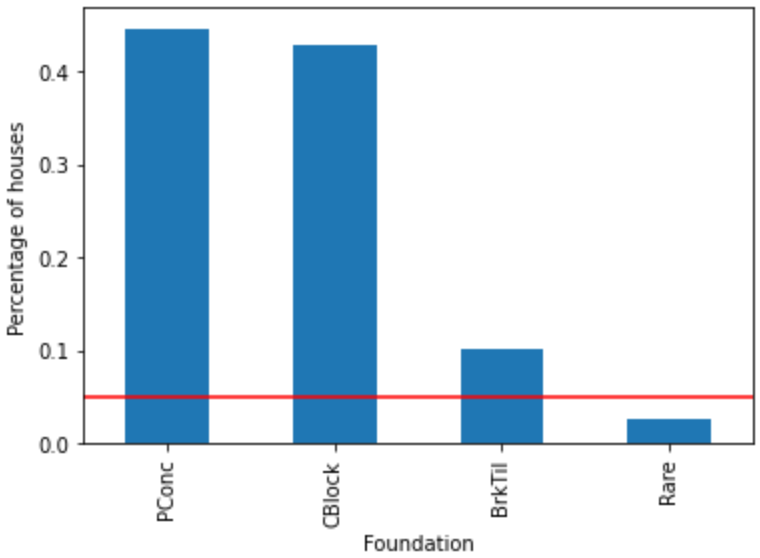

Percentage of houses
0.5
0.4
0.3
0.2
0.1
0.0
1Story
2Story
1.5Fin
Rare
HouseStyle

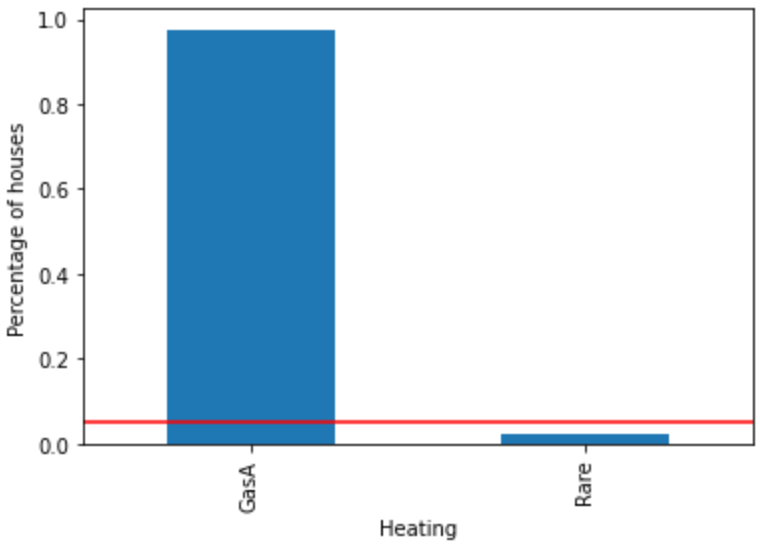

Percentage of houses
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Gable
Hip
Rare
RoofStyle

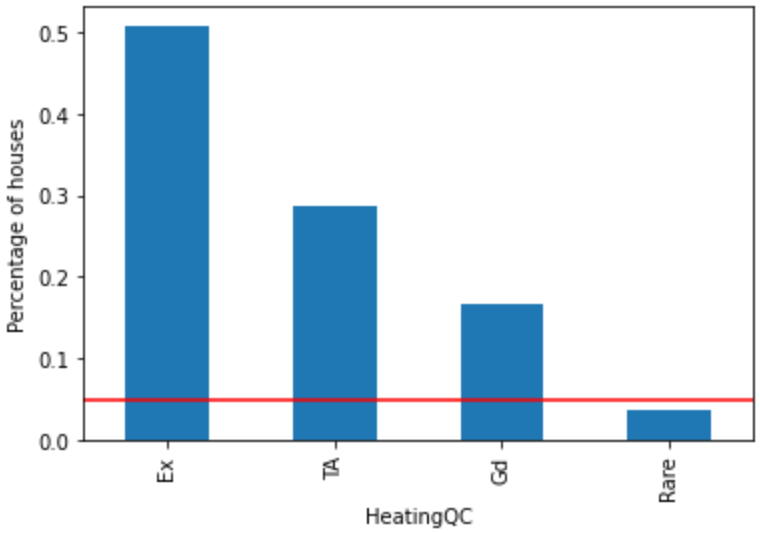

Percentage of houses
0.0
0.2
0.4
0.6
0.8
1.0
CompShg
Rare
RoofMatl

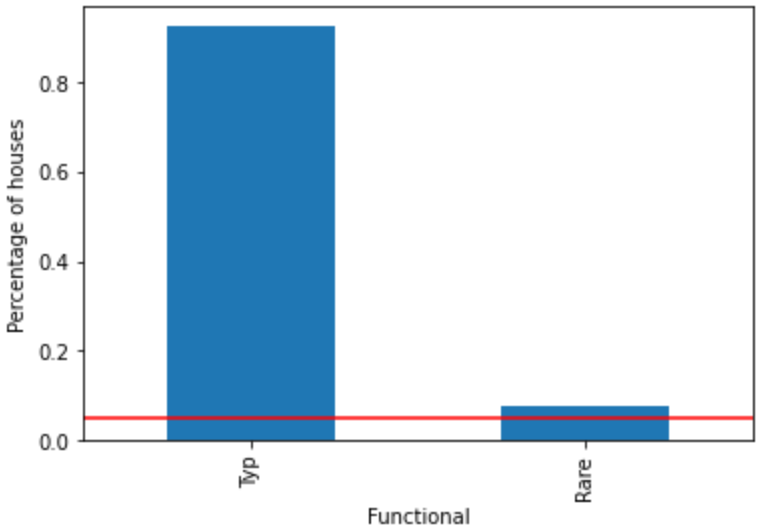

Percentage of houses
0.0
0.1
0.2
0.3
0.4
0.5
0.6
TA
Gd
Rare
ExterQual

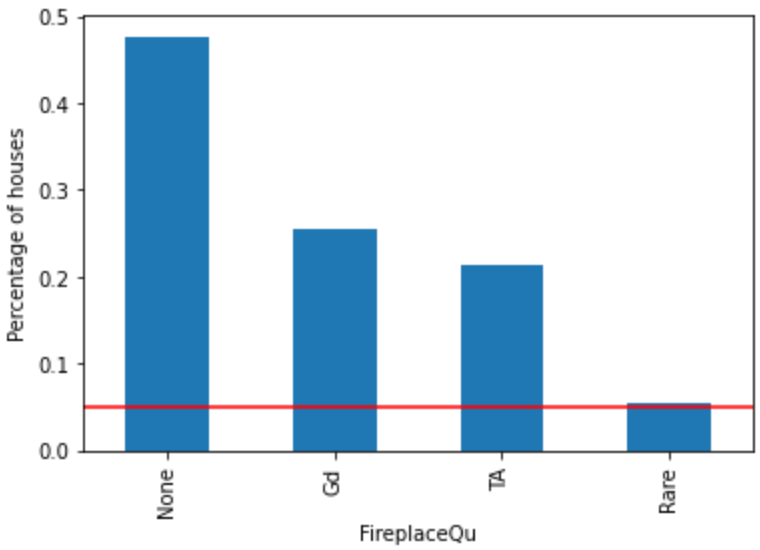

Percentage of houses
0.0
0.2
0.4
0.6
0.8
TA
Gd
Rare
ExterCond

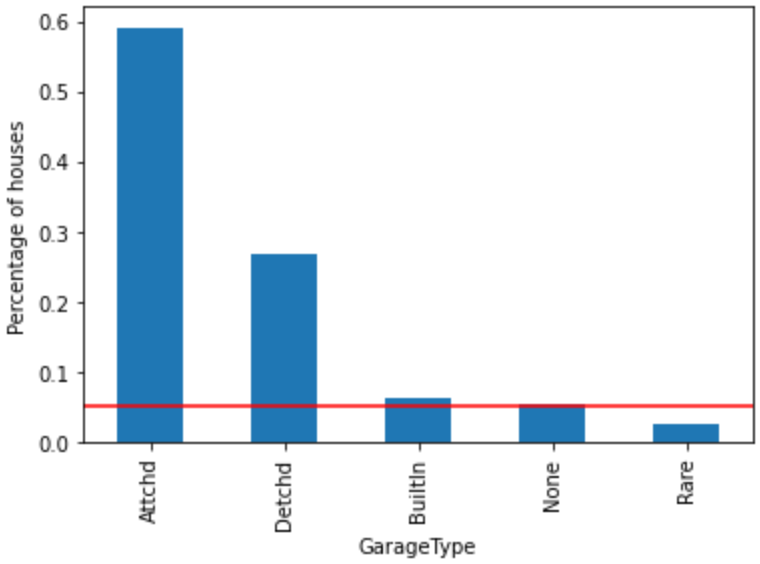

Percentage of houses
0.0
0.1
0.2
0.3
0.4
PConc
CBlock
BrkTil
Rare
Foundation

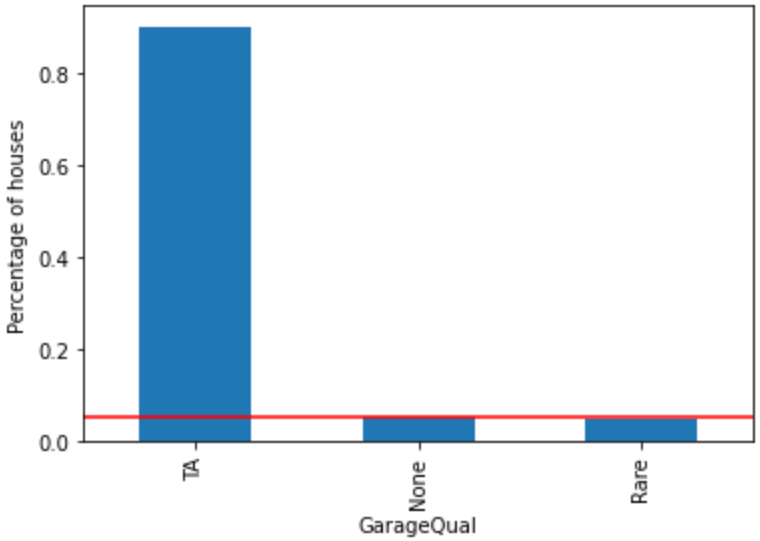

Percentage of houses
0.0
0.2
0.4
0.6
0.8
1.0
GasA
Rare
Heating

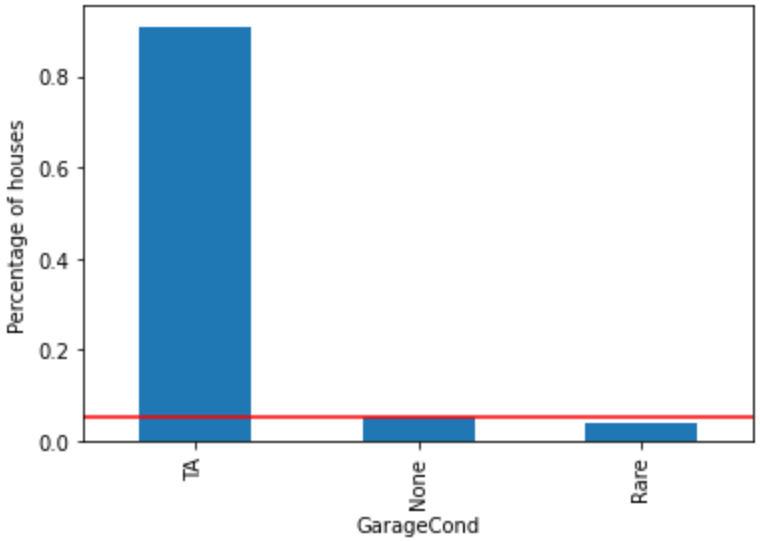

Percentage of houses
0.0
0.1
0.2
0.3
0.4
0.5
Ex
TA
Gd
Rare
HeatingQC

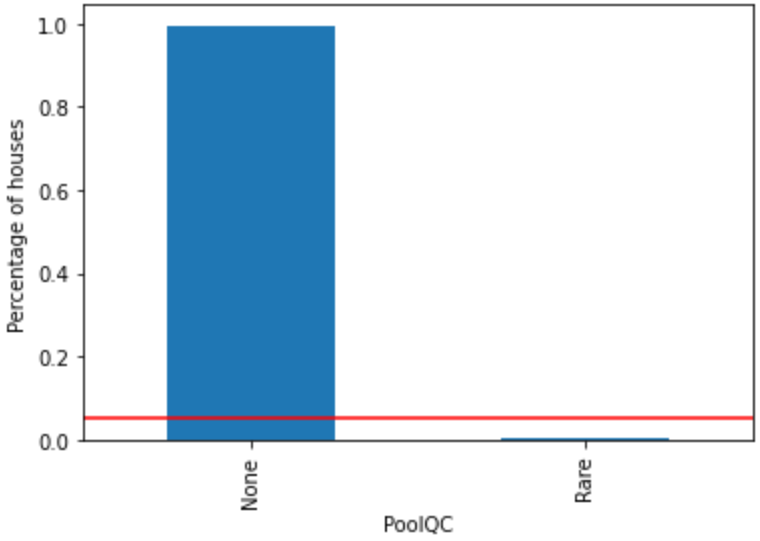

Percentage of houses
0.0
0.2
0.4
0.6
0.8
Typ
Rare
Functional

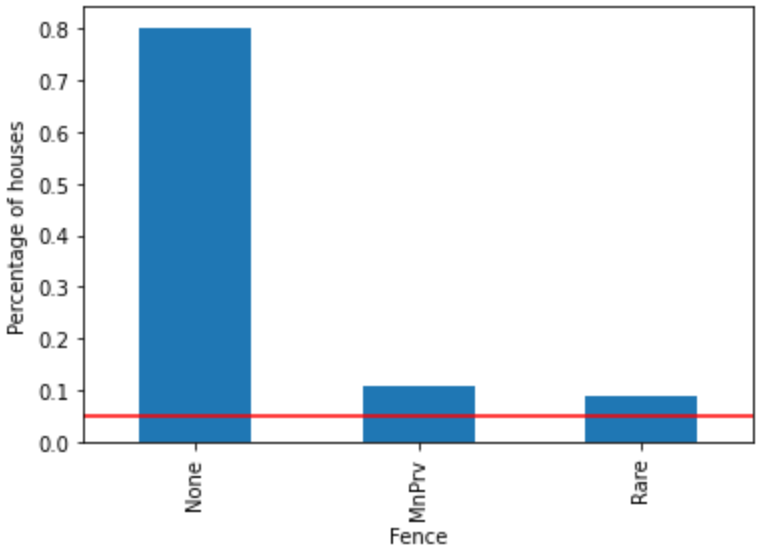

Percentage of houses
0.0
0.1
0.2
0.3
0.4
0.5
None
Gd
TA
Rare
FireplaceQu

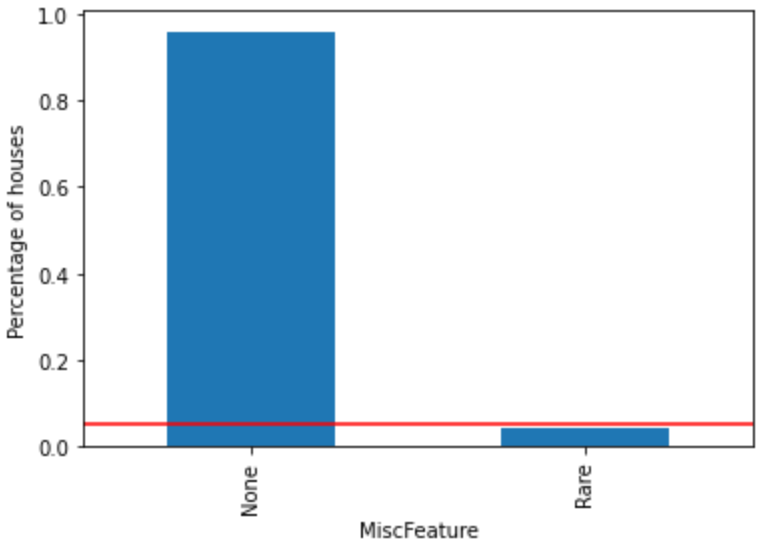

Percentage of houses
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Attchd
Detchd
BuiltIn
None
Rare
GarageType

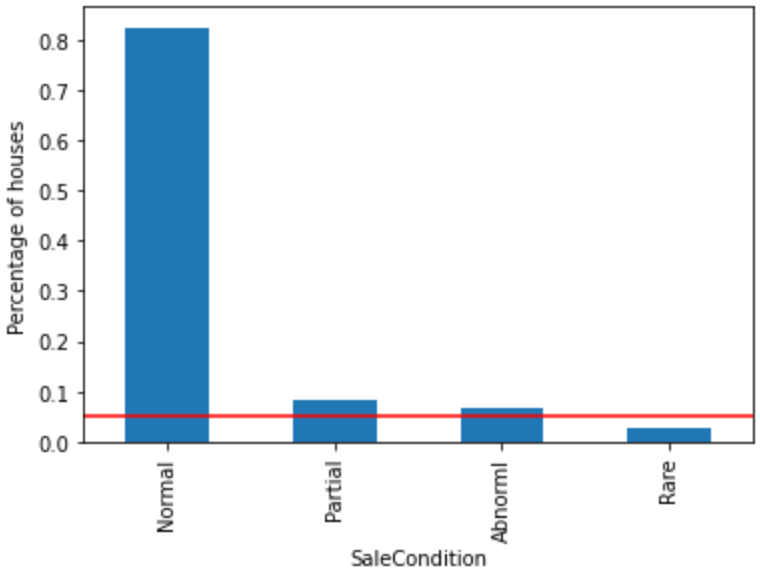

Percentage of houses
0.0
0.2
0.4
0.6
0.8
TA
None
Rare
GarageQual

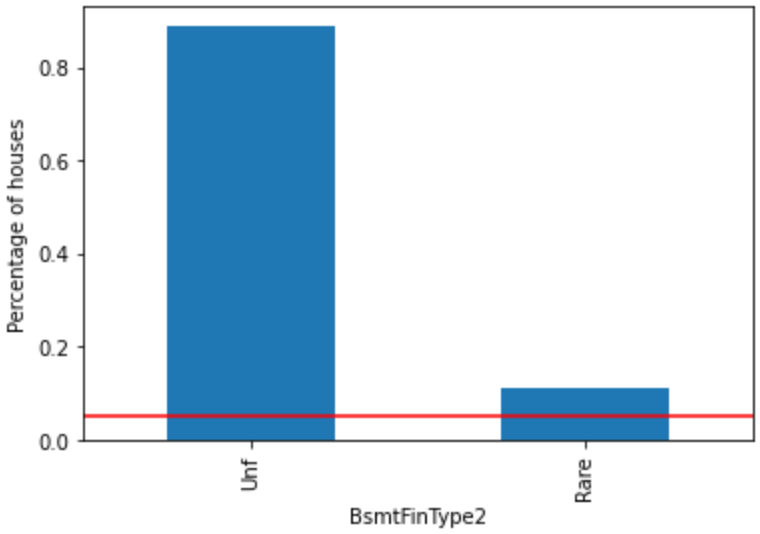

Percentage of houses
0.0
0.2
0.4
0.6
0.8
TA
None
Rare
GarageCond

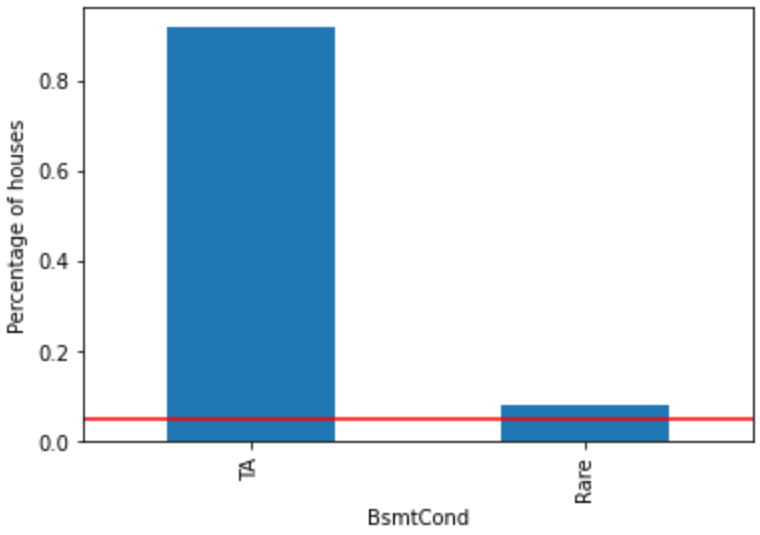

Percentage of houses
1.0
0.8
0.6
0.4
0.2
0.0
None
Rare
PoolQC

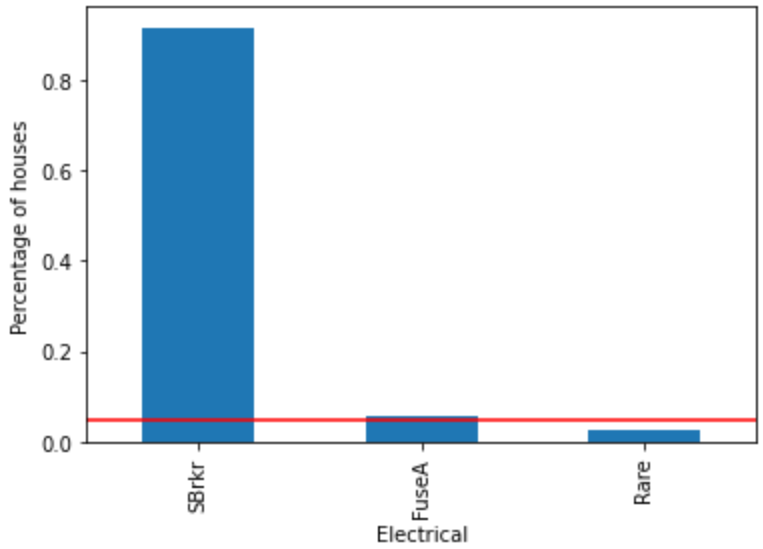

Percentage of houses
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
None
MnPrv
Rare
Fence


Percentage of houses
1.0
0.8
0.6
0.4
0.2
0.0
None
Rare
MiscFeature


Percentage of houses
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Normal
Partial
Abnorml
Rare
SaleCondition


Percentage of houses
0.0
0.2
0.4
0.6
0.8
Unf
Rare
BsmtFinType2


Percentage of houses
0.0
0.2
0.4
0.6
0.8
TA
Rare
BsmtCond



As we can see with new group Rare we can reduce the number of labels in each columns and can reduce the feature after we precess the one hot encodeing

For another feature with very high cadinality, we'll do the same as the feature has number unique less than 9 and group rare label with less than 5 %

In [261…

```
multi_cat_cols = []
for col in X_train.columns:
    if X_train[col].dtypes == 'O':
        if X_train[col].nunique()>=9:
            multi_cat_cols.append(col)
            print(X_train.groupby(col)[col].count()/len(X_train))
            print()
```

```
Neighborhood
Blmngtn    0.013699
Blueste    0.000978
BrDale     0.011742
BrkSide    0.040117
ClearCr    0.018591
CollgCr    0.106654
Crawfor    0.037182
Edwards    0.077299
Gilbert    0.050881
IDOTRR     0.023483
MeadowV    0.009785
Mitchel    0.033268
NAmes      0.151663
NPkVill    0.005871
NWAmes     0.052838
NoRidge    0.027397
NridgHt    0.048924
OldTown    0.080235
SWISU      0.015656
Sawyer     0.046967
SawyerW    0.037182
Somerst    0.055773
StoneBr    0.019569
Timber     0.026419
Veenker    0.007828
Name: Neighborhood, dtype: float64

Condition1
Artery    0.035225
Feedr     0.055773
Norm      0.859100
```

```
PosA      0.005871
PosN      0.013699
RRAe      0.008806
RRAn      0.015656
RRNe      0.000978
RRNn      0.004892
Name: Condition1, dtype: float64

Exterior1st
AsbShng    0.014677
AsphShn    0.000978
BrkComm    0.001957
BrkFace    0.034247
CBlock     0.000978
CemntBd    0.038160
HdBoard    0.151663
MetalSd    0.145793
Plywood    0.069472
Stone      0.000978
Stucco     0.017613
VinylSd    0.360078
Wd Sdng    0.146771
WdShing    0.016634
Name: Exterior1st, dtype: float64

Exterior2nd
AsbShng    0.015656
AsphShn    0.001957
Brk Cmn    0.005871
BrkFace    0.013699
CBlock     0.000978
CmentBd    0.037182
HdBoard    0.139922
ImStucc    0.004892
MetalSd    0.138943
Other      0.000978
Plywood    0.095890
Stone      0.002935
Stucco     0.019569
VinylSd    0.351272
Wd Sdng    0.140900
Wd Shng    0.029354
Name: Exterior2nd, dtype: float64

SaleType
COD      0.026419
CWD      0.003914
Con      0.001957
ConLD    0.006849
ConLI    0.000978
ConLw    0.002935
New      0.082192
Oth      0.000978
WD       0.873777
Name: SaleType, dtype: float64
```

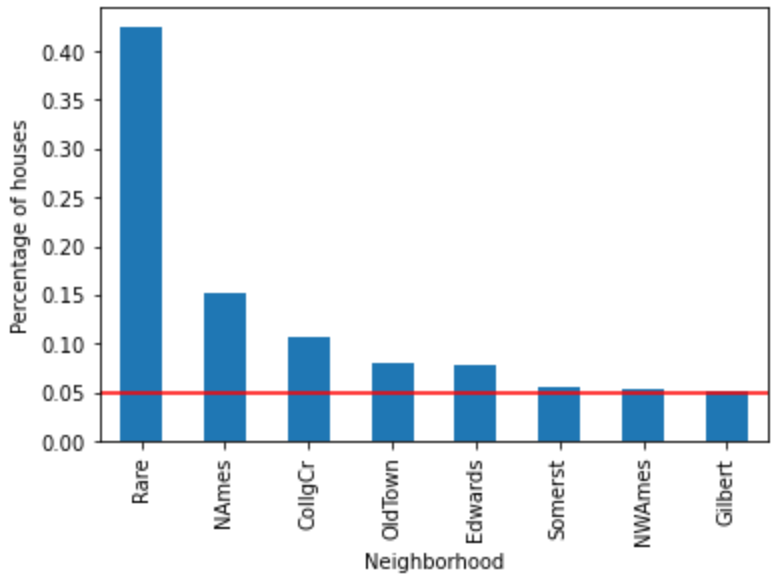
In [261…

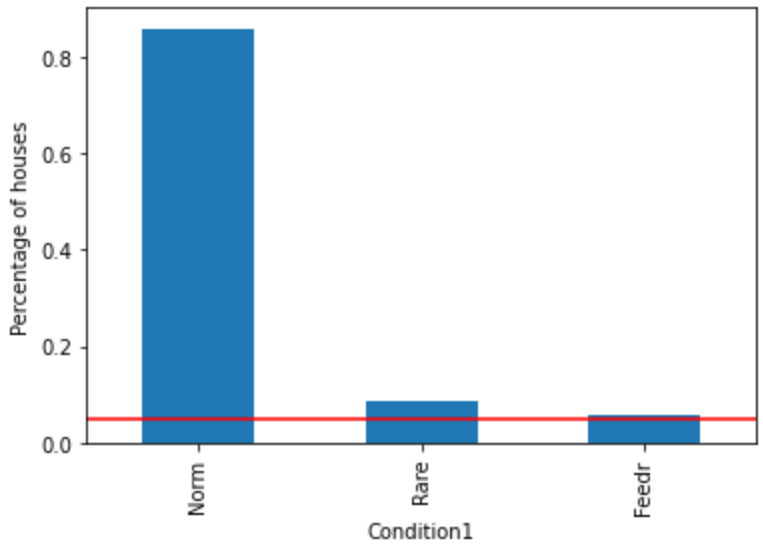
```
for variable in multi_cat_cols:

    X_train, X_test, df_test = rare_encoding(X_train, X_test, df_test, variable, 0.05)
```

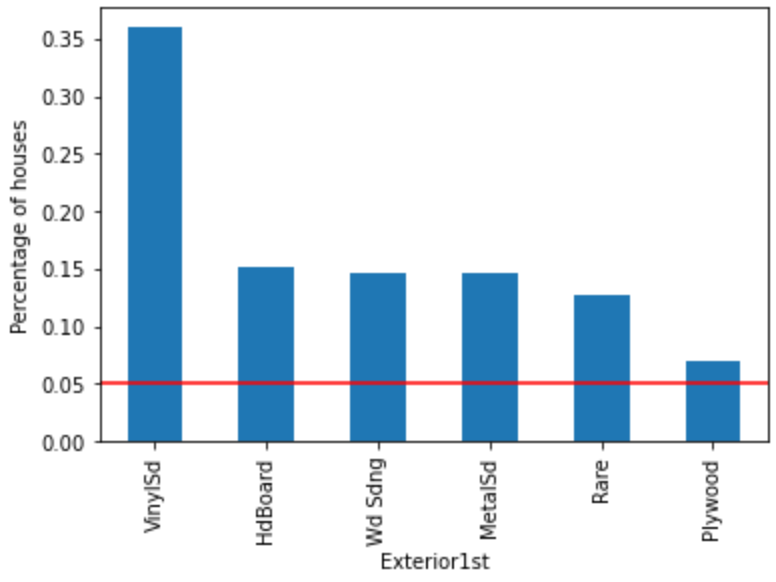
In [262…

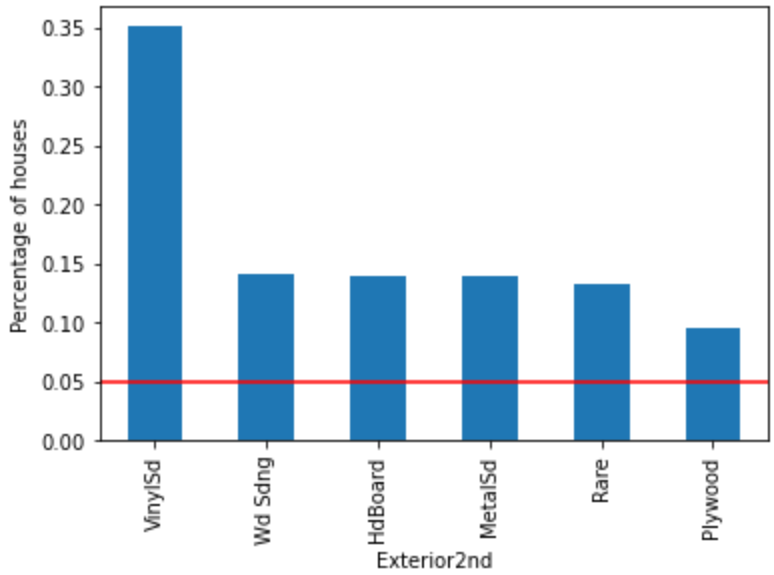
```
for col in multi_cat_cols:

    temp_df = pd.Series(X_train[col].value_counts() / len(X_train) )
```

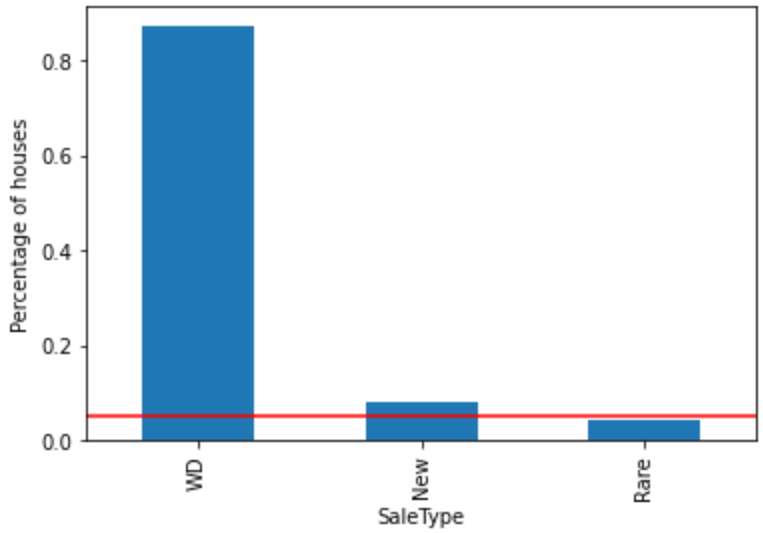
```
    fig = temp_df.sort_values(ascending=False).plot.bar()
    fig.set_xlabel(col)


    fig.axhline(y=0.05, color='red')
    fig.set_ylabel('Percentage of houses')
    plt.show()
```











In [262…
```
order_col=['ExterQual','ExterCond','BsmtQual','BsmtCond','HeatingQC','KitchenQual','Garage
```

In [262…
```
X_train.drop('SalePrice',axis=1,inplace=True)
X_test.drop('SalePrice',axis=1,inplace=True)
```

For some columne with order category in X_train dataset we'll encode by OrdinalEncoder and transform into X_test and df_test

In [262…
```
order_encode = OrdinalEncoder(encoding_method='ordered',
                              variables=order_col)
order_encode.fit(X_train,y_train)
```

Out[262…
```
OrdinalEncoder(variables=['ExterQual', 'ExterCond', 'BsmtQual', 'BsmtCond',
                          'HeatingQC', 'KitchenQual', 'GarageQual',
                          'GarageCond', 'LotShape', 'LandSlope', 'BsmtExposure',
                          'BsmtFinType1', 'BsmtFinType2', 'Functional',
                          'GarageFinish', 'PavedDrive', 'Utilities',
                          'CentralAir', 'Electrical', 'Lotsize', 'Housesize'])
```

In [262…
```
order_encode.encoder_dict_
```

Out[262…
```
{'ExterQual': {'TA': 0, 'Gd': 1, 'Rare': 2},
 'ExterCond': {'Rare': 0, 'Gd': 1, 'TA': 2},
 'BsmtQual': {'Fa': 0, 'TA': 1, 'Gd': 2, 'Ex': 3},
```

```
 'BsmtCond': {'Rare': 0, 'TA': 1},
 'HeatingQC': {'Rare': 0, 'TA': 1, 'Gd': 2, 'Ex': 3},
 'KitchenQual': {'Fa': 0, 'TA': 1, 'Gd': 2, 'Ex': 3},
 'GarageQual': {'None': 0, 'Rare': 1, 'TA': 2},
 'GarageCond': {'None': 0, 'Rare': 1, 'TA': 2},
 'LotShape': {'Reg': 0, 'IR1': 1, 'Rare': 2},
 'LandSlope': {'Gtl': 0, 'Rare': 1},
 'BsmtExposure': {'No': 0, 'Mn': 1, 'Av': 2, 'Gd': 3},
 'BsmtFinType1': {'BLQ': 0, 'LwQ': 1, 'Rec': 2, 'ALQ': 3, 'Unf': 4, 'GLQ': 5},
 'BsmtFinType2': {'Rare': 0, 'Unf': 1},
 'Functional': {'Rare': 0, 'Typ': 1},
 'GarageFinish': {'None': 0, 'Unf': 1, 'RFn': 2, 'Fin': 3},
 'PavedDrive': {'N': 0, 'P': 1, 'Y': 2},
 'Utilities': {'NoSeWa': 0, 'AllPub': 1},
 'CentralAir': {'N': 0, 'Y': 1},
 'Electrical': {'Rare': 0, 'FuseA': 1, 'SBrkr': 2},
 'Lotsize': {1: 0, 0: 1, 2: 2, 3: 3},
 'Housesize': {0: 0, 3: 1, 1: 2, 2: 3}}
```

In [262…

```
X_train=order_encode.transform(X_train)
X_test=order_encode.transform(X_test)
df_test=order_encode.transform(df_test)
```

For other category will using the one hot encoding

In [262…

```
multi_cat_cols = []
for col in X_train.columns:
    if X_train[col].dtypes == 'O':
            multi_cat_cols.append(col)
            print(X_train.groupby(col)[col].count()/len(X_train))
            print()
```

```
MSZoning
RL      0.789628
RM      0.151663
Rare    0.058708
Name: MSZoning, dtype: float64

Street
Grvl    0.003914
Pave    0.996086
Name: Street, dtype: float64

Alley
None    0.935421
Rare    0.064579
Name: Alley, dtype: float64

LandContour
Lvl     0.908023
Rare    0.091977
Name: LandContour, dtype: float64

LotConfig
Corner     0.194716
CulDSac    0.073386
Inside     0.694716
Rare       0.037182
Name: LotConfig, dtype: float64

Neighborhood
CollgCr    0.106654
Edwards    0.077299
Gilbert    0.050881
```

```
NAmes      0.151663
NWAmes     0.052838
OldTown    0.080235
Rare       0.424658
Somerst    0.055773
Name: Neighborhood, dtype: float64

Condition1
Feedr    0.055773
Norm     0.859100
Rare     0.085127
Name: Condition1, dtype: float64

Condition2
Norm    0.991194
Rare    0.008806
Name: Condition2, dtype: float64

BldgType
1Fam      0.834638
Rare      0.087084
TwnhsE    0.078278
Name: BldgType, dtype: float64

HouseStyle
1.5Fin    0.101761
1Story    0.495108
2Story    0.309198
Rare      0.093933
Name: HouseStyle, dtype: float64

RoofStyle
Gable    0.771037
Hip      0.203523
Rare     0.025440
Name: RoofStyle, dtype: float64

RoofMatl
CompShg    0.981409
Rare       0.018591
Name: RoofMatl, dtype: float64

Exterior1st
HdBoard    0.151663
MetalSd    0.145793
Plywood    0.069472
Rare       0.126223
VinylSd    0.360078
Wd Sdng    0.146771
Name: Exterior1st, dtype: float64

Exterior2nd
HdBoard    0.139922
MetalSd    0.138943
Plywood    0.095890
Rare       0.133072
VinylSd    0.351272
Wd Sdng    0.140900
Name: Exterior2nd, dtype: float64

Foundation
BrkTil    0.100783
CBlock    0.427593
PConc     0.446184
Rare      0.025440
Name: Foundation, dtype: float64
```

```
Heating
GasA    0.975538
Rare    0.024462
Name: Heating, dtype: float64

FireplaceQu
Gd      0.255382
None    0.476517
Rare    0.053816
TA      0.214286
Name: FireplaceQu, dtype: float64

GarageType
Attchd     0.590998
BuiltIn    0.062622
Detchd     0.269080
None       0.052838
Rare       0.024462
Name: GarageType, dtype: float64

PoolQC
None    0.995108
Rare    0.004892
Name: PoolQC, dtype: float64

Fence
MnPrv    0.109589
None     0.802348
Rare     0.088063
Name: Fence, dtype: float64

MiscFeature
None    0.960861
Rare    0.039139
Name: MiscFeature, dtype: float64

SaleType
New     0.082192
Rare    0.044031
WD      0.873777
Name: SaleType, dtype: float64

SaleCondition
Abnorml    0.066536
Normal     0.824853
Partial    0.083170
Rare       0.025440
Name: SaleCondition, dtype: float64

MasVnrType
BrkCmn     0.011742
BrkFace    0.321918
None       0.577299
Stone      0.089041
Name: MasVnrType, dtype: float64
```

In [262…

```
multi_cat_cols
```

Out[262…

```
['MSZoning',
 'Street',
 'Alley',
 'LandContour',
 'LotConfig',
```

```
 'Neighborhood',
 'Condition1',
 'Condition2',
 'BldgType',
 'HouseStyle',
 'RoofStyle',
 'RoofMatl',
 'Exterior1st',
 'Exterior2nd',
 'Foundation',
 'Heating',
 'FireplaceQu',
 'GarageType',
 'PoolQC',
 'Fence',
 'MiscFeature',
 'SaleType',
 'SaleCondition',
 'MasVnrType']
```

In [262…
```
ohe_encode =OneHotEncoder(
    top_categories=None,
    drop_last=True)
```

In [262…
```
ohe_encode.fit(X_train)
```

Out[262…
```
OneHotEncoder(drop_last=True)
```

In [263…
```
ohe_encode.variables_
```

Out[263…
```
['MSZoning',
 'Street',
 'Alley',
 'LandContour',
 'LotConfig',
 'Neighborhood',
 'Condition1',
 'Condition2',
 'BldgType',
 'HouseStyle',
 'RoofStyle',
 'RoofMatl',
 'Exterior1st',
 'Exterior2nd',
 'Foundation',
 'Heating',
 'FireplaceQu',
 'GarageType',
 'PoolQC',
 'Fence',
 'MiscFeature',
 'SaleType',
 'SaleCondition',
 'MasVnrType',
 'GroupYearBuilt']
```

In [263…
```
X_train=ohe_encode.transform(X_train)
X_test=ohe_encode.transform(X_test)
df_test=ohe_encode.transform(df_test)
```

Data Transformation and scaling

basically for building the regression model, need the assumsion of feature to be linear and As the dataset with skew, some outliner and difference of range data, need to scale and transform data to normal distribution before we'll do the next process of built model

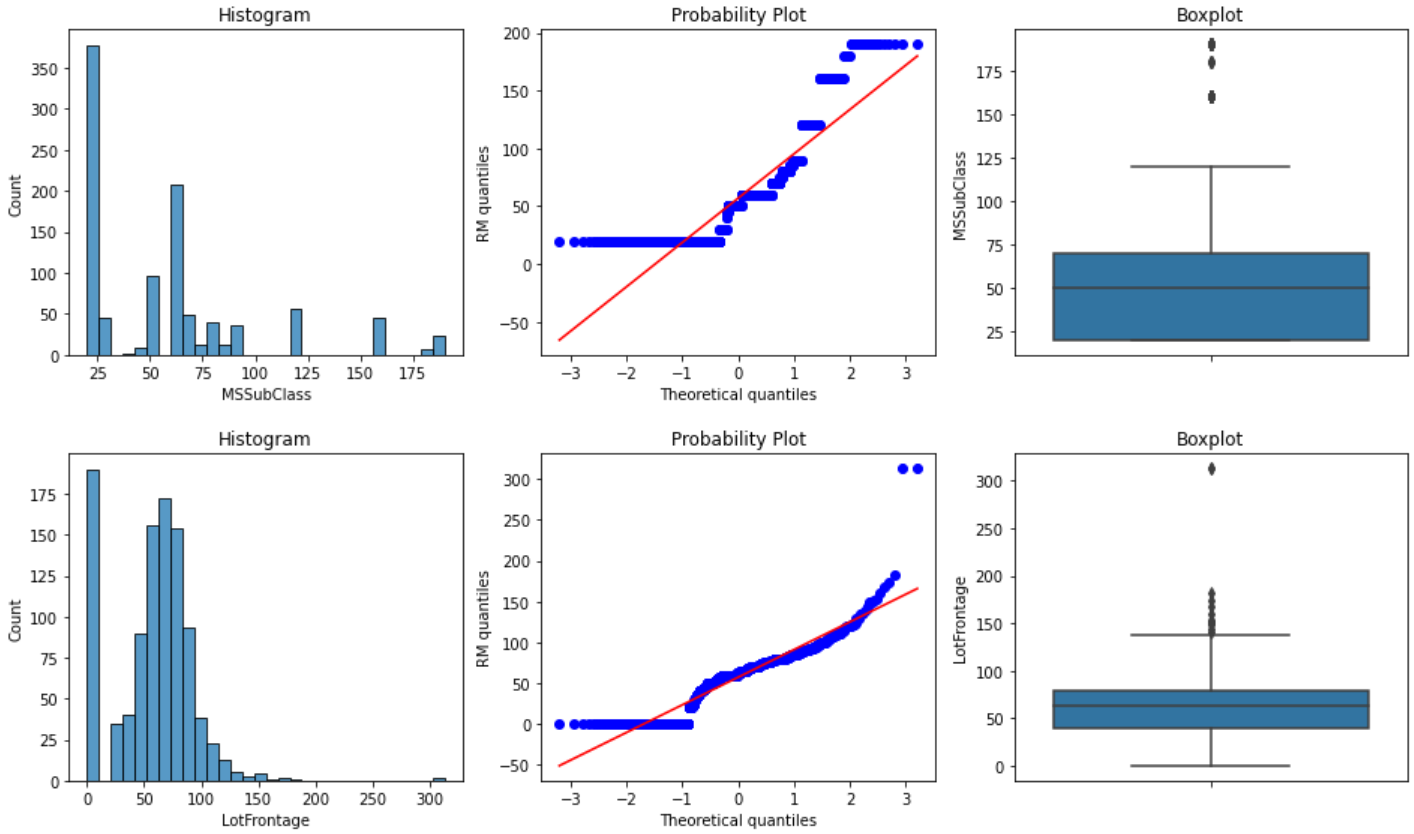
In [263…

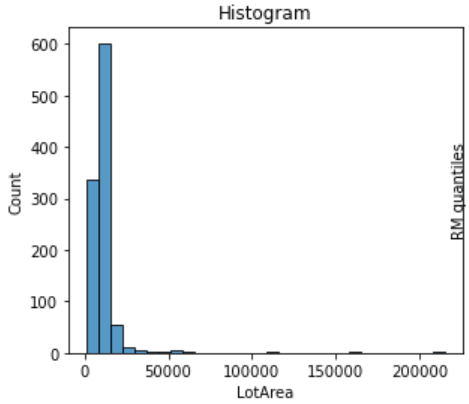
```
def diagnostic_plots(df, variable):
    plt.figure(figsize=(16, 4))
    plt.subplot(1, 3, 1)
    sns.histplot(df[variable], bins=30)
    plt.title('Histogram')
    plt.subplot(1, 3, 2)
    stats.probplot(df[variable], dist="norm", plot=plt)
    plt.ylabel('RM quantiles')
    plt.subplot(1, 3, 3)
    sns.boxplot(y=df[variable])
    plt.title('Boxplot')

    plt.show()
```

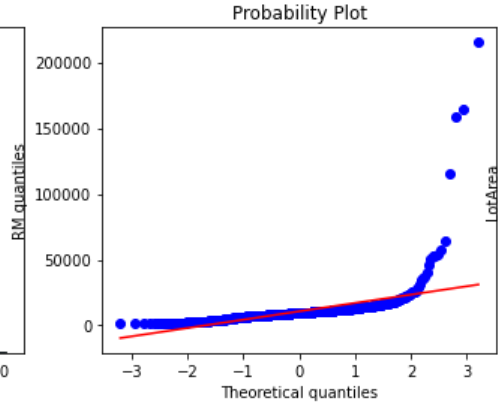
The chart below show the distribution, outliner and feature linear assumtion

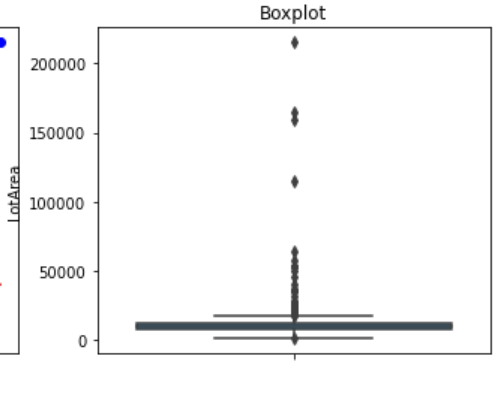
In [263…

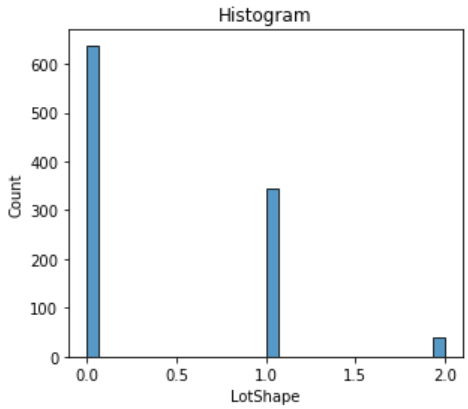
```
for i in X_train.columns:
    diagnostic_plots(X_train,i)
```

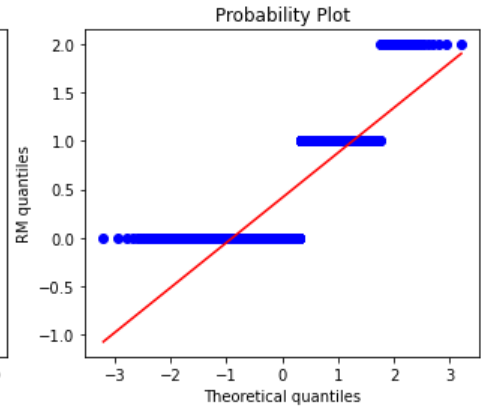


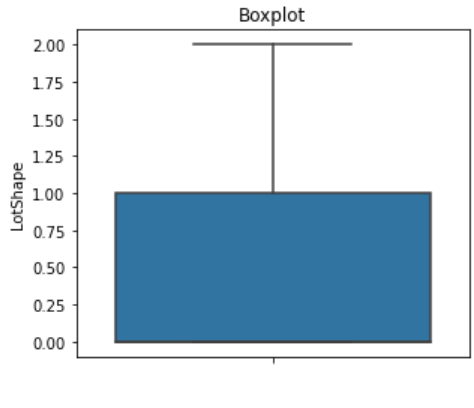

Histogram
Count
LotArea

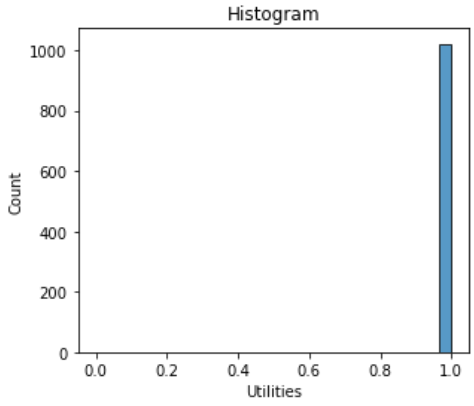

Probability Plot
RM quantiles
Theoretical quantiles

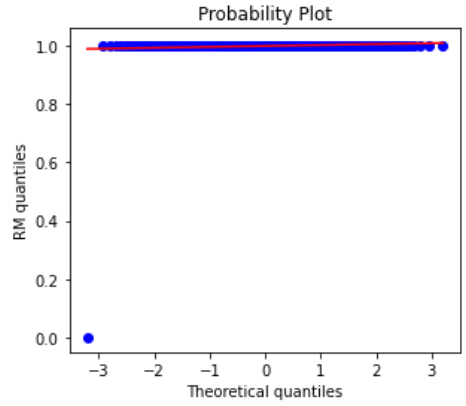

Boxplot
LotArea

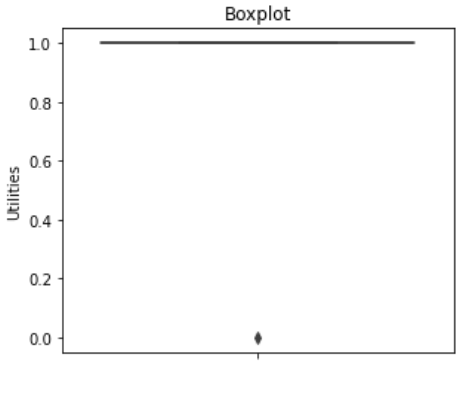

Histogram
Count
LotShape

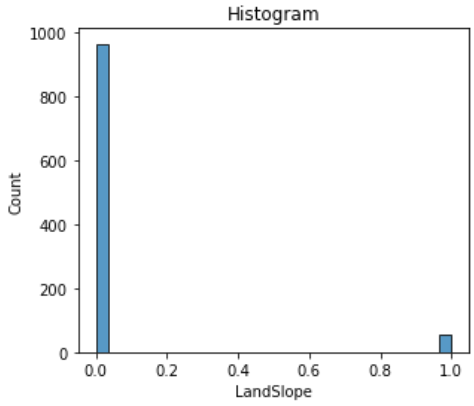

Probability Plot
RM quantiles
Theoretical quantiles

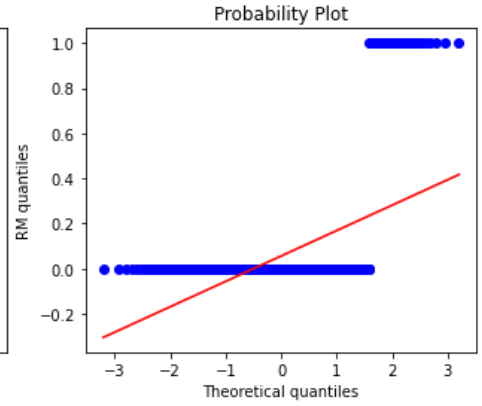

Boxplot
LotShape

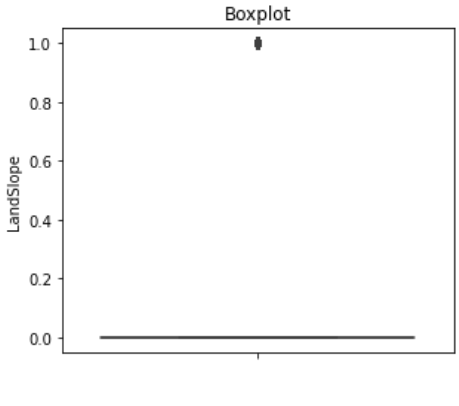

Histogram
Count
Utilities

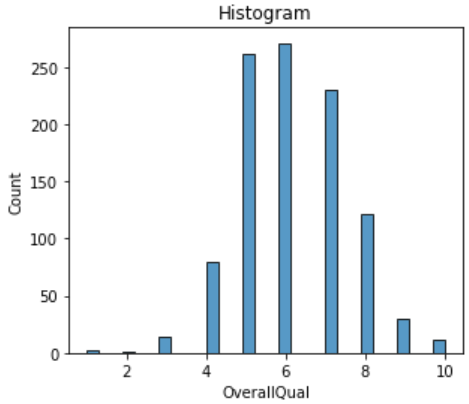

Probability Plot
RM quantiles
Theoretical quantiles

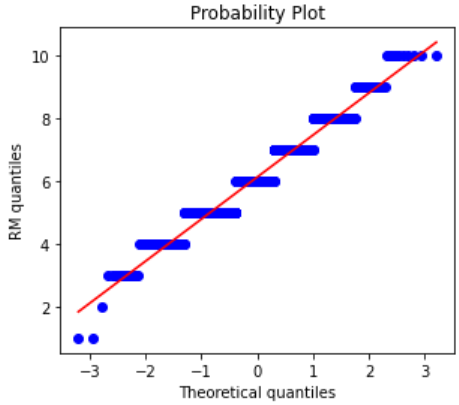

Boxplot
Utilities

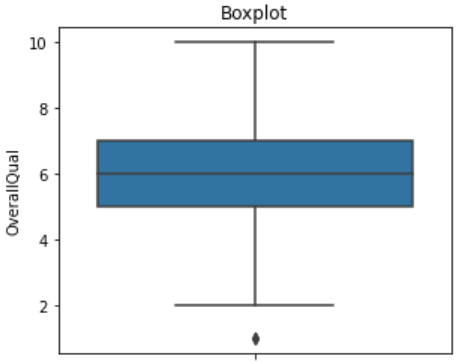

Histogram
Count
LandSlope

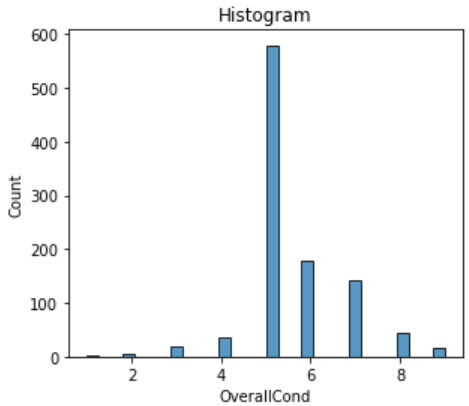

Probability Plot
RM quantiles
Theoretical quantiles

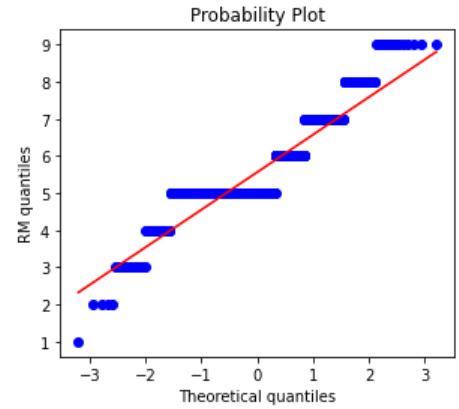

Boxplot
LandSlope

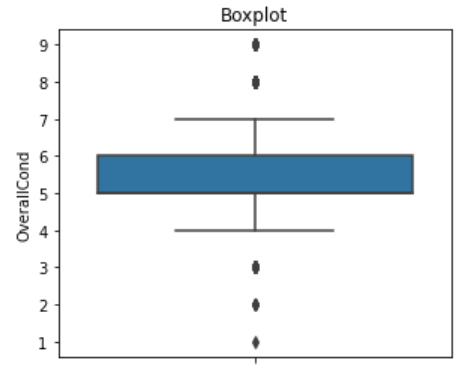

Histogram
Count
OverallQual

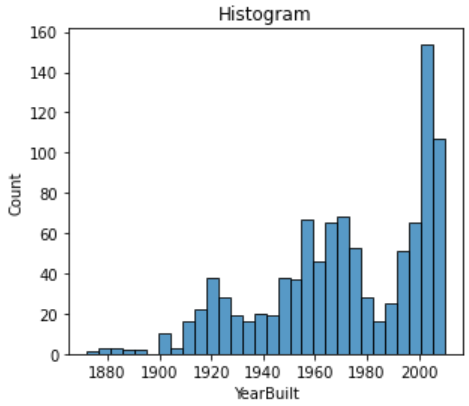

Probability Plot
RM quantiles
Theoretical quantiles

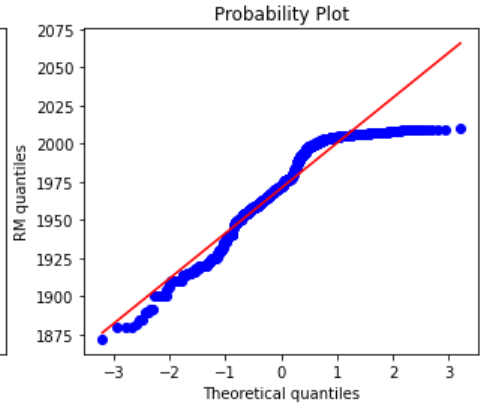

Boxplot
OverallQual

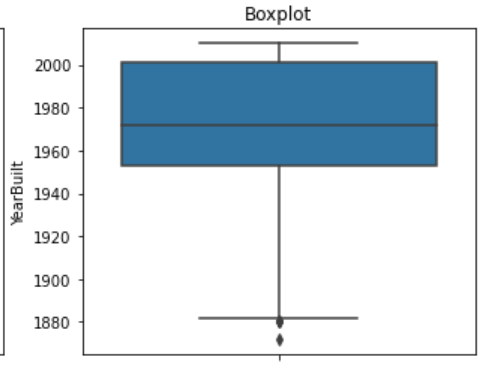

Histogram
Count
OverallCond

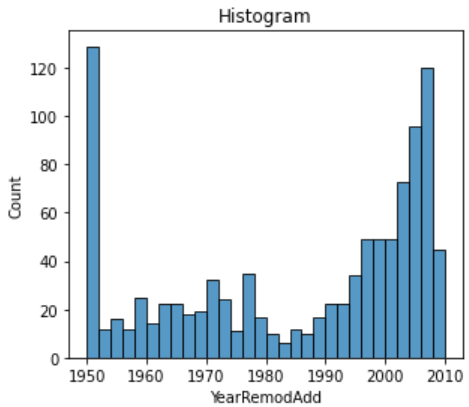

Probability Plot
RM quantiles
Theoretical quantiles

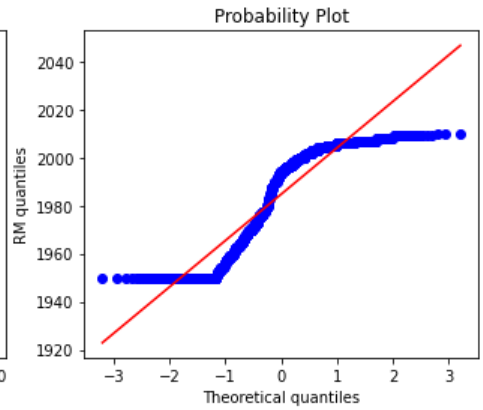

Boxplot
OverallCond

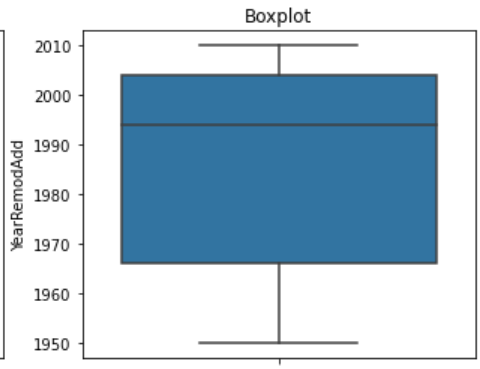

Histogram
Count
YearBuilt

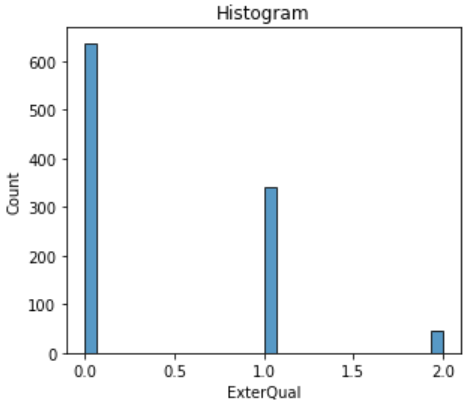

Probability Plot
RM quantiles
Theoretical quantiles

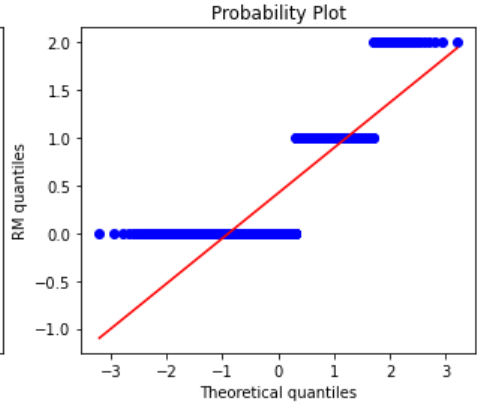

Boxplot
YearBuilt

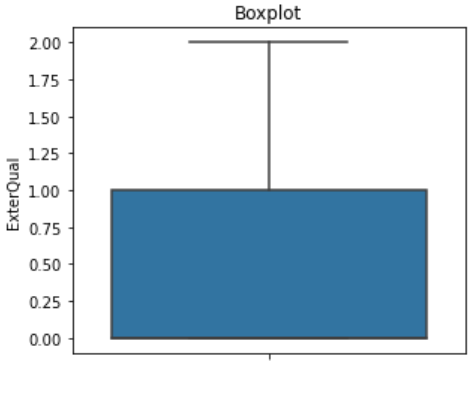

Histogram
Count
YearRemodAdd

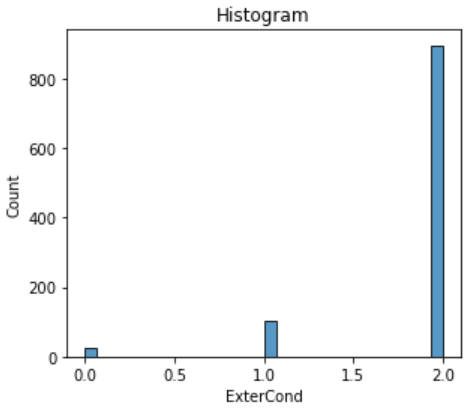

Probability Plot
RM quantiles
Theoretical quantiles

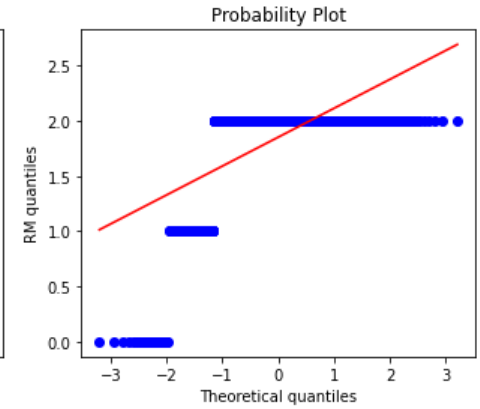

Boxplot
YearRemodAdd

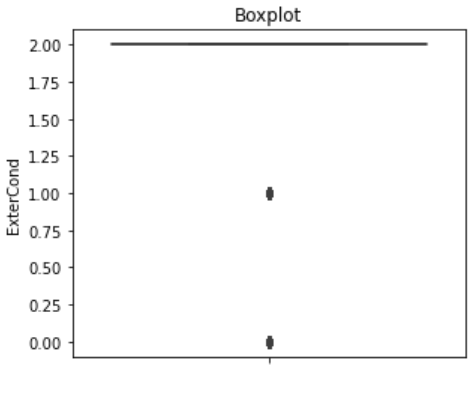

Histogram
Count
ExterQual

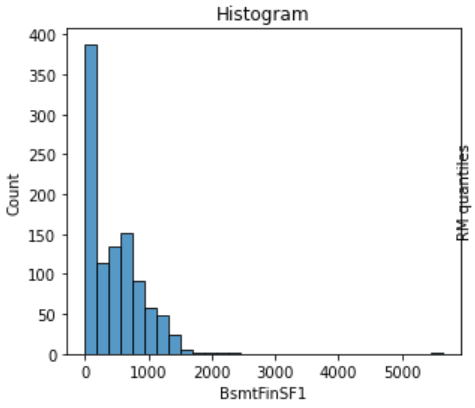

Probability Plot
RM quantiles
Theoretical quantiles

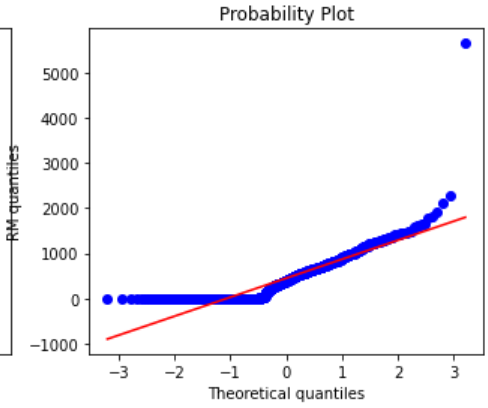

Boxplot
ExterQual

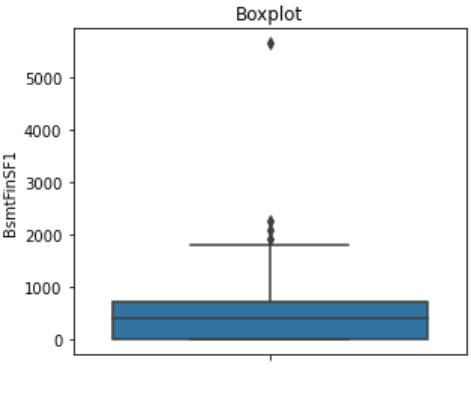

Histogram
Count
ExterCond

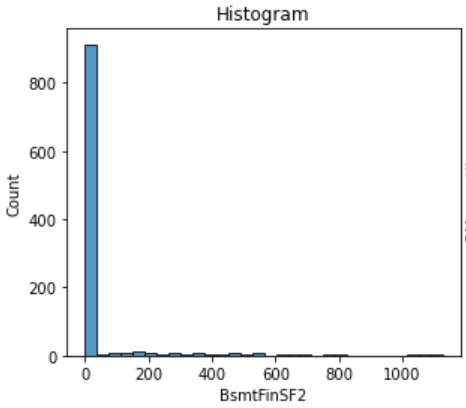

Probability Plot
RM quantiles
Theoretical quantiles

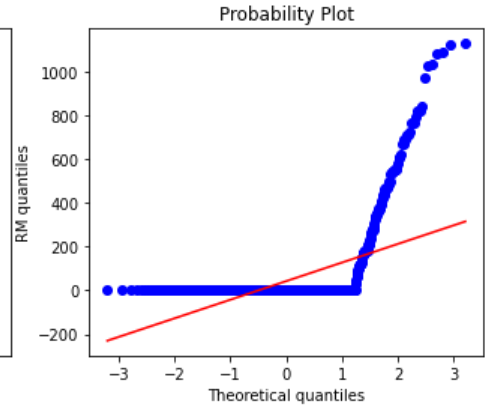

Boxplot
ExterCond

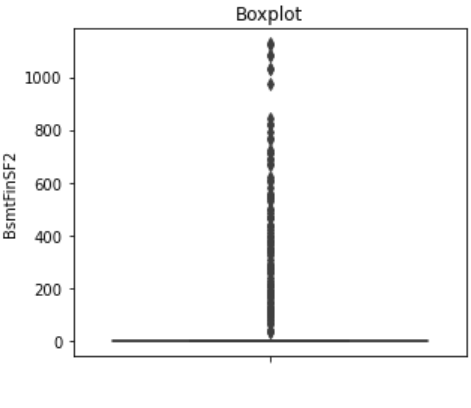

Histogram
Count
BsmtFinSF1

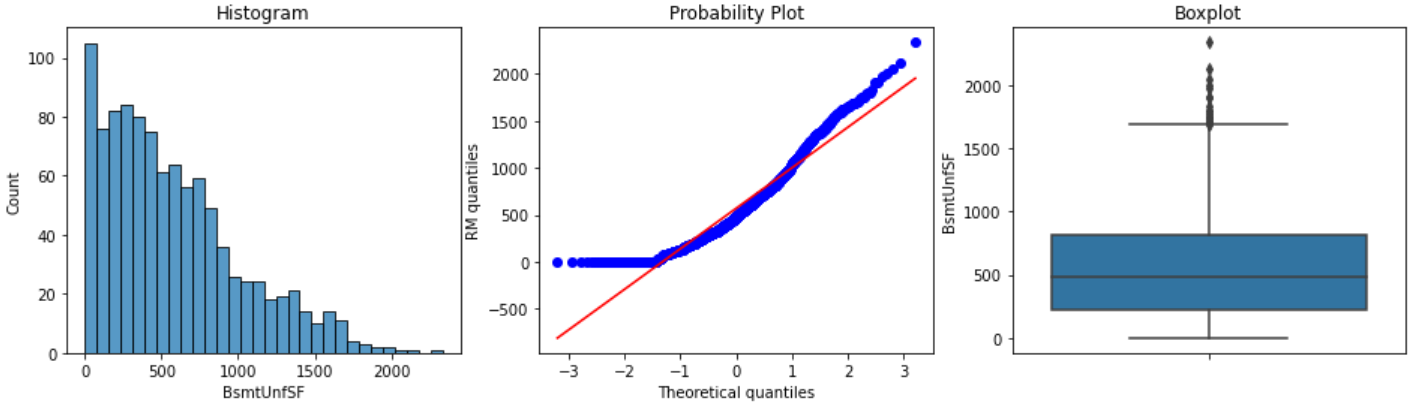

Probability Plot
RM quantiles
Theoretical quantiles

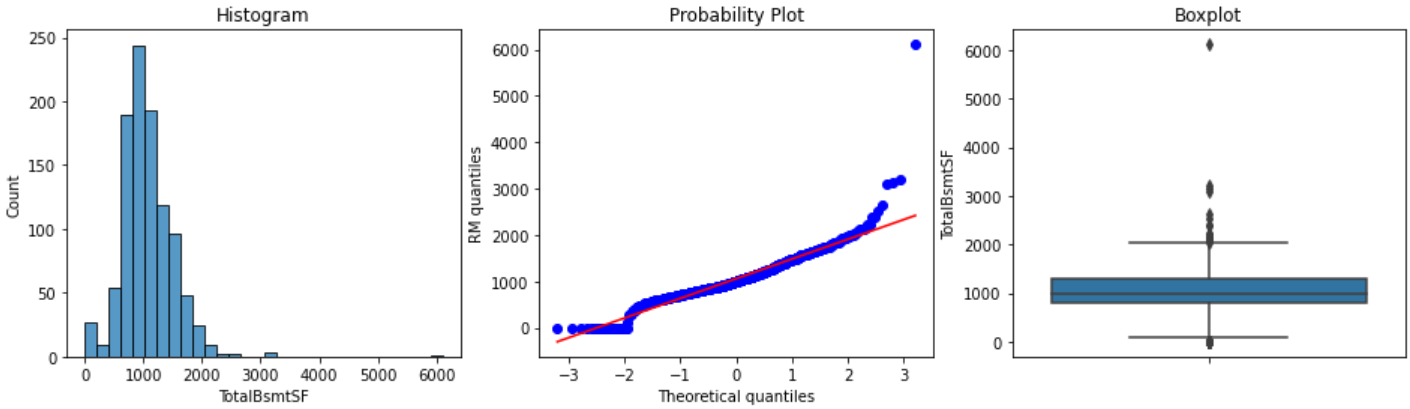

Boxplot
BsmtFinSF1

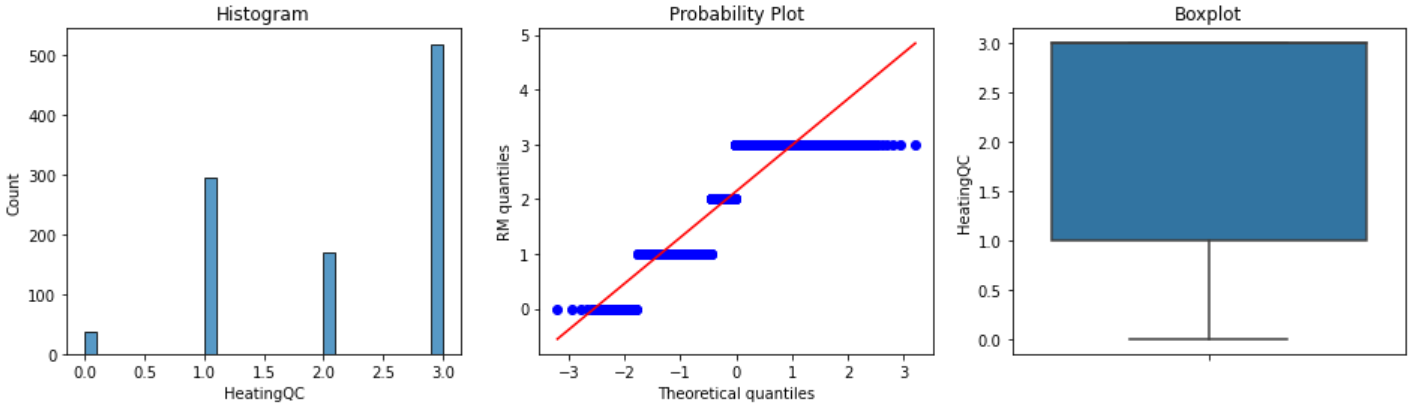

Histogram
Count
BsmtFinSF2

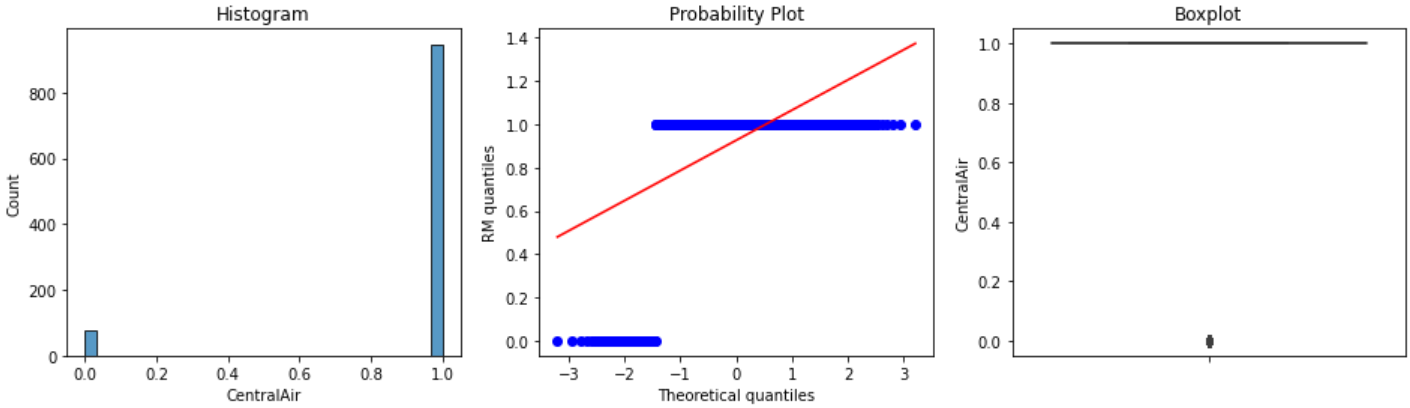

Probability Plot
RM quantiles
Theoretical quantiles

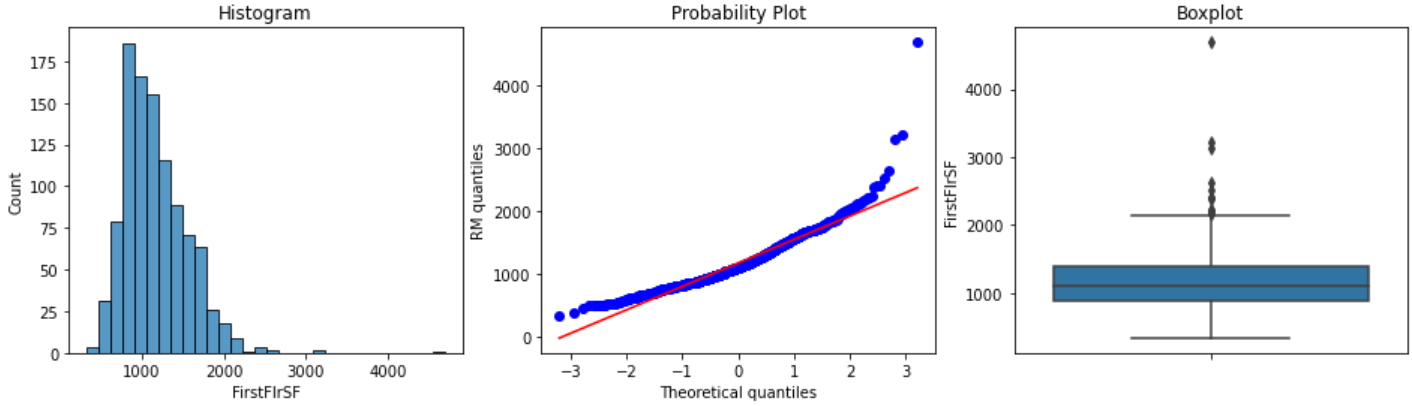

Boxplot
BsmtFinSF2

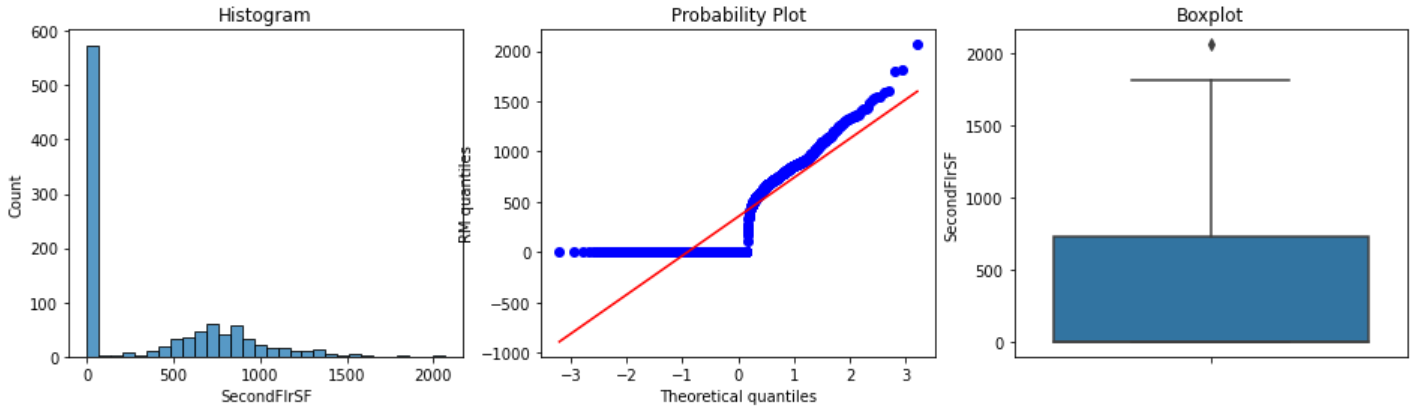

Histogram
Count
BsmtUnfSF
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
BsmtUnfSF

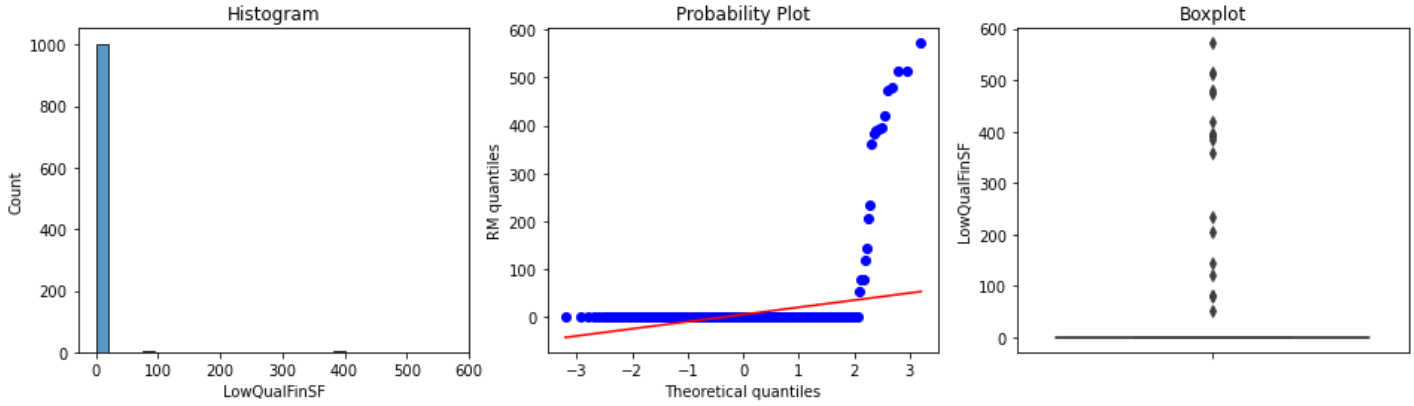

Histogram
Count
TotalBsmtSF
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
TotalBsmtSF


Histogram
Count
HeatingQC
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
HeatingQC


Histogram
Count
CentralAir
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
CentralAir


Histogram
Count
FirstFlrSF
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
FirstFlrSF


Histogram
Count
SecondFlrSF
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SecondFlrSF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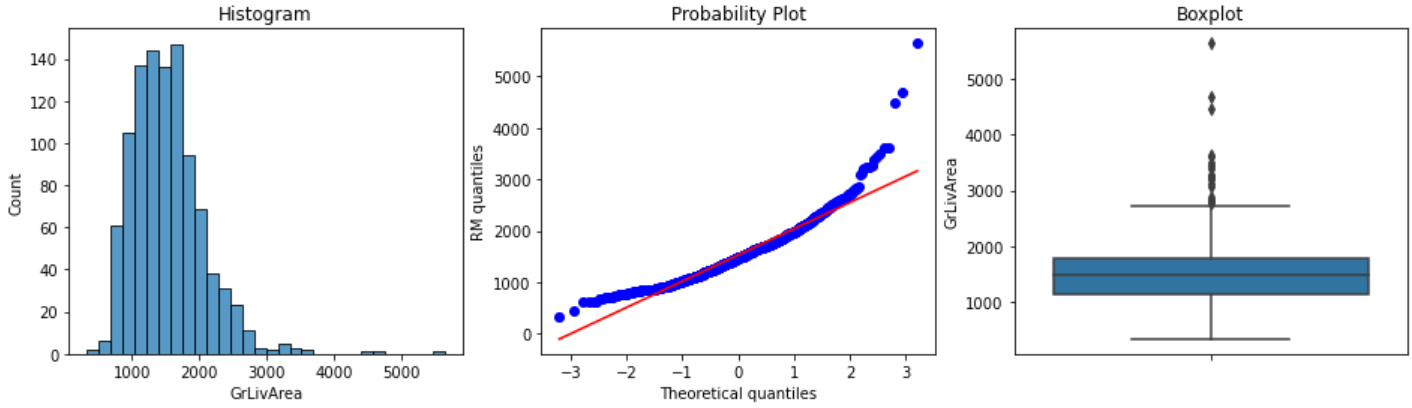
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
LowQualFinSF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Theoretical quantiles
Boxplot
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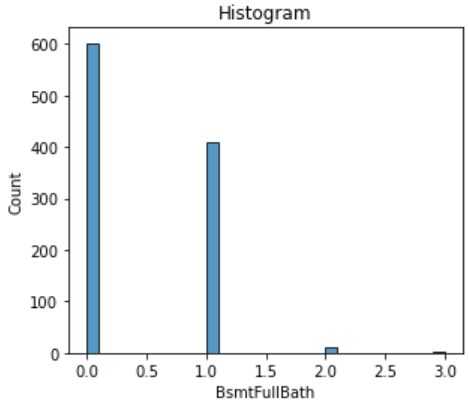
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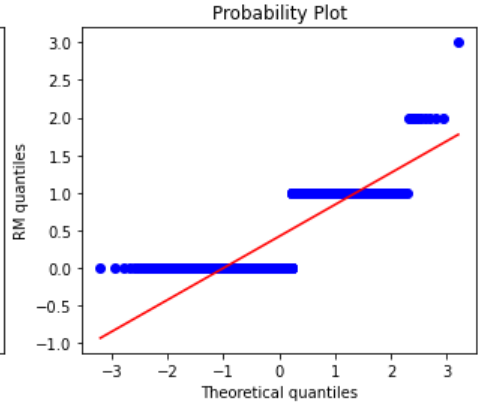
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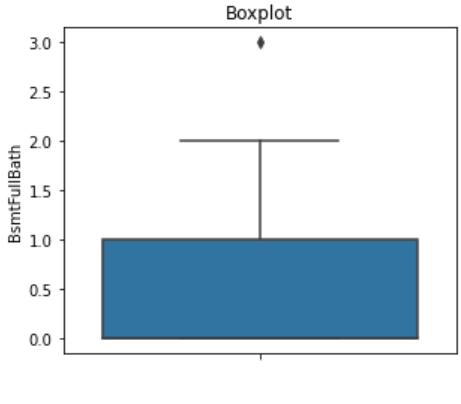
Theoretical quantiles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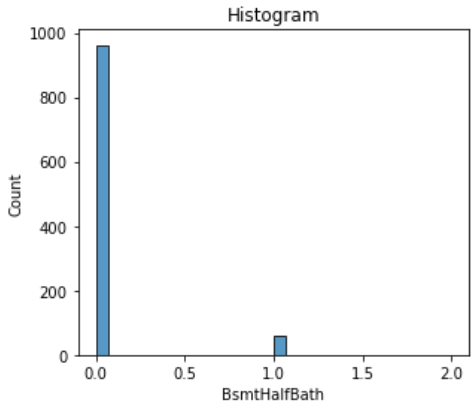
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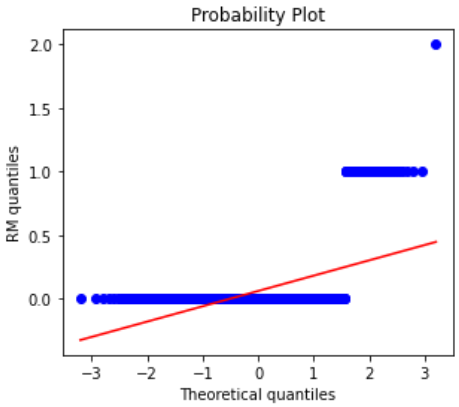
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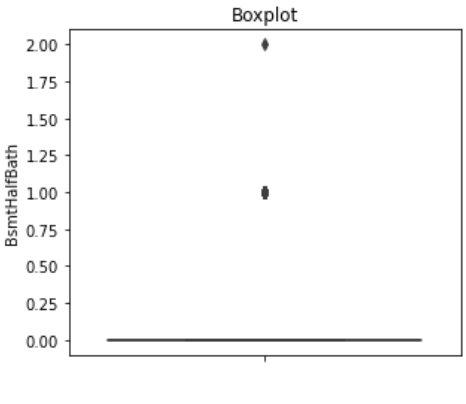
Theoretical quantiles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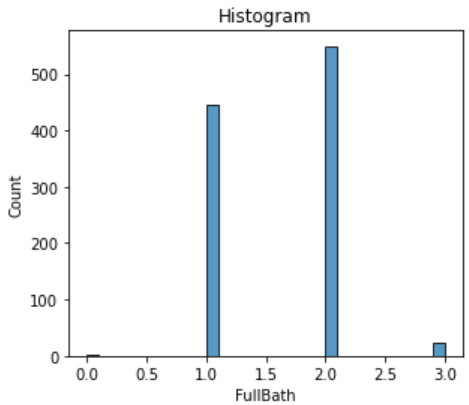
BsmtHalfBath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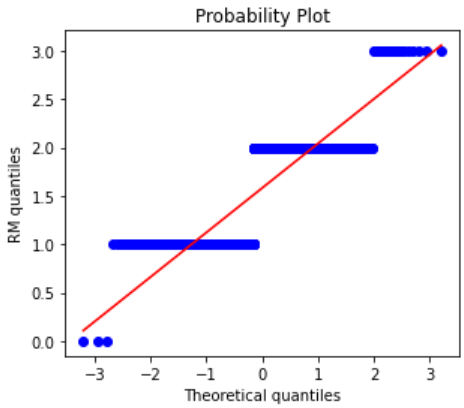
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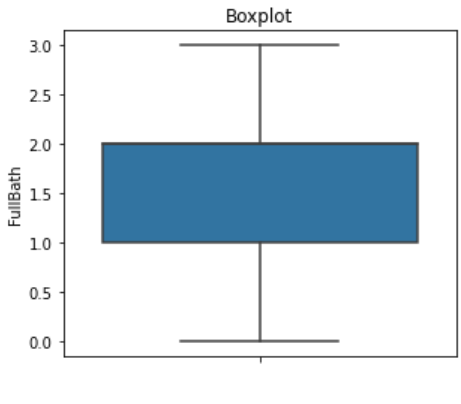
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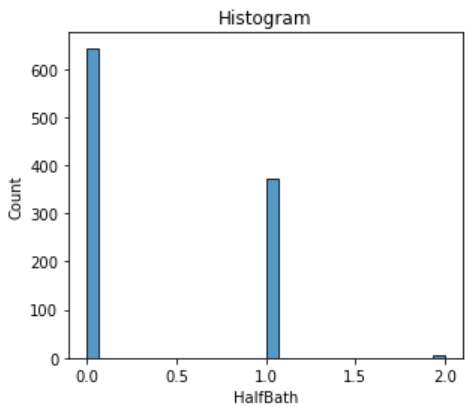
FullBath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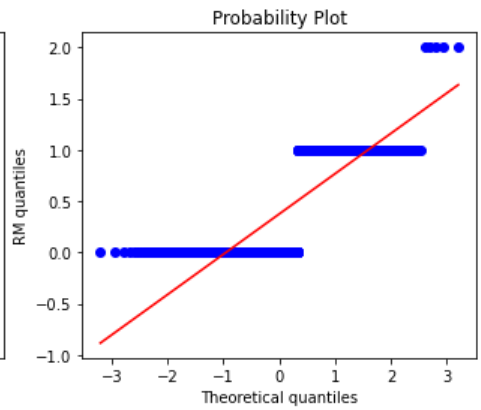
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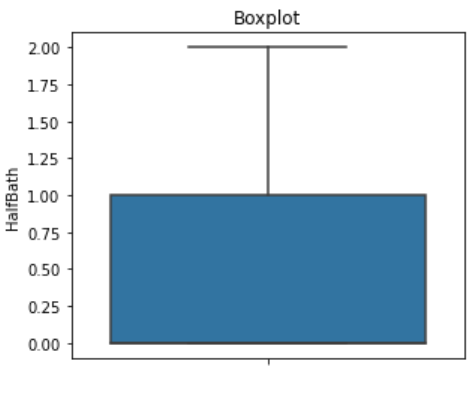
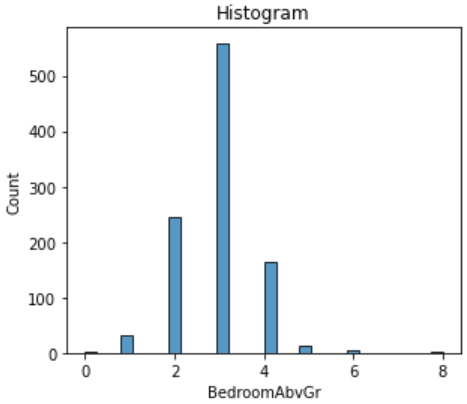

Boxplot
HalfBath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Count
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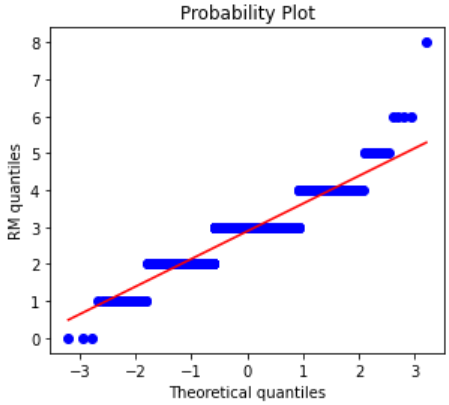
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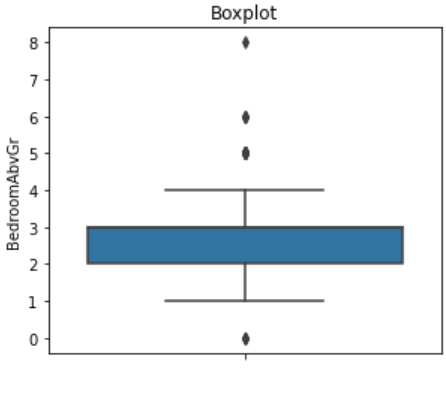
Theoretical quantiles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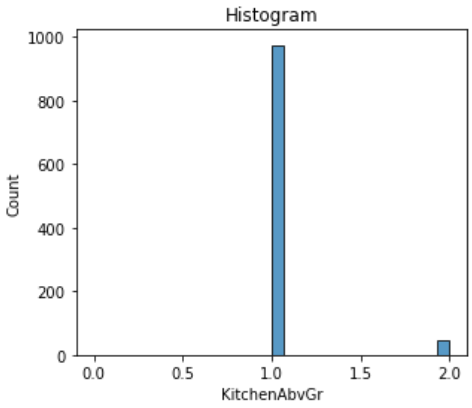
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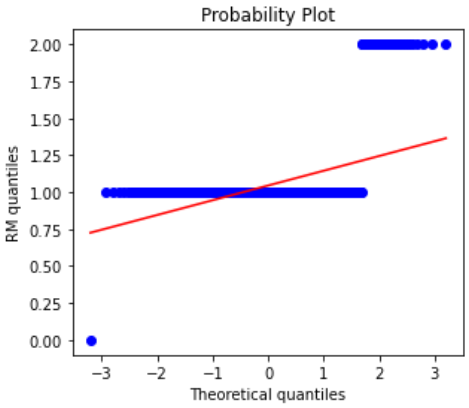
Count
KitchenAbvGr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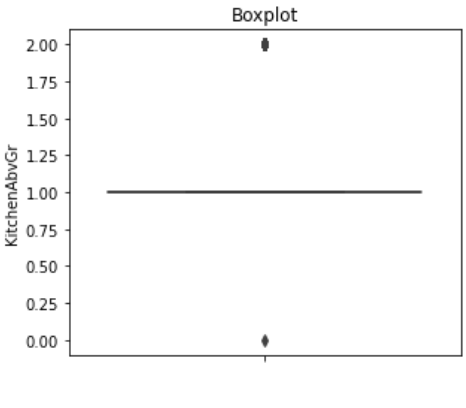
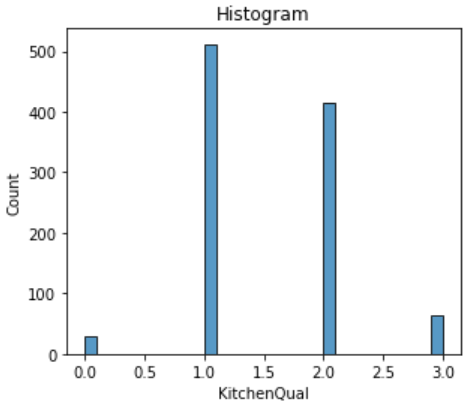
RM quantiles
Theoretical quantiles


Boxplot
KitchenAbvGr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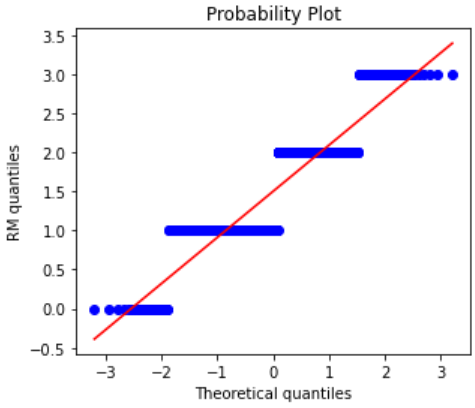
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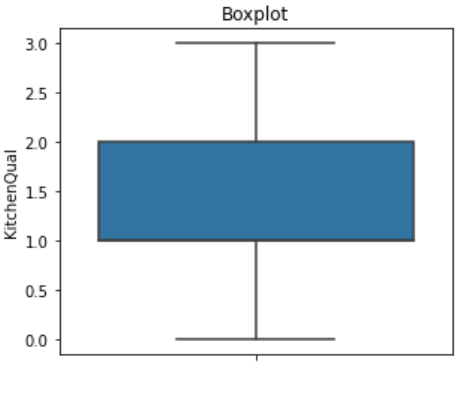
RM quantiles
Theoretical quantiles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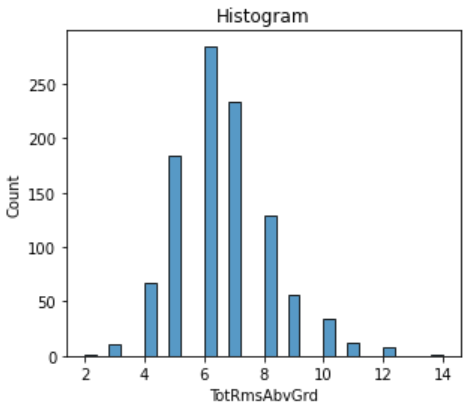
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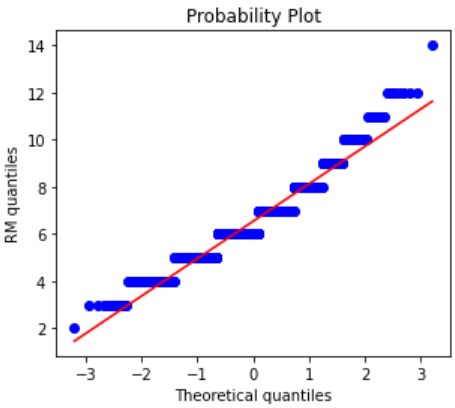
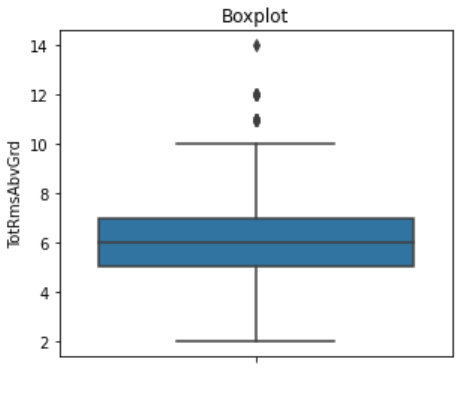
Count
TotRmsAbvGrd


Probability Plot
RM quantiles
Theoretical quantiles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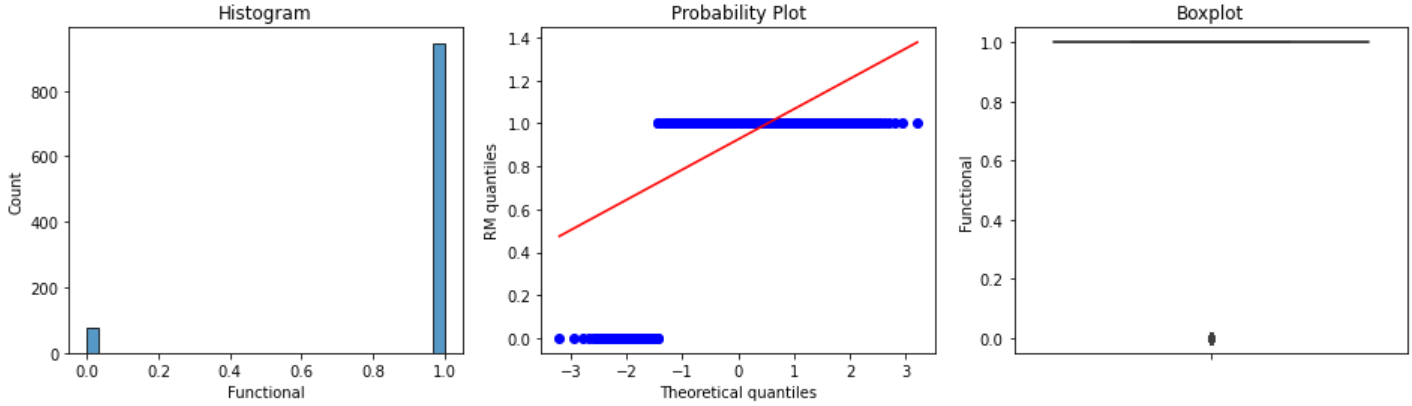
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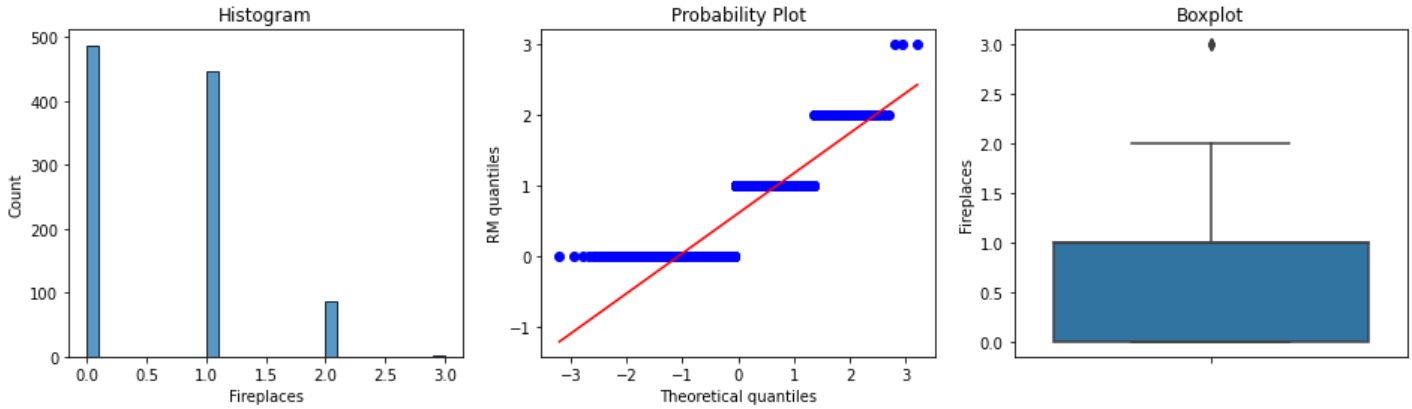
Functional
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Functional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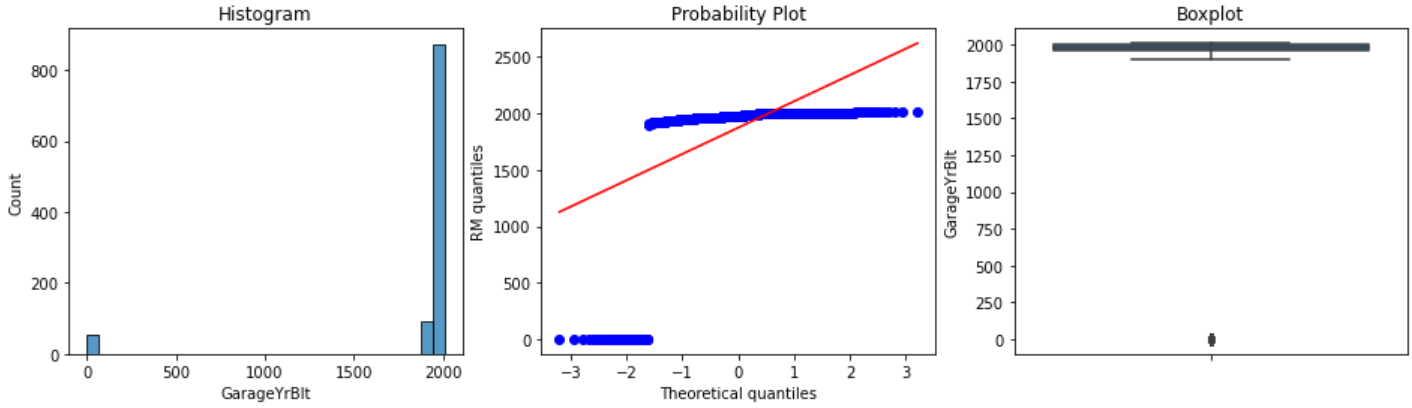
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Fireplaces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Theoretical quantiles
Boxplot
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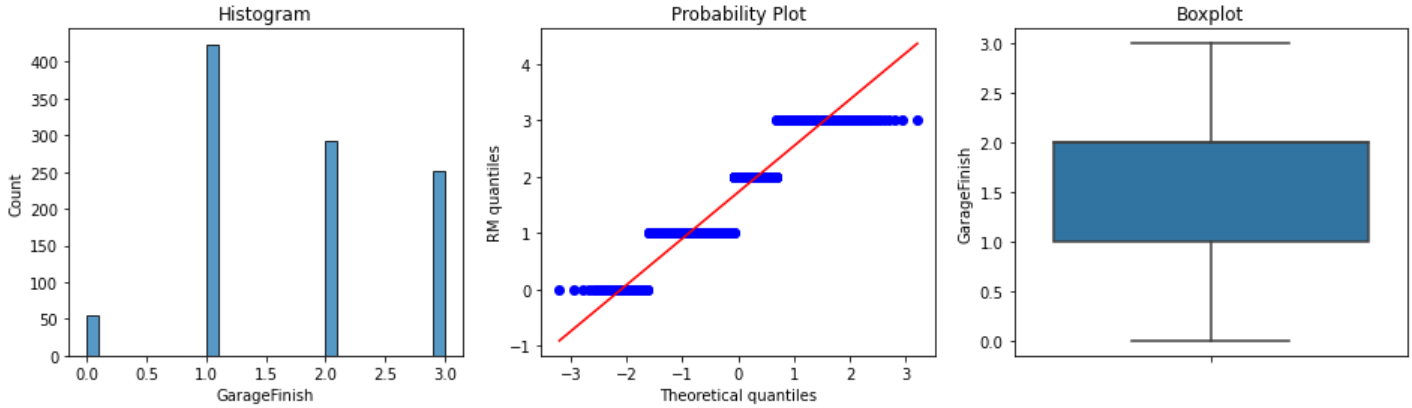
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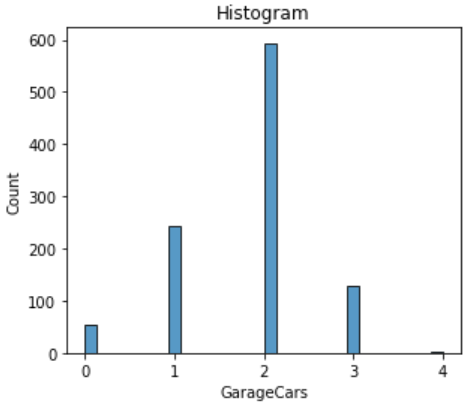
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
GarageFinish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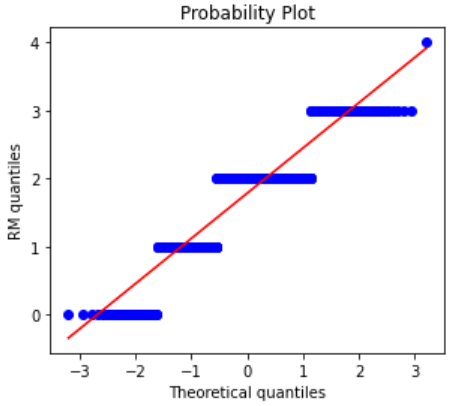
Probability Plot
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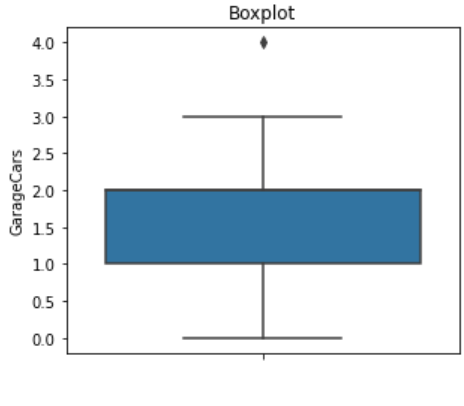
Theoretical quantiles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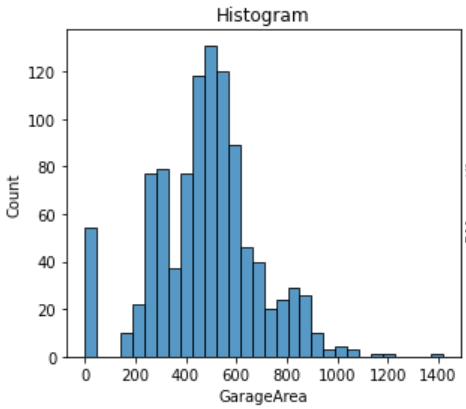
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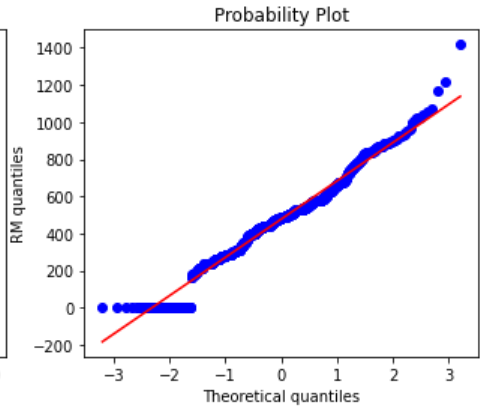
Probability Plot
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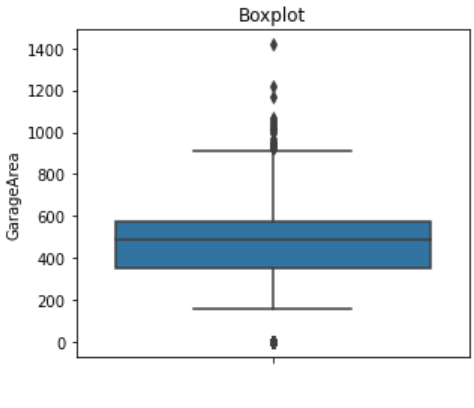
Theoretical quantiles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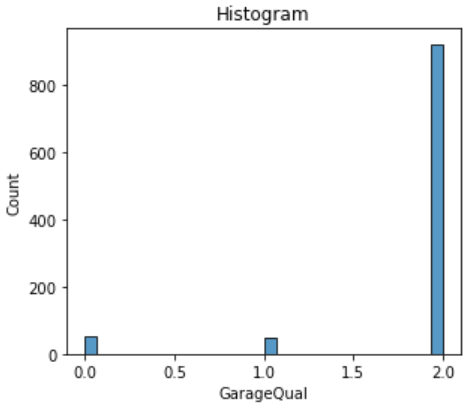
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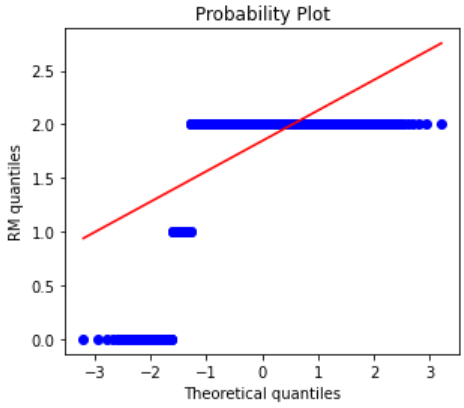
Probability Plot
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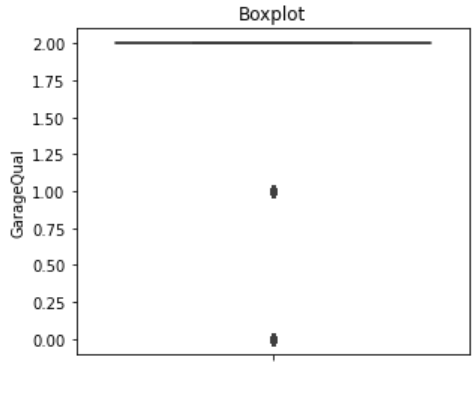
Theoretical quantiles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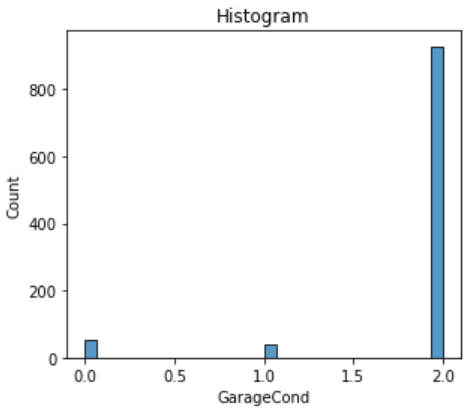
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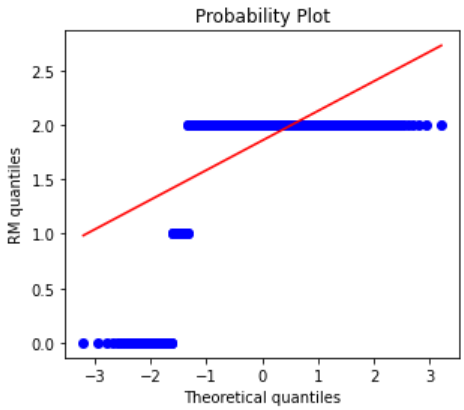
Probability Plot
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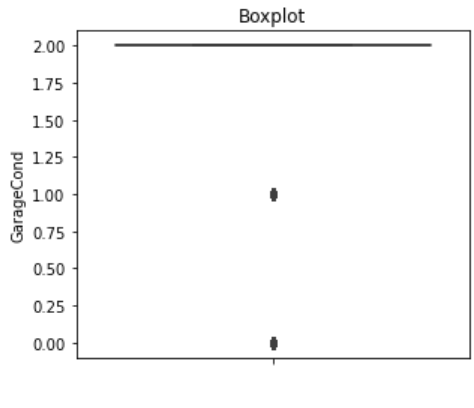
Theoretical quantiles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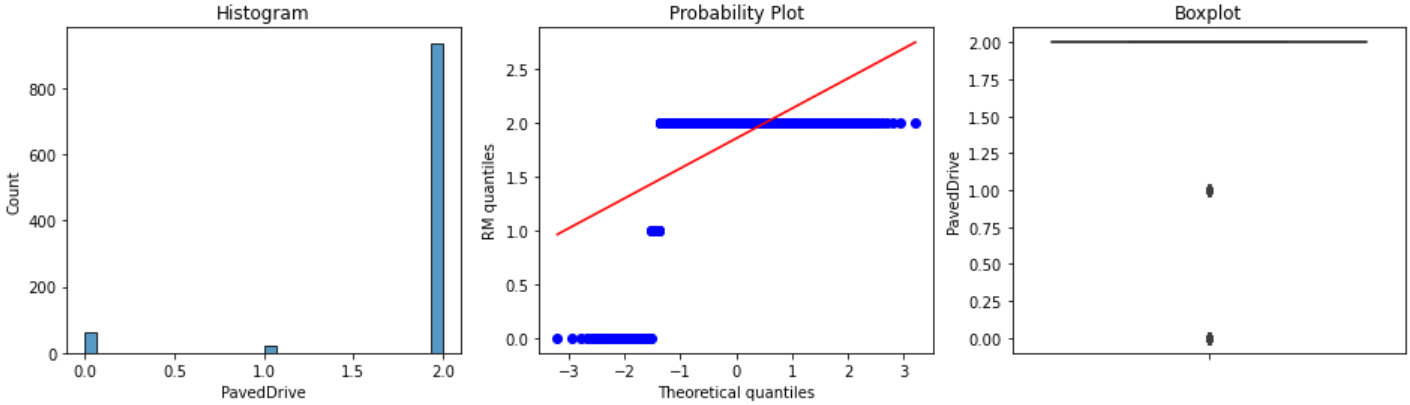
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Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
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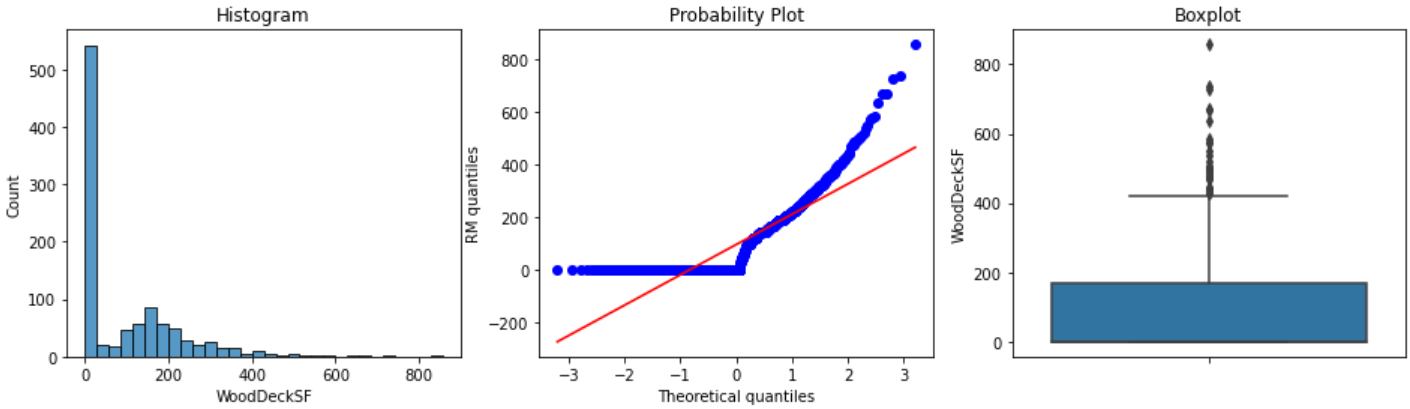
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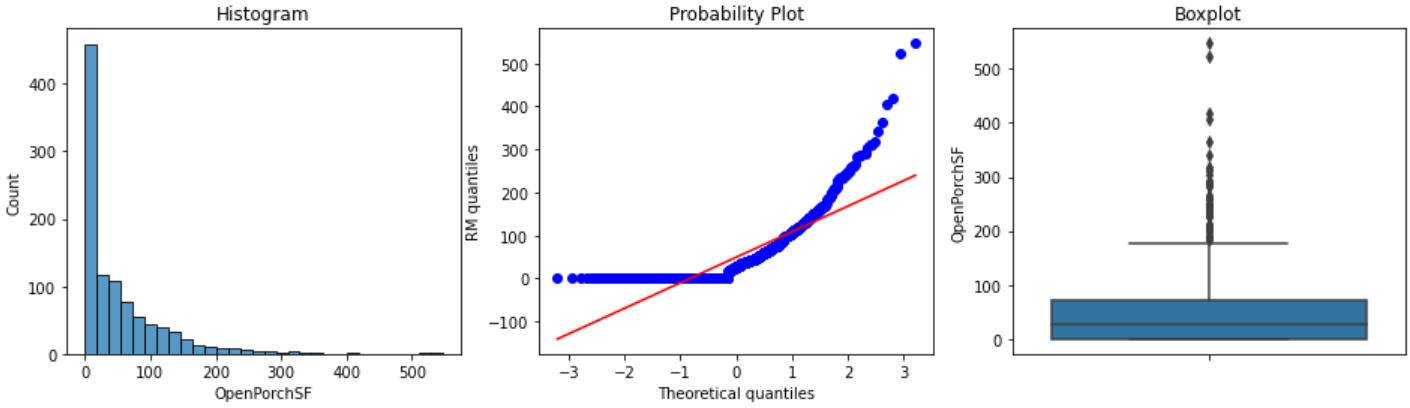
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
WoodDeckSF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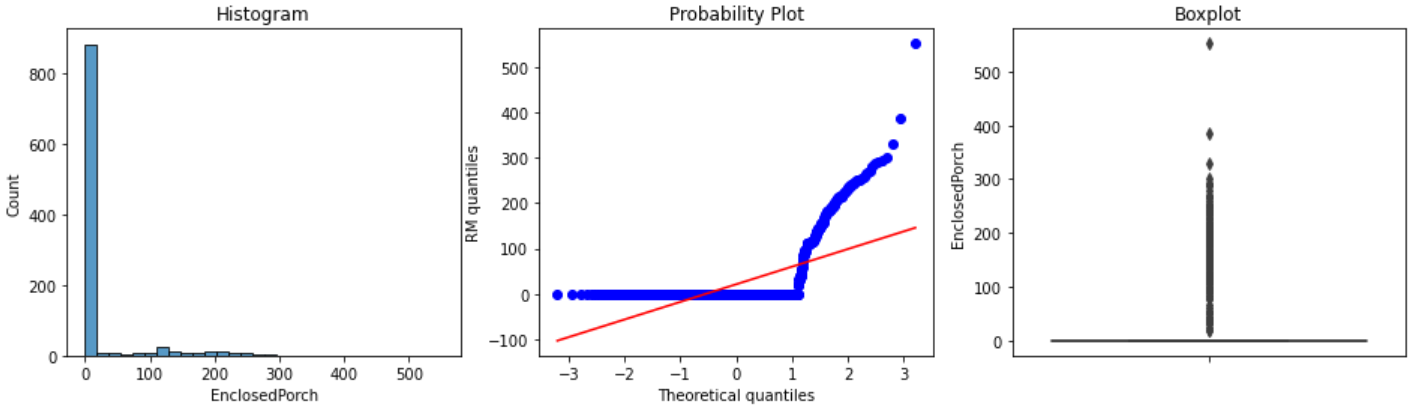
RM quantiles
Theoretical quantiles
Boxplot
OpenPorchSF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Theoretical quantiles
Boxplot
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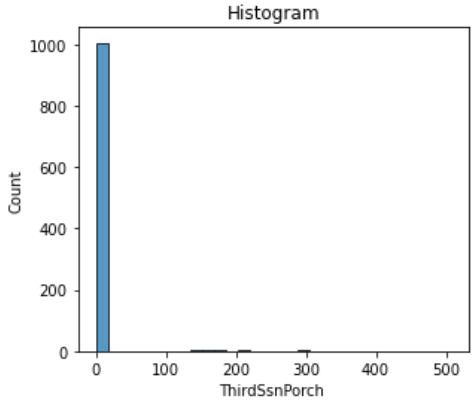
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Count
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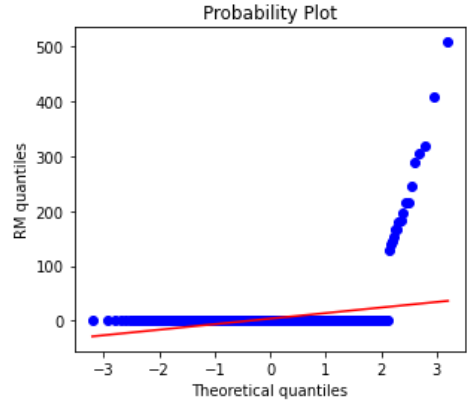
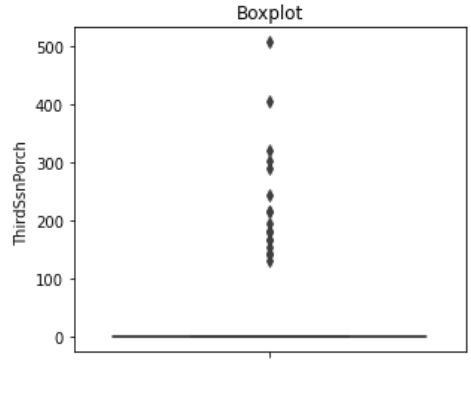
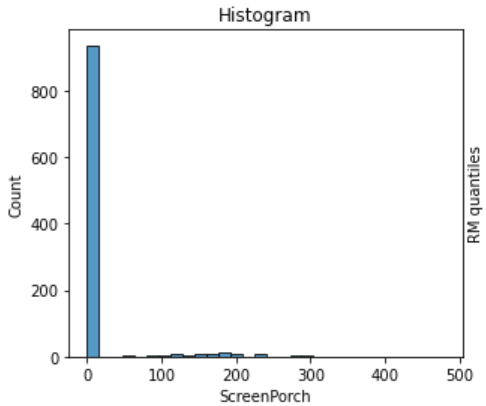

Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
ThirdSsnPorch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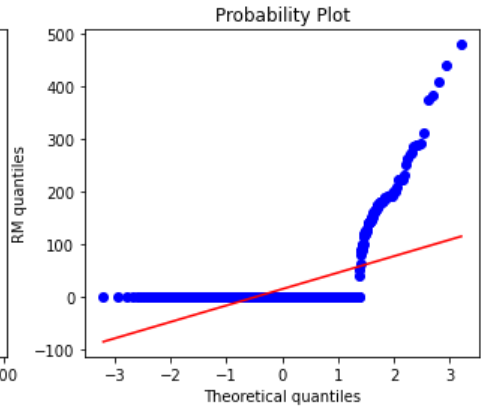
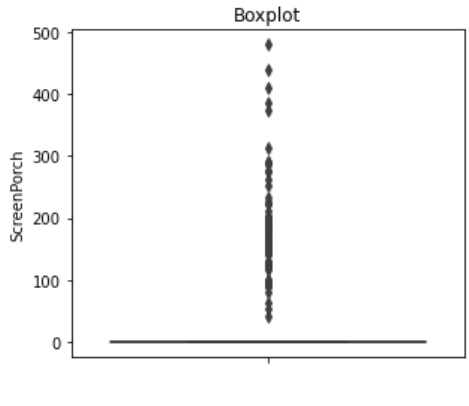
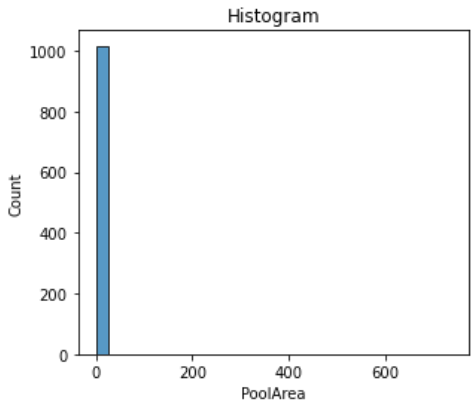
Count
ScreenPorch


Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
ScreenPorch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Count
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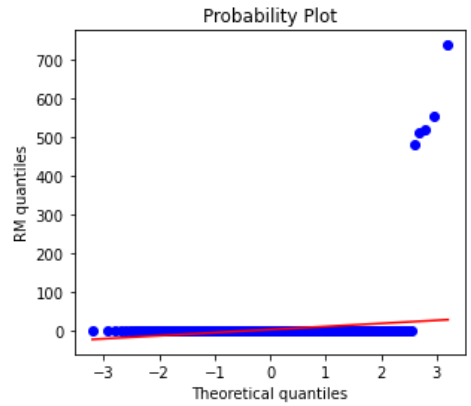
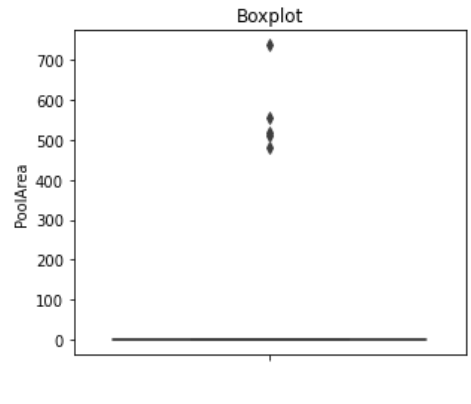
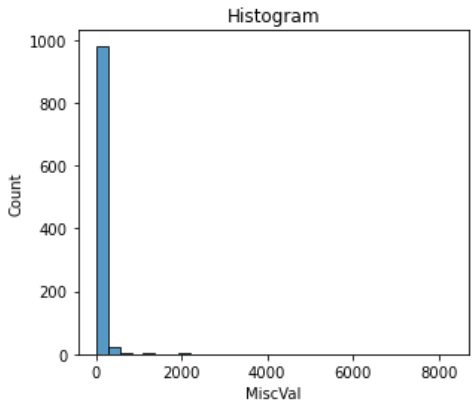
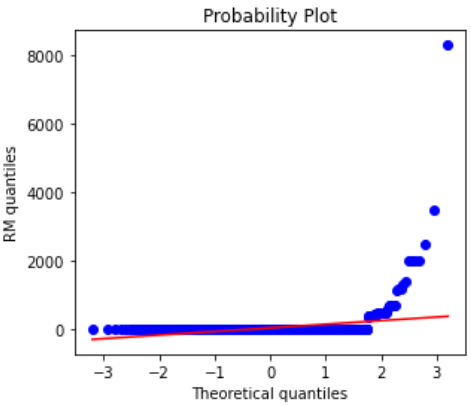
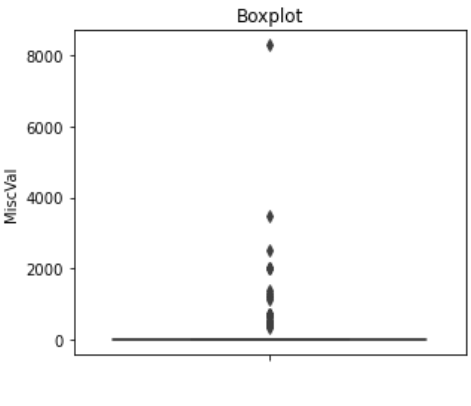
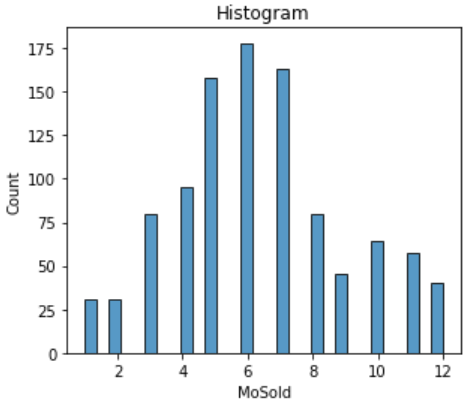

Probability Plot
RM quantiles
Theoretical quantiles

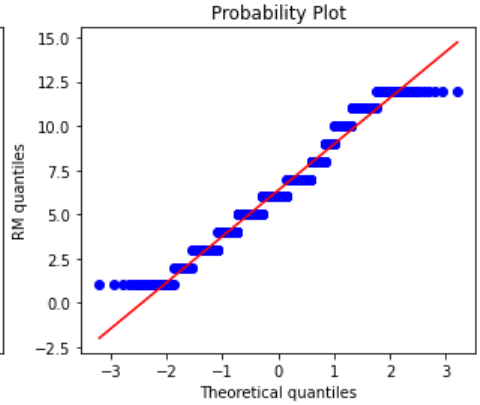

Boxplot
PoolArea

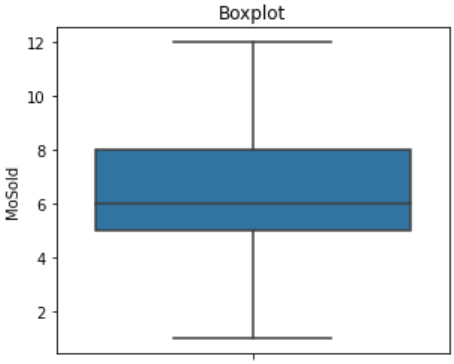

Histogram
Count
MiscVal


Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
MiscVal


Histogram
Count
MoSold


Probability Plot
RM quantiles
Theoretical quantiles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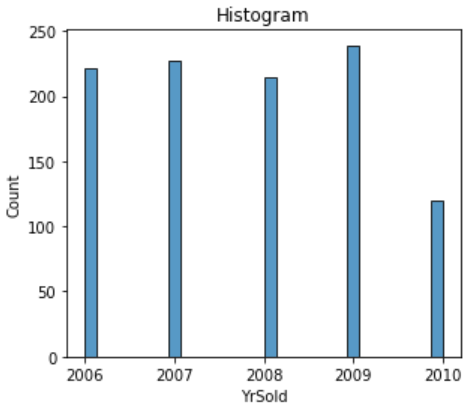
MoSold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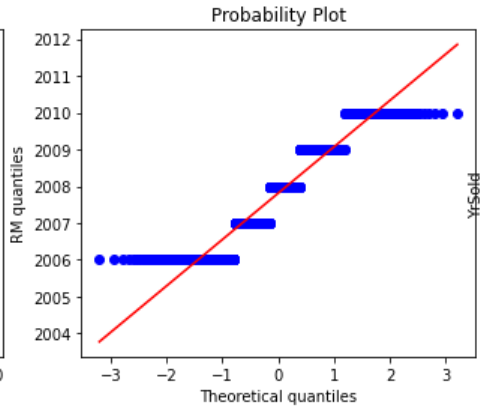
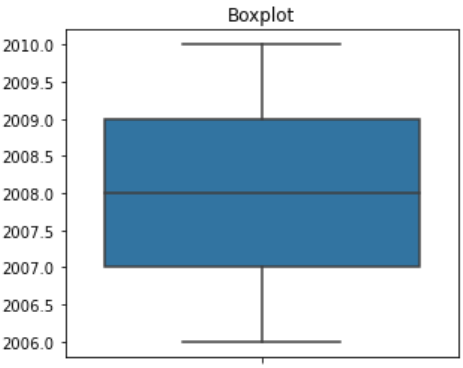
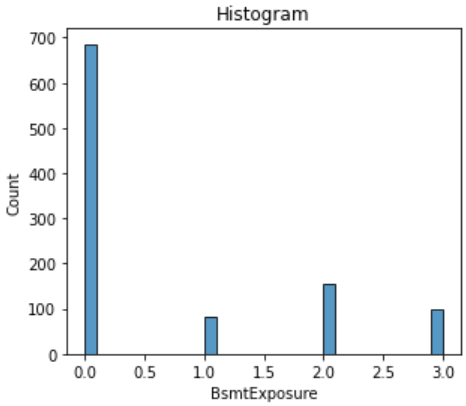
Count
YrSold


Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
YrSold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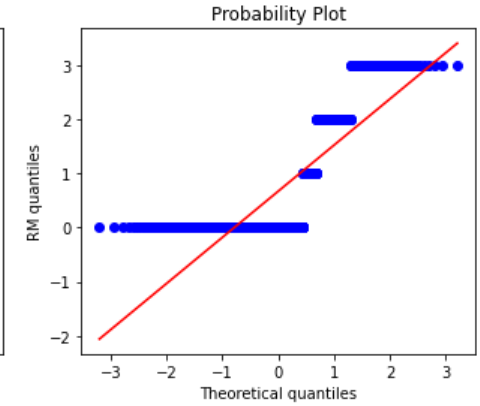
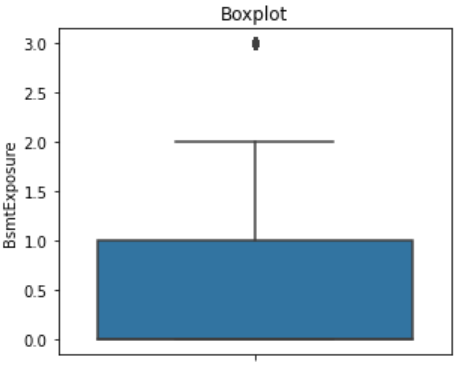
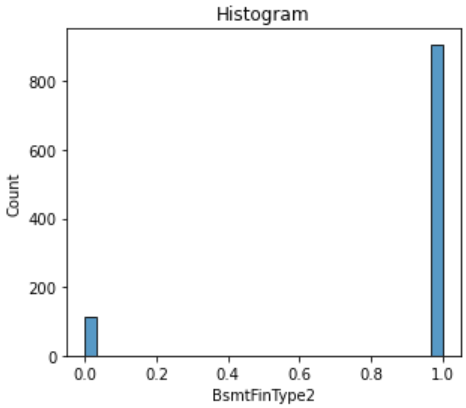
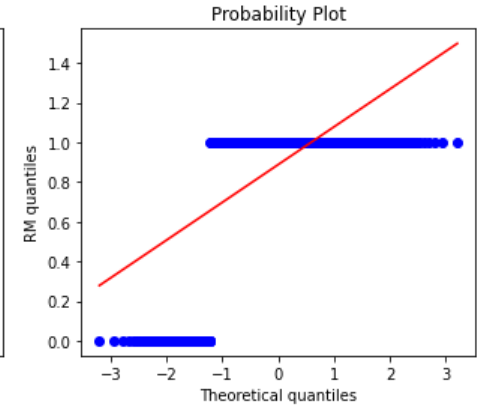
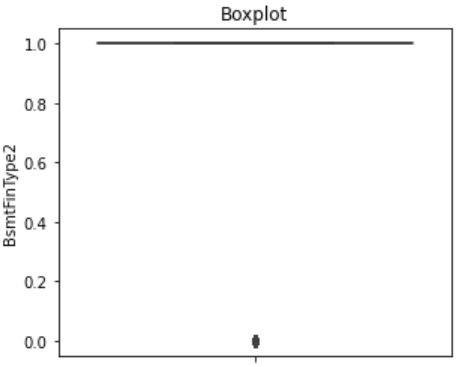
Count
BsmtExposure


Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
BsmtExposure


Histogram
Count
BsmtFinType2


Probability Plot
RM quantiles
Theoretical quantiles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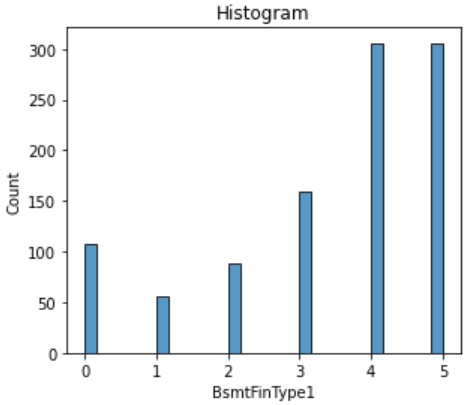
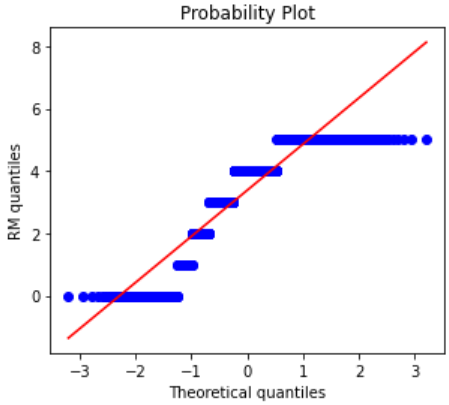
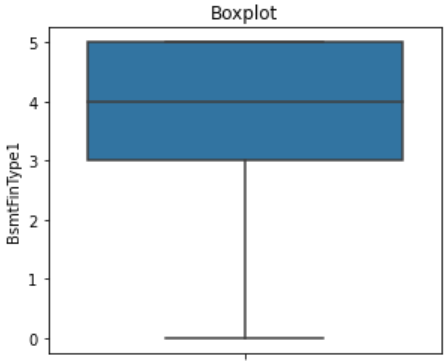
BsmtFinType2


Histogram
Count
BsmtFinType1


Probability Plot
RM quantiles
Theoretical quantiles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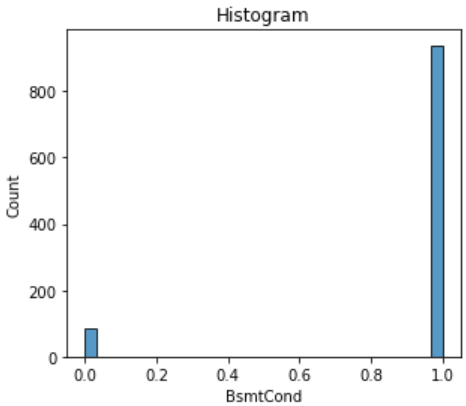
BsmtFinType1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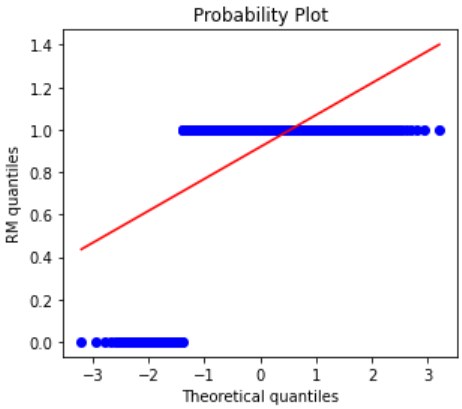
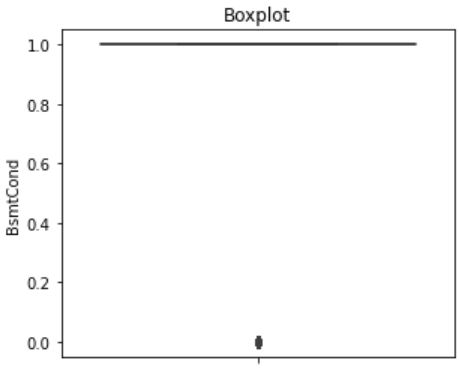
Count
BsmtCond


Probability Plot
RM quantiles
Theoretical quantiles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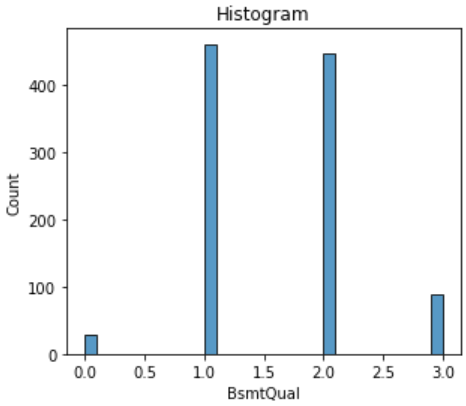
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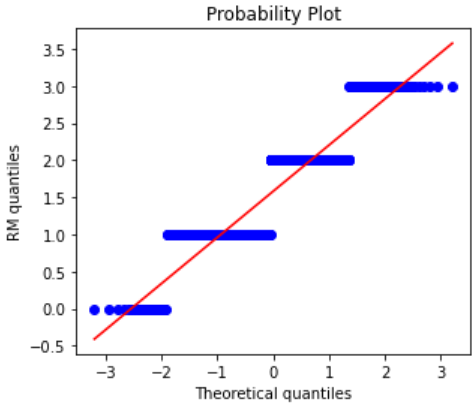
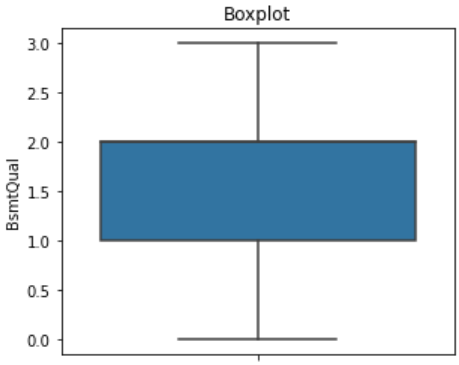
Count
BsmtQual


Probability Plot
RM quantiles
Theoretical quantiles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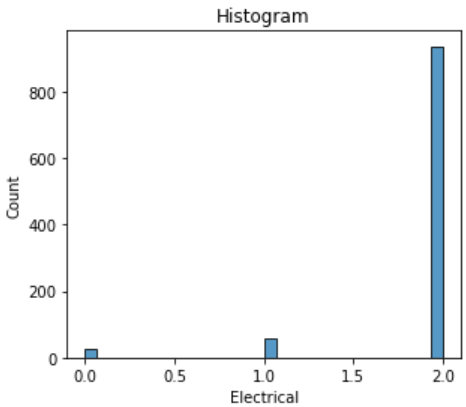
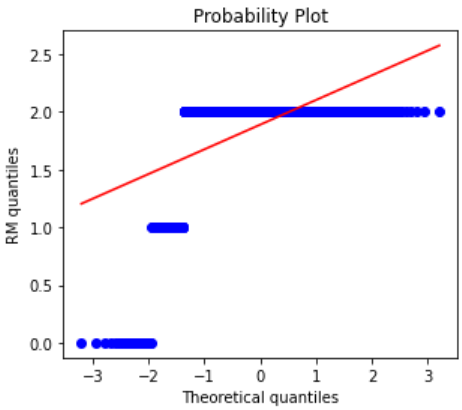
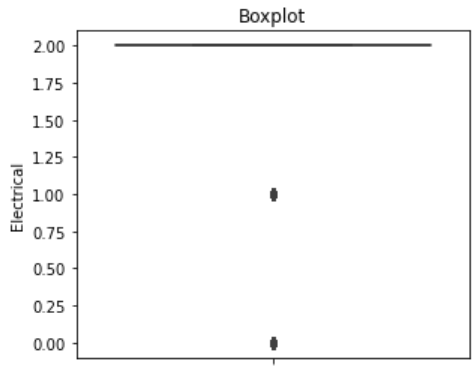
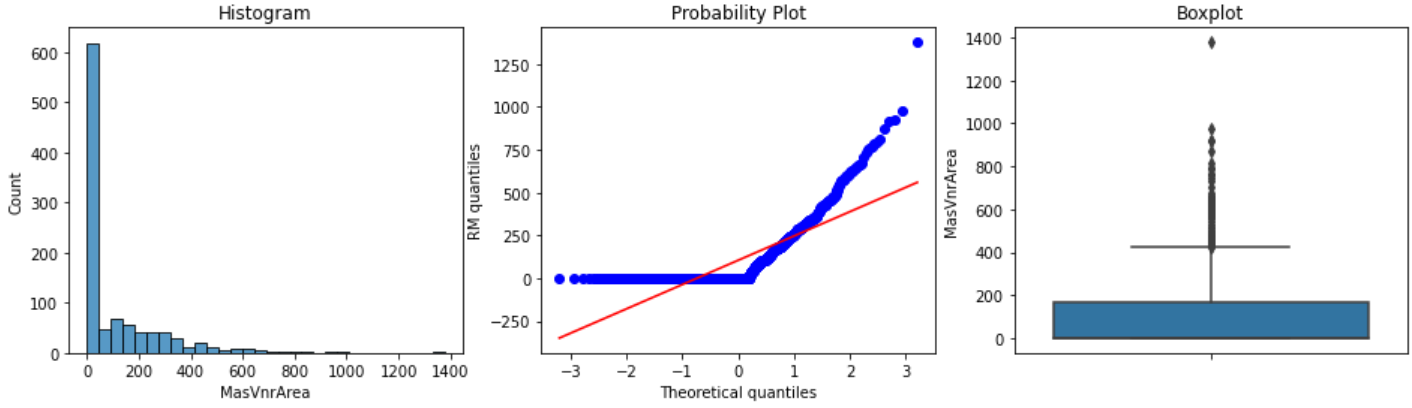
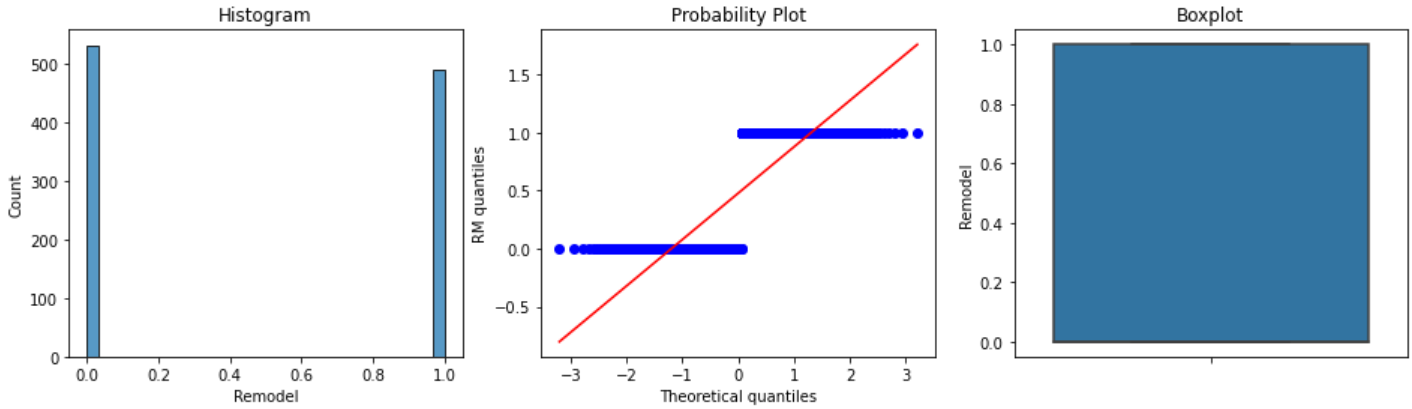
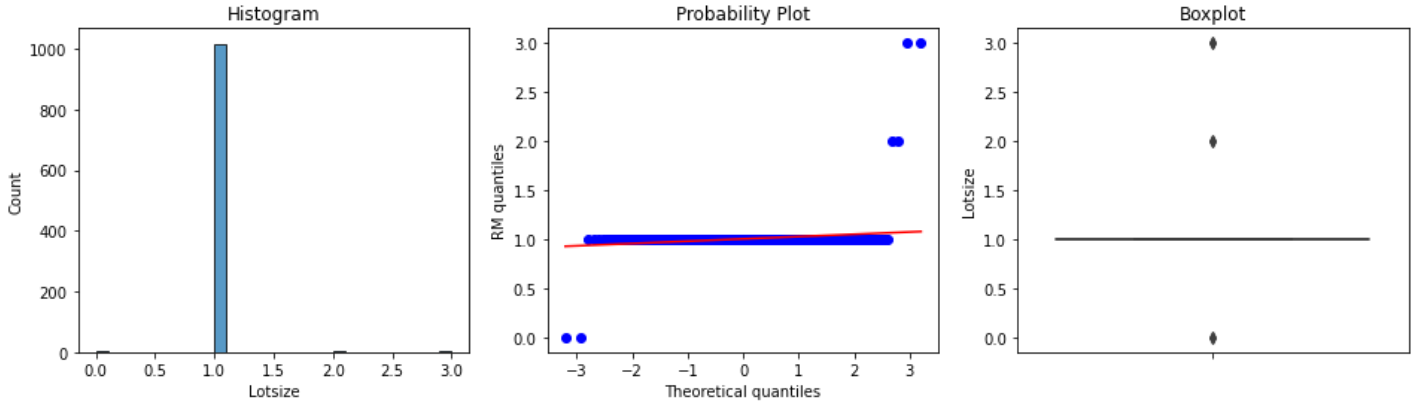

Histogram
Count
Electrical


Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
Electrical


Histogram
Count
MasVnrArea
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MasVnrArea


Histogram
Count
Remodel
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Remodel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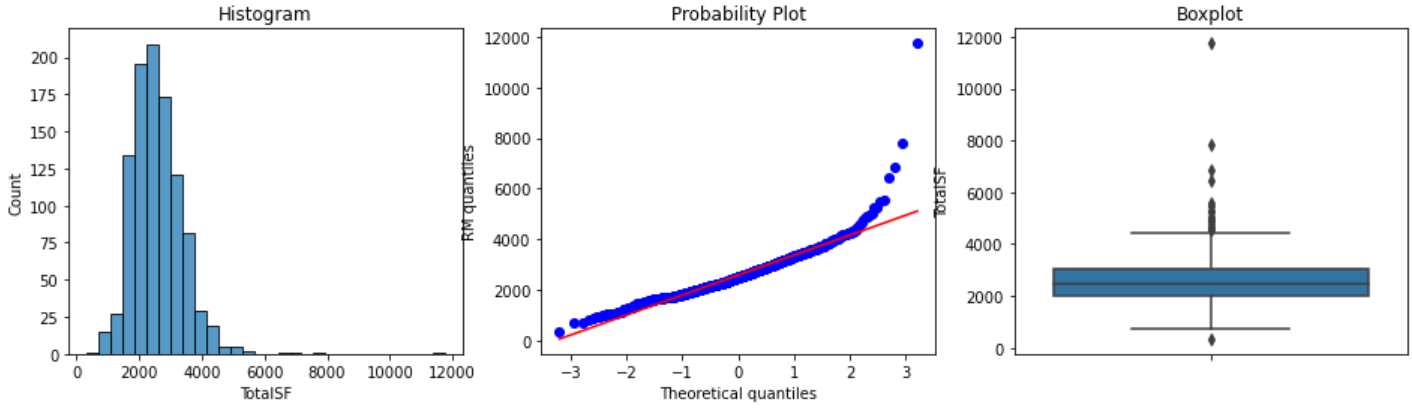
Count
Lotsize
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Lotsize


Histogram
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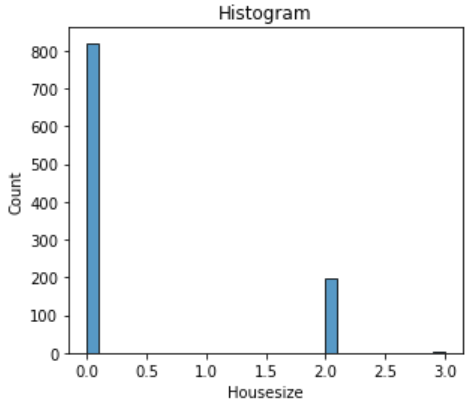
TotalSF
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
TotalSF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Count
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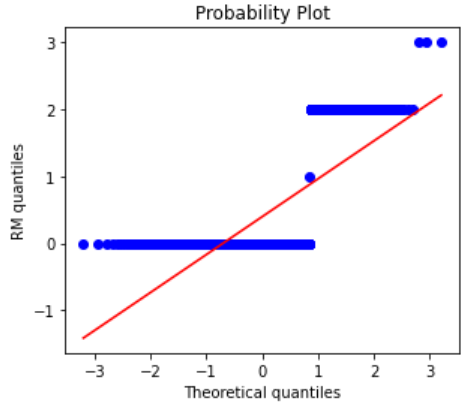
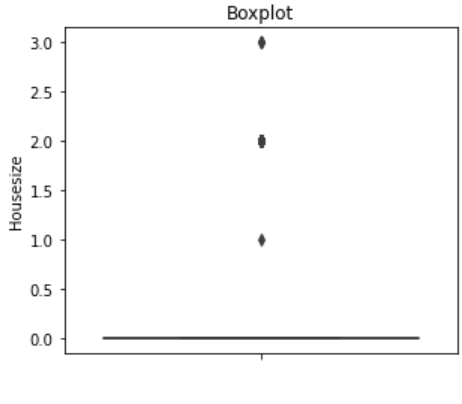
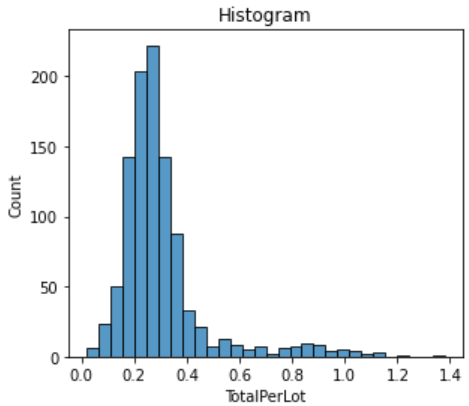

Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
Housesize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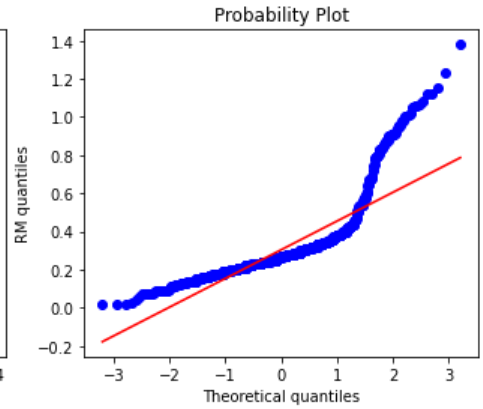
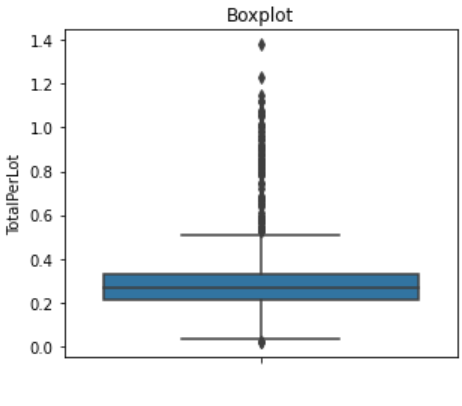
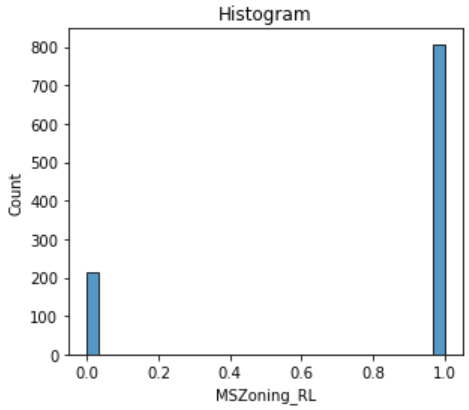

Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
TotalPerLot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Count
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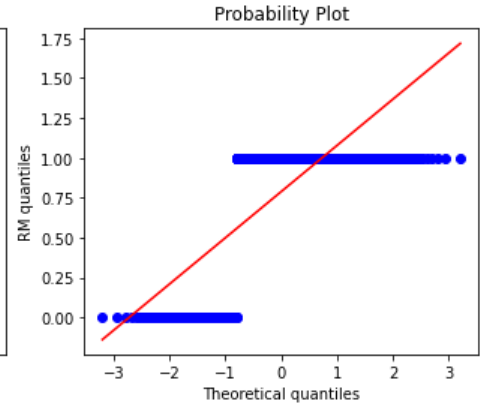
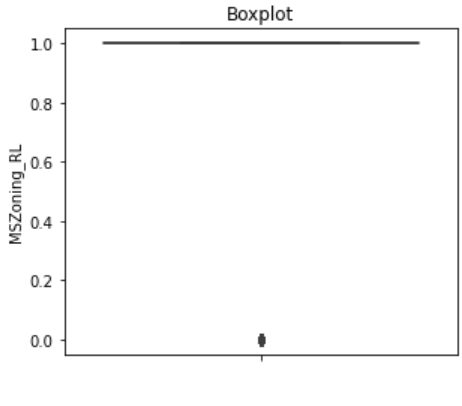
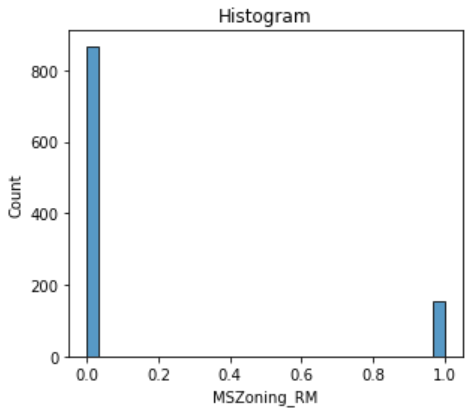

Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
MSZoning_RL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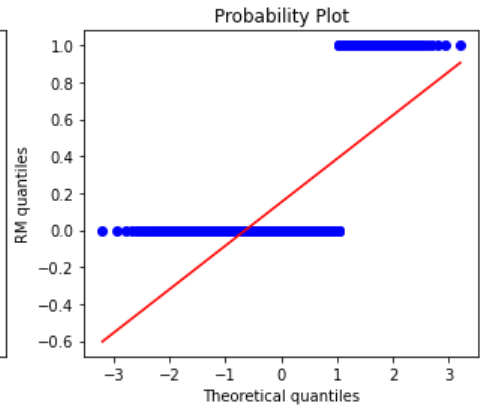
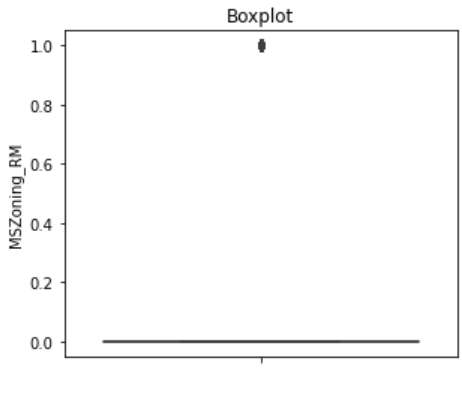
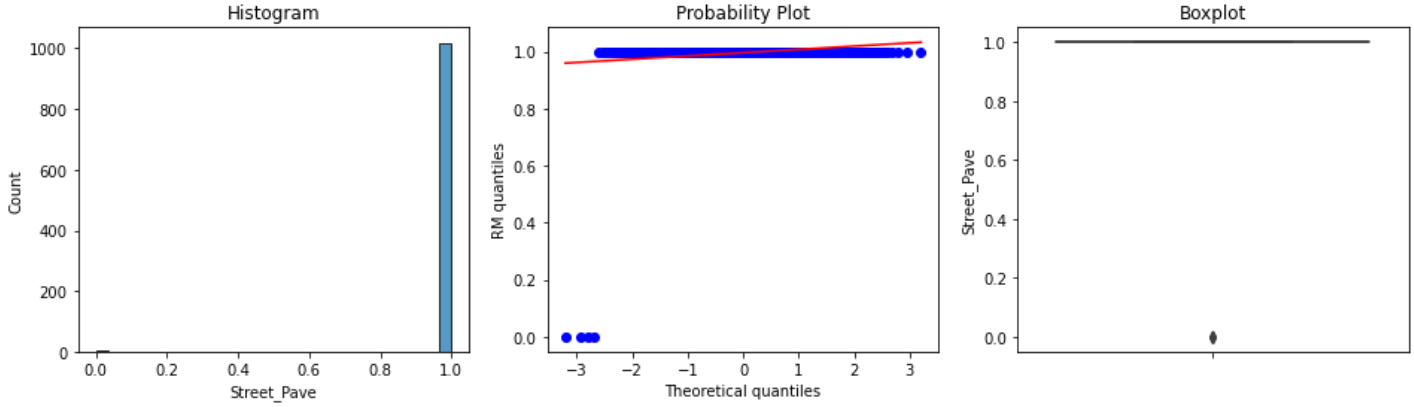
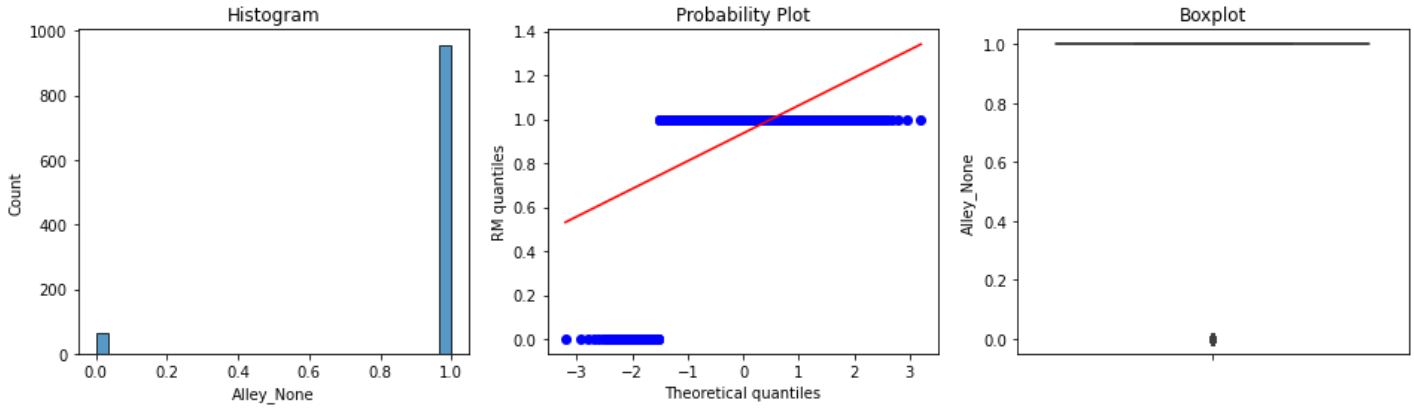
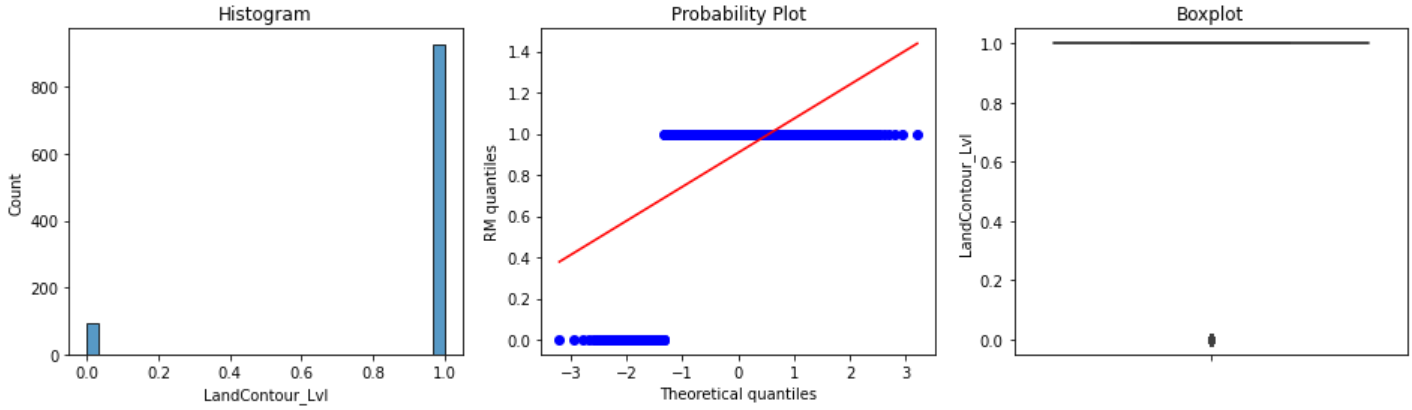
Count
MSZoning_RM

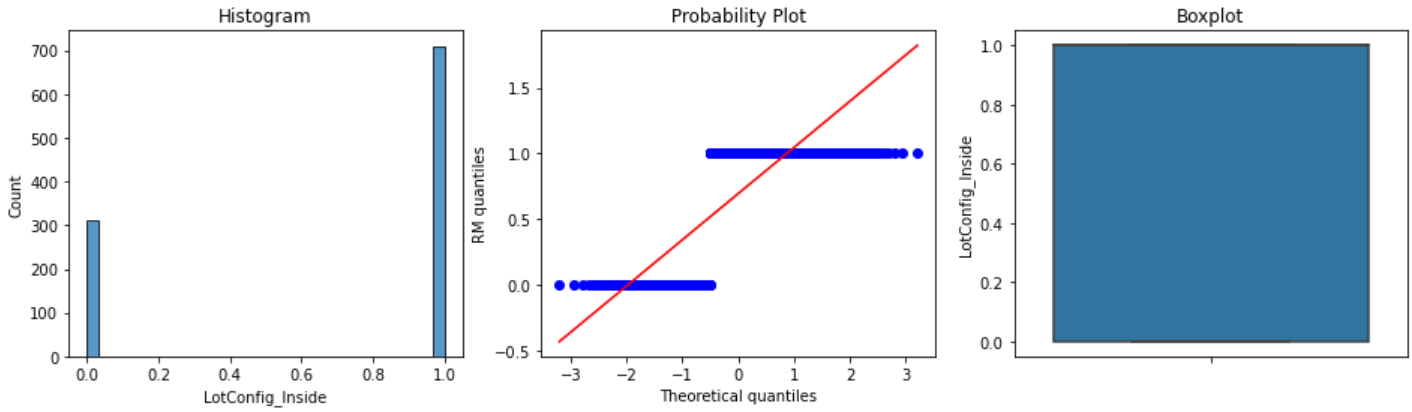

Probability Plot
RM quantiles
Theoretical quantiles

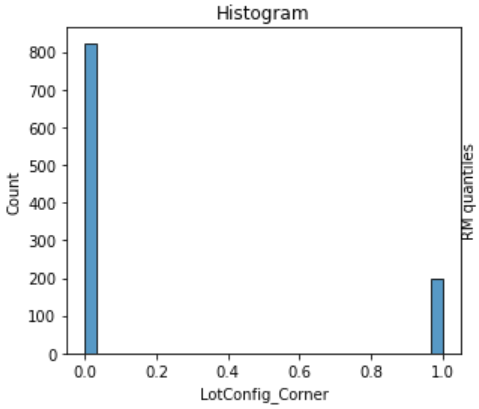

Boxplot
MSZoning_RM

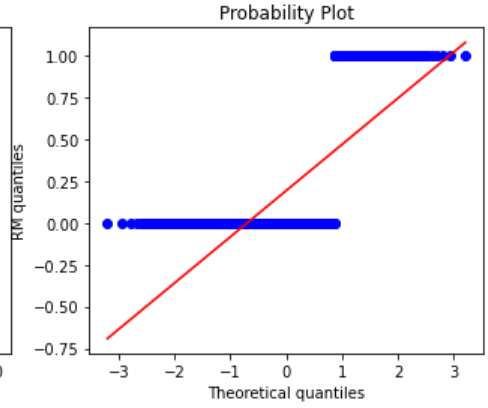

Histogram
Count
Street_Pave
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Street_Pave

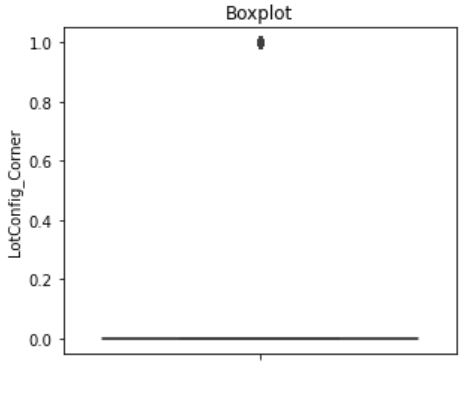

Histogram
Count
Alley_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Alley_None

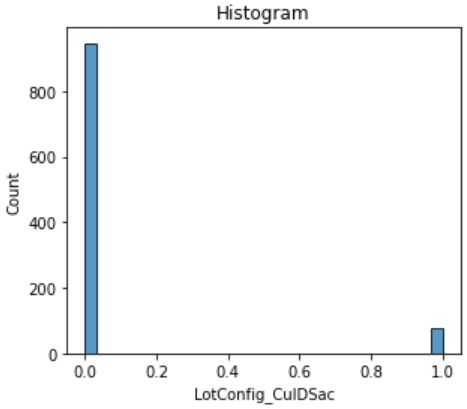

Histogram
Count
LandContour_Lvl
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
LandContour_Lvl

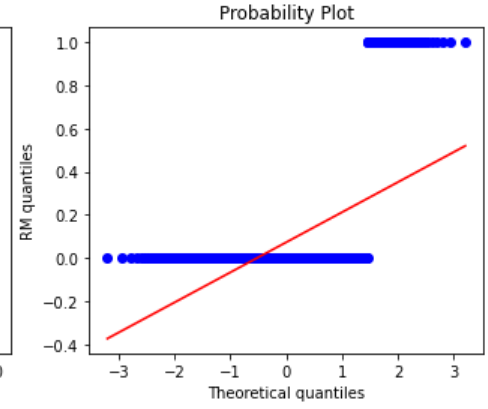

Histogram
Count
LotConfig_Inside
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
LotConfig_Inside

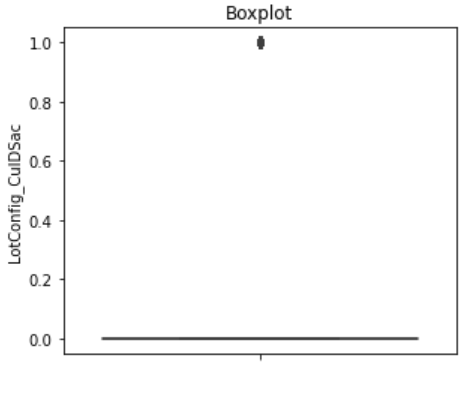

Histogram
Count
LotConfig_Corner

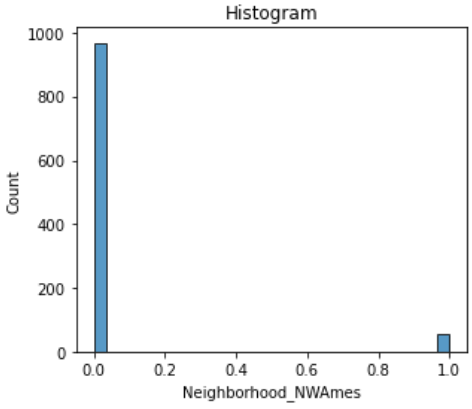

Probability Plot
RM quantiles
Theoretical quantiles

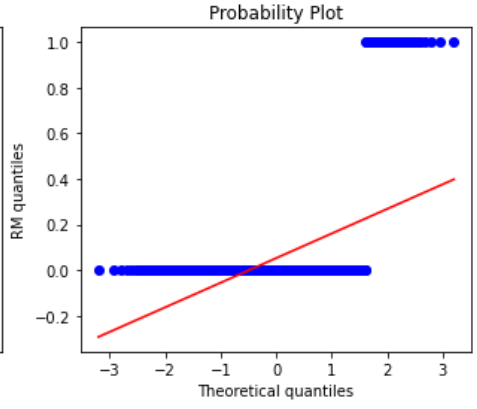

Boxplot
LotConfig_Corner

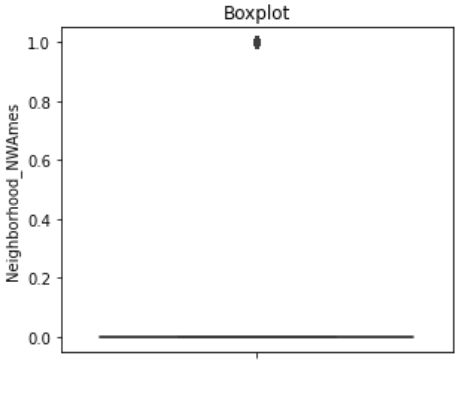

Histogram
Count
LotConfig_CulDSac

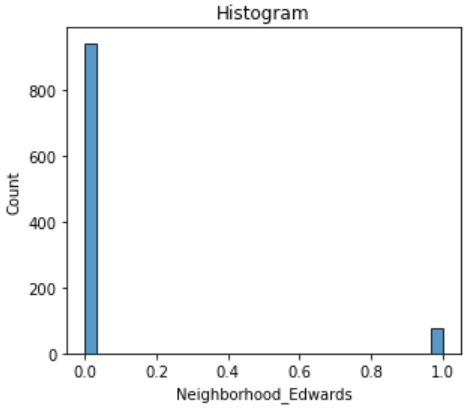

Probability Plot
RM quantiles
Theoretical quantiles

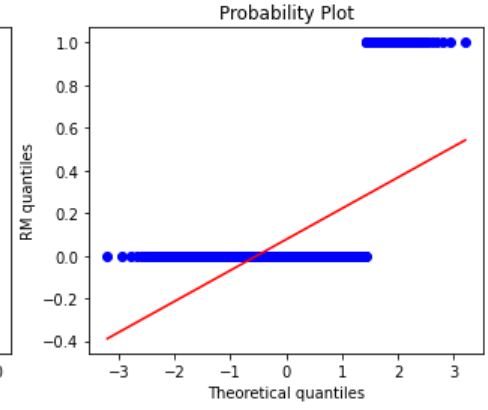

Boxplot
LotConfig_CulDSac

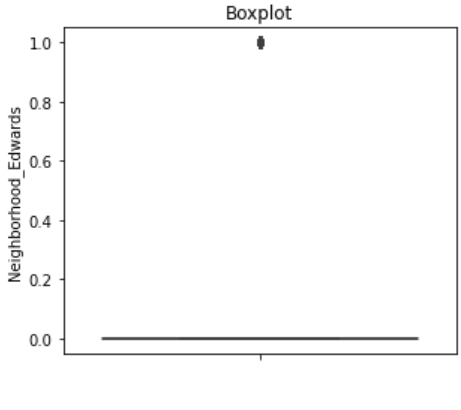

Histogram
Count
Neighborhood_NWAmes

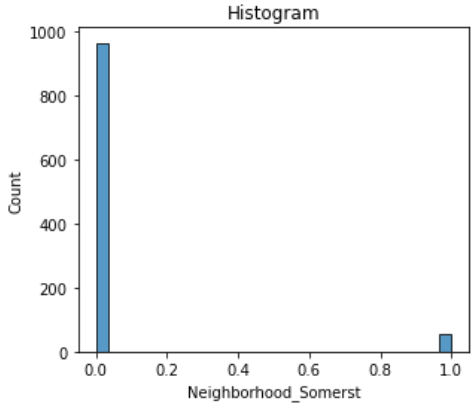

Probability Plot
RM quantiles
Theoretical quantiles

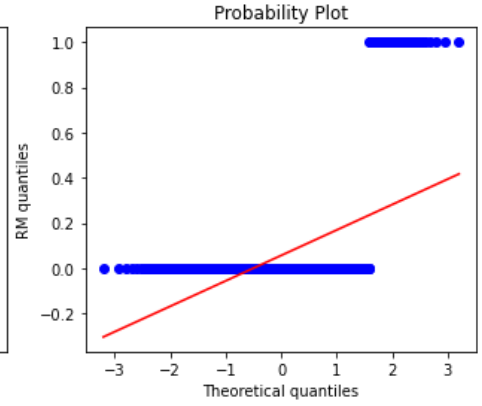

Boxplot
Neighborhood_NWAmes

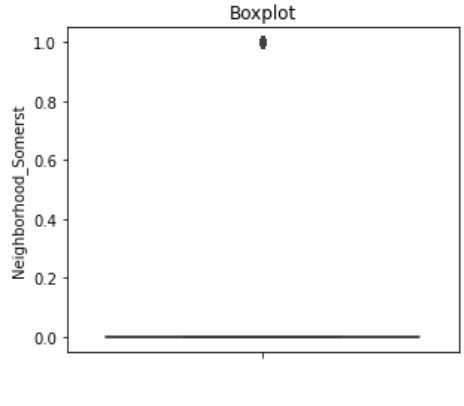

Histogram
Count
Neighborhood_Edwards

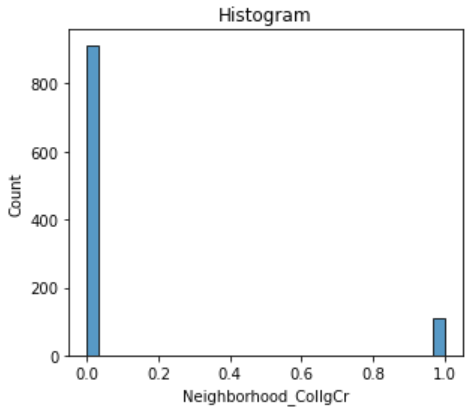

Probability Plot
RM quantiles
Theoretical quantiles

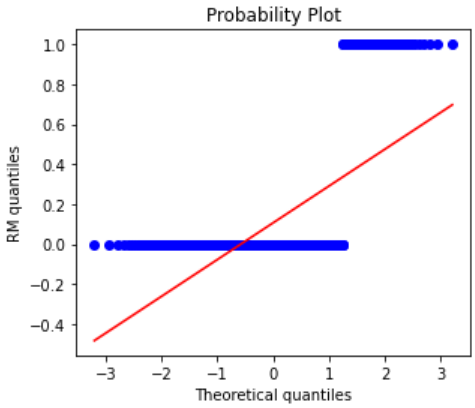

Boxplot
Neighborhood_Edwards

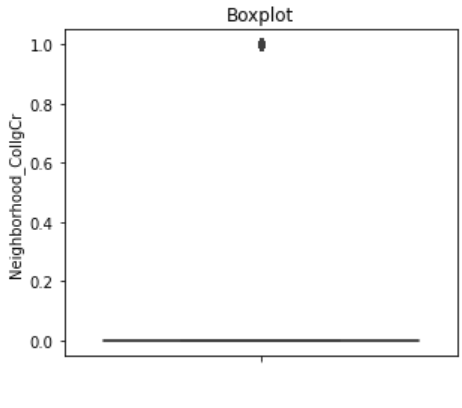

Histogram
Count
Neighborhood_Somerst

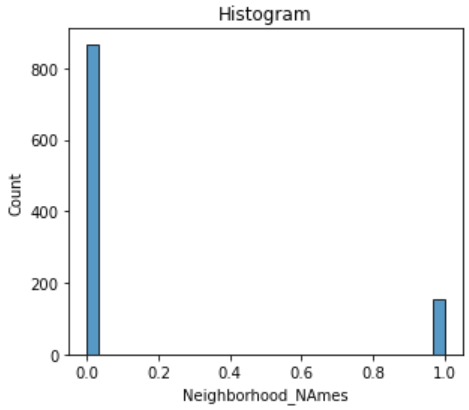

Probability Plot
RM quantiles
Theoretical quantiles

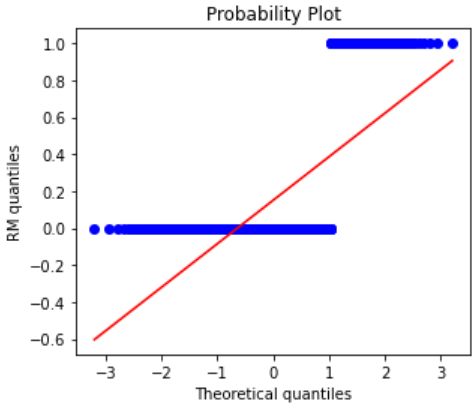

Boxplot
Neighborhood_Somerst

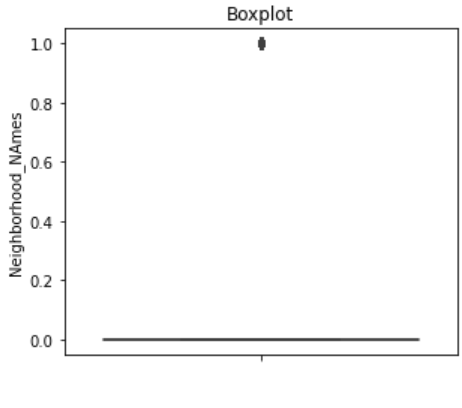

Histogram
Count
Neighborhood_CollgCr

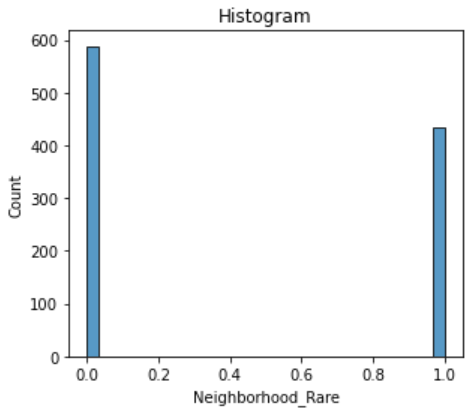

Probability Plot
RM quantiles
Theoretical quantiles

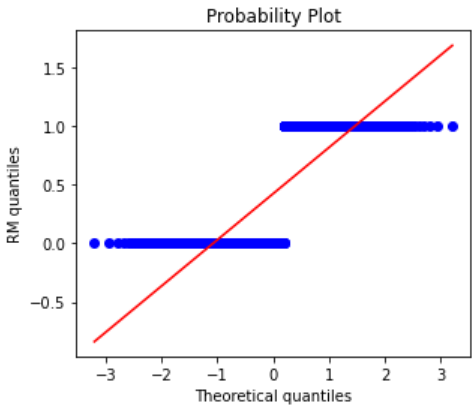

Boxplot
Neighborhood_CollgCr

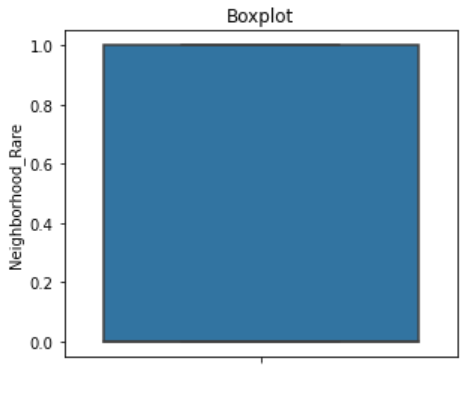

Histogram
Count
Neighborhood_NAmes

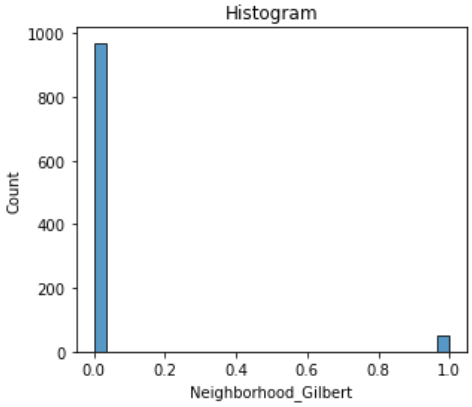

Probability Plot
RM quantiles
Theoretical quantiles

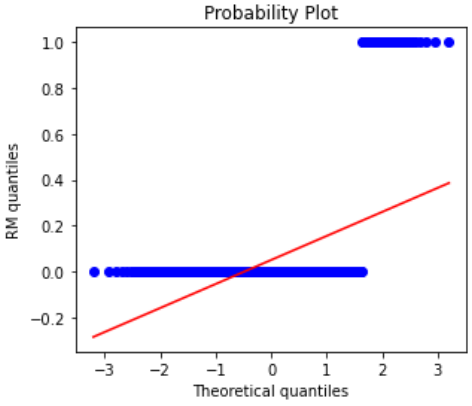

Boxplot
Neighborhood_NAmes

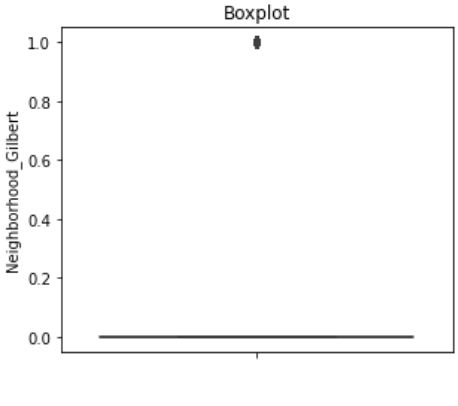

Histogram
Count
Neighborhood_Rare

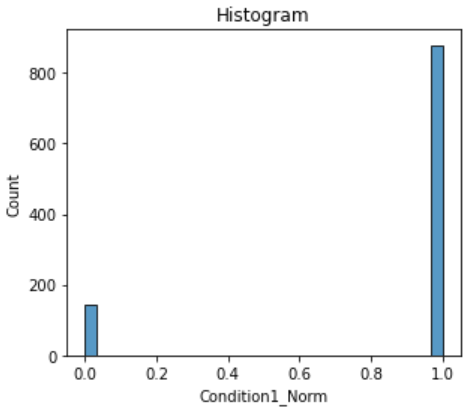

Probability Plot
RM quantiles
Theoretical quantiles

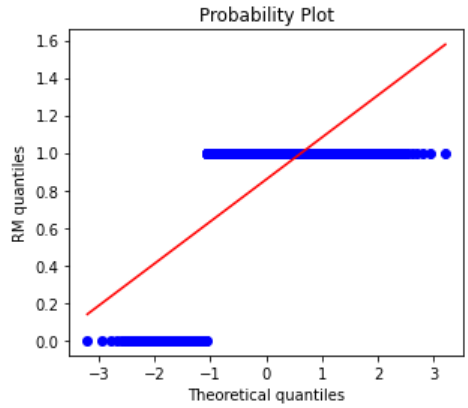

Boxplot
Neighborhood_Rare

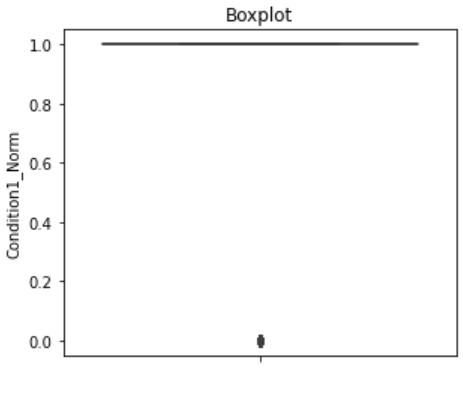

Histogram
Count
Neighborhood_Gilbert

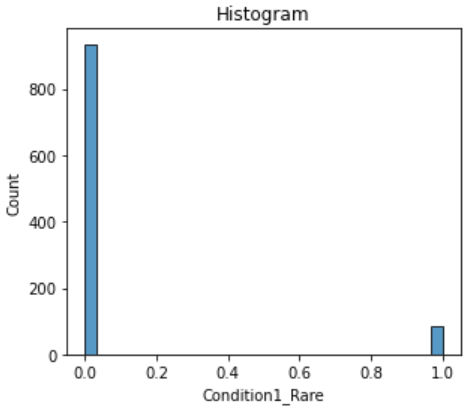

Probability Plot
RM quantiles
Theoretical quantiles

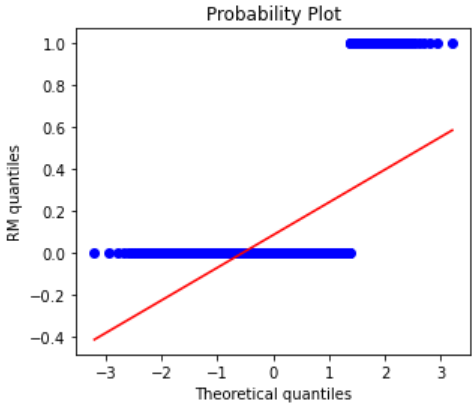

Boxplot
Neighborhood_Gilbert

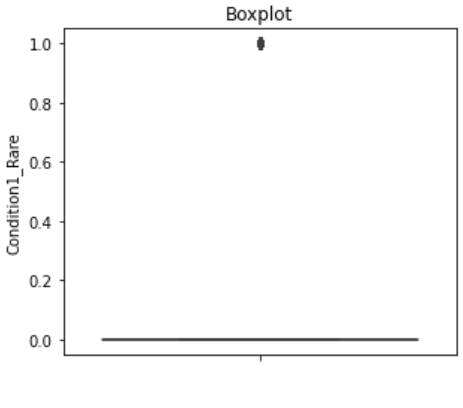

Histogram
Count
Condition1_Norm

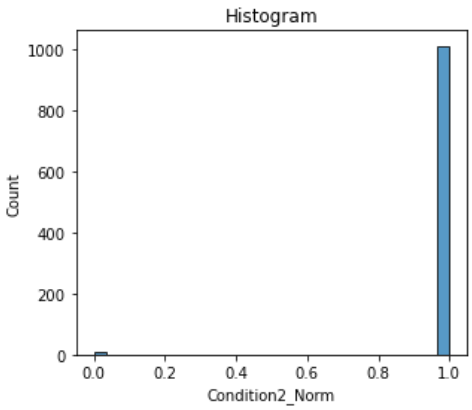

Probability Plot
RM quantiles
Theoretical quantiles

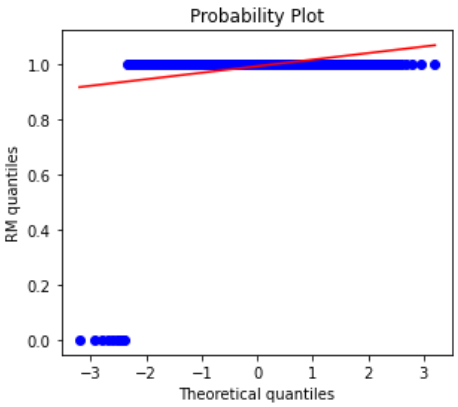

Boxplot
Condition1_Norm

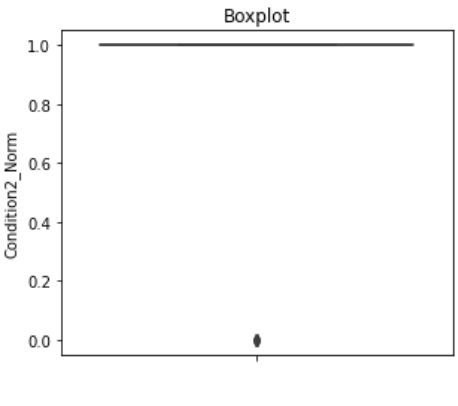

Histogram
Count
Condition1_Rare

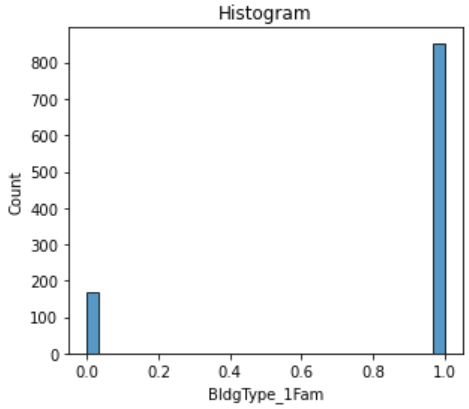

Probability Plot
RM quantiles
Theoretical quantiles

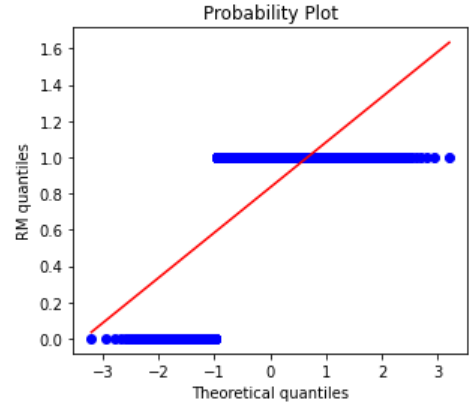

Boxplot
Condition1_Rare

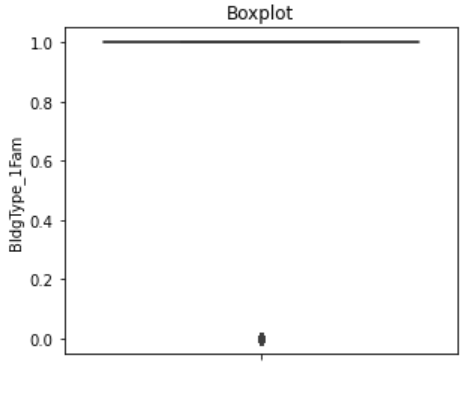

Histogram
Count
Condition2_Norm

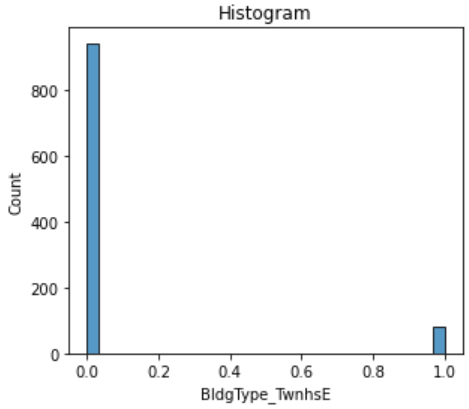

Probability Plot
RM quantiles
Theoretical quantiles

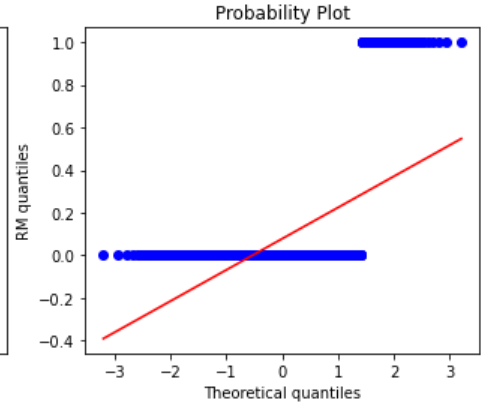

Boxplot
Condition2_Norm

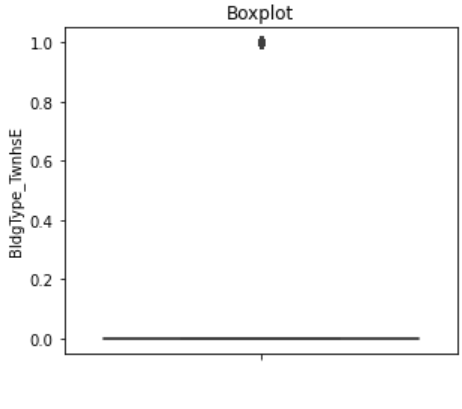

Histogram
Count
BldgType_1Fam

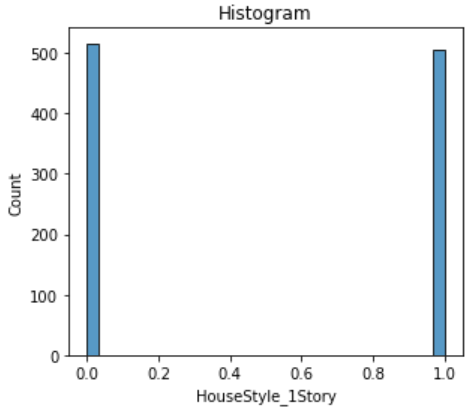

Probability Plot
RM quantiles
Theoretical quantiles

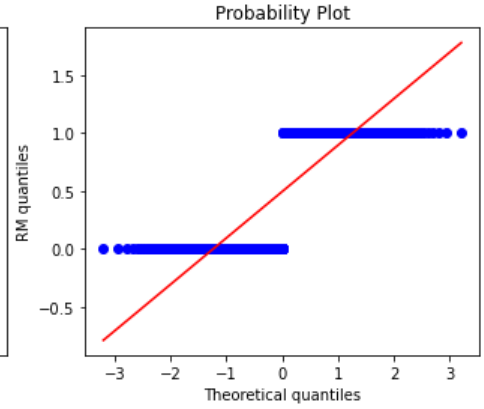

Boxplot
BldgType_1Fam

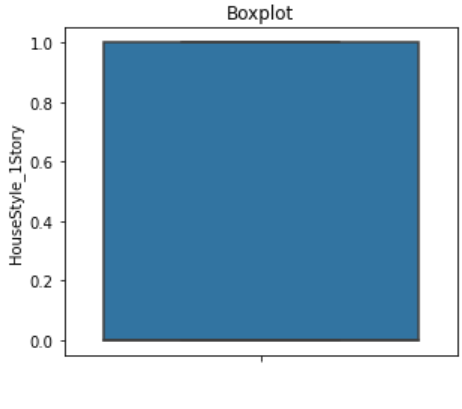

Histogram
Count
BldgType_TwnhsE

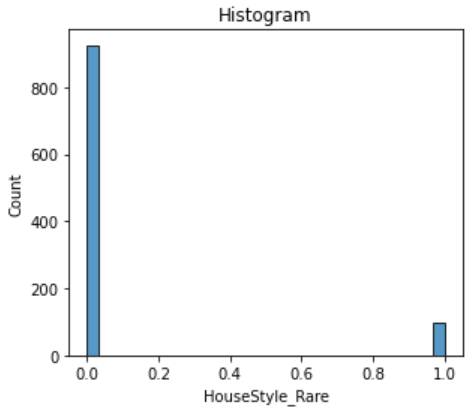

Probability Plot
RM quantiles
Theoretical quantiles

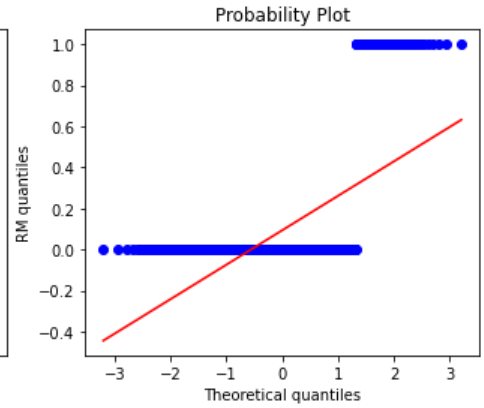

Boxplot
BldgType_TwnhsE

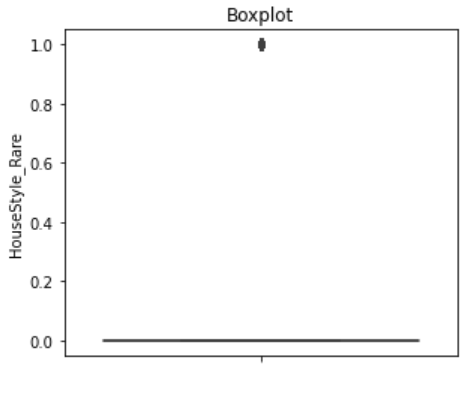

Histogram
Count
HouseStyle_1Story

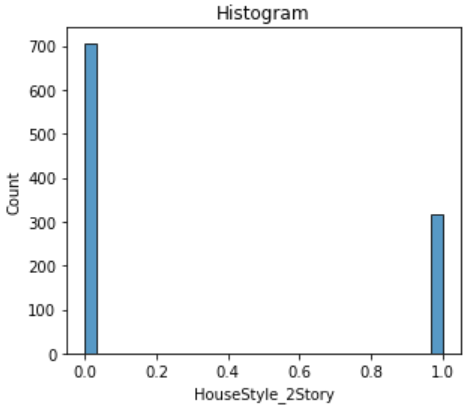

Probability Plot
RM quantiles
Theoretical quantiles

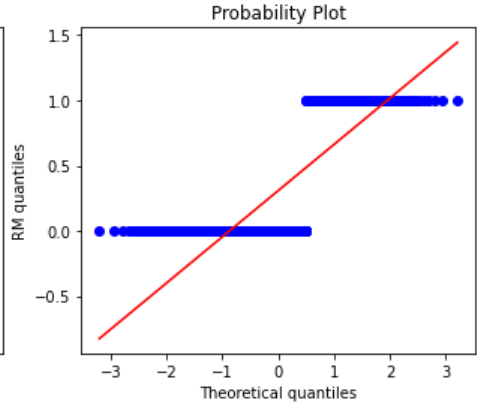

Boxplot
HouseStyle_1Story

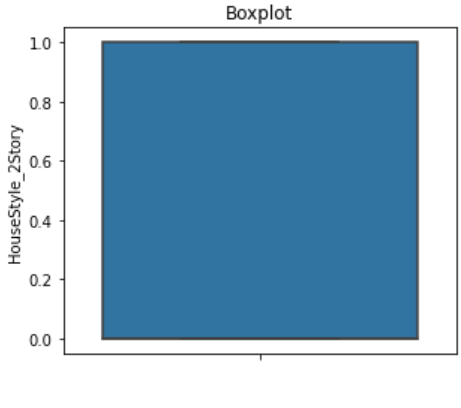

Histogram
Count
HouseStyle_Rare

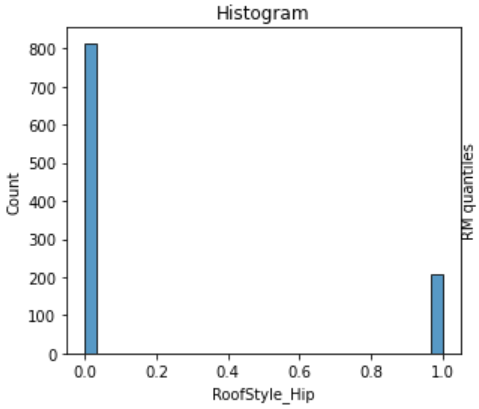

Probability Plot
RM quantiles
Theoretical quantiles

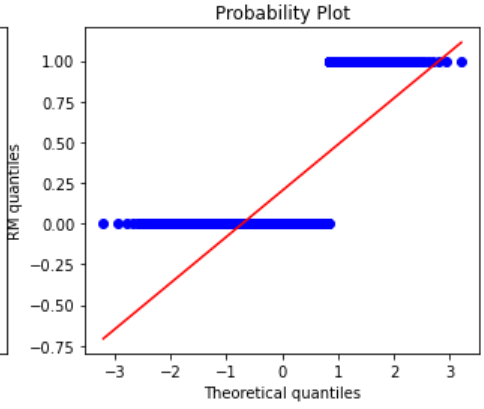

Boxplot
HouseStyle_Rare

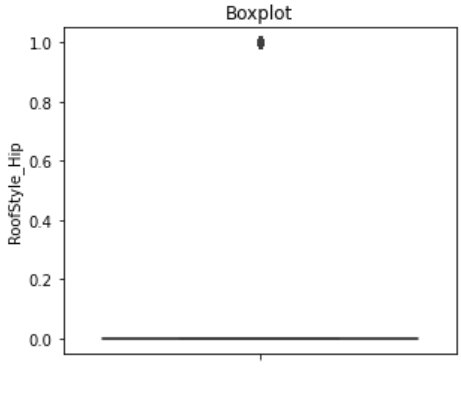

Histogram
Count
HouseStyle_2Story

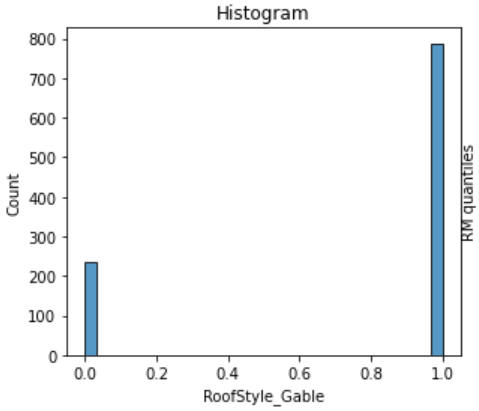

Probability Plot
RM quantiles
Theoretical quantiles

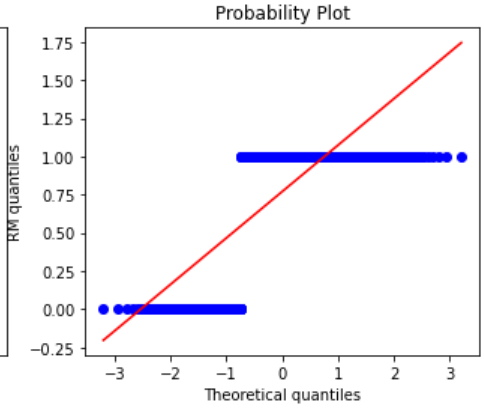

Boxplot
HouseStyle_2Story

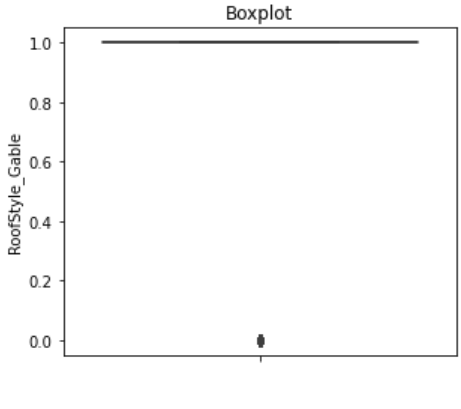

Histogram
Count
RoofStyle_Hip

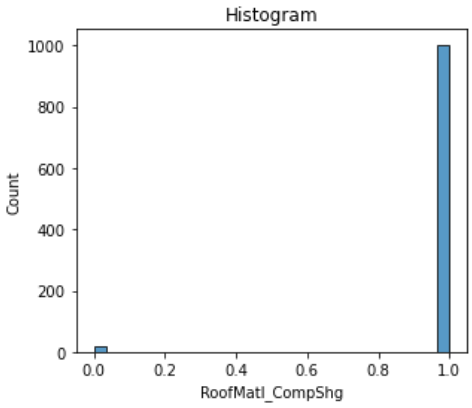

Probability Plot
RM quantiles
Theoretical quantiles

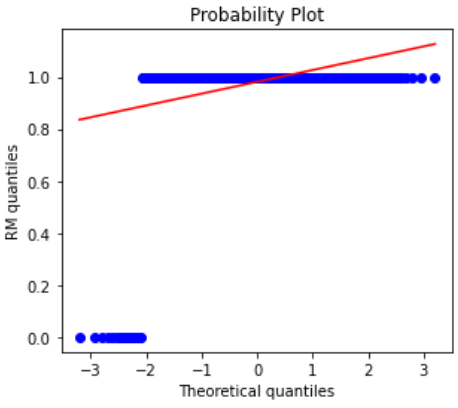

Boxplot
RoofStyle_Hip

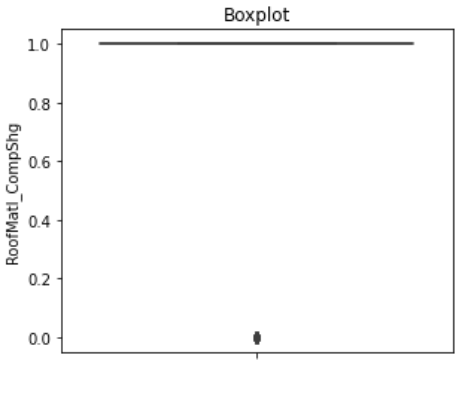

Histogram
Count
RoofStyle_Gable

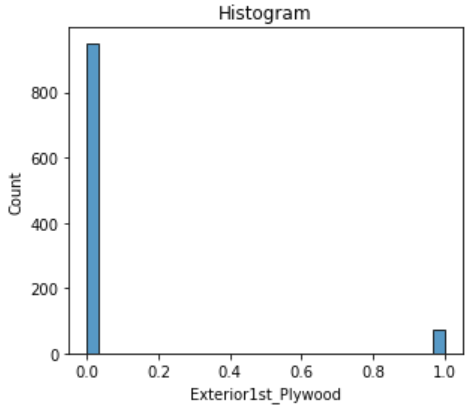

Probability Plot
RM quantiles
Theoretical quantiles

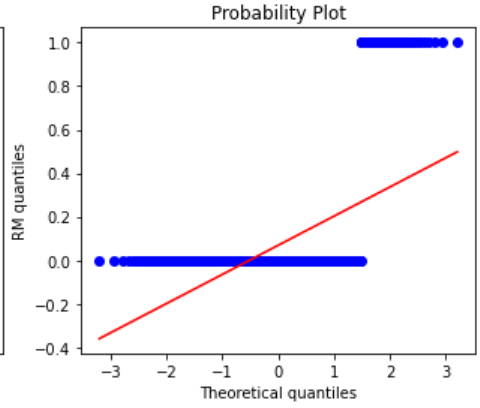

Boxplot
RoofStyle_Gable

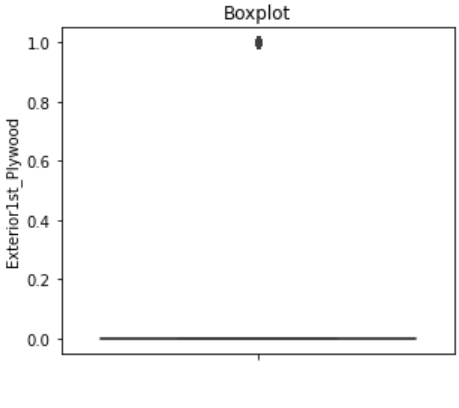

Histogram
Count
RoofMatl_CompShg

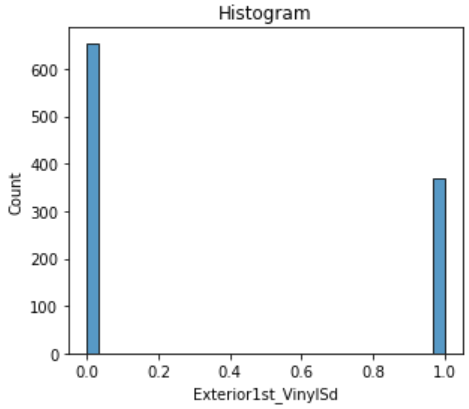

Probability Plot
RM quantiles
Theoretical quantiles

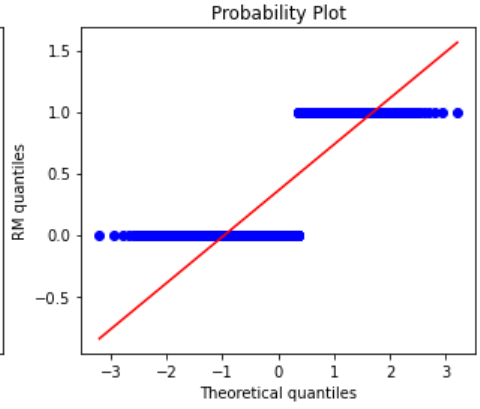

Boxplot
RoofMatl_CompShg

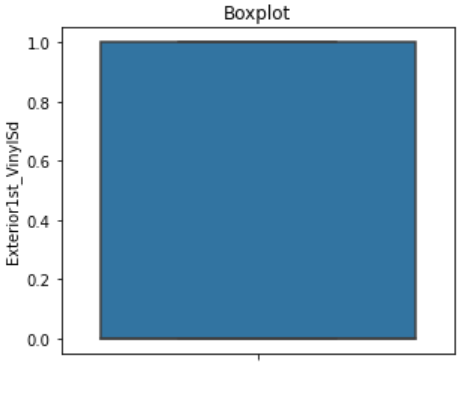

Histogram
Count
Exterior1st_Plywood

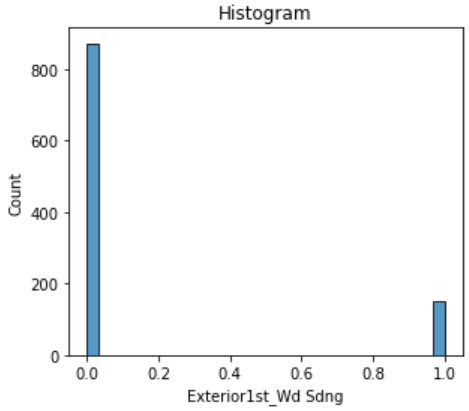

Probability Plot
RM quantiles
Theoretical quantiles

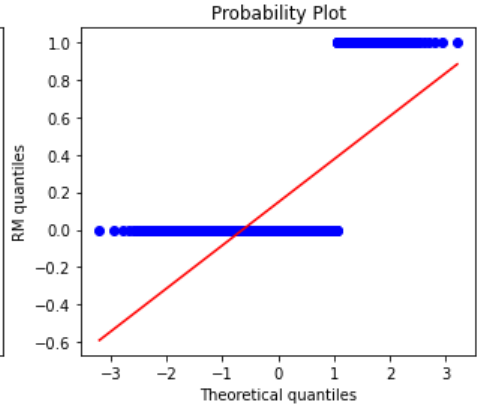

Boxplot
Exterior1st_Plywood

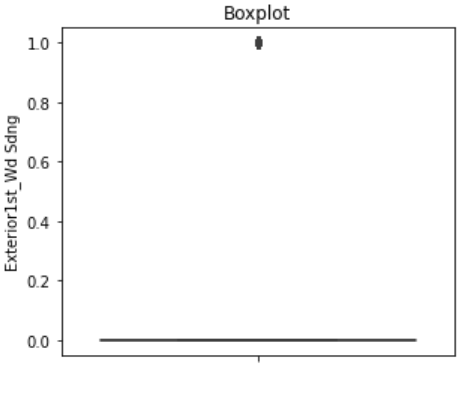

Histogram
Count
Exterior1st_VinylSd

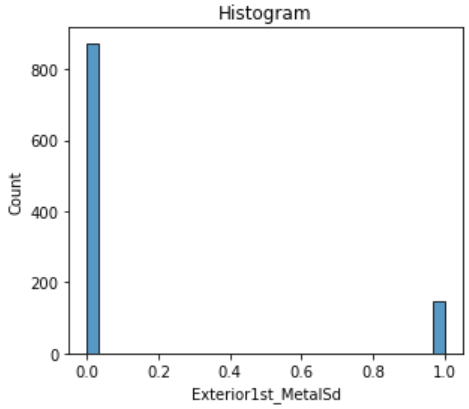

Probability Plot
RM quantiles
Theoretical quantiles

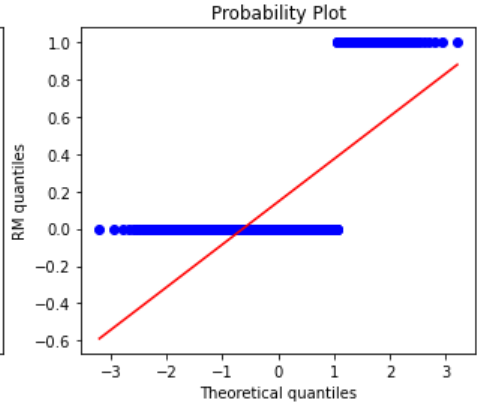

Boxplot
Exterior1st_VinylSd

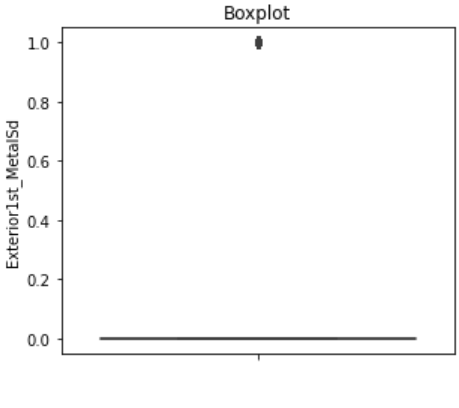

Histogram
Count
Exterior1st_Wd Sdng

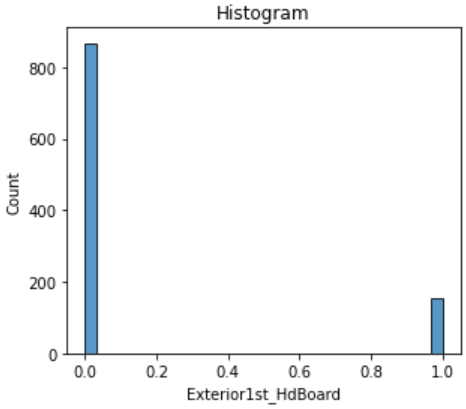

Probability Plot
RM quantiles
Theoretical quantiles

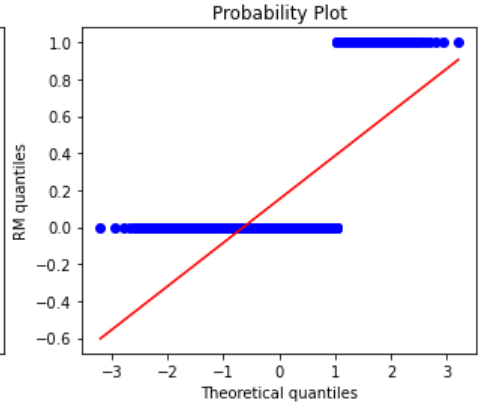

Boxplot
Exterior1st_Wd Sdng

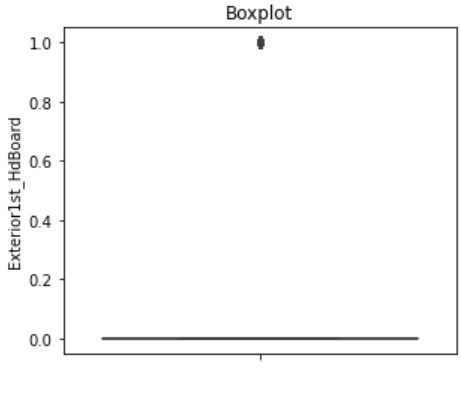

Histogram
Count
Exterior1st_MetalSd

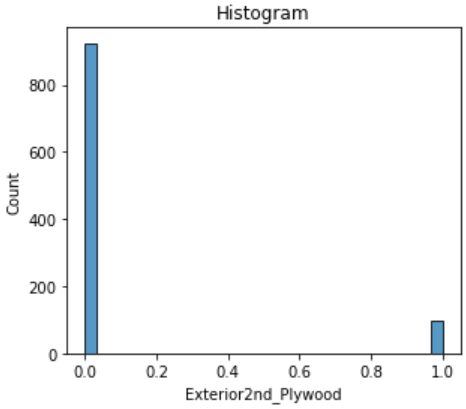

Probability Plot
RM quantiles
Theoretical quantiles

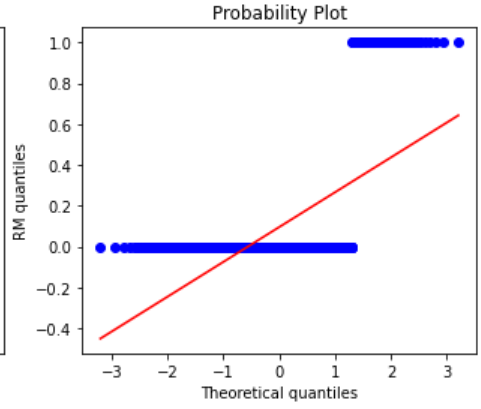

Boxplot
Exterior1st_MetalSd

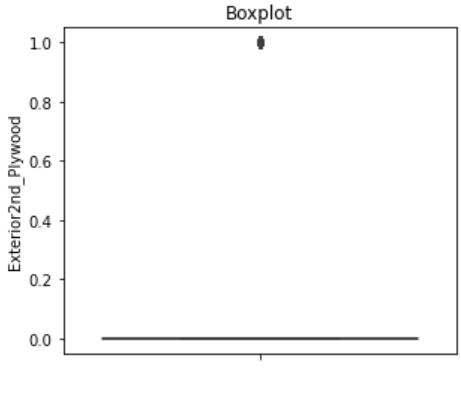

Histogram
Count
Exterior1st_HdBoard

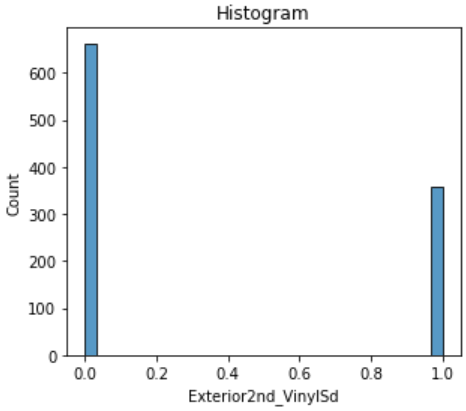

Probability Plot
RM quantiles
Theoretical quantiles

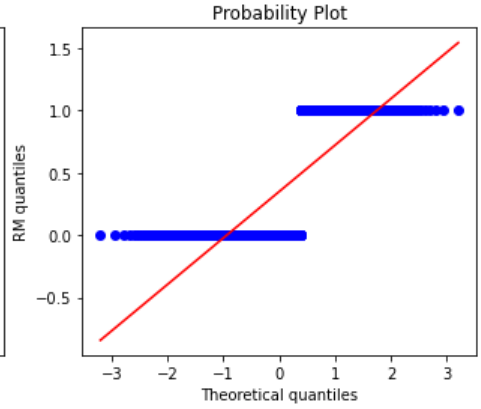

Boxplot
Exterior1st_HdBoard

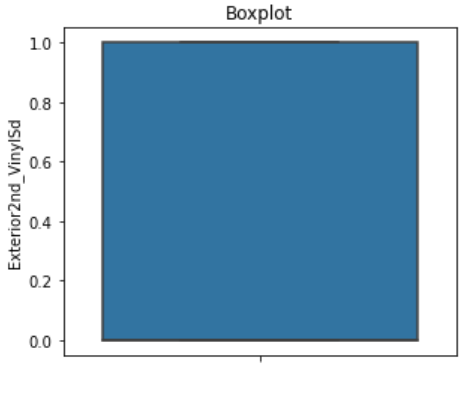

Histogram
Count
Exterior2nd_Plywood

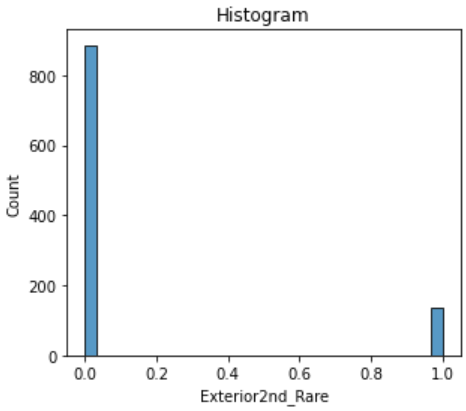

Probability Plot
RM quantiles
Theoretical quantiles

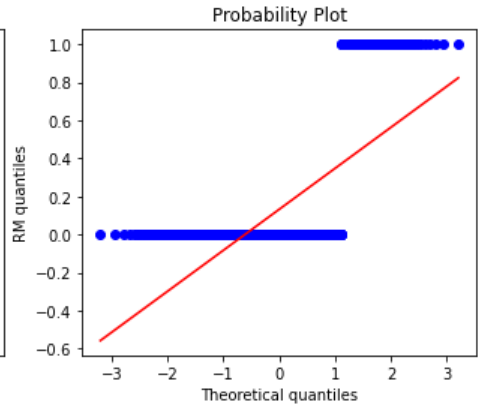

Boxplot
Exterior2nd_Plywood

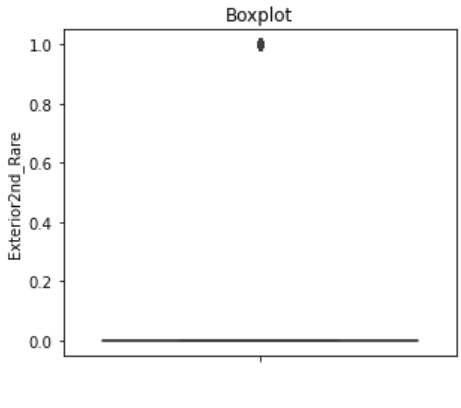

Histogram
Count
Exterior2nd_VinylSd

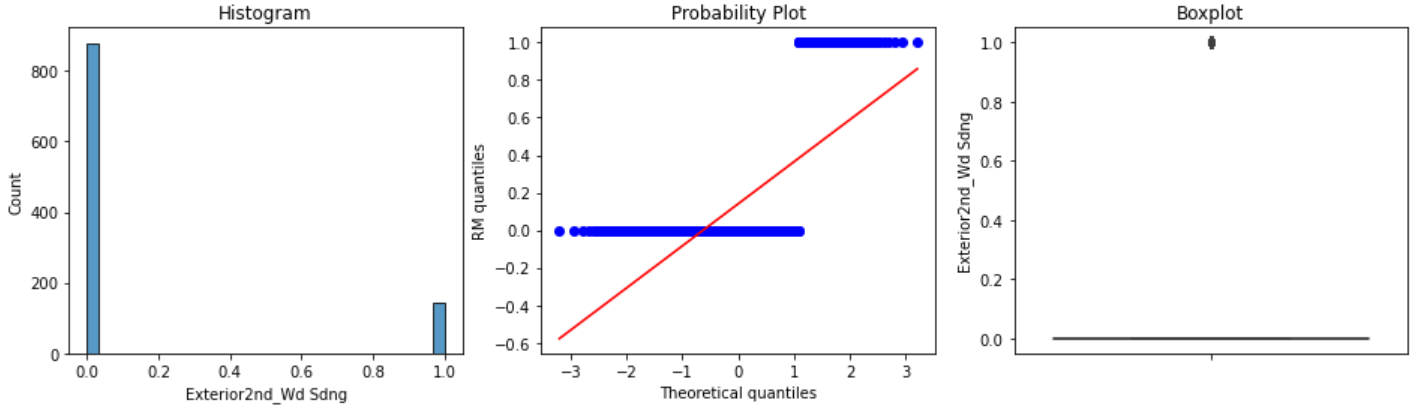

Probability Plot
RM quantiles
Theoretical quantiles

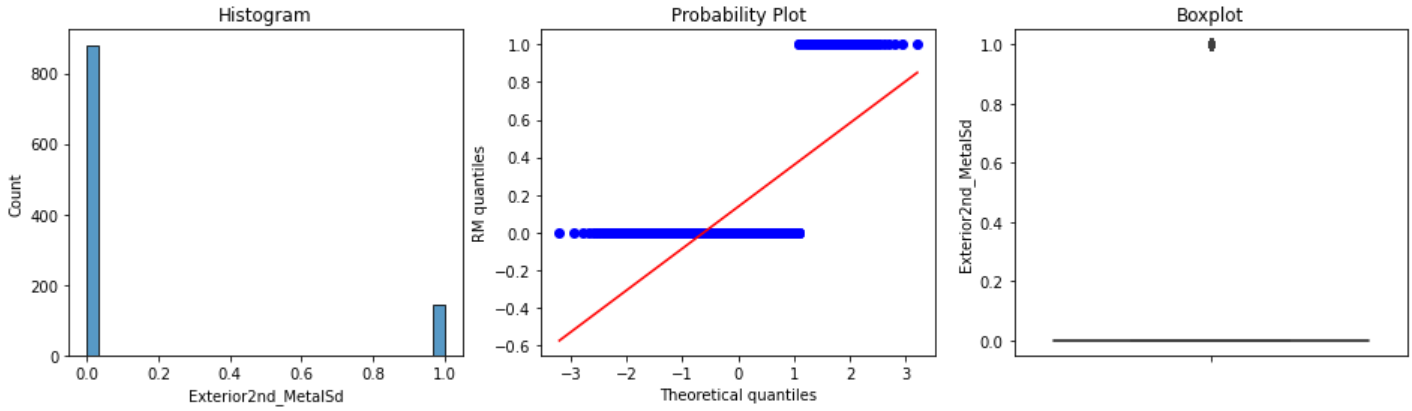

Boxplot
Exterior2nd_VinylSd

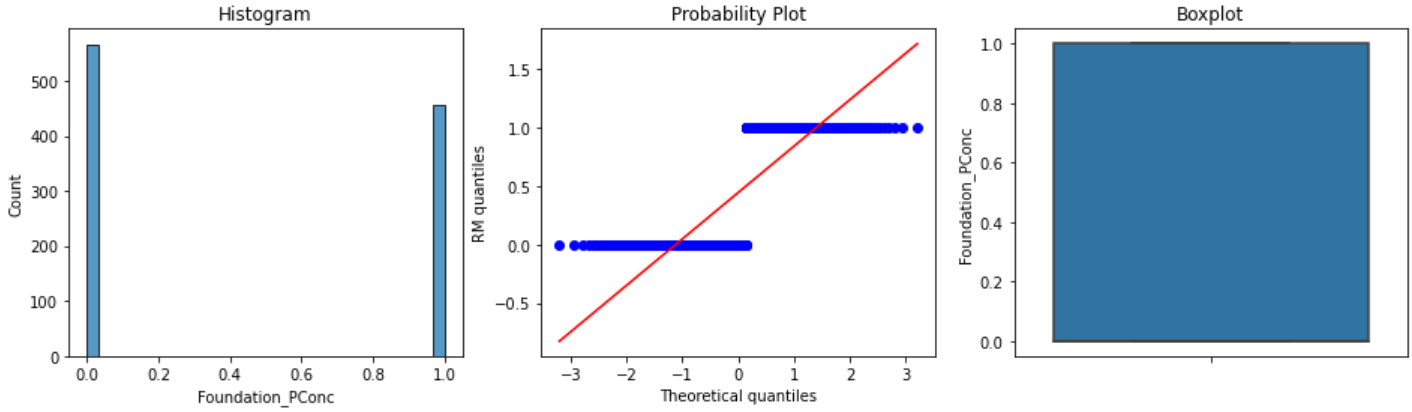

Histogram
Count
Exterior2nd_Rare

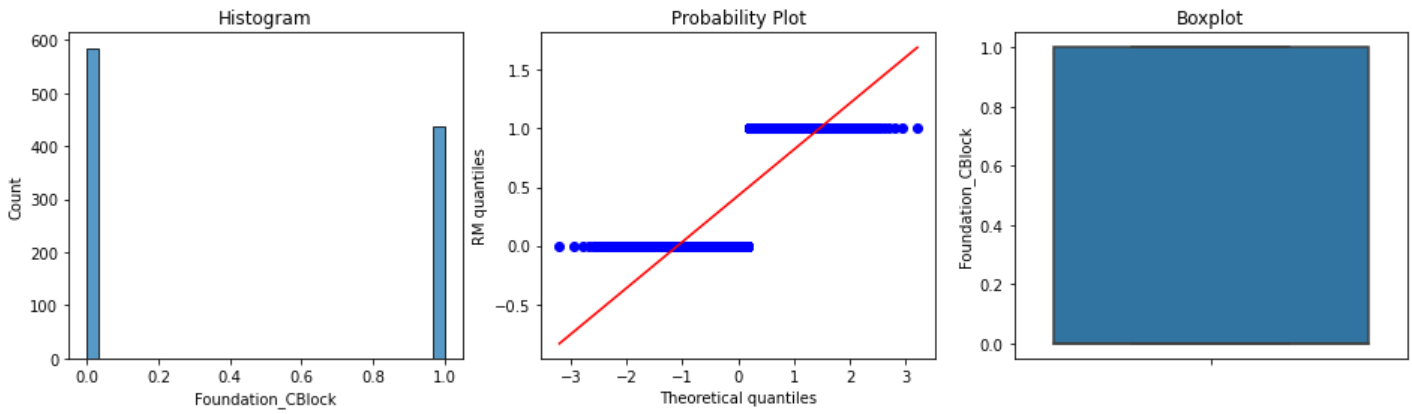

Probability Plot
RM quantiles
Theoretical quantiles

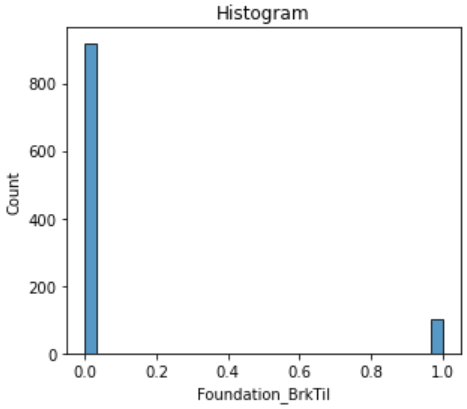

Boxplot
Exterior2nd_Rare

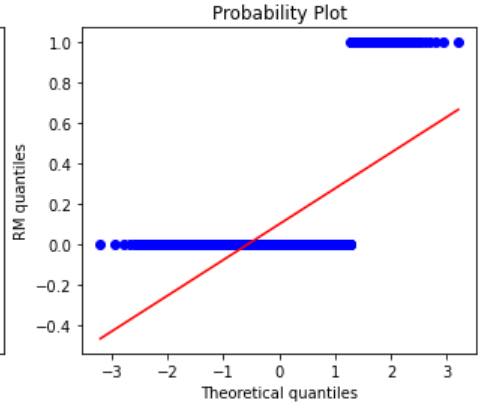

Histogram
Count
Exterior2nd_Wd Sdng
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior2nd_Wd Sdng

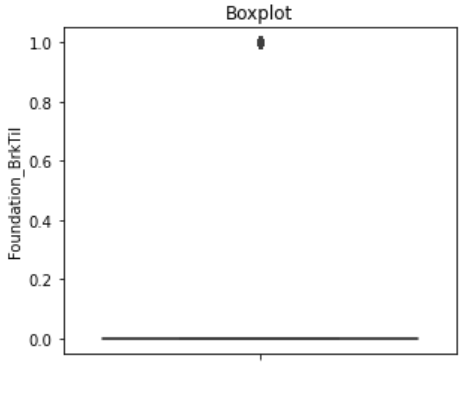

Histogram
Count
Exterior2nd_MetalSd
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior2nd_MetalSd

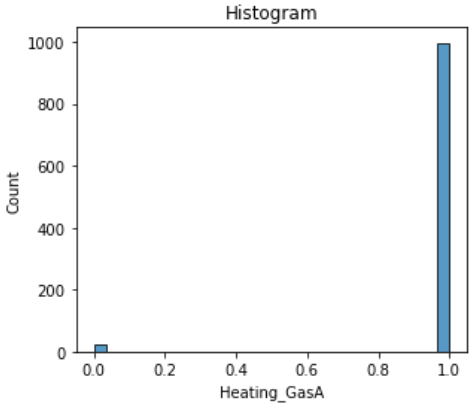

Histogram
Count
Foundation_PConc
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Foundation_PConc

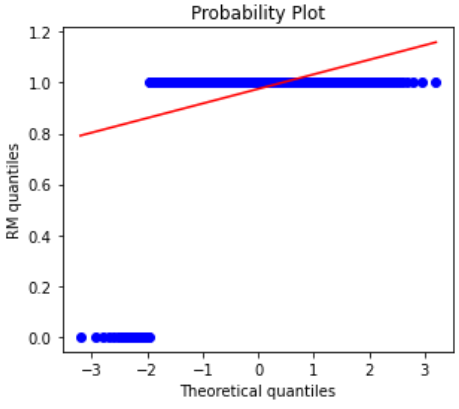

Histogram
Count
Foundation_CBlock
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Foundation_CBlock

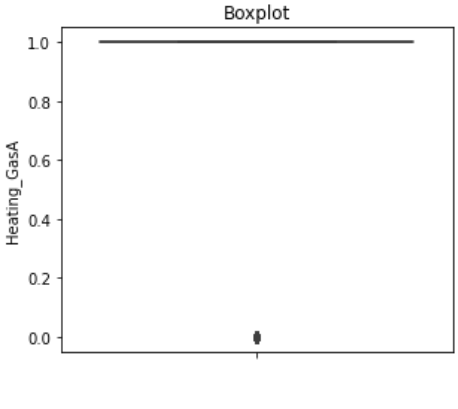

Histogram
Count
Foundation_BrkTil

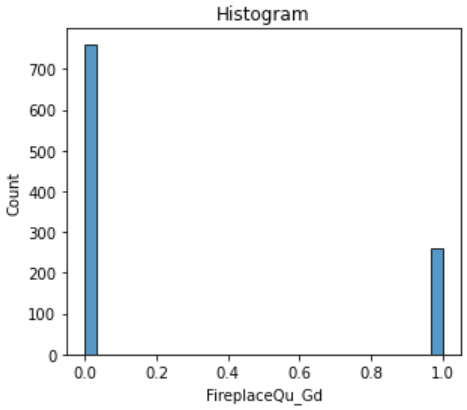

Probability Plot
RM quantiles
Theoretical quantiles

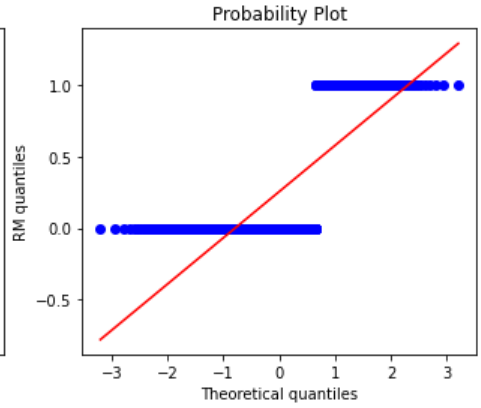

Boxplot
Foundation_BrkTil

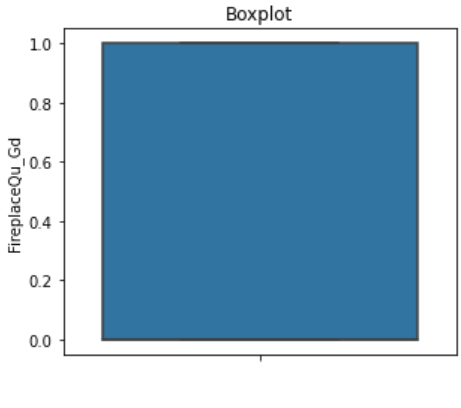

Histogram
Count
Heating_GasA

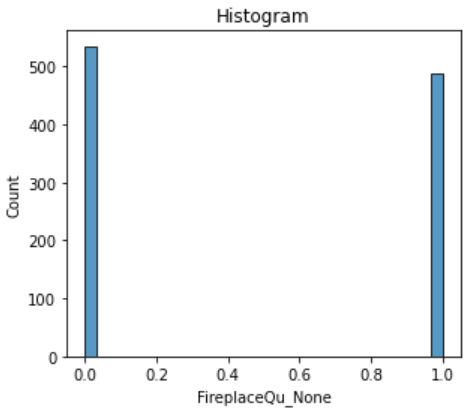

Probability Plot
RM quantiles
Theoretical quantiles

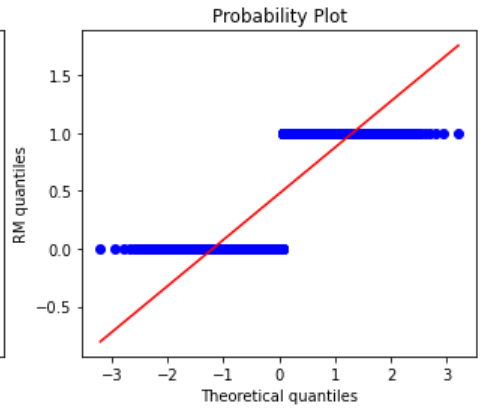

Boxplot
Heating_GasA

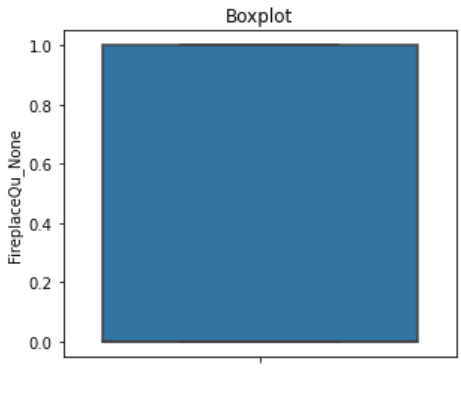

Histogram
Count
FireplaceQu_Gd

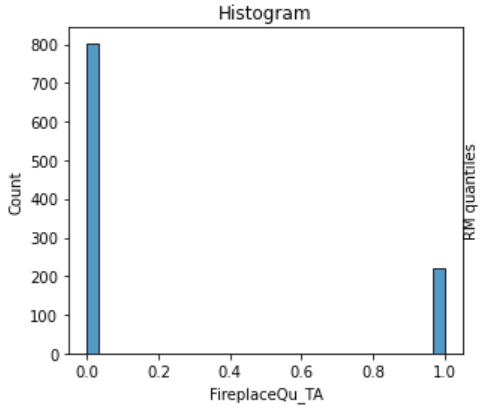

Probability Plot
RM quantiles
Theoretical quantiles

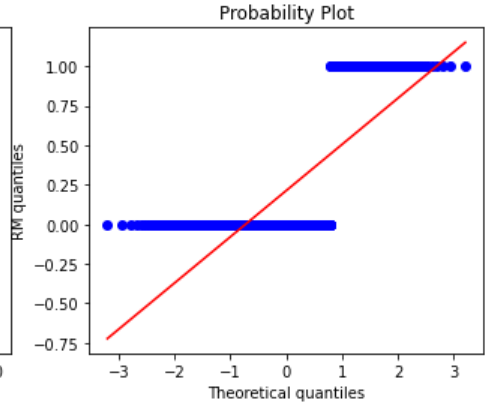

Boxplot
FireplaceQu_Gd

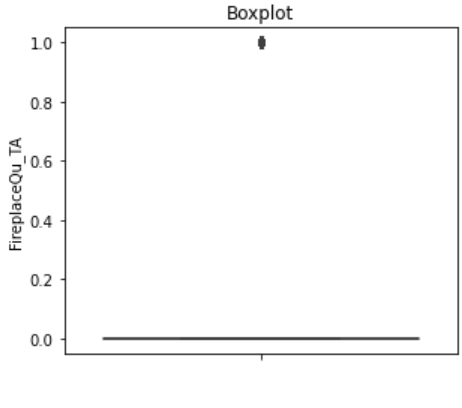

Histogram
Count
FireplaceQu_None

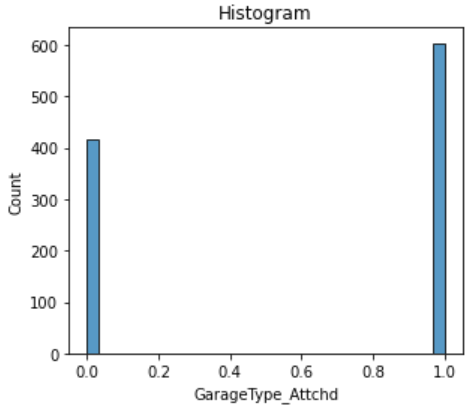

Probability Plot
RM quantiles
Theoretical quantiles

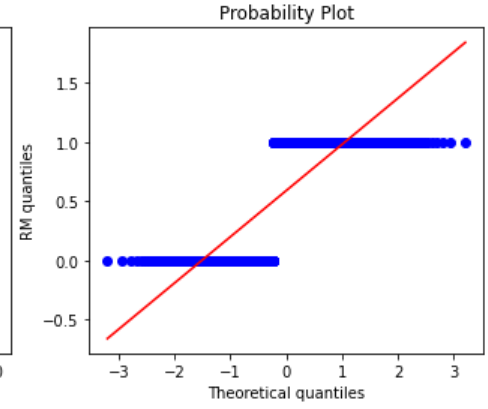

Boxplot
FireplaceQu_None

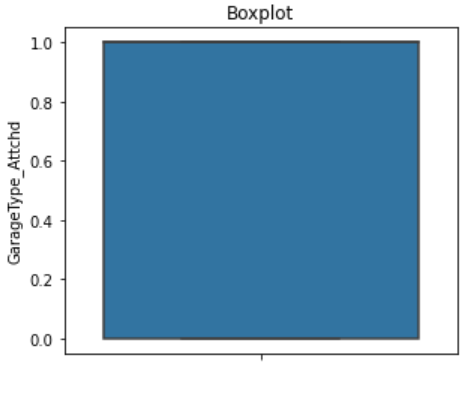

Histogram
Count
FireplaceQu_TA

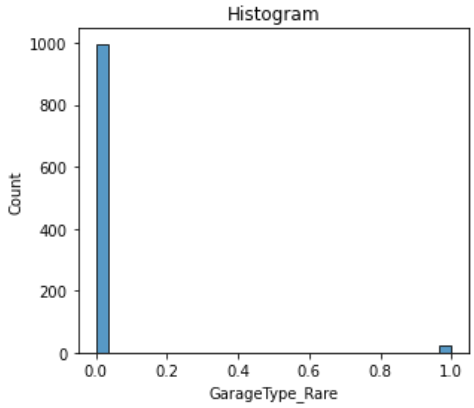

Probability Plot
RM quantiles
Theoretical quantiles

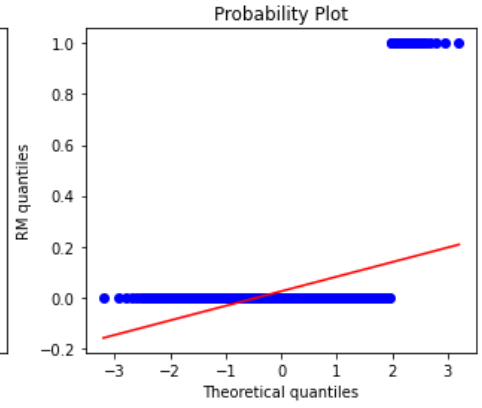

Boxplot
FireplaceQu_TA

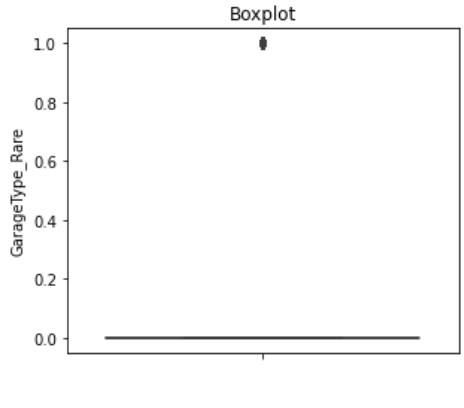

Histogram
Count
GarageType_Attchd

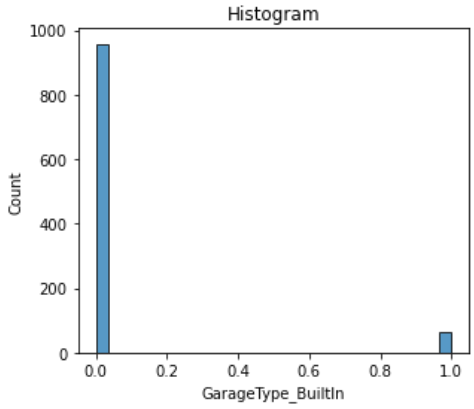

Probability Plot
RM quantiles
Theoretical quantiles

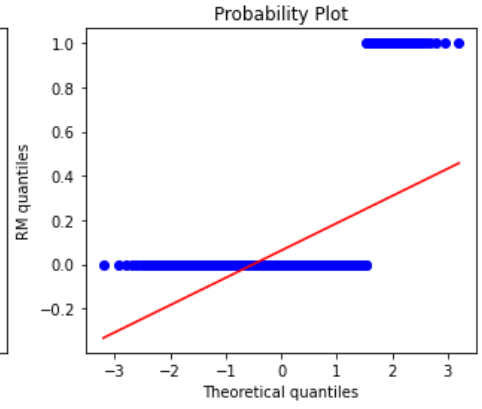

Boxplot
GarageType_Attchd

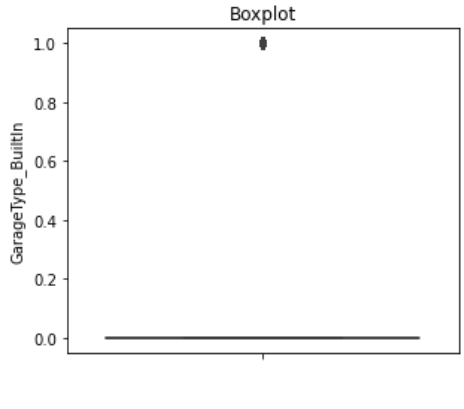

Histogram
Count
GarageType_Rare

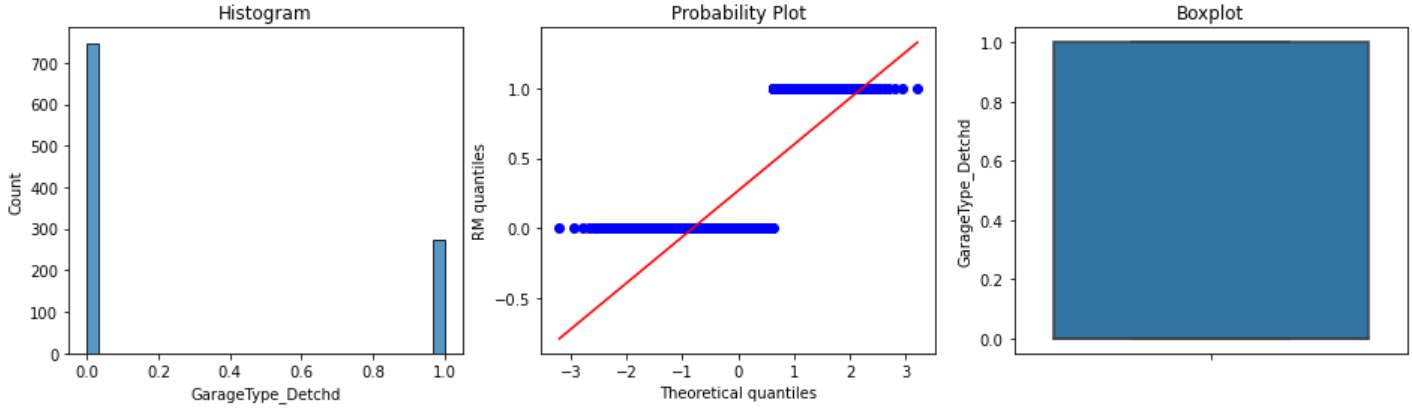

Probability Plot
RM quantiles
Theoretical quantiles

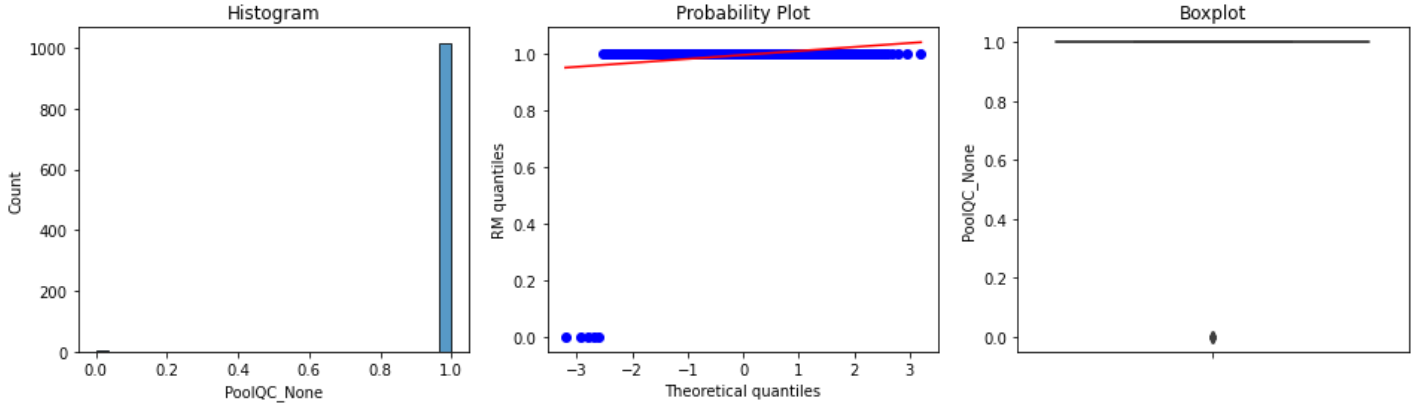

Boxplot
GarageType_Rare

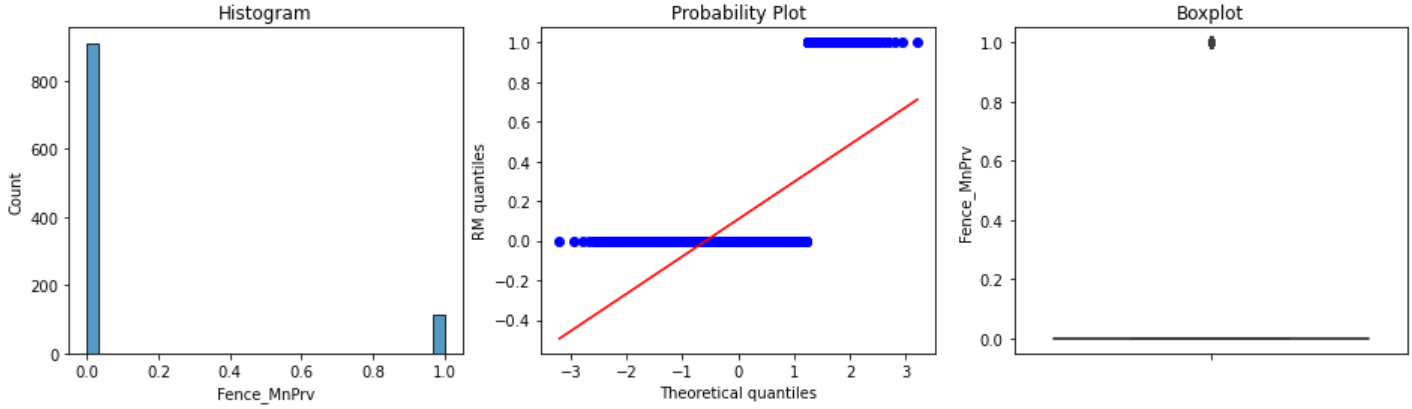

Histogram
Count
GarageType_BuiltIn

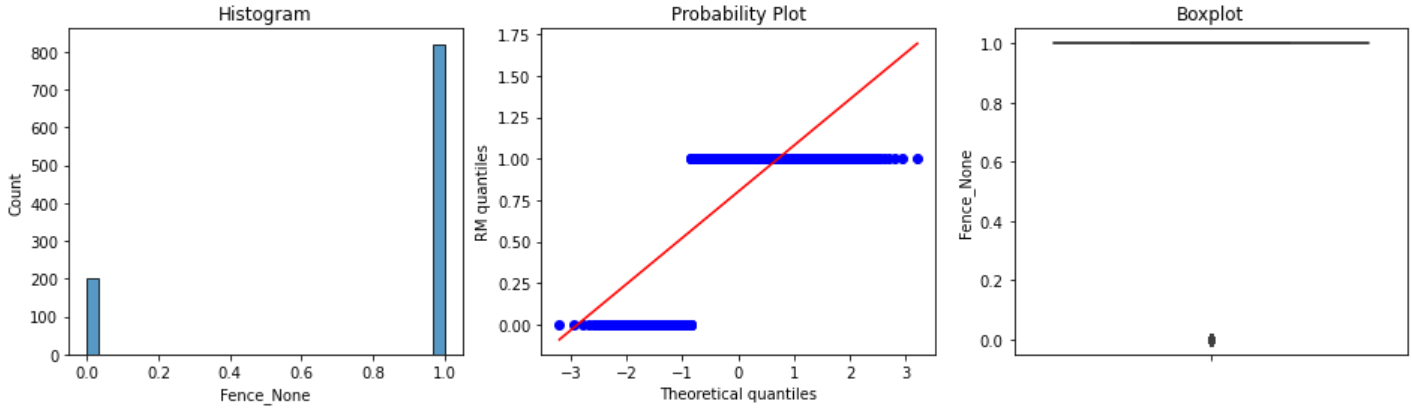

Probability Plot
RM quantiles
Theoretical quantiles

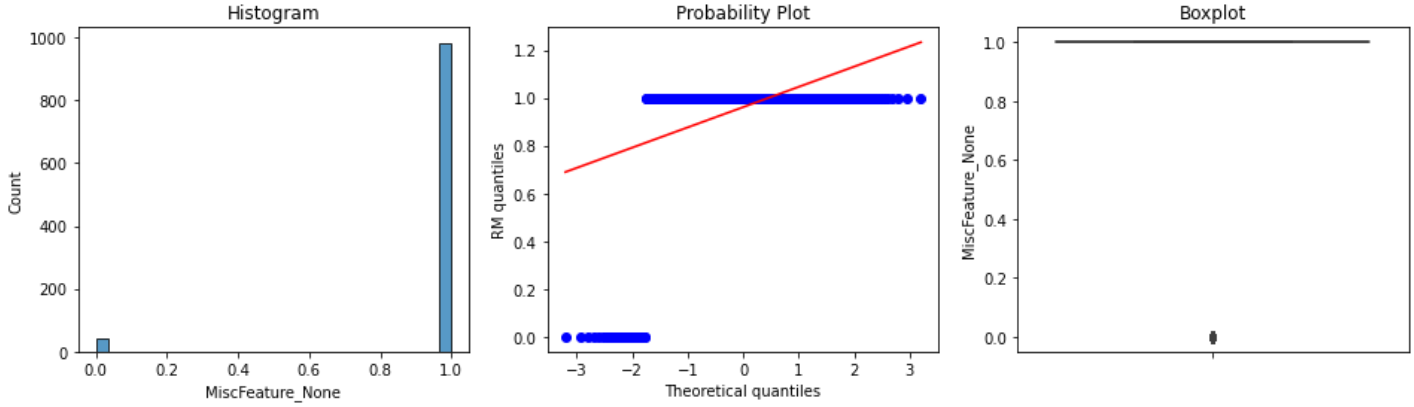

Boxplot
GarageType_BuiltIn

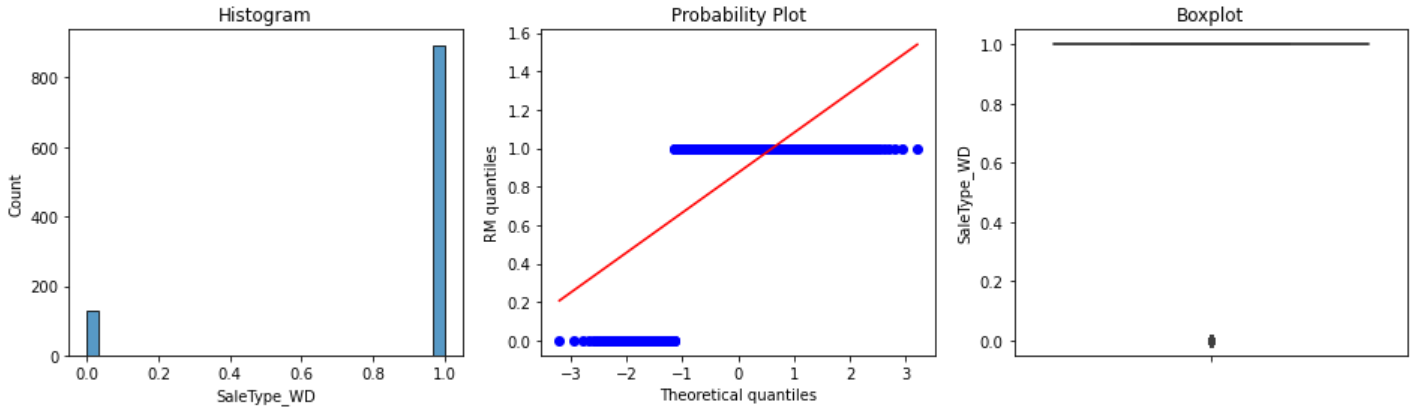

Histogram
Count
GarageType_Detchd
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
GarageType_Detchd

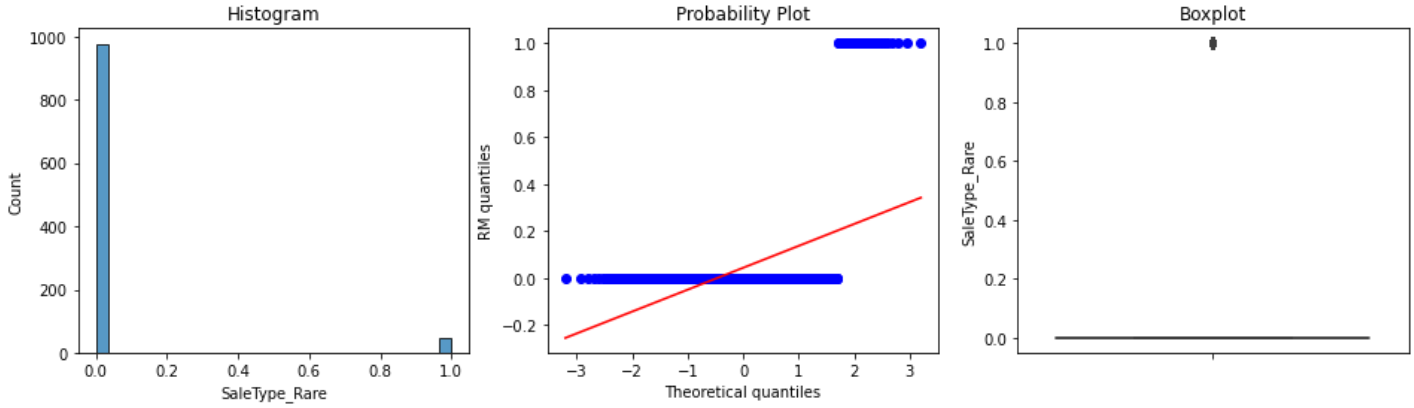

Histogram
Count
PoolQC_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
PoolQC_None

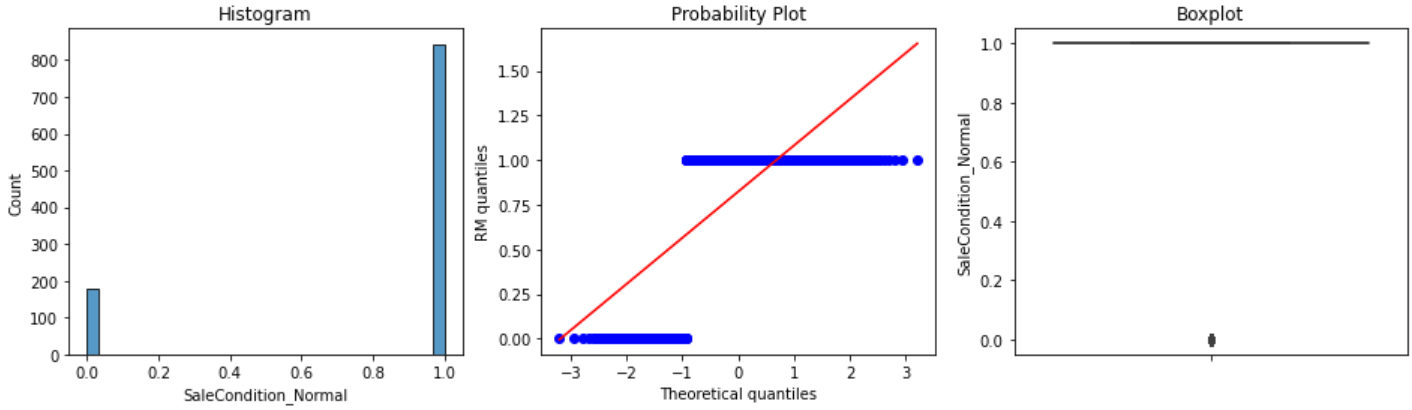

Histogram
Count
Fence_MnPrv
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Fence_MnPrv

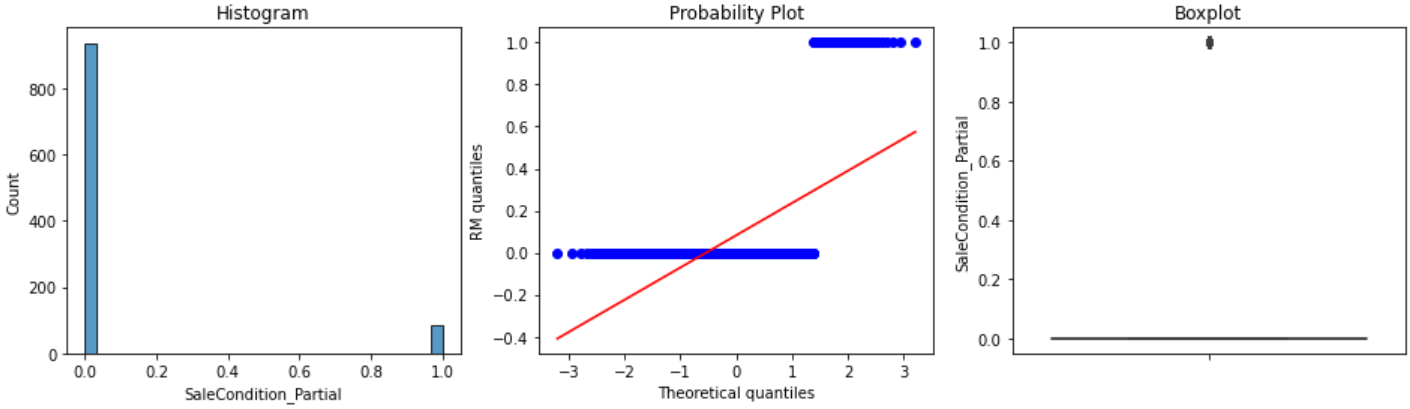

Histogram
Count
Fence_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Fence_None

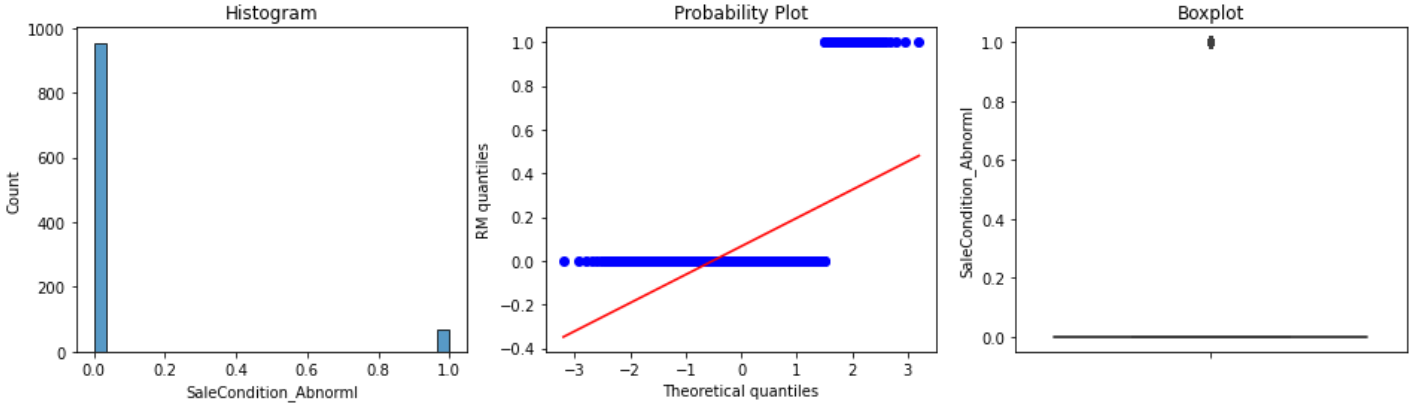

Histogram
Count
MiscFeature_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MiscFeature_None

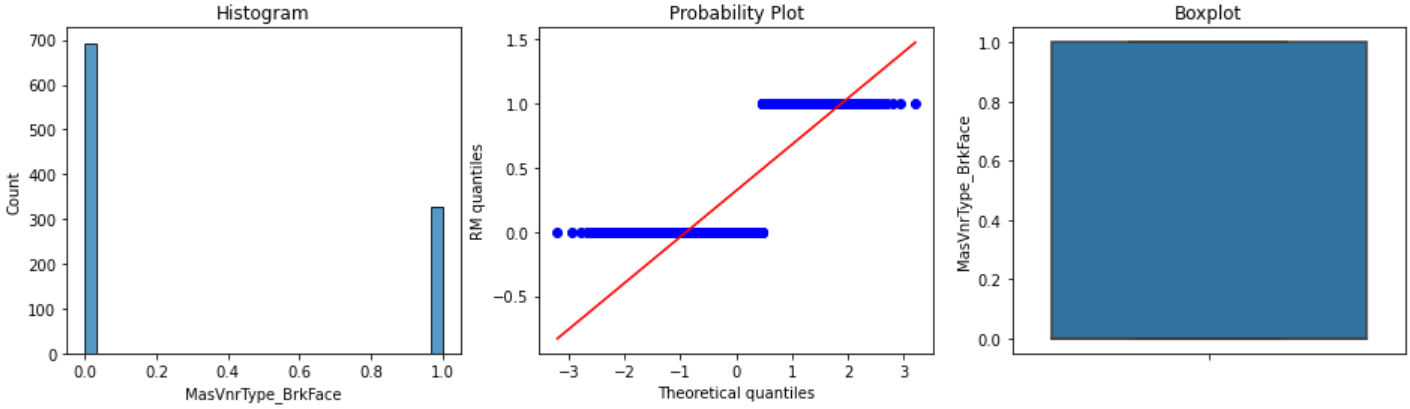

Histogram
Count
SaleType_WD
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleType_WD

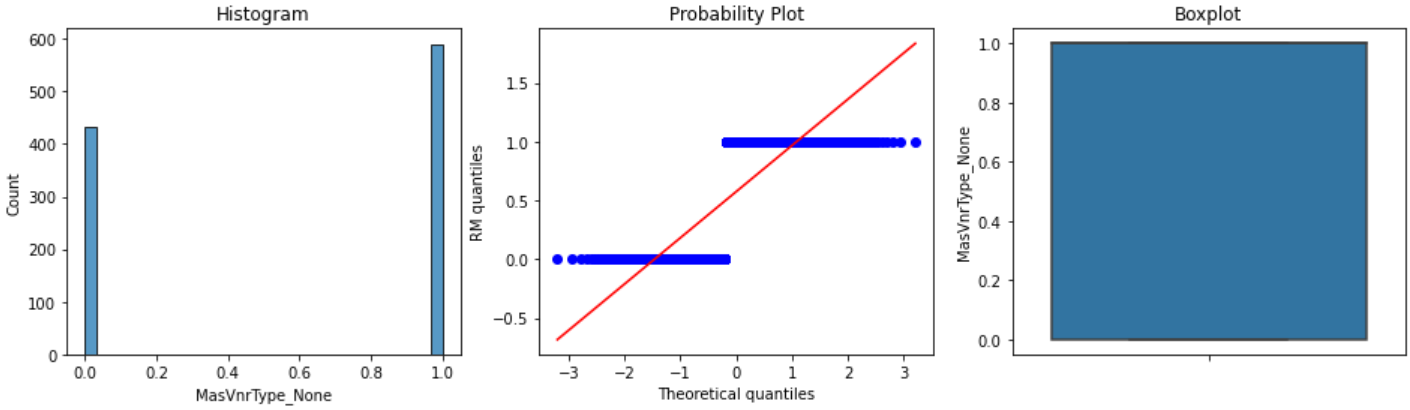

Histogram
Count
SaleType_Rare
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleType_Rare

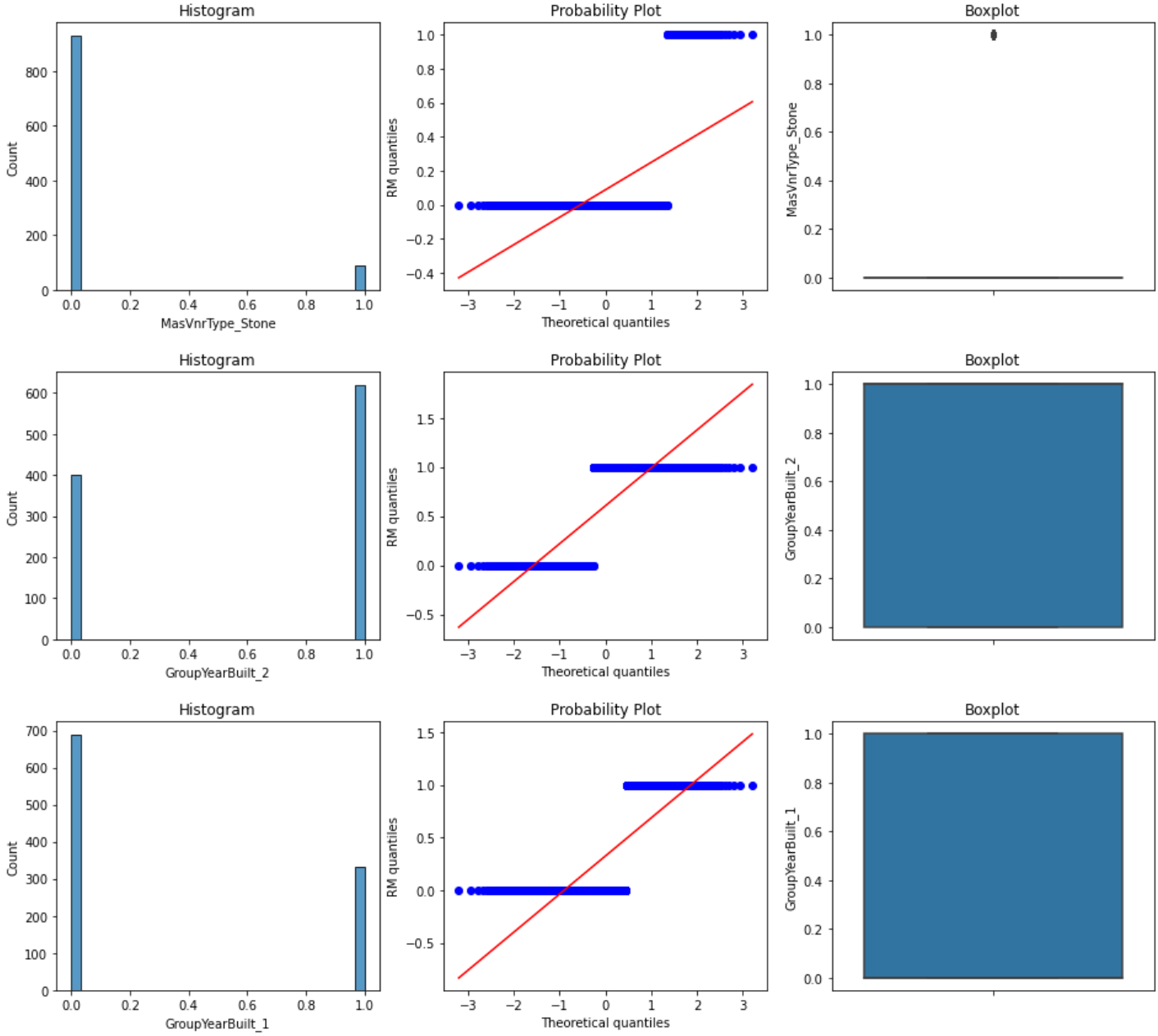

Histogram
Count
SaleCondition_Normal
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleCondition_Normal


Histogram
Count
SaleCondition_Partial
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleCondition_Partial


Histogram
Count
SaleCondition_Abnorml
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleCondition_Abnorml


Histogram
Count
MasVnrType_BrkFace
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MasVnrType_BrkFace


Histogram
Count
MasVnrType_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MasVnrType_None



In [263…

```
numeric_features = X_train.dtypes[X_train.dtypes != "object"].index

skewed_df = X_train[numeric_features].apply(lambda x: skew(x.dropna())).sort_values(ascend
skewness = pd.DataFrame({'Skew' :abs(skewed_df)})
skewn_table = skewness[skewness > 0.75]
```

In [263…

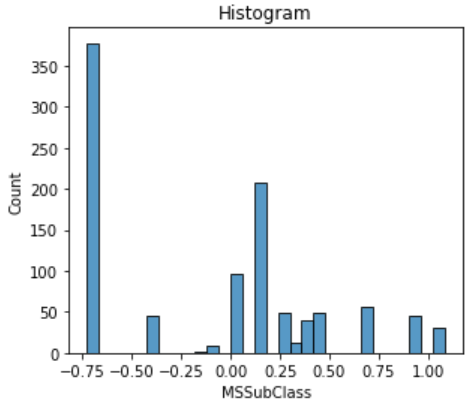
```
X_train[skewed_df.index] = np.log1p(X_train[skewed_df.index])
X_test[skewed_df.index] = np.log1p(X_test[skewed_df.index])
df_test[skewed_df.index] = np.log1p(df_test[skewed_df.index])
```

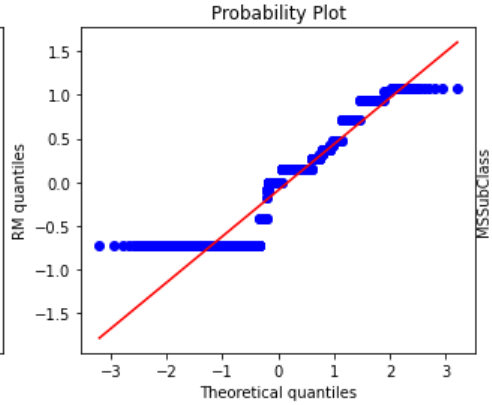
In [263…

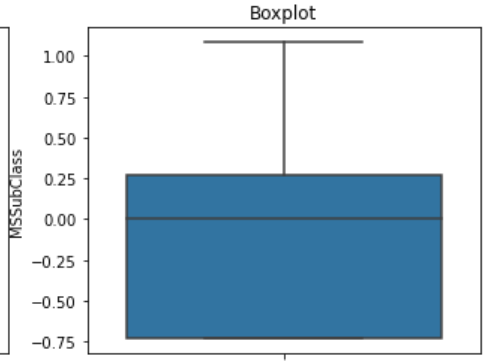
```
for col in X_train[X_train.columns]:
        scaler = RobustScaler()
        X_train[col] = scaler.fit_transform(X_train[[col]])
        X_test[col] = scaler.transform(X_test[[col]])
        df_test[col] = scaler.transform(df_test[[col]])
```

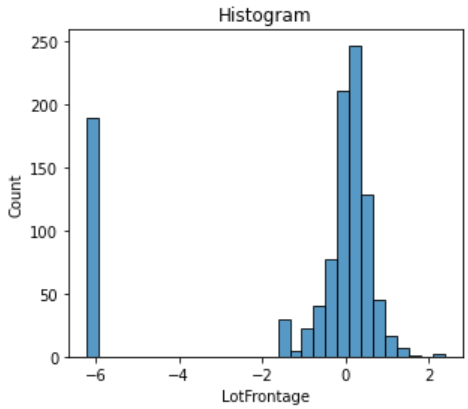
In [263…

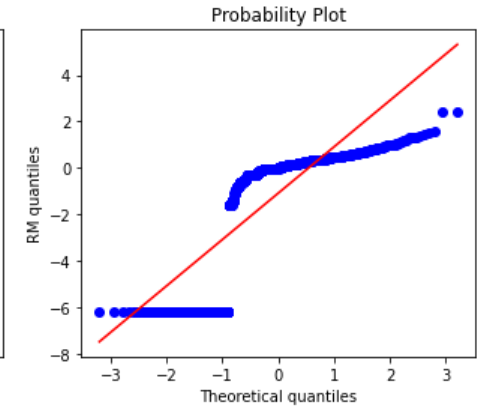
```
for i in X_train.columns:
    diagnostic_plots(X_train,i)
```

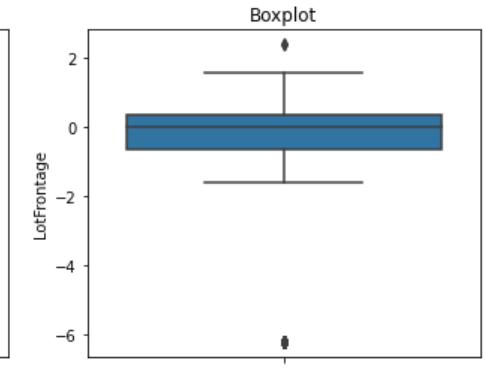

Histogram
Count
MSSubClass

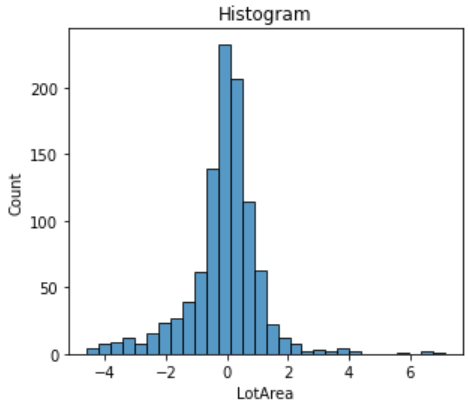

Probability Plot
RM quantiles
Theoretical quantiles

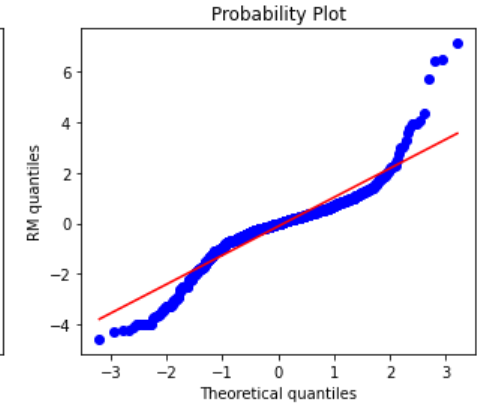

Boxplot
MSSubClass

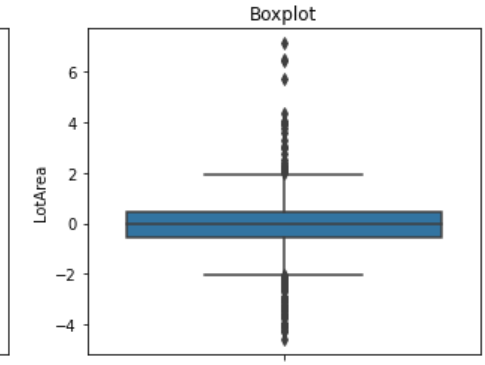

Histogram
Count
LotFrontage

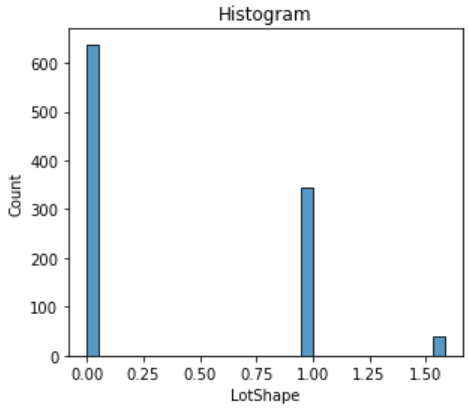

Probability Plot
RM quantiles
Theoretical quantiles

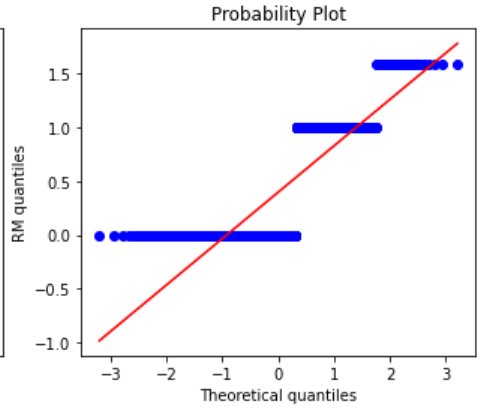

Boxplot
LotFrontage

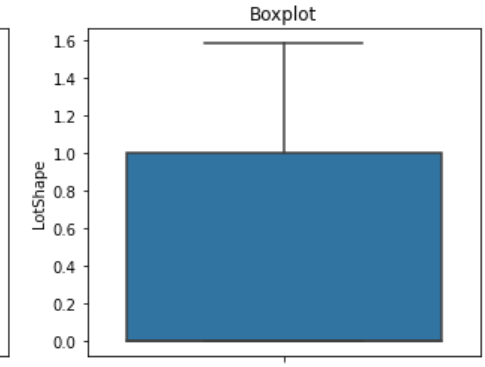

Histogram
Count
LotArea

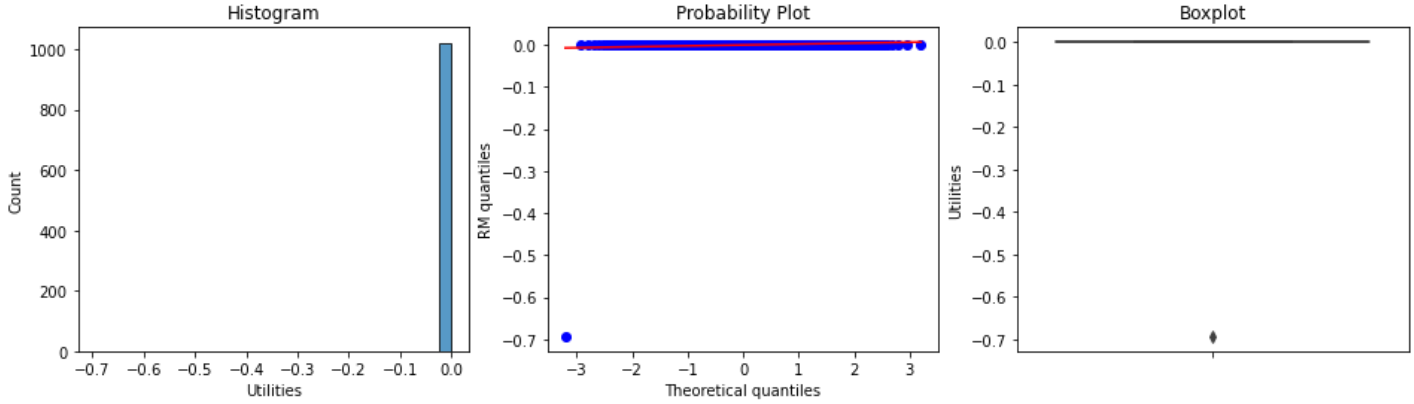

Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
LotArea


Histogram
Count
LotShape


Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
LotShape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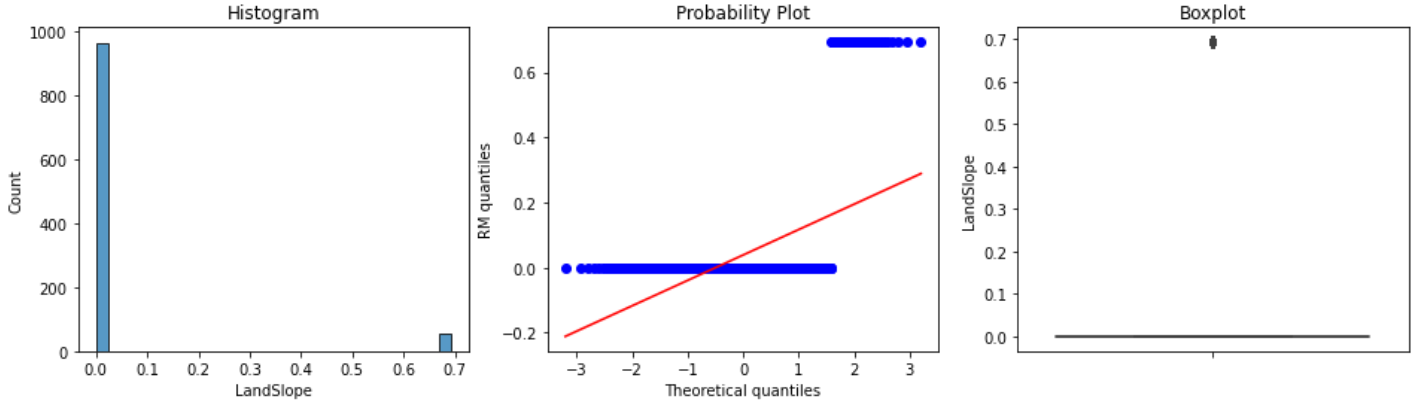
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Utilities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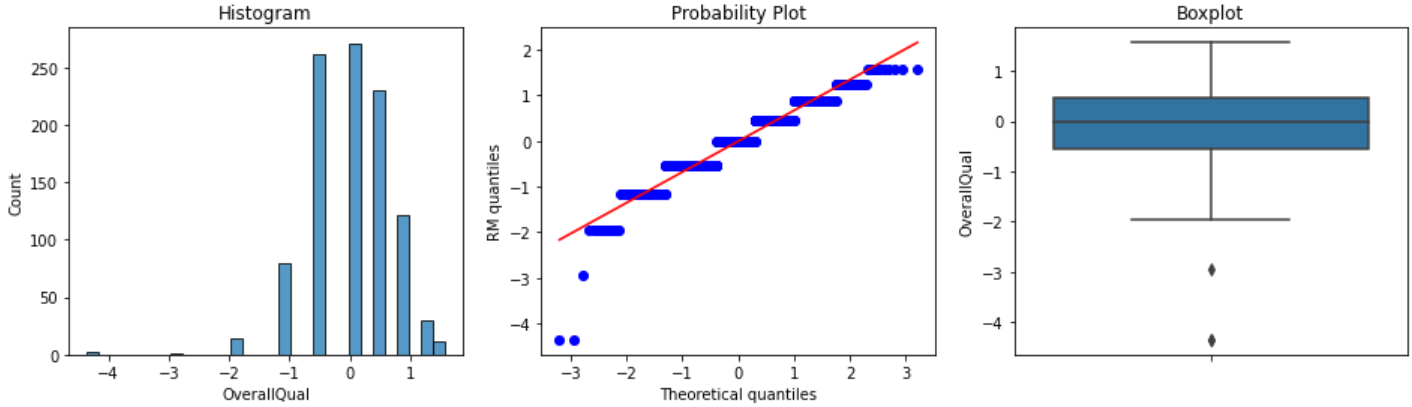
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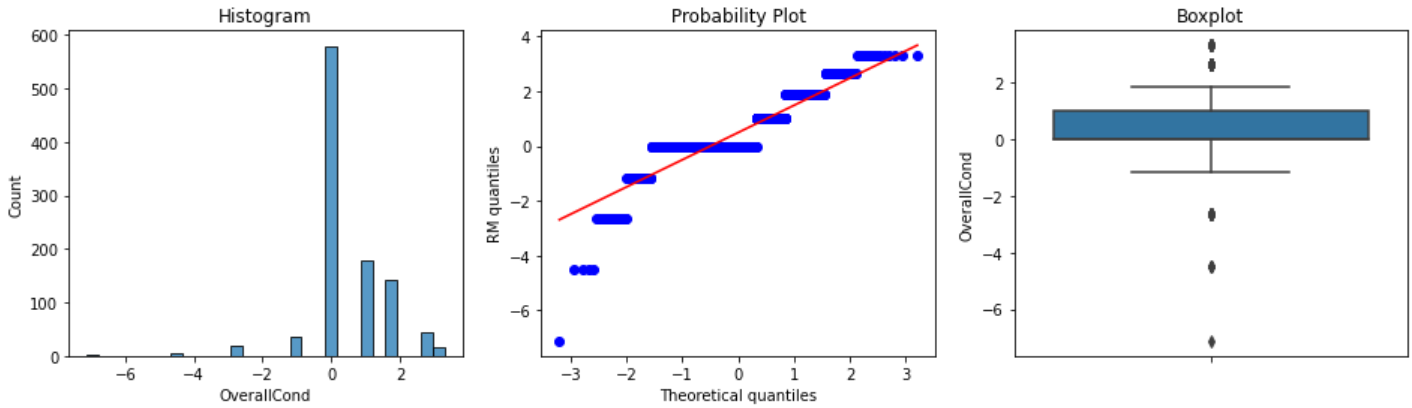
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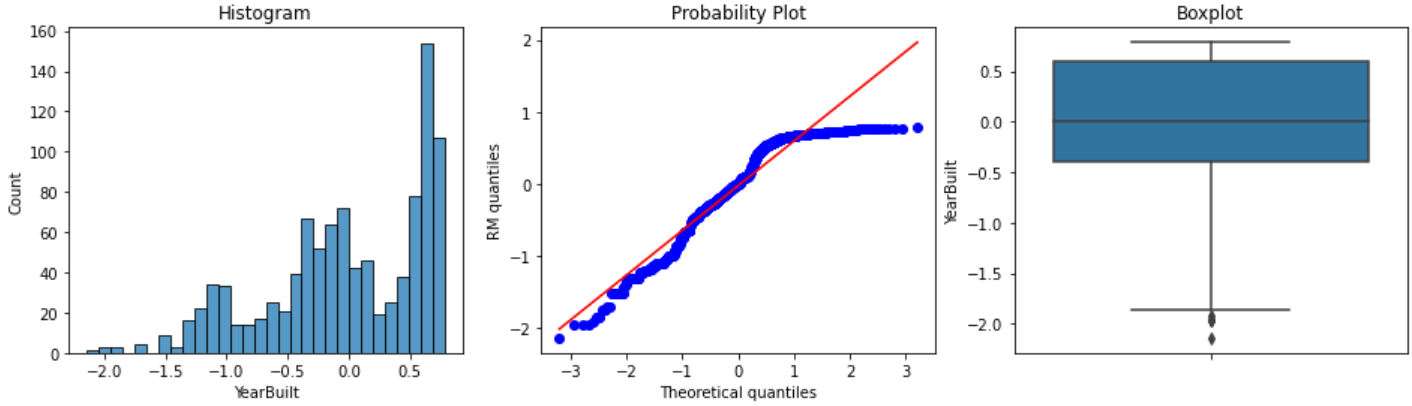
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Boxplot
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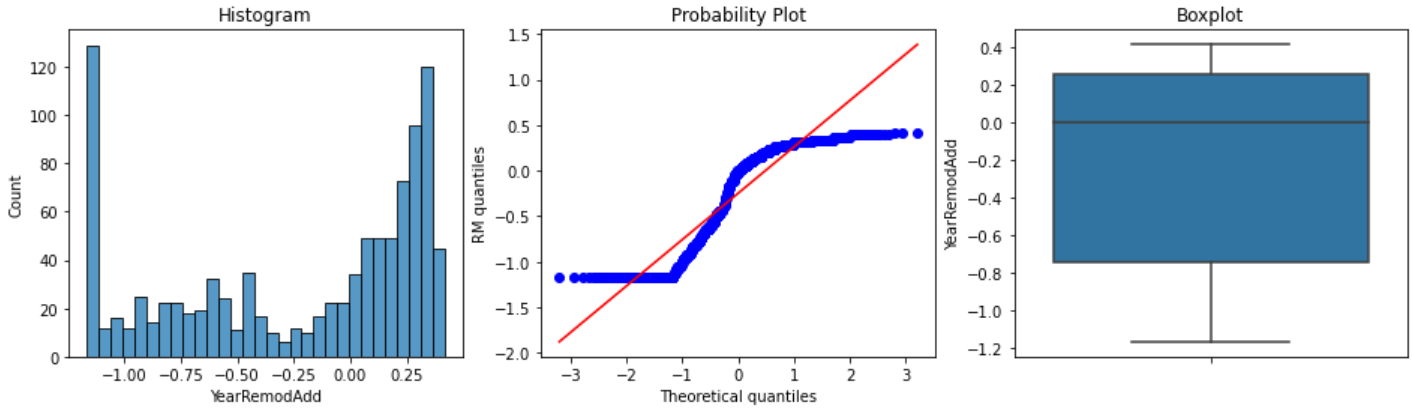
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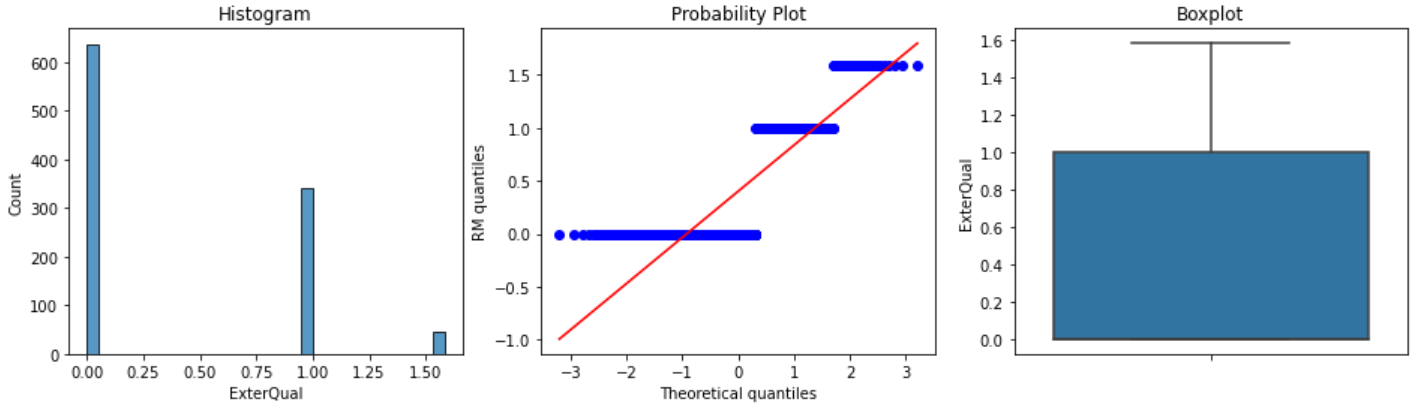
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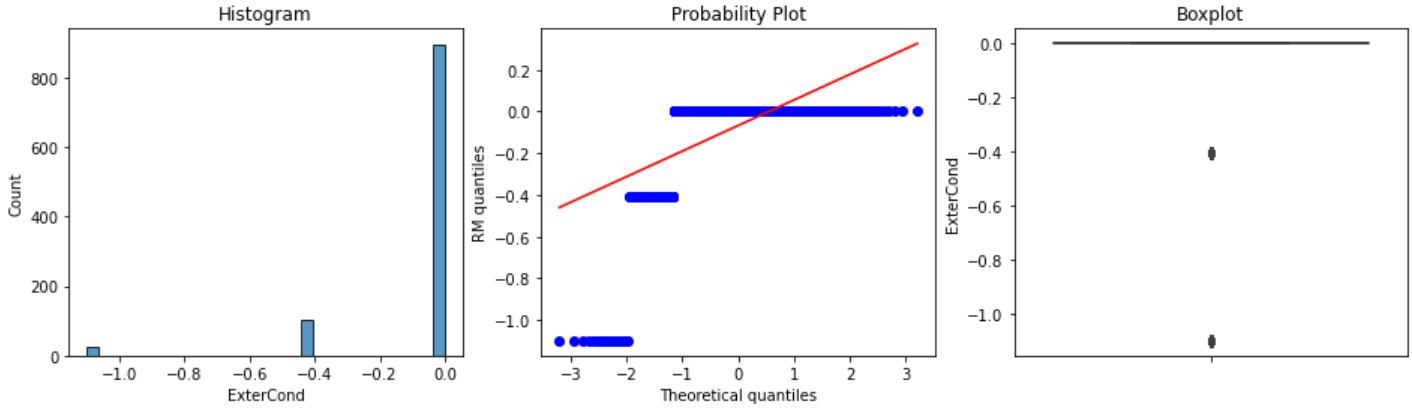
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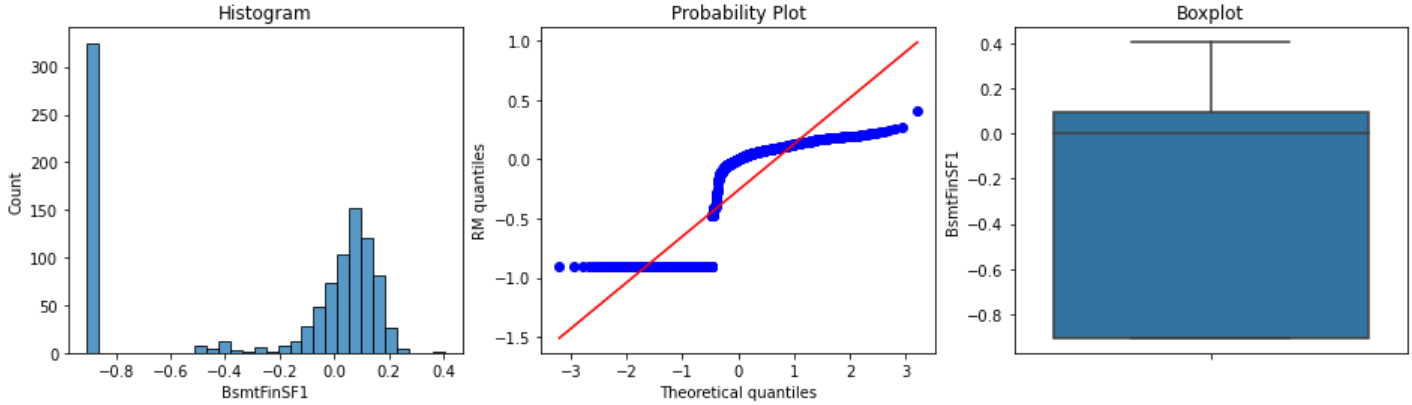
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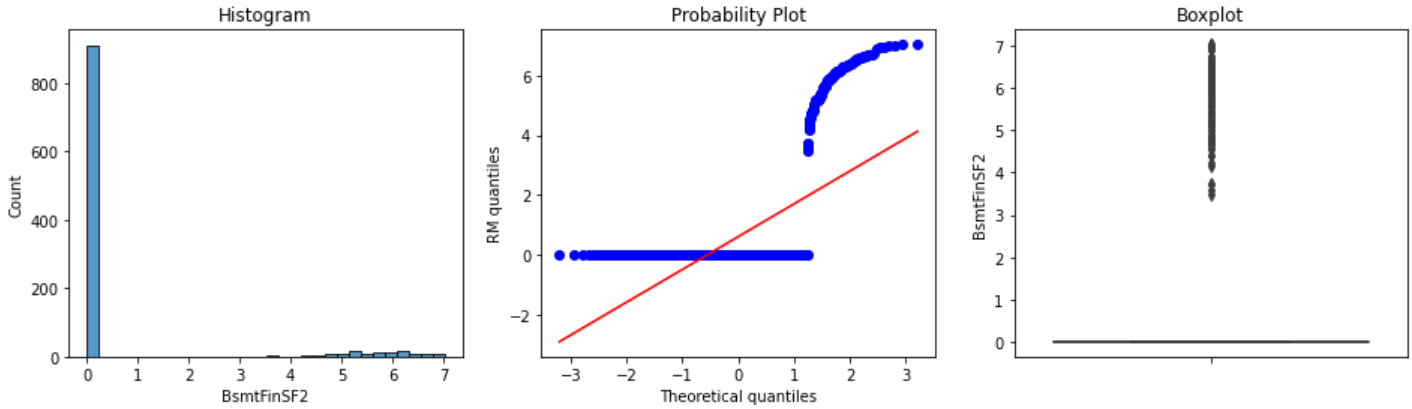
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Boxplot
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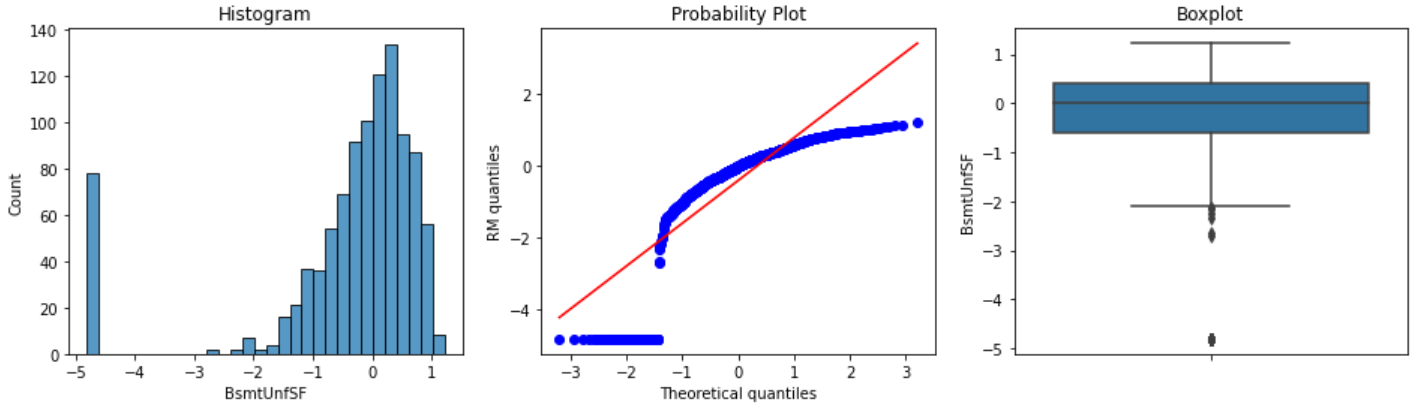
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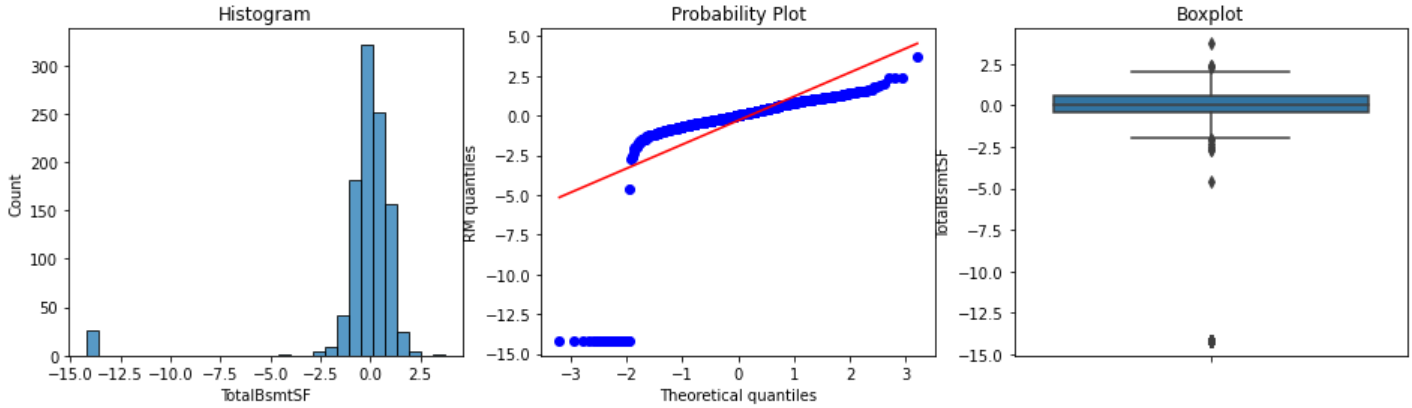
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Probability Plot
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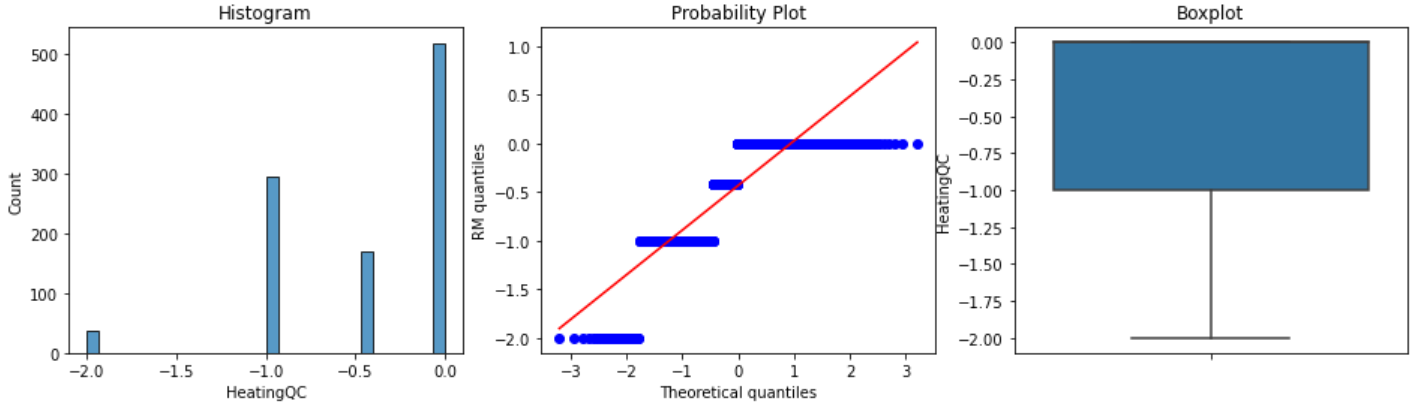
Theoretical quantiles
Boxplot
TotalBsmtSF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Count
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Probability Plot
RM quantiles
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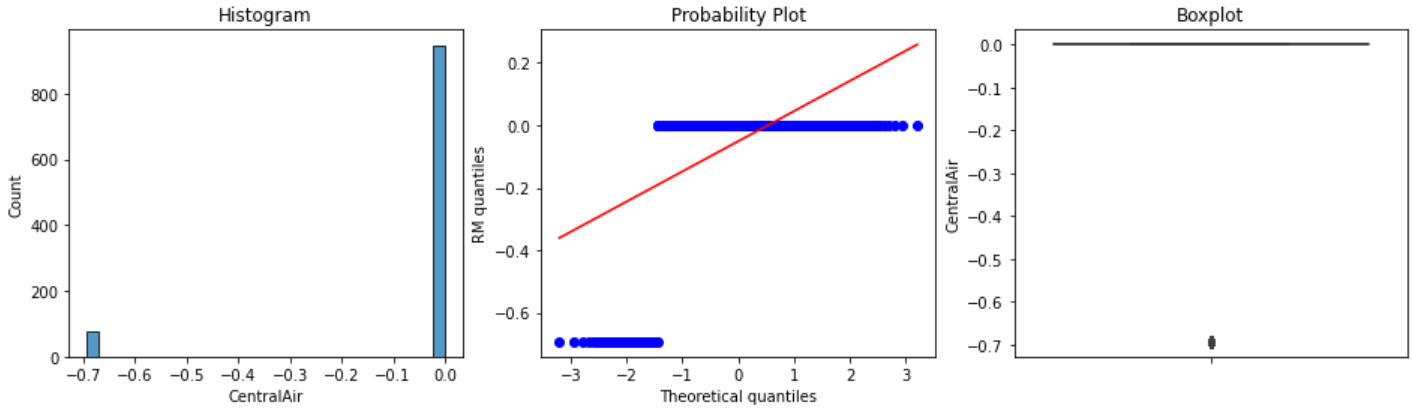
Boxplot
HeatingQC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Count
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Probability Plot
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Boxplot
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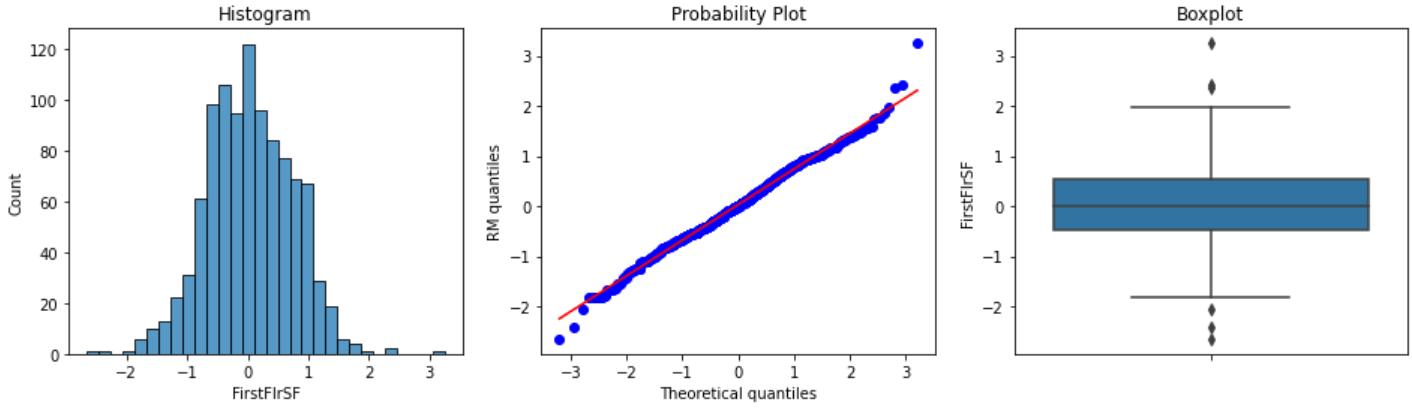
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Count
FirstFlrSF
Probability Plot
RM quantiles
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Boxplot
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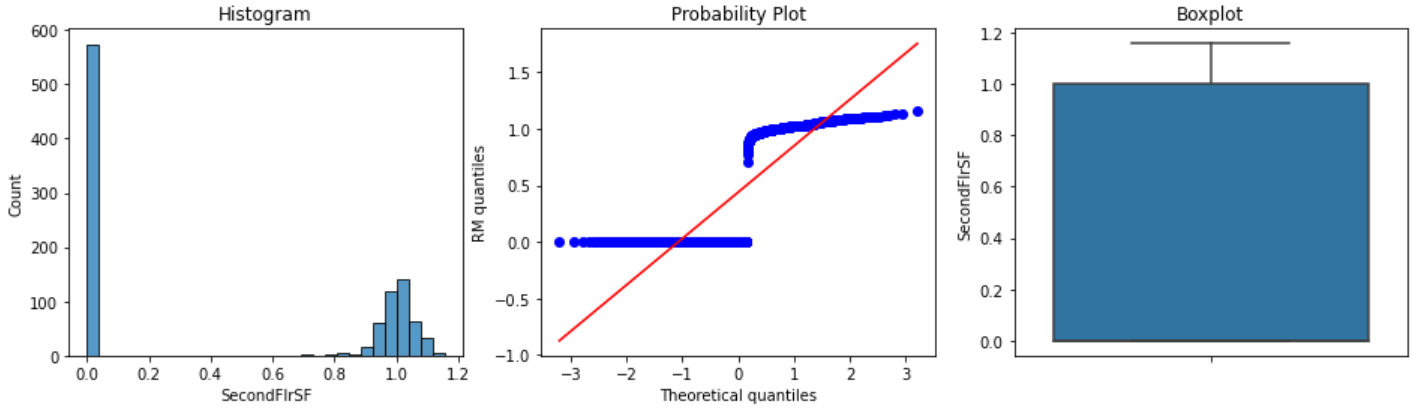
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Count
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Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
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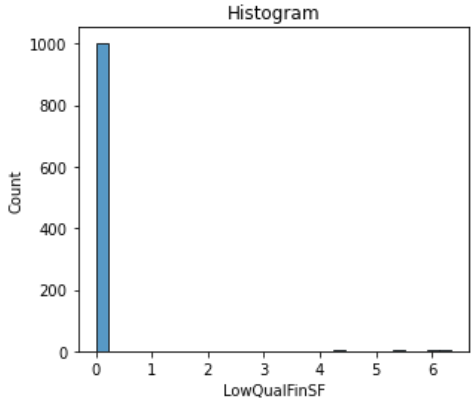
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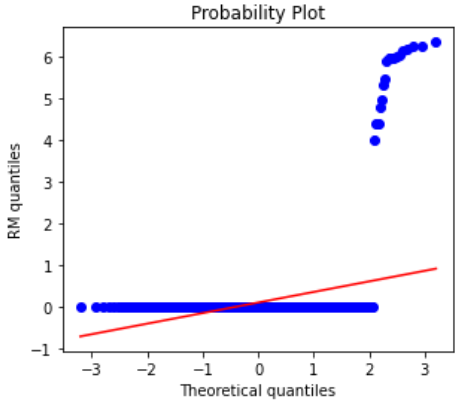
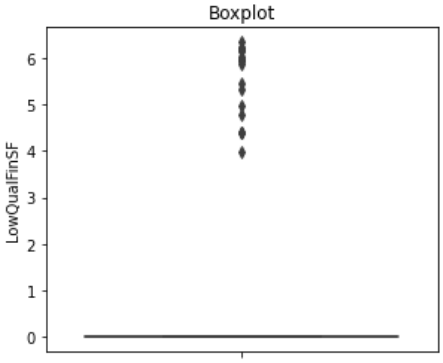
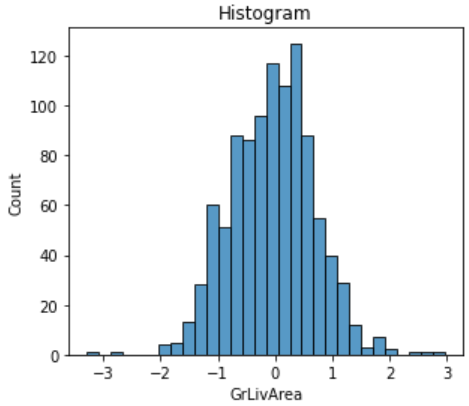

Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
LowQualFinSF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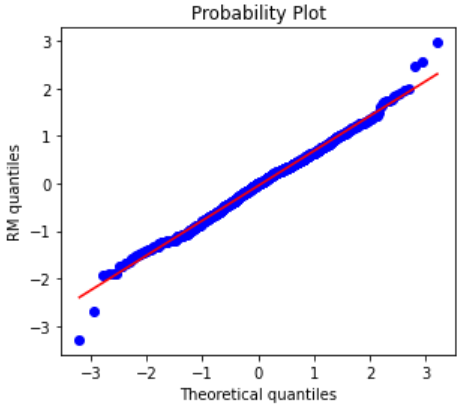
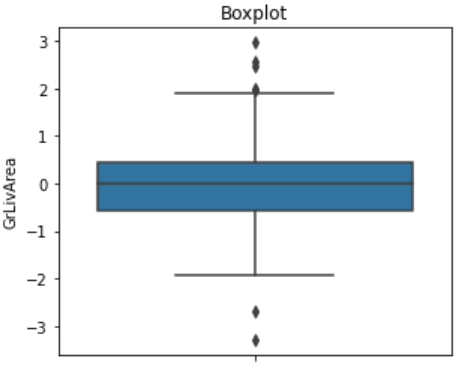

Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
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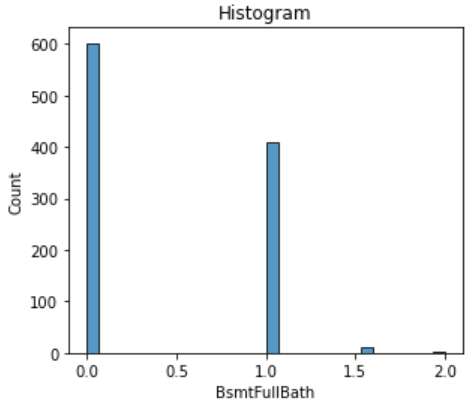
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Count
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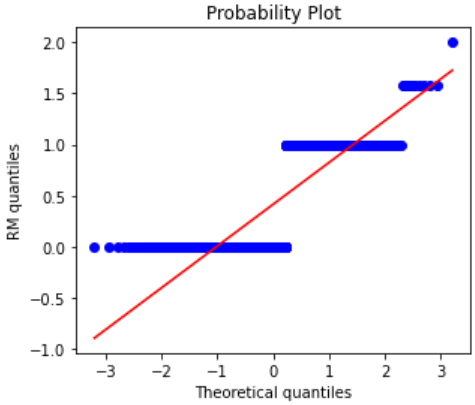
Probability Plot
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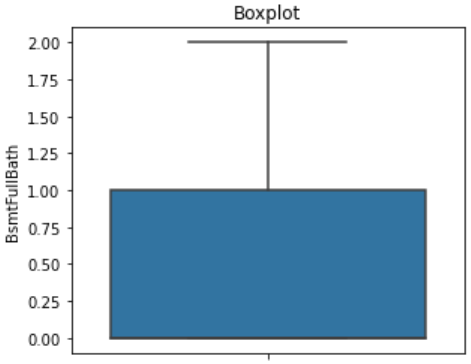
Theoretical quantiles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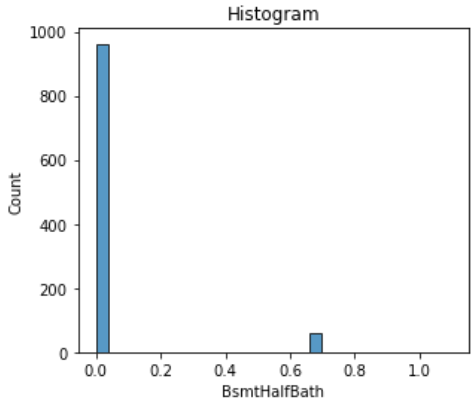
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Count
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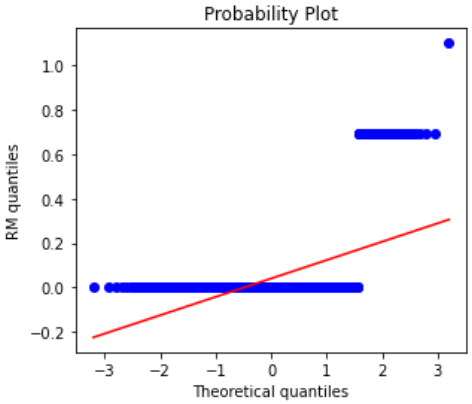
Probability Plot
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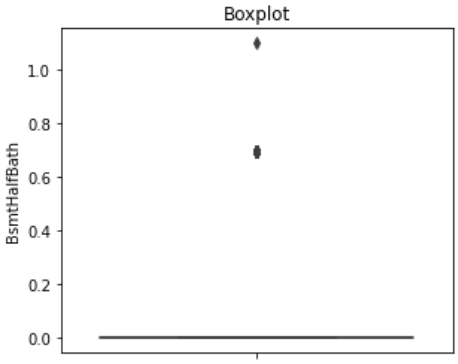
Theoretical quantiles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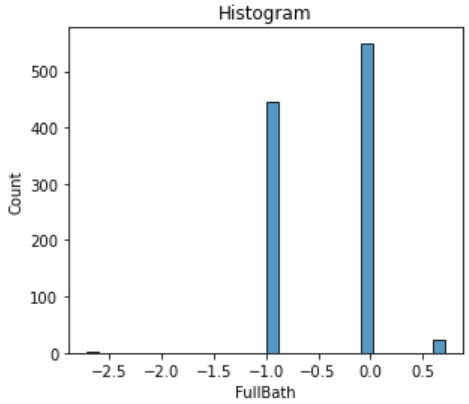
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Count
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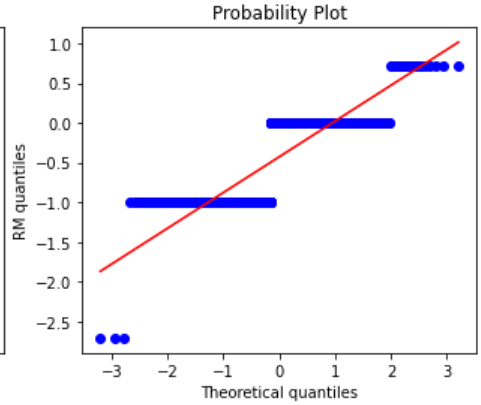
Probability Plot
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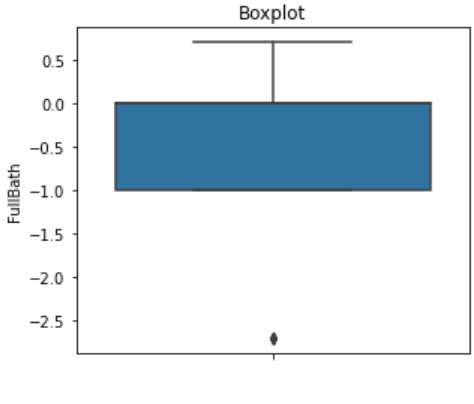
Theoretical quantiles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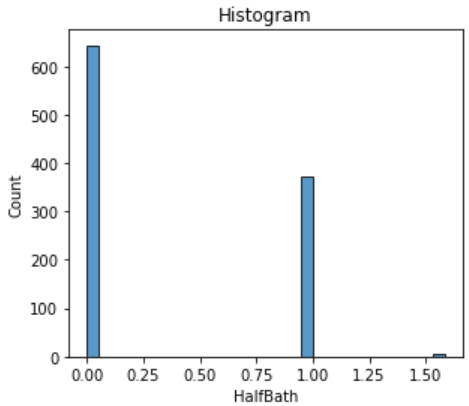
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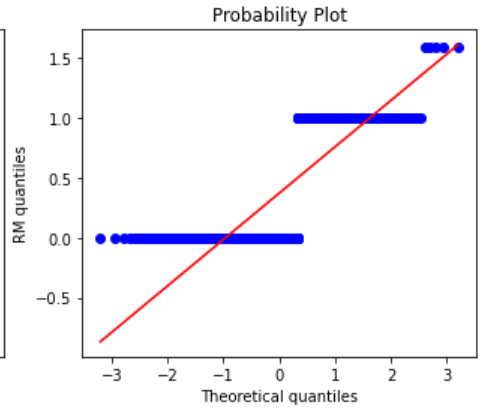
Probability Plot
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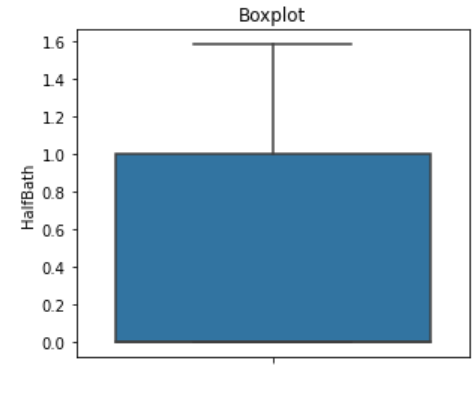
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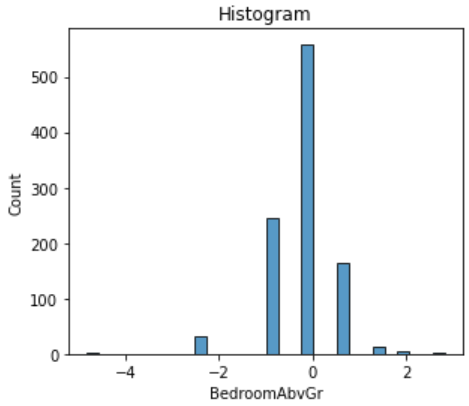
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Count
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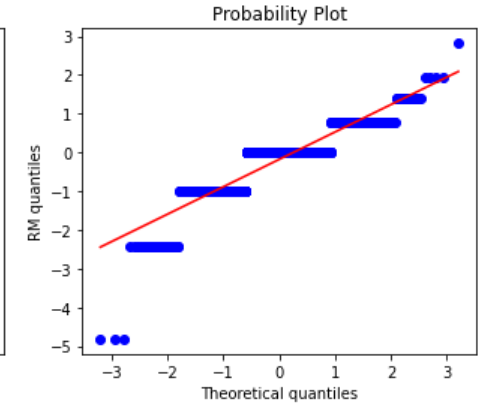
Probability Plot
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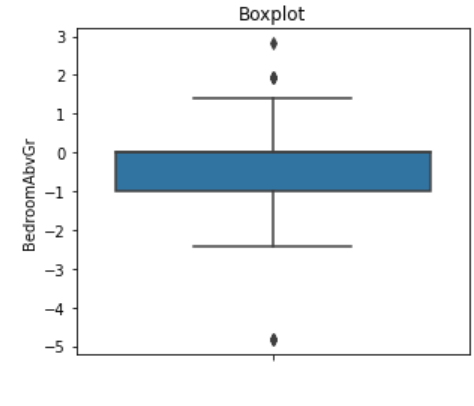
Theoretical quantiles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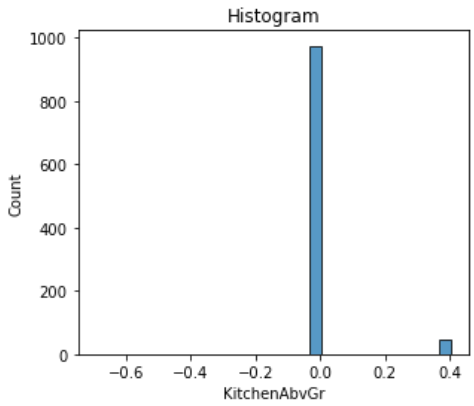
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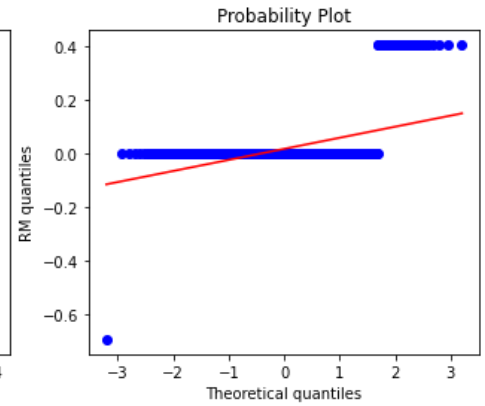
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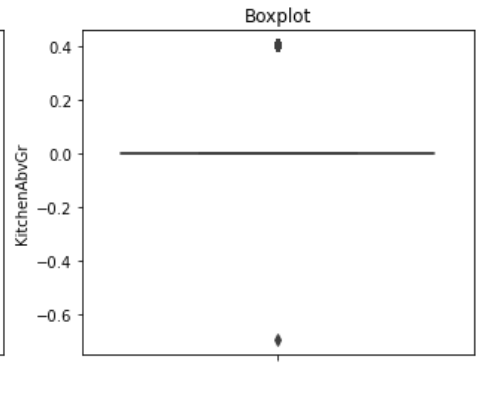
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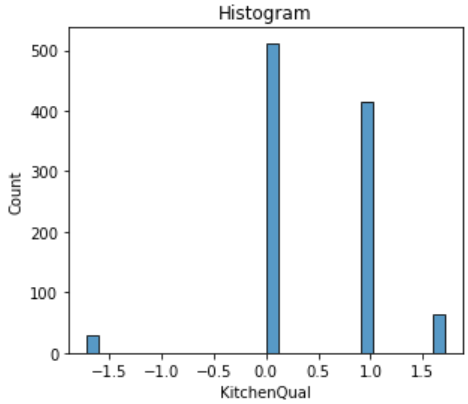
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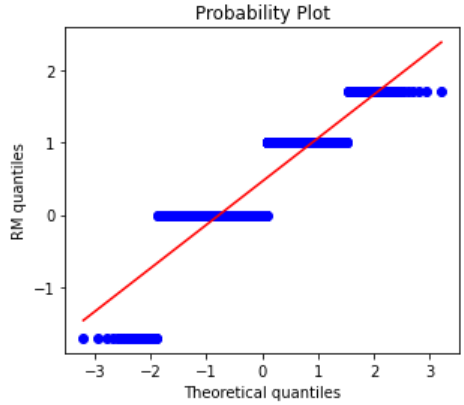
Probability Plot
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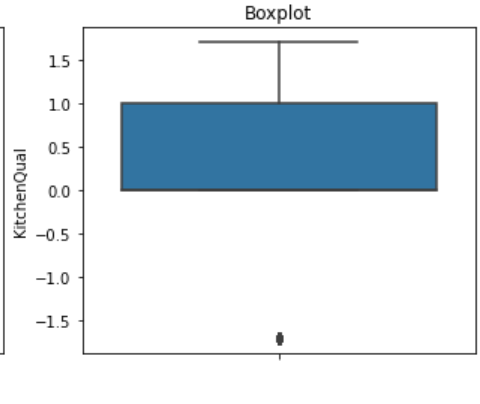
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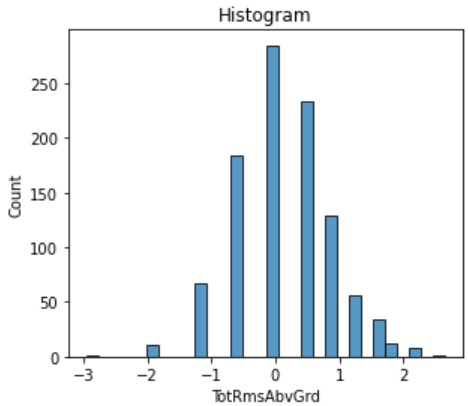
KitchenQual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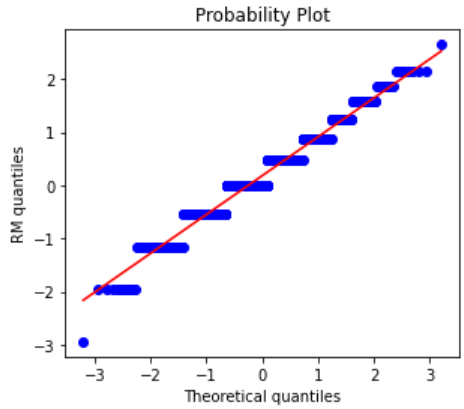
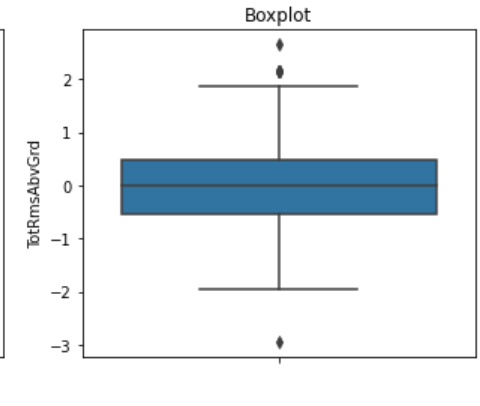

Probability Plot
RM quantiles
Theoretical quantiles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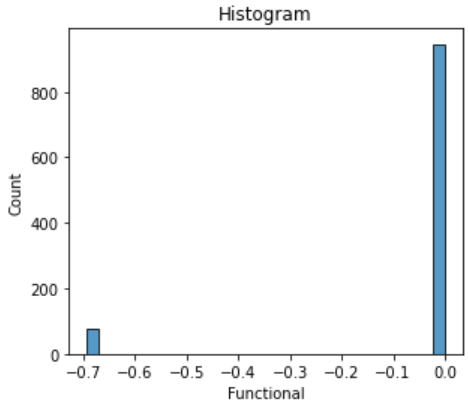
Histogram
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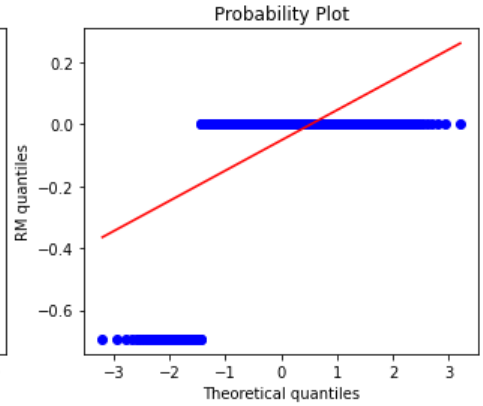
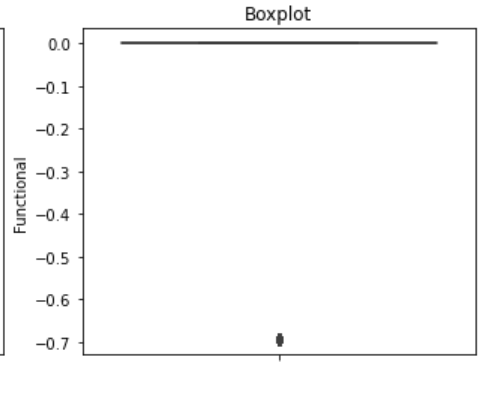
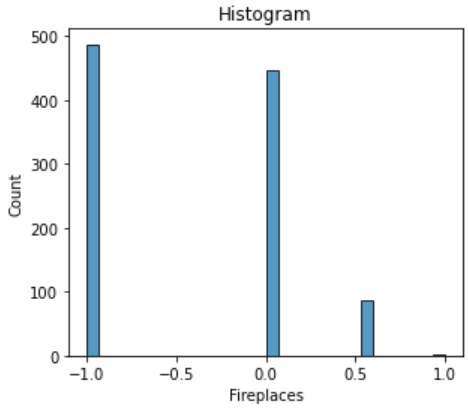
Functional


Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
Functional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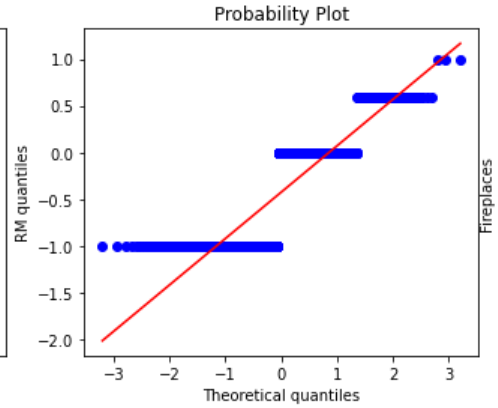
Fireplaces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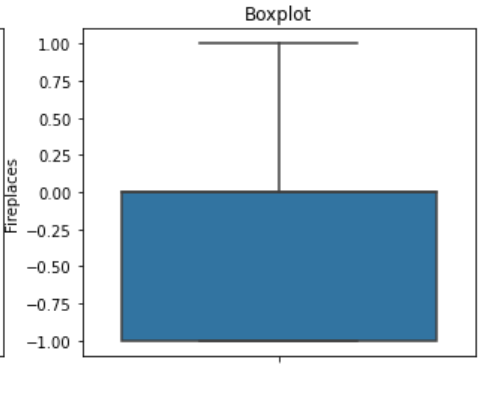
Theoretical quantiles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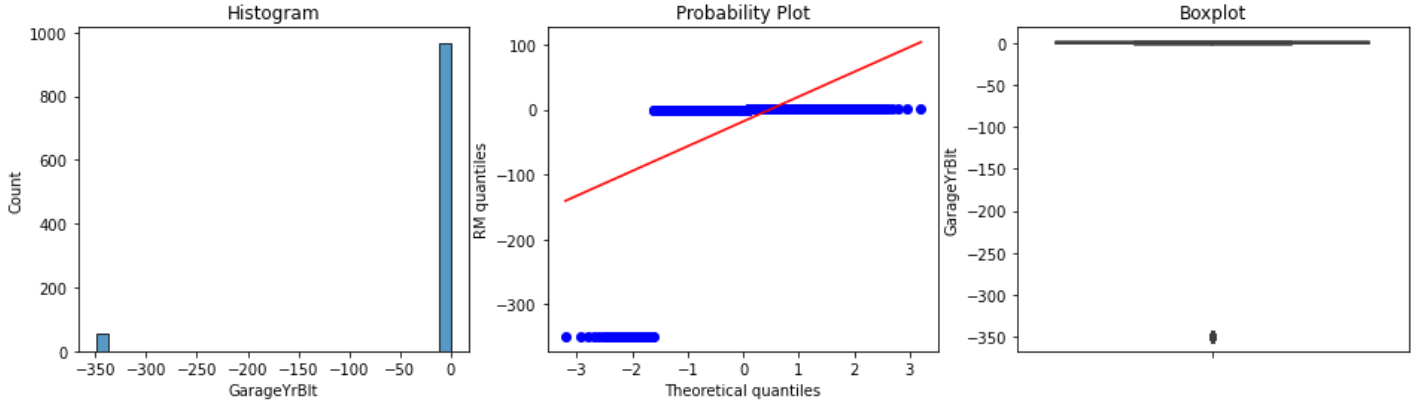
Fireplaces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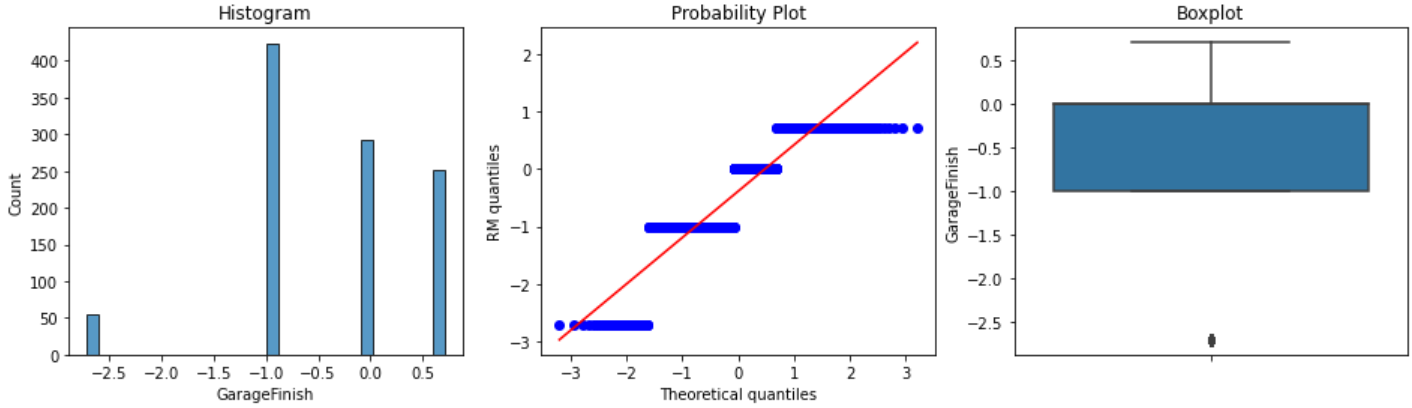
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
GarageYrBlt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Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
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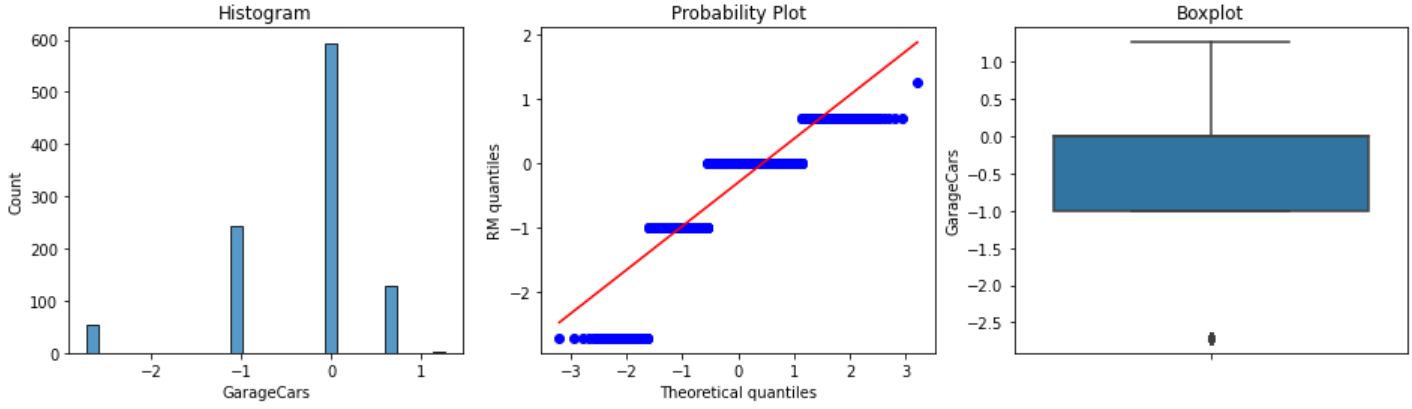
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Theoretical quantiles
Boxplot
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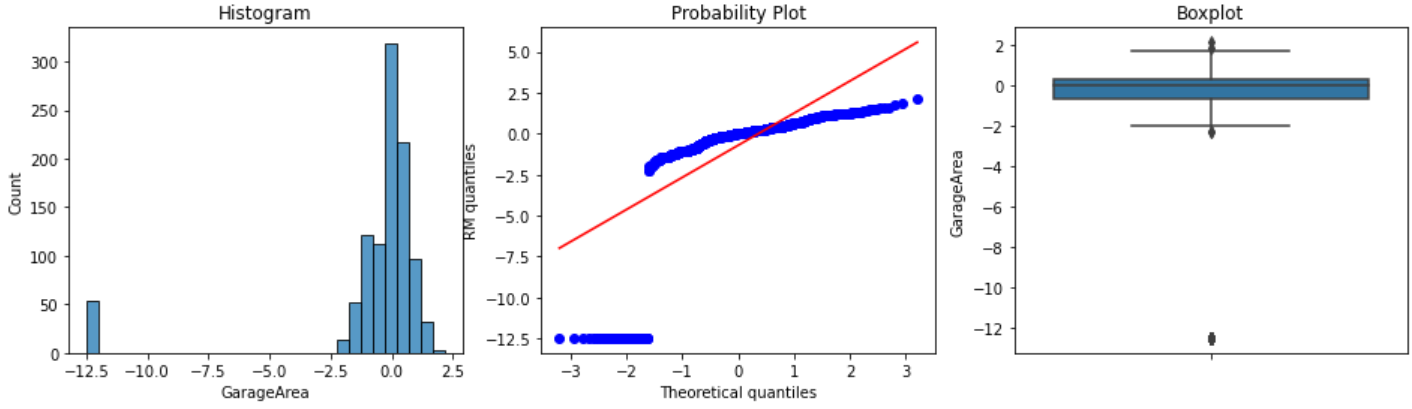
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Count
GarageArea
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
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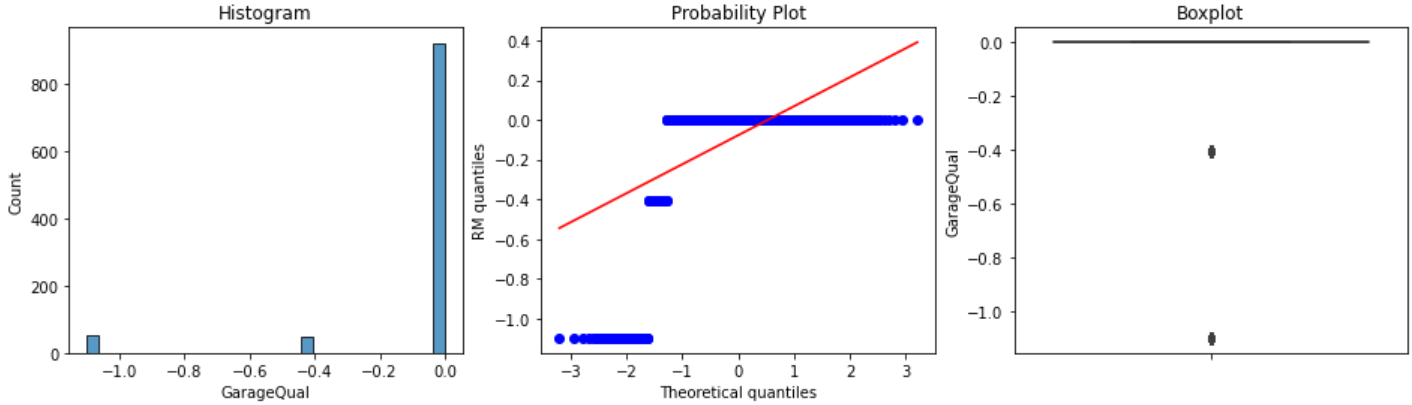
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Theoretical quantiles
Boxplot
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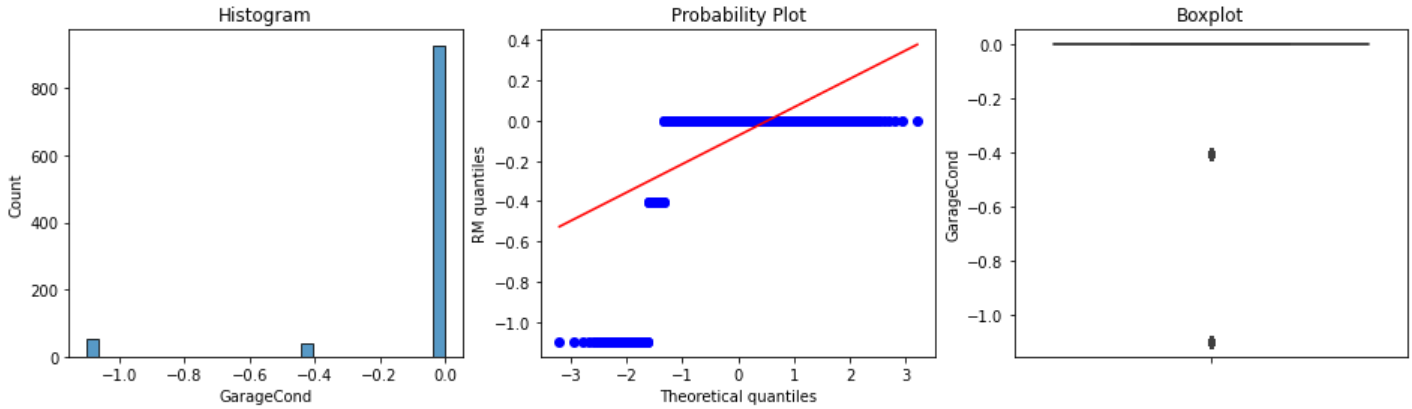
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Probability Plot
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Theoretical quantiles
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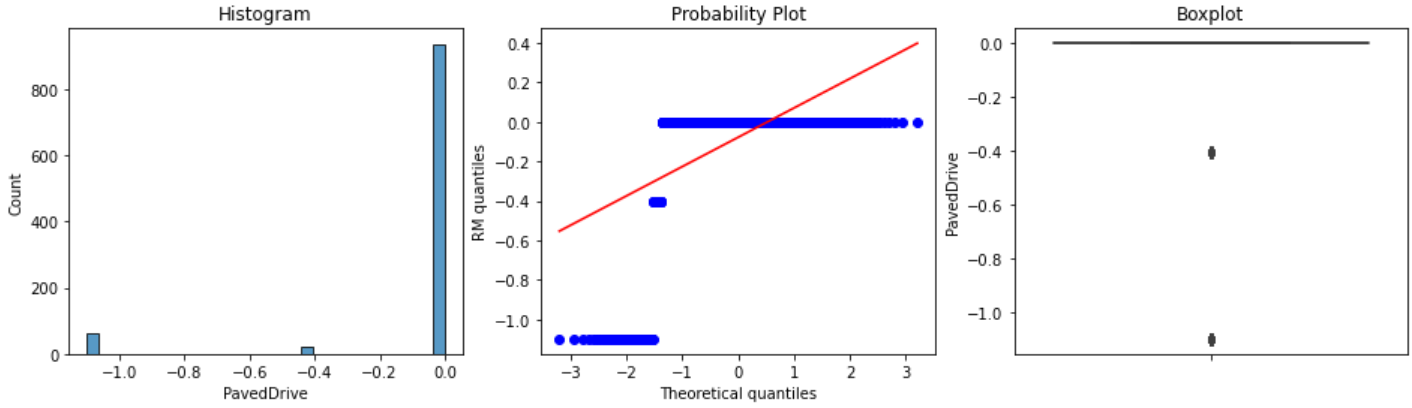
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Probability Plot
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Boxplot
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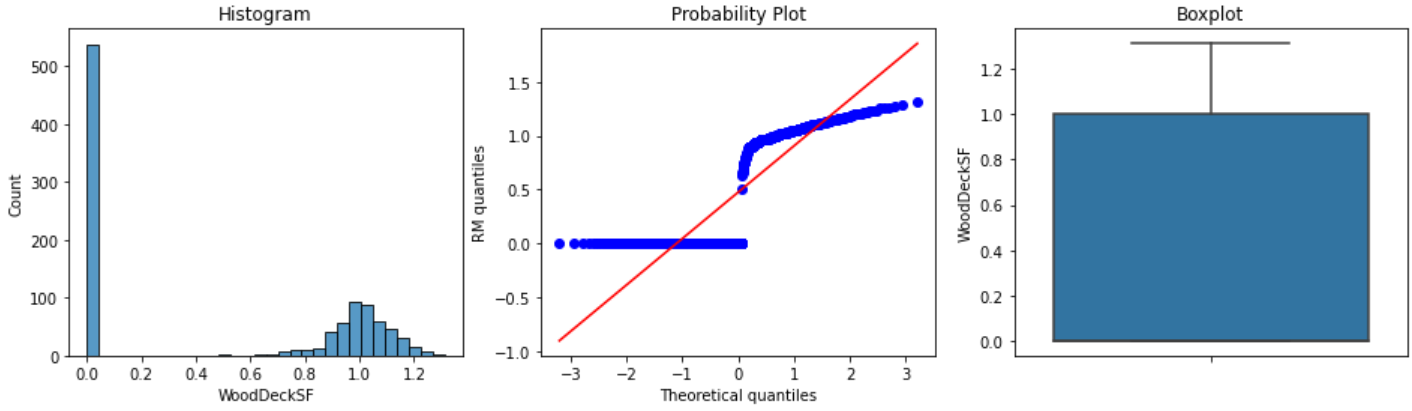
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Count
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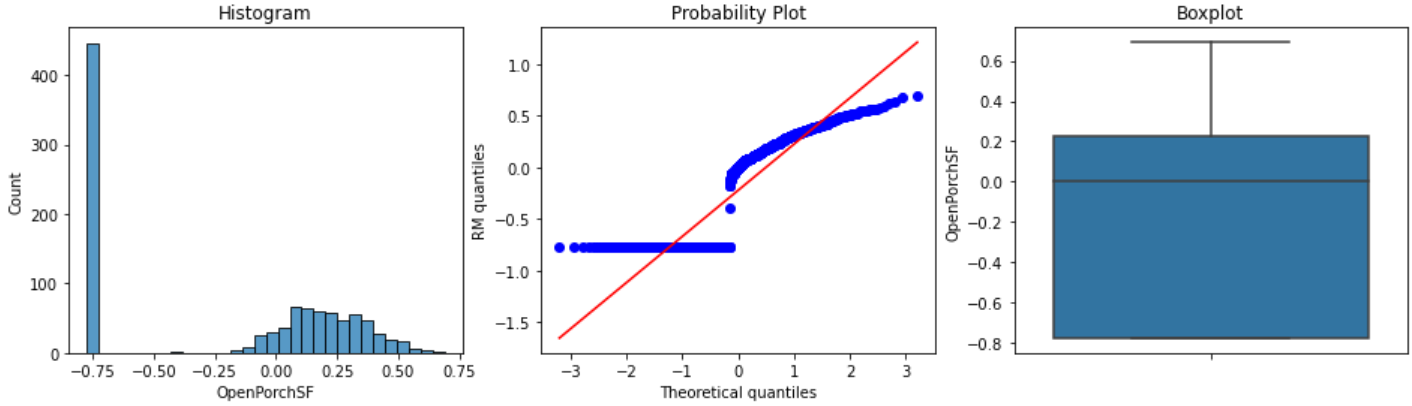
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
WoodDeckSF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Count
OpenPorchSF
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
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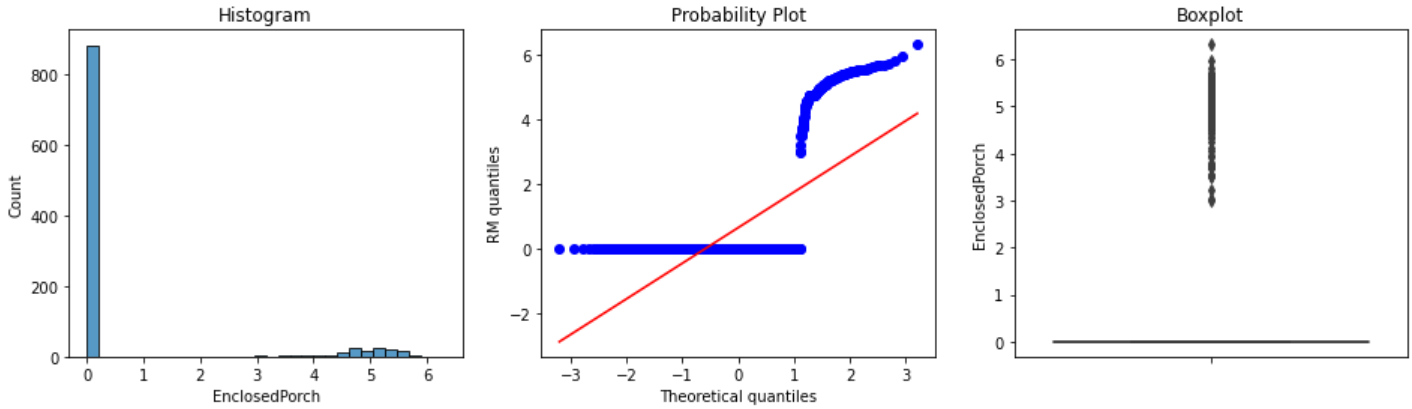
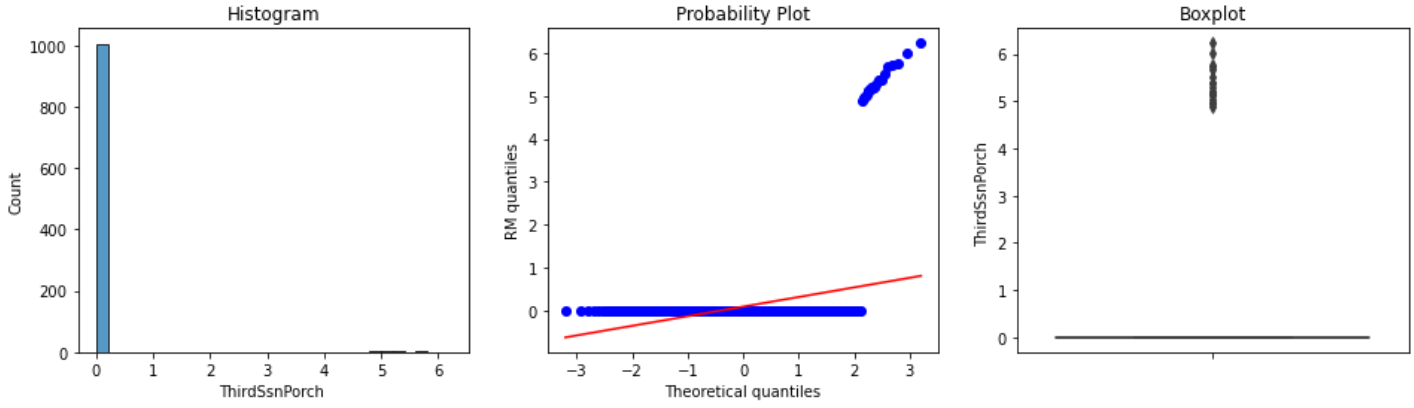

Histogram
Count
EnclosedPorch
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
EnclosedPorch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Count
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Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
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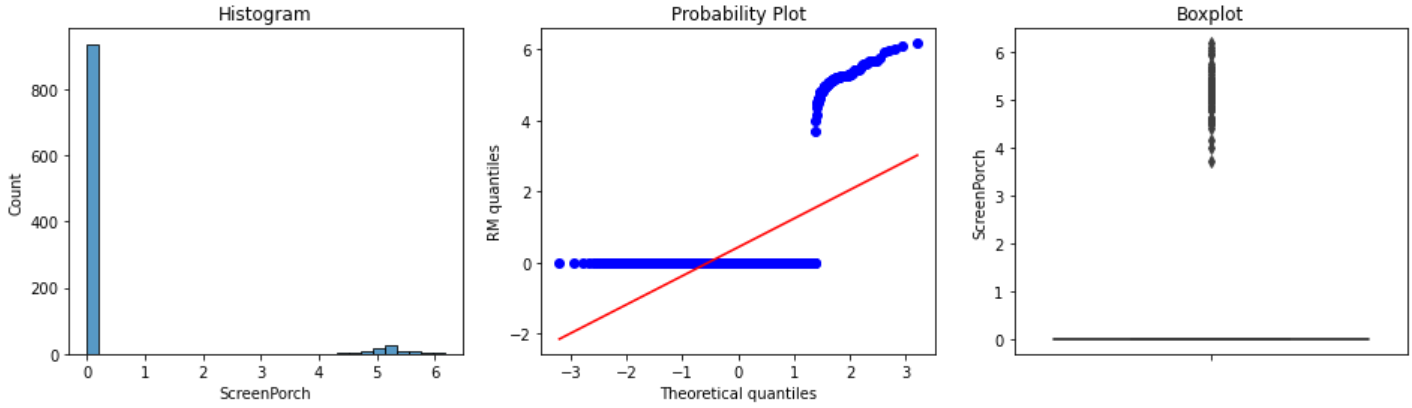
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Count
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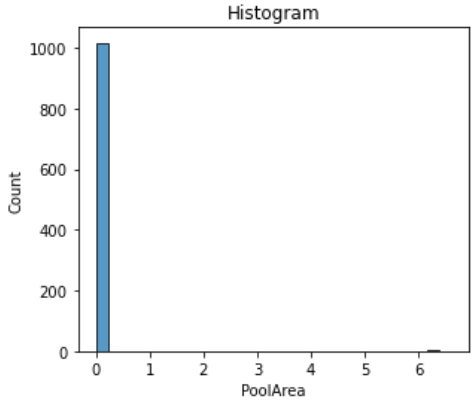
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
ScreenPorch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Count
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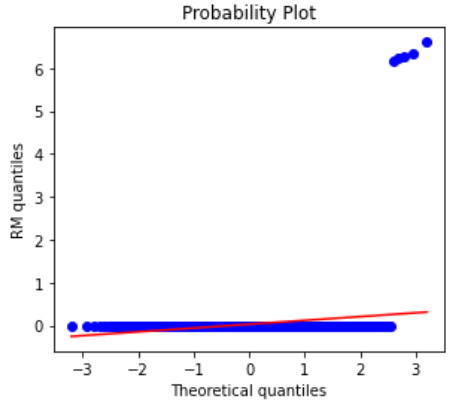
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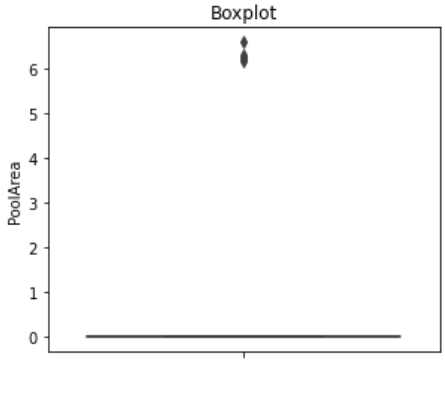
Theoretical quantiles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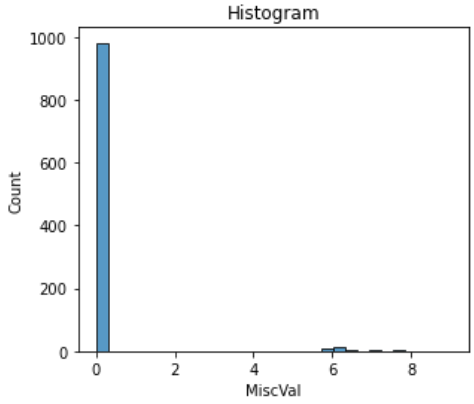
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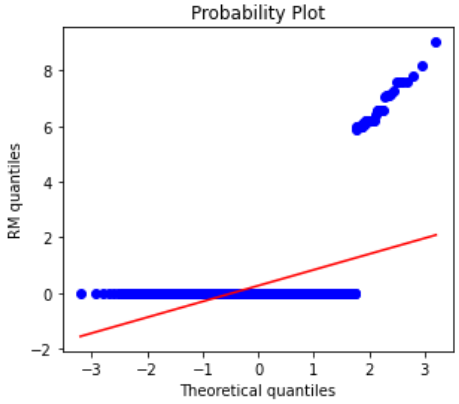
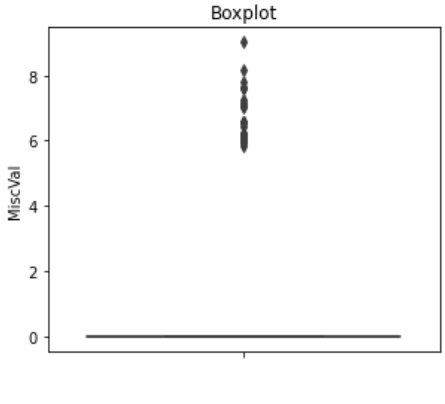

Probability Plot
RM quantiles
Theoretical quantiles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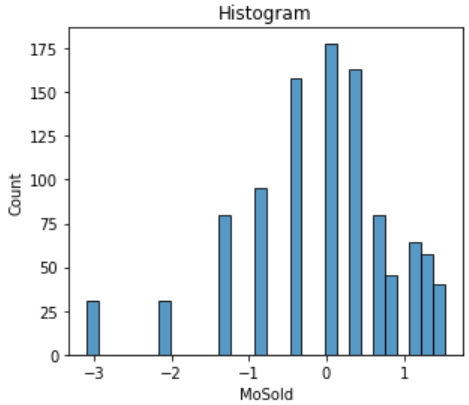
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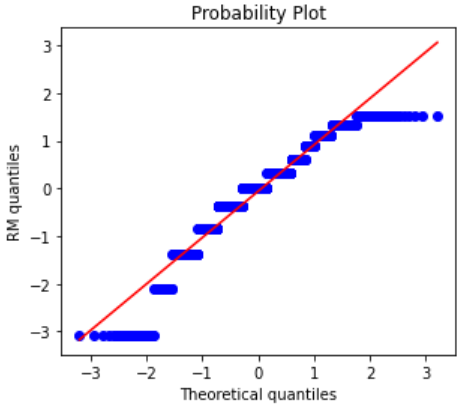
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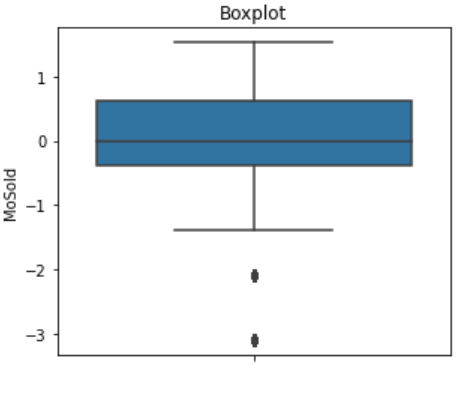
RM quantiles
Theoretical quantiles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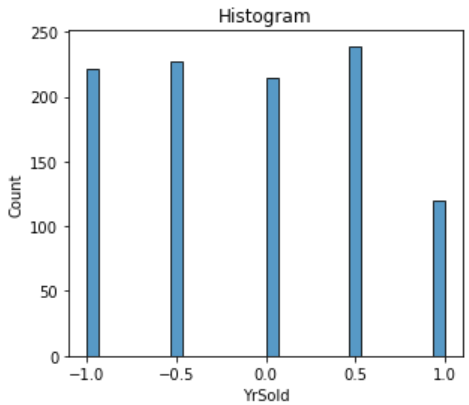
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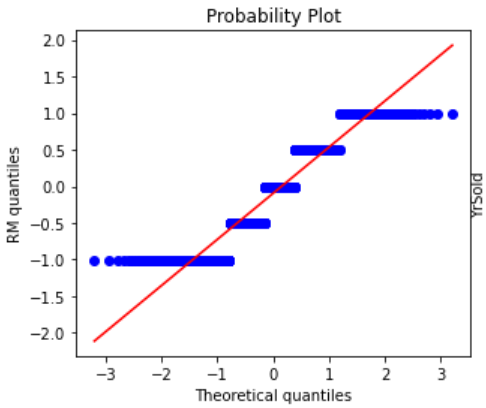
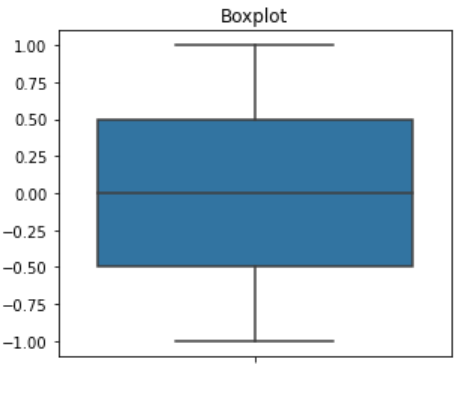

Probability Plot
RM quantiles
Theoretical quantiles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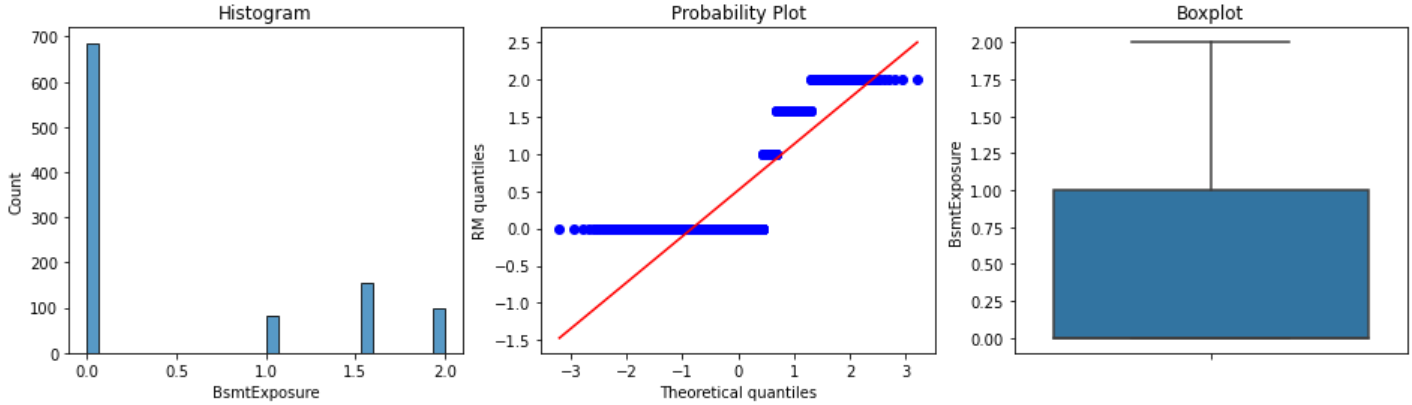
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Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
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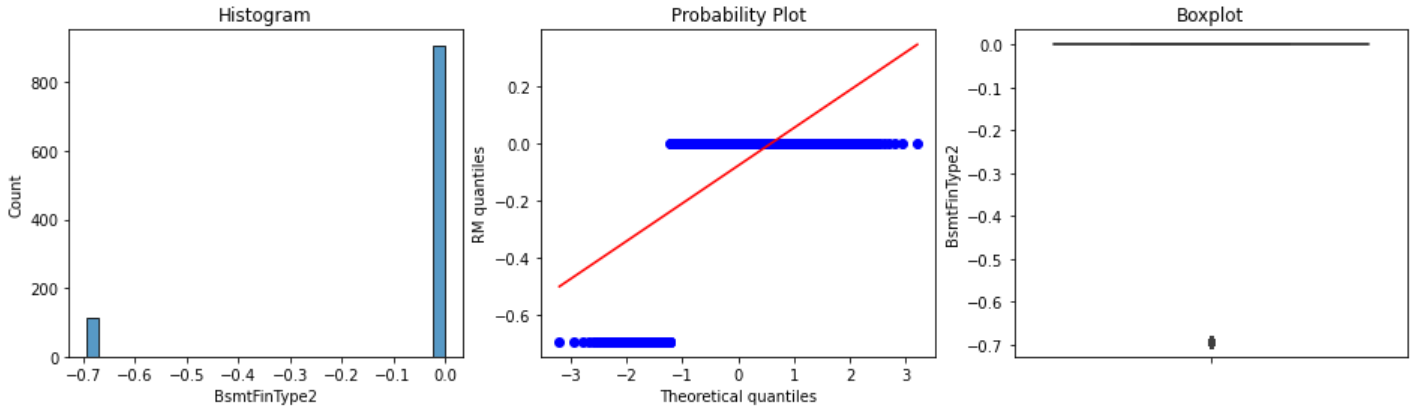
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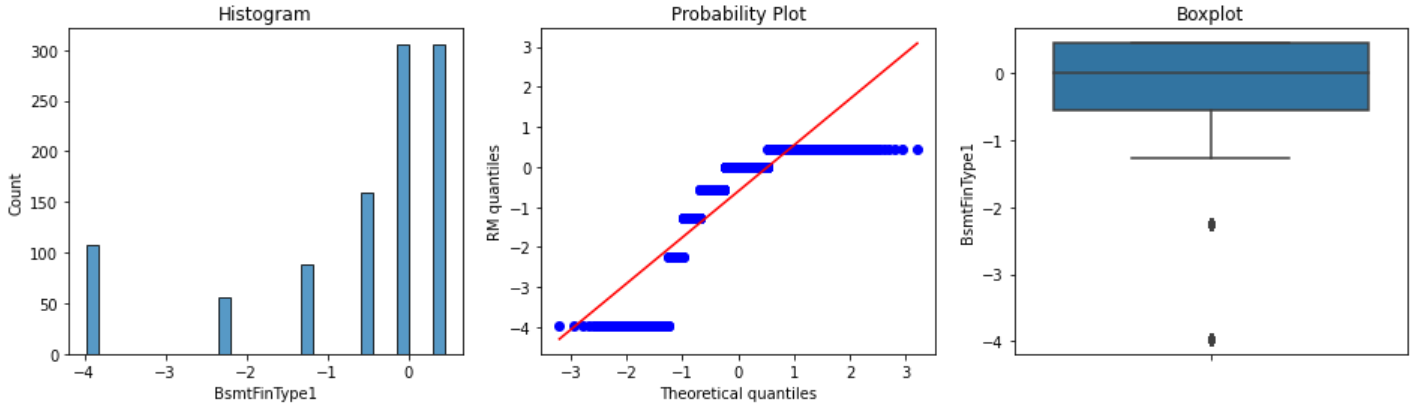
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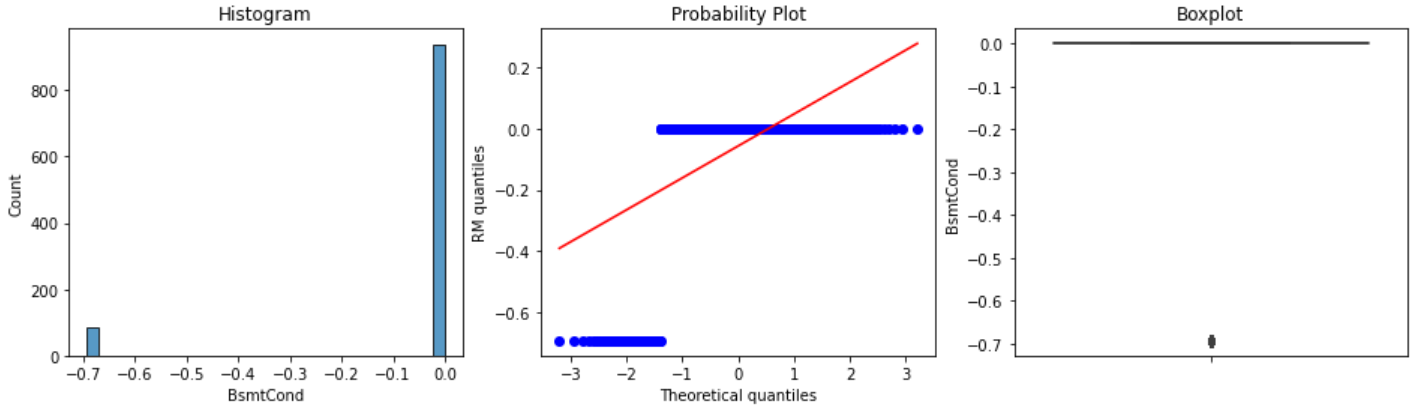
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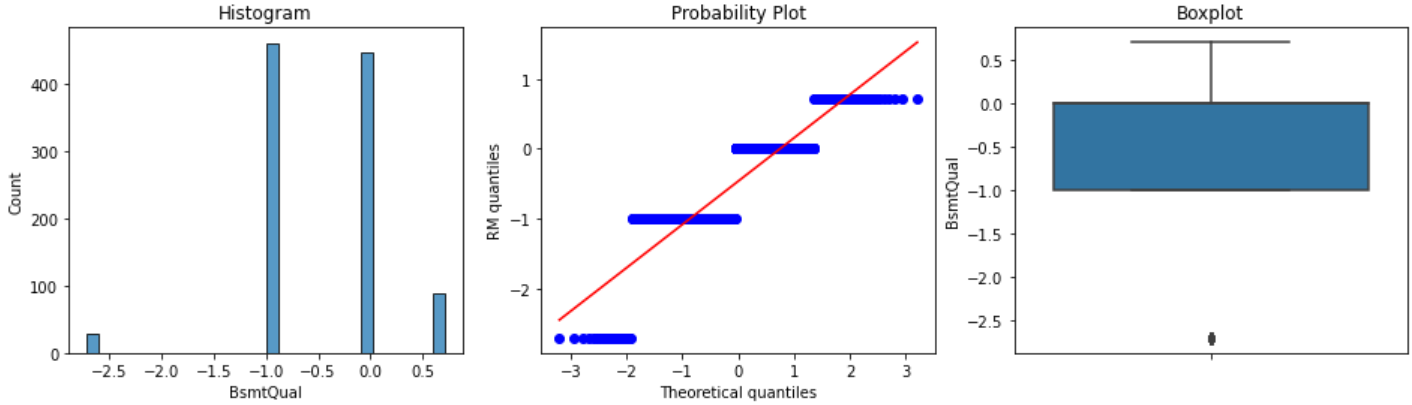
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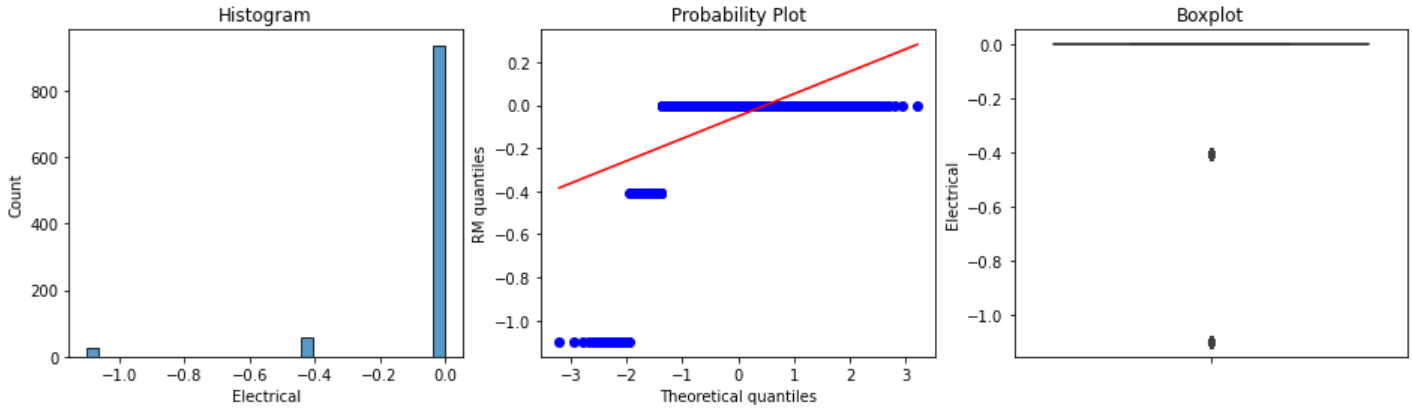
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Probability Plot
RM quantiles
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Boxplot
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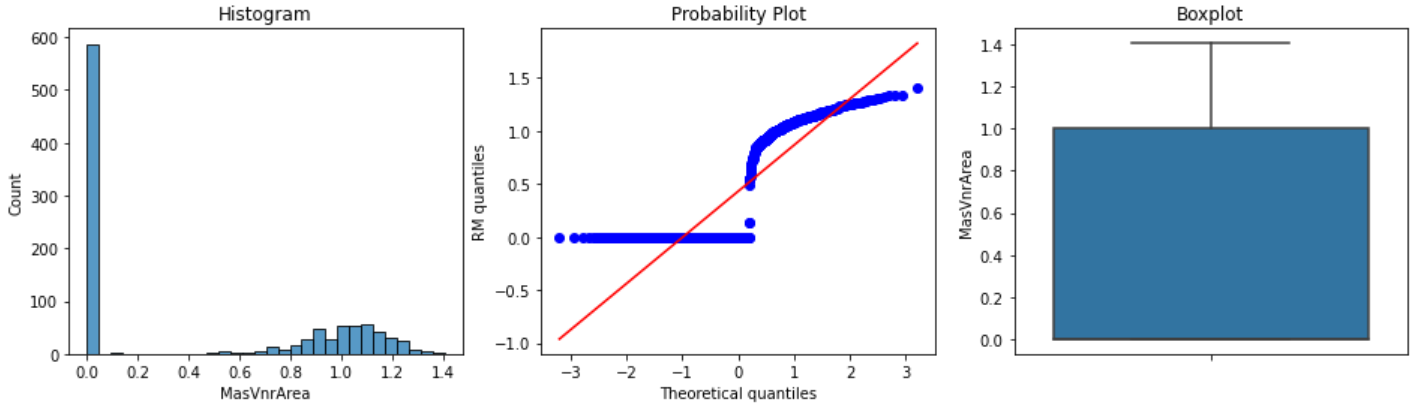
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Boxplot
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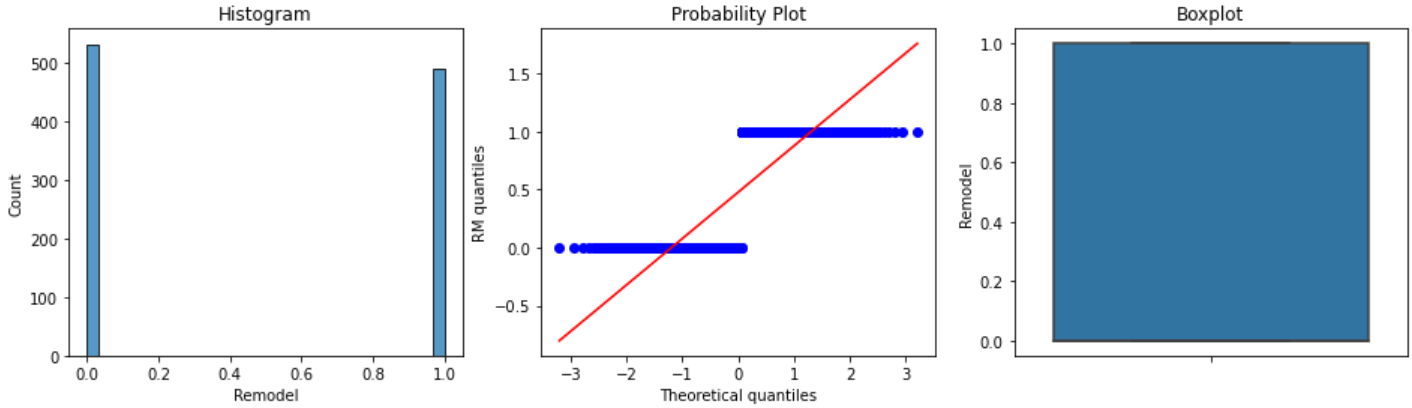
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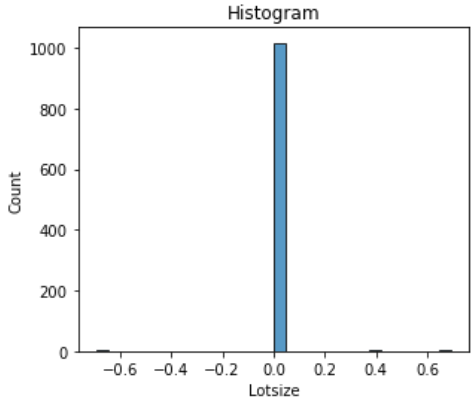
RM quantiles
Theoretical quantiles
Boxplot
Remodel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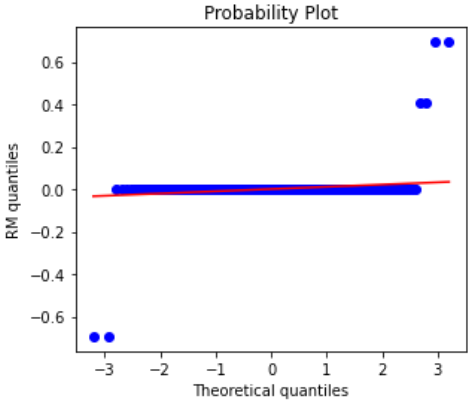
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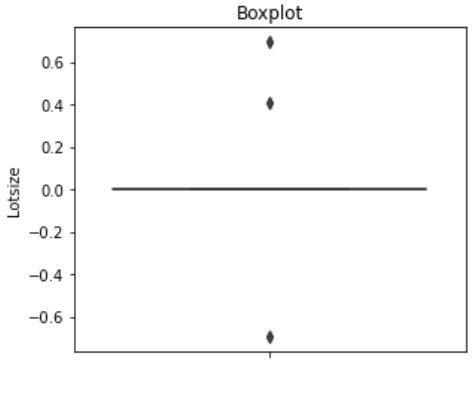
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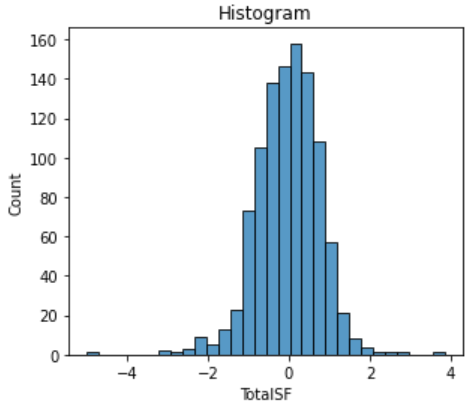
Lotsize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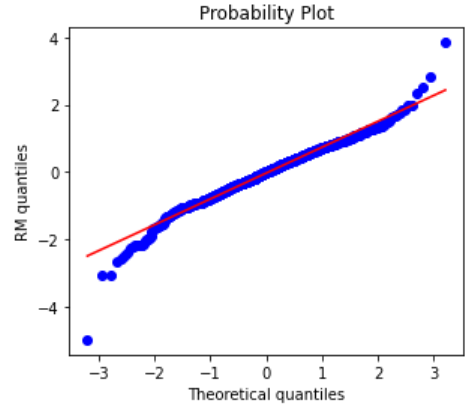
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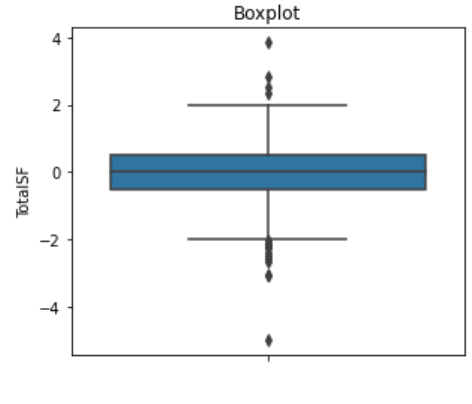
Theoretical quantiles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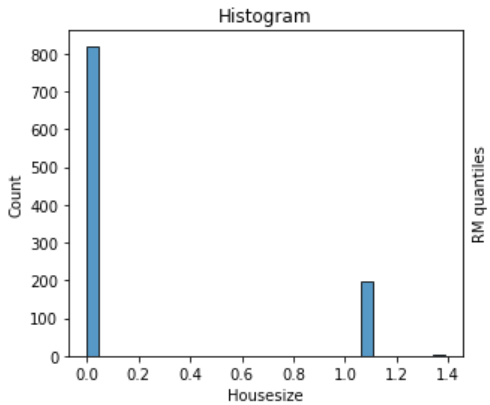
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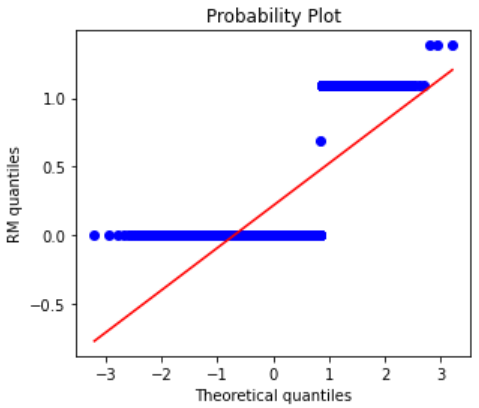
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RM quantiles
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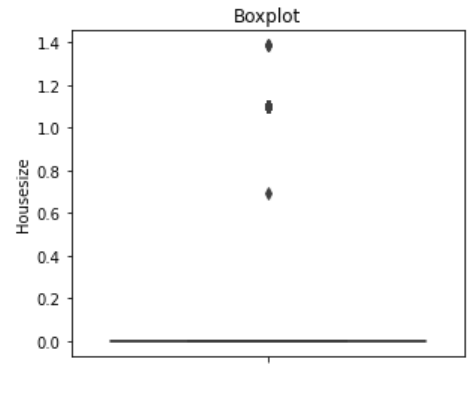
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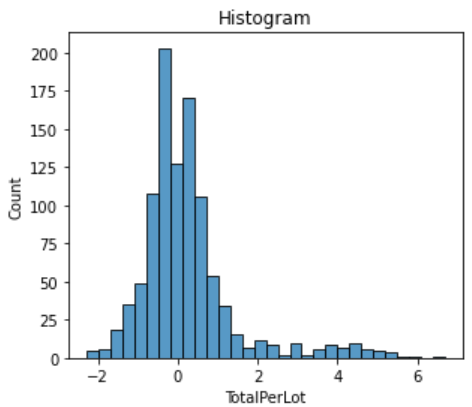
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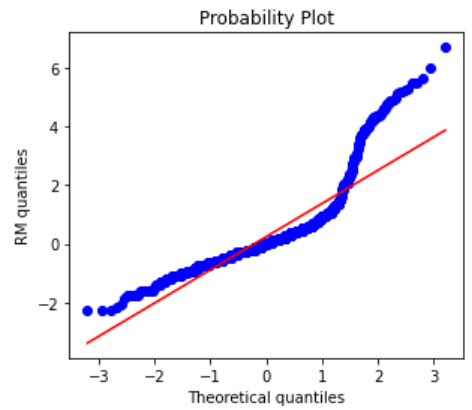
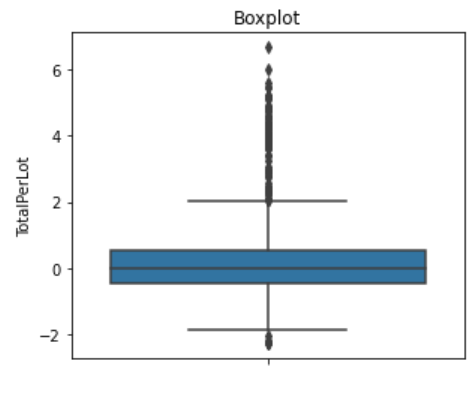
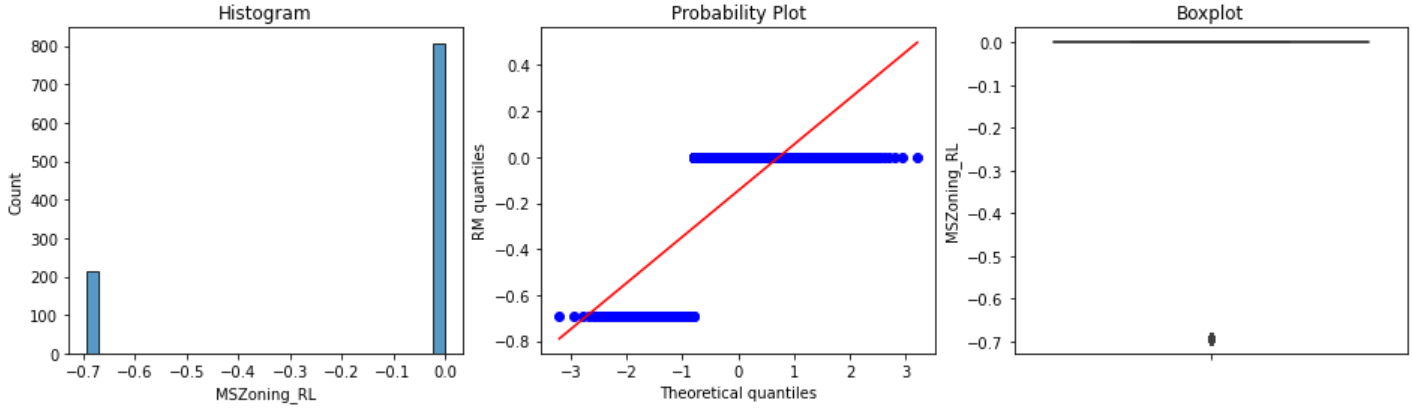
TotalPerLot


Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
TotalPerLot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Count
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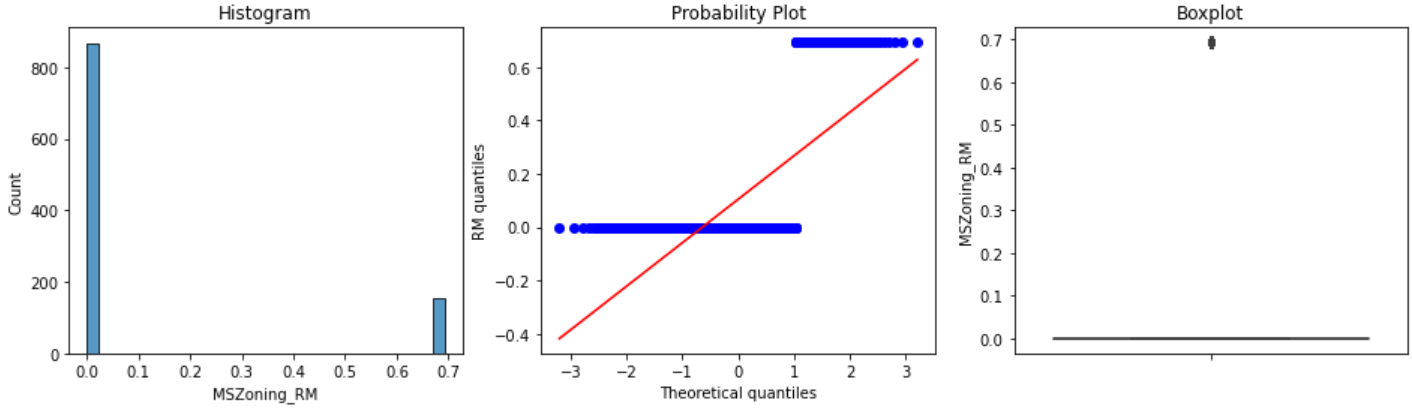
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MSZoning_RL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Count
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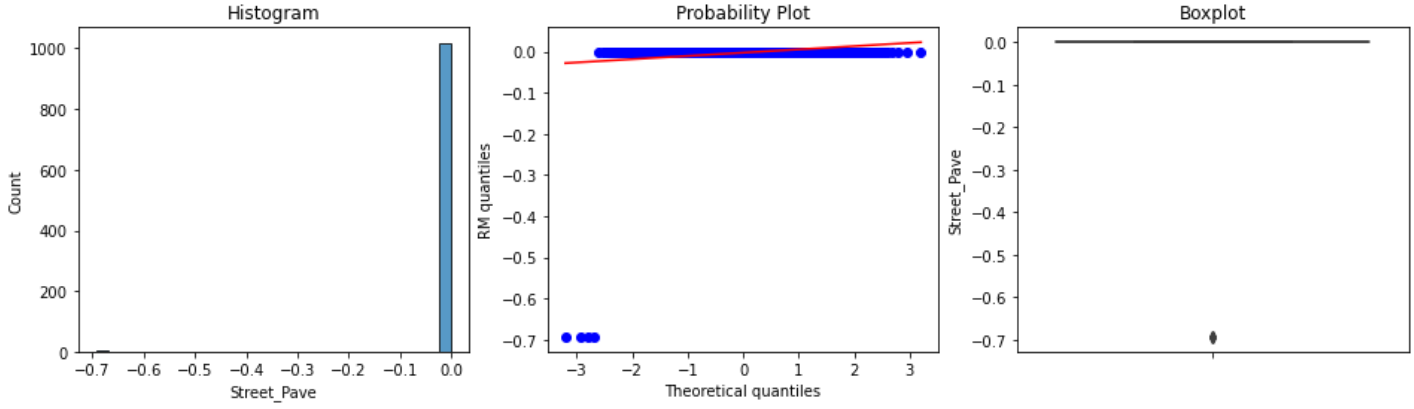
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MSZoning_RM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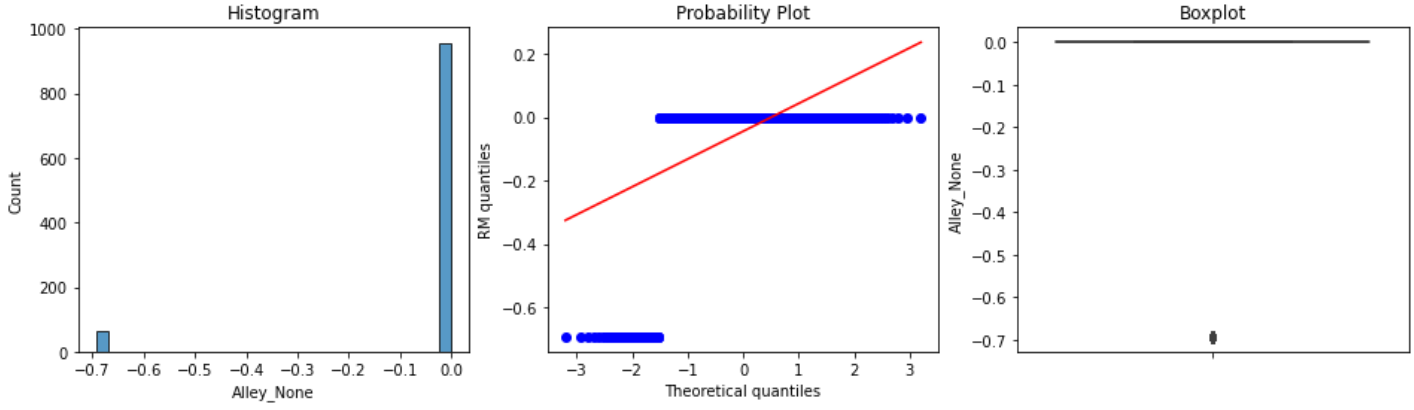
Street_Pave
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Street_Pave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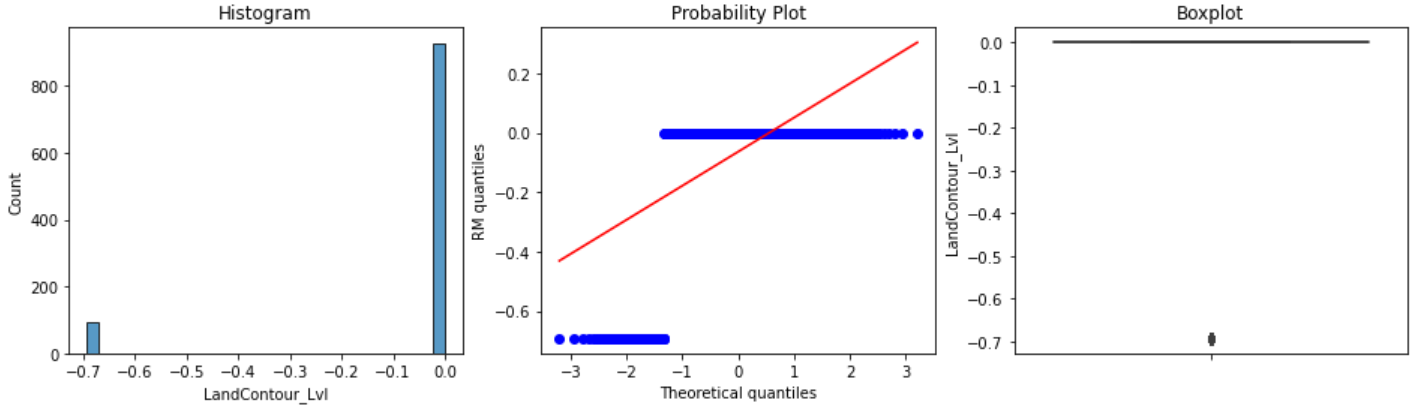
Count
Alley_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Alley_None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Count
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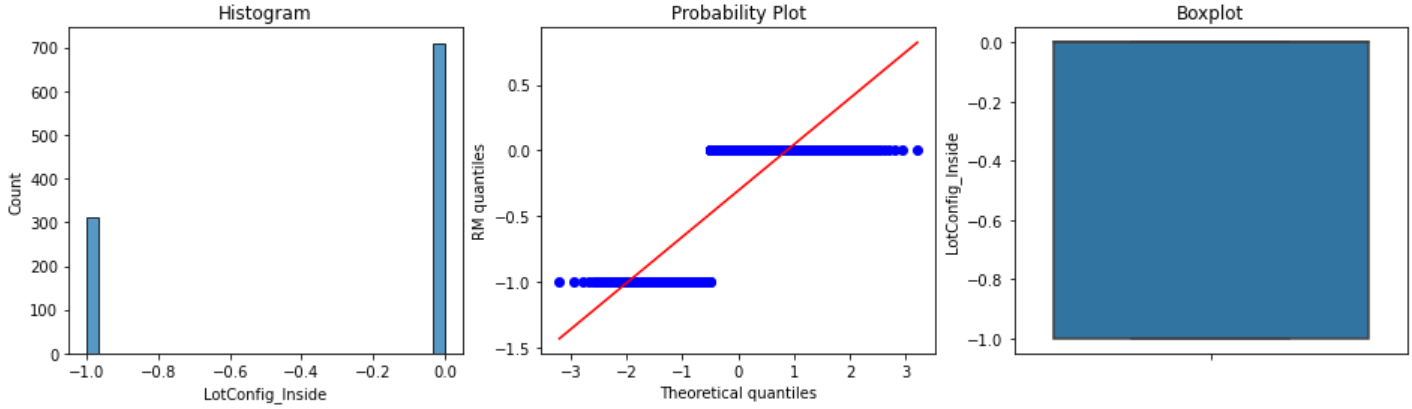
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
LandContour_Lvl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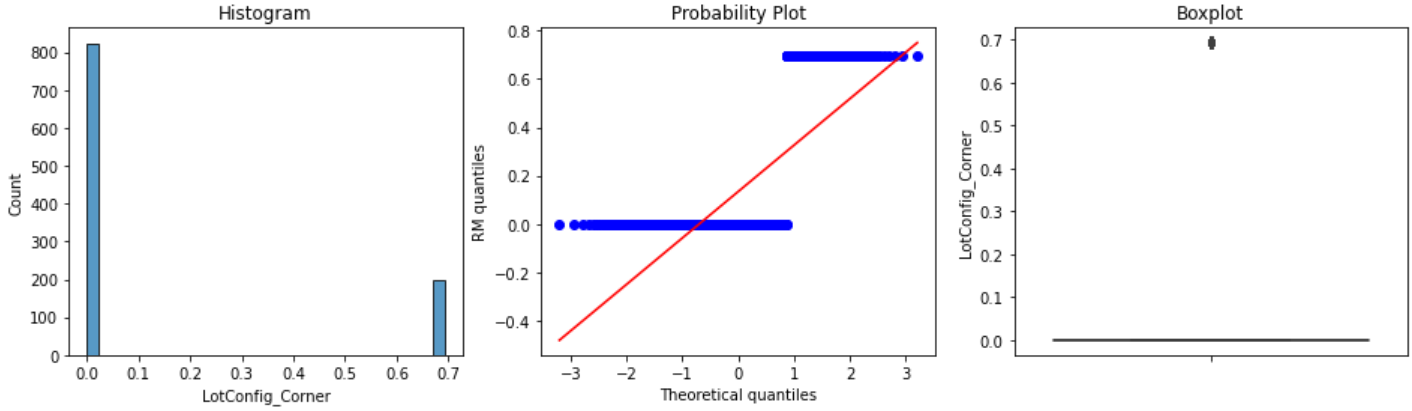
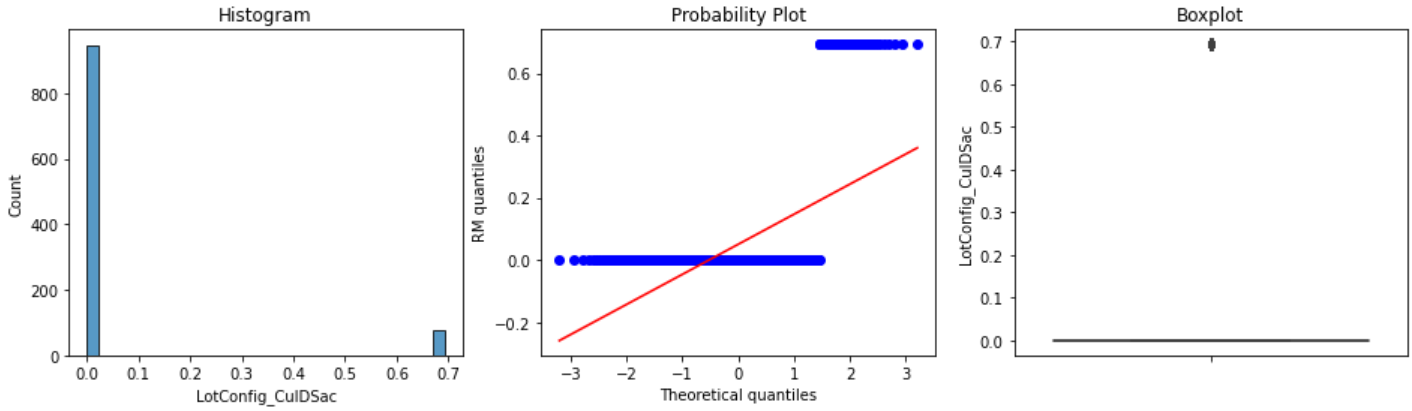
Count
LotConfig_Inside
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
LotConfig_Inside


Histogram
Count
LotConfig_Corner
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
LotConfig_Corner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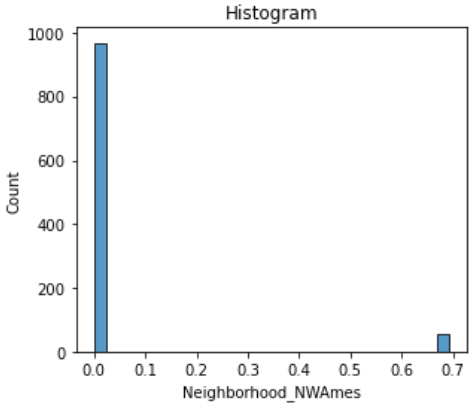
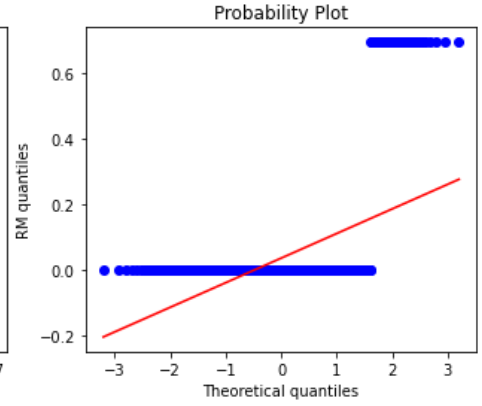
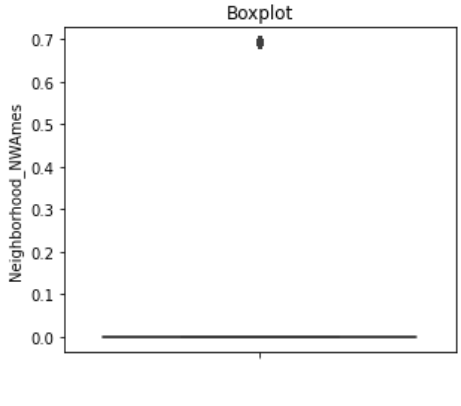
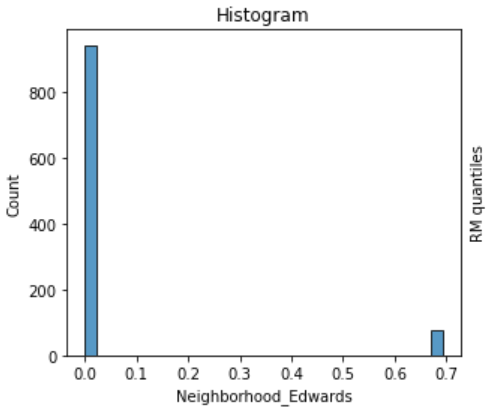
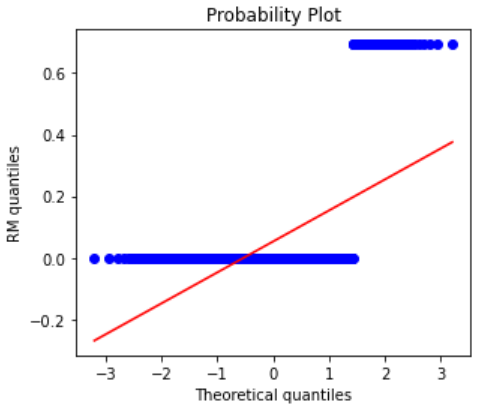
Count
LotConfig_CulDSac
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
LotConfig_CulDSac

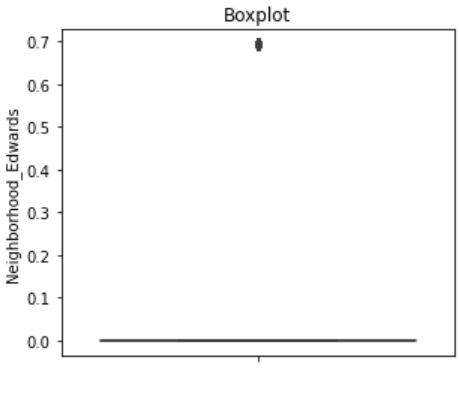

Histogram
Count
Neighborhood_NWAmes

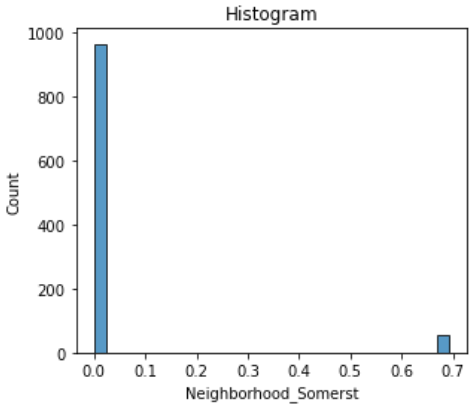

Probability Plot
RM quantiles
Theoretical quantiles

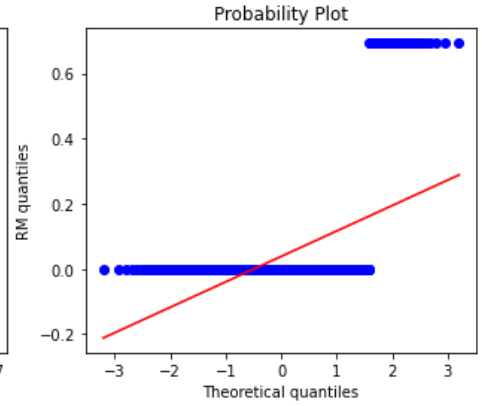

Boxplot
Neighborhood_NWAmes

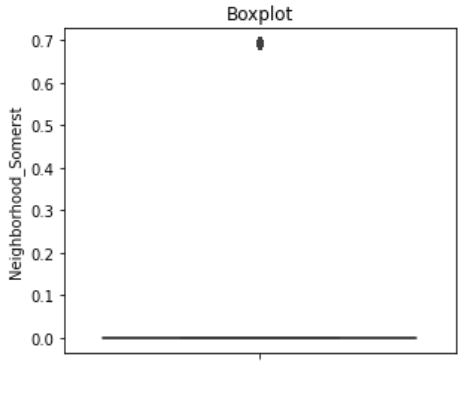

Histogram
Count
Neighborhood_Edwards

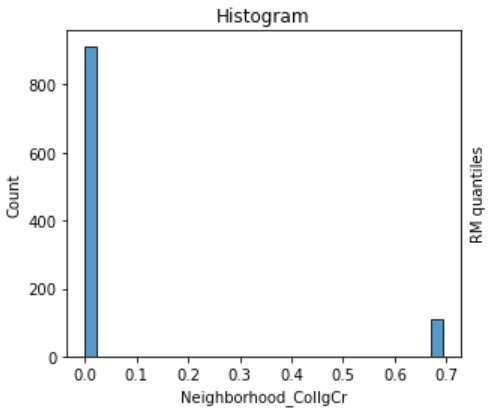

Probability Plot
RM quantiles
Theoretical quantiles

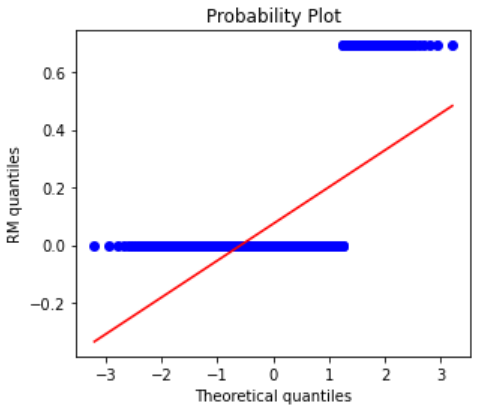

Boxplot
Neighborhood_Edwards

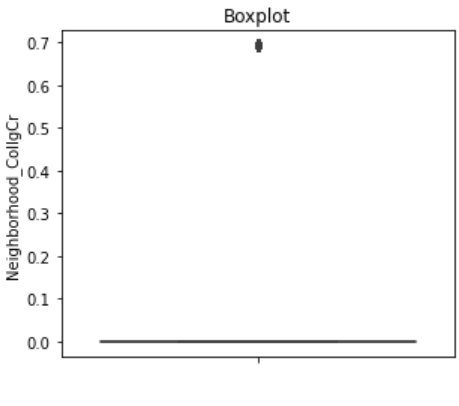

Histogram
Count
Neighborhood_Somerst

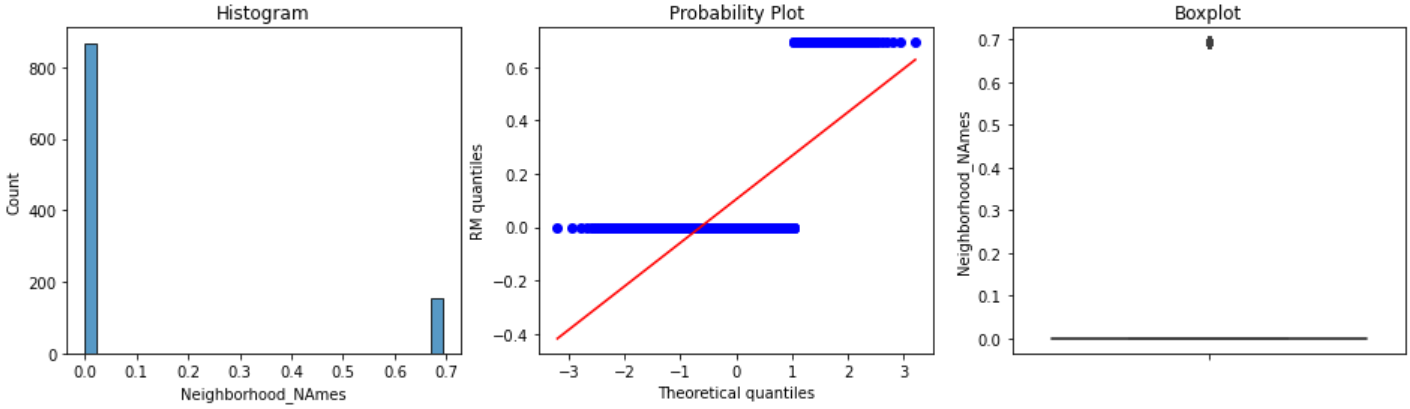

Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
Neighborhood_Somerst


Histogram
Count
Neighborhood_CollgCr


Probability Plot
RM quantiles
Theoretical quantiles


Boxplot
Neighborhood_CollgCr


Histogram
Count
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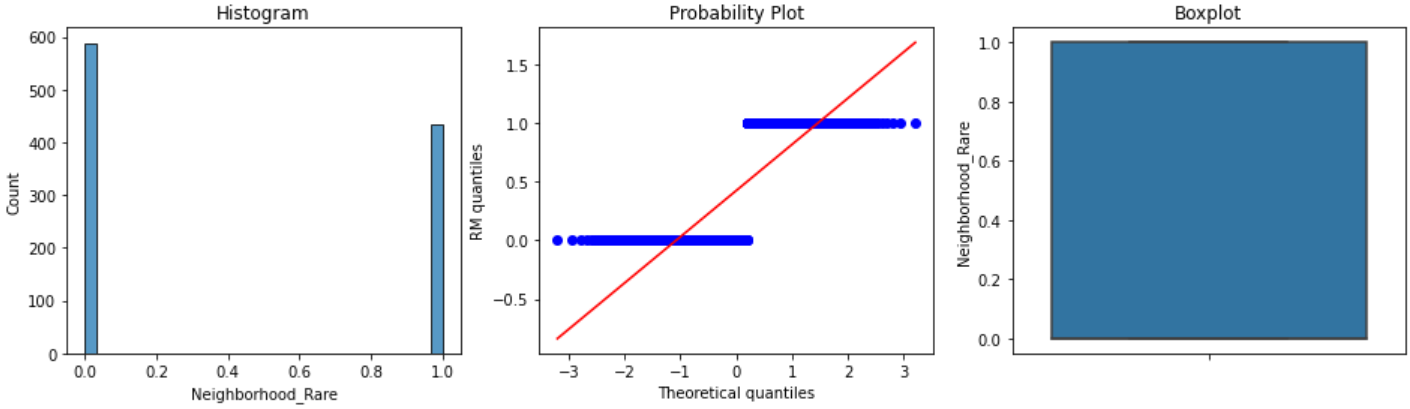
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Neighborhood_NAmes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Count
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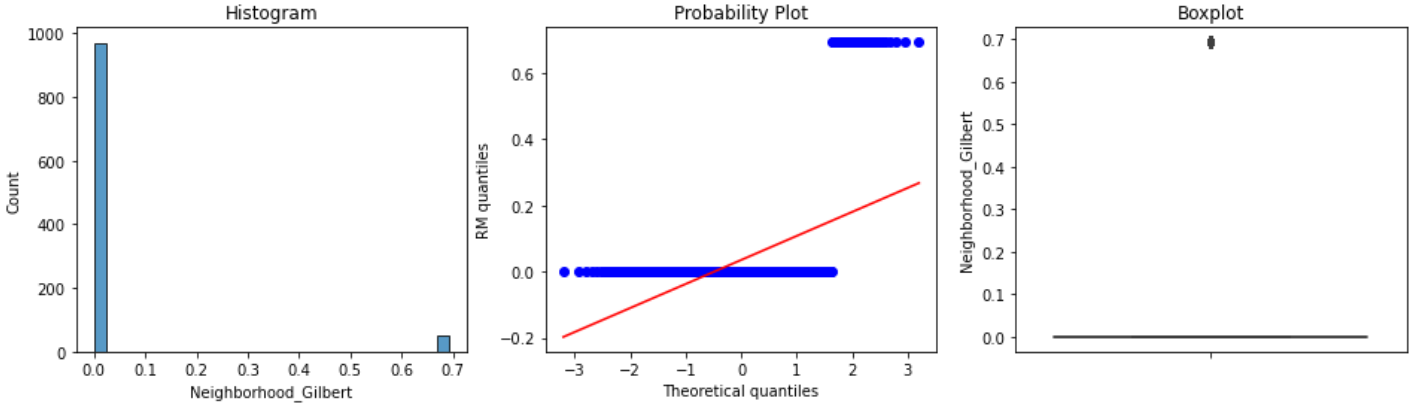
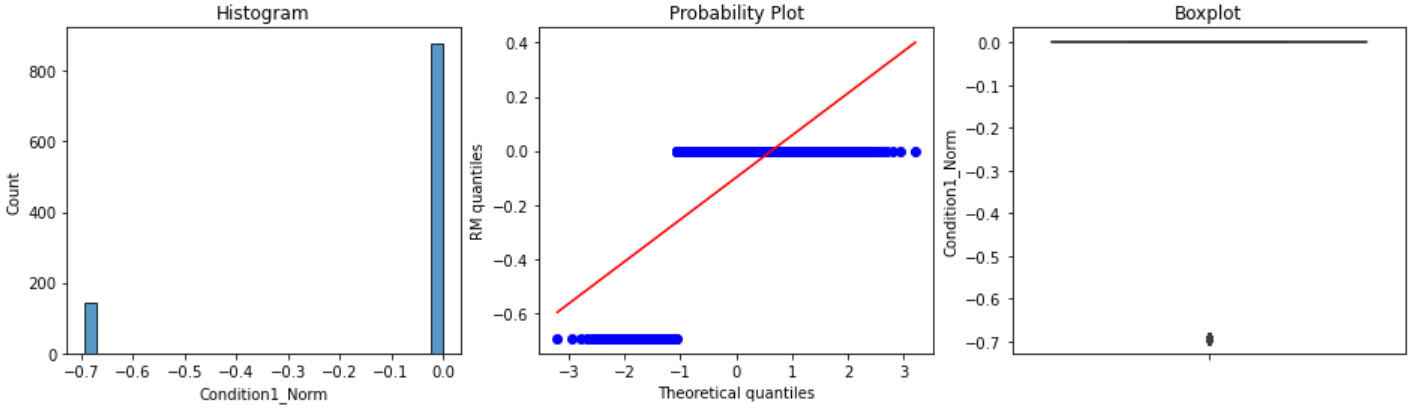
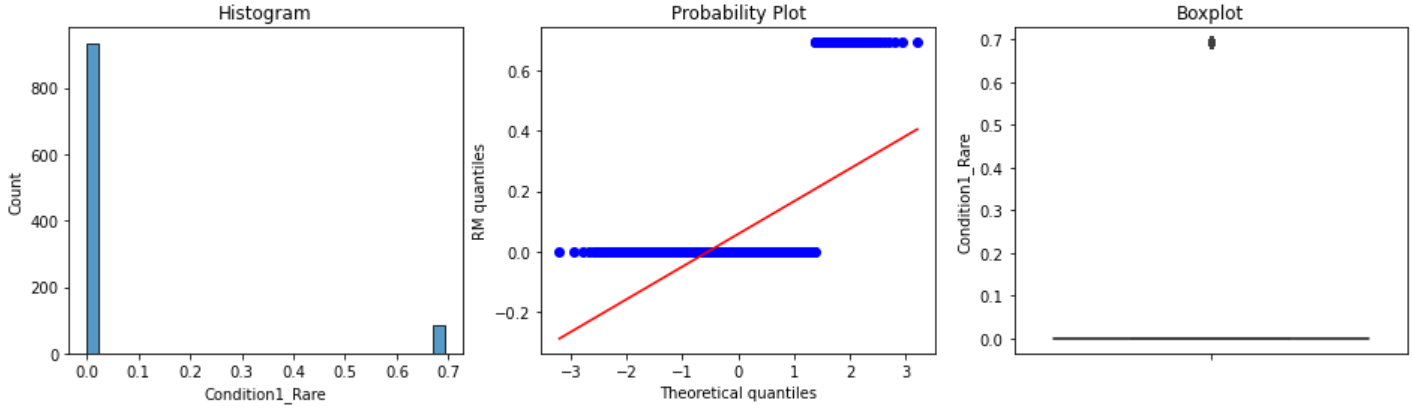
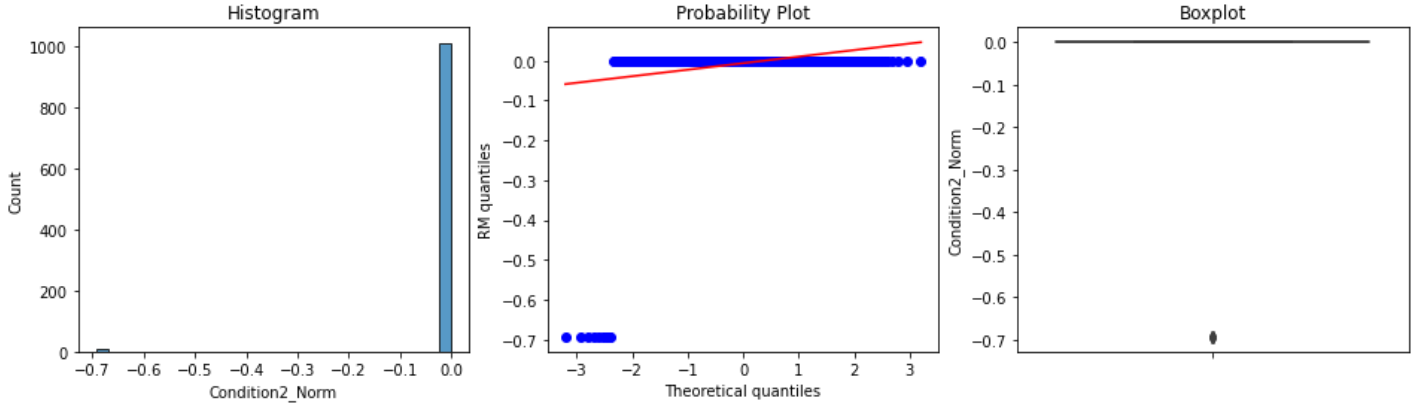
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Neighborhood_Rare


Histogram
Count
Neighborhood_Gilbert
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Neighborhood_Gilbert


Histogram
Count
Condition1_Norm
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Condition1_Norm


Histogram
Count
Condition1_Rare
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Condition1_Rare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Count
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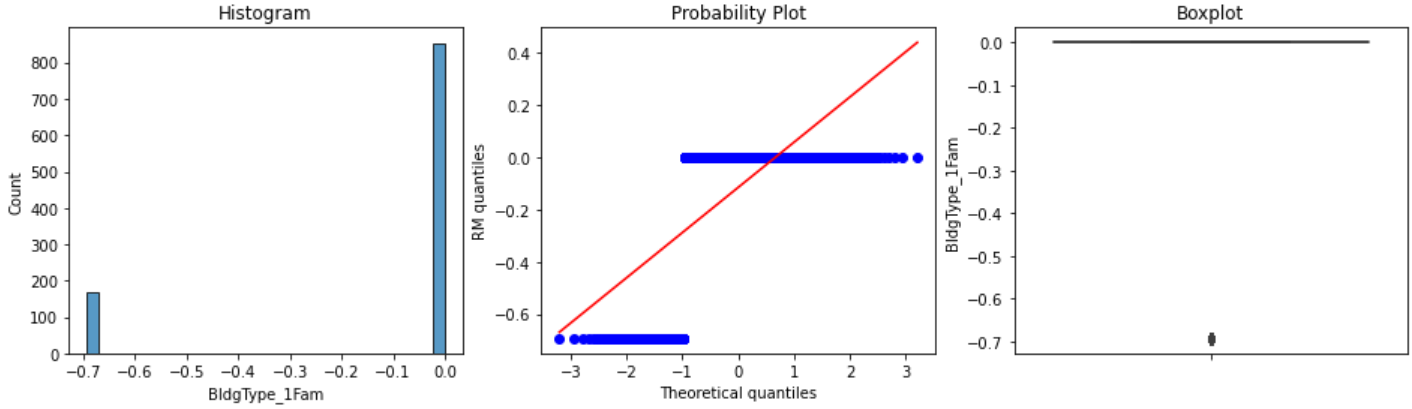
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Condition2_Norm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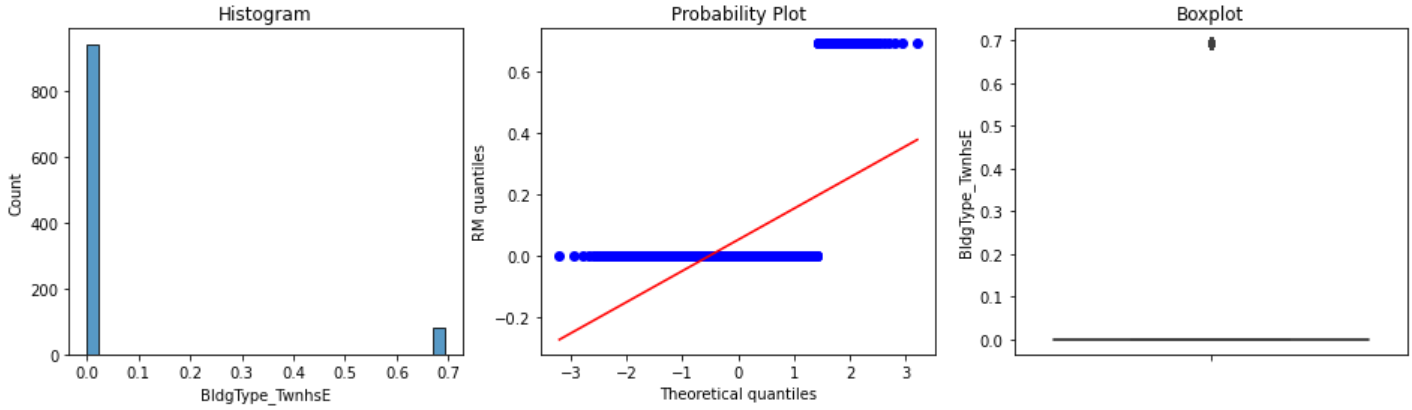
Count
BldgType_1Fam
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
BldgType_1Fam


Histogram
Count
BldgType_TwnhsE
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
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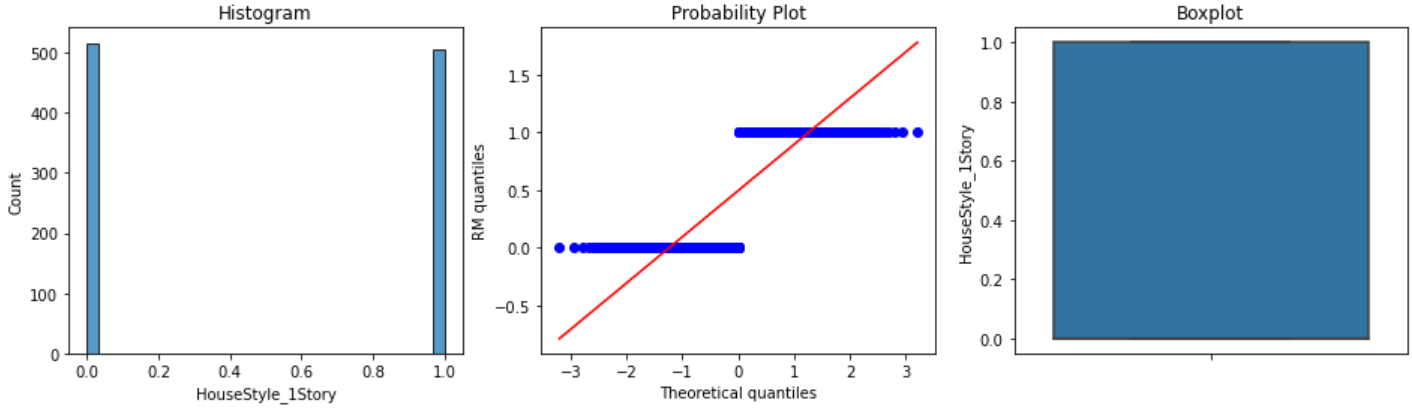
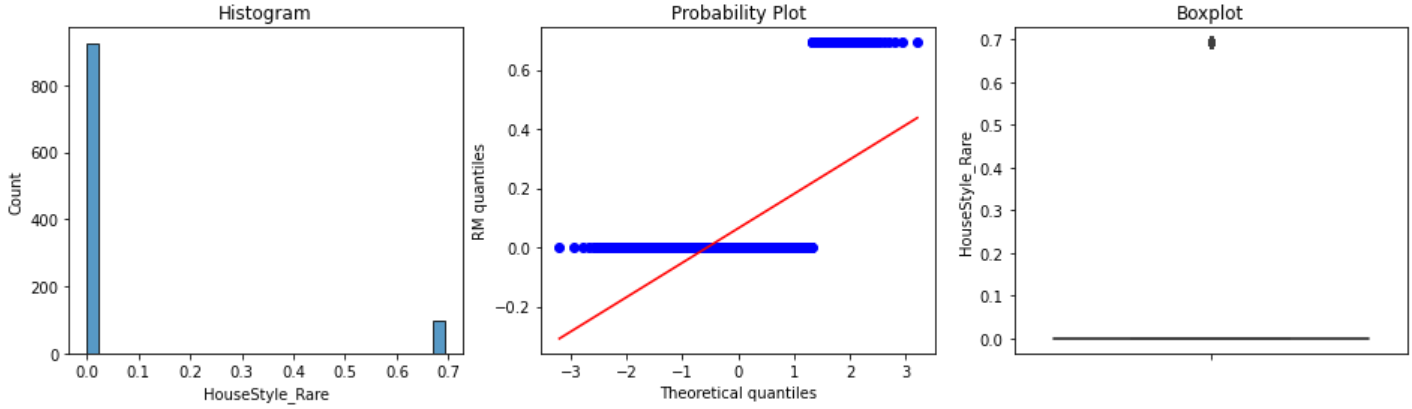

Histogram
Count
HouseStyle_1Story
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
HouseStyle_1Story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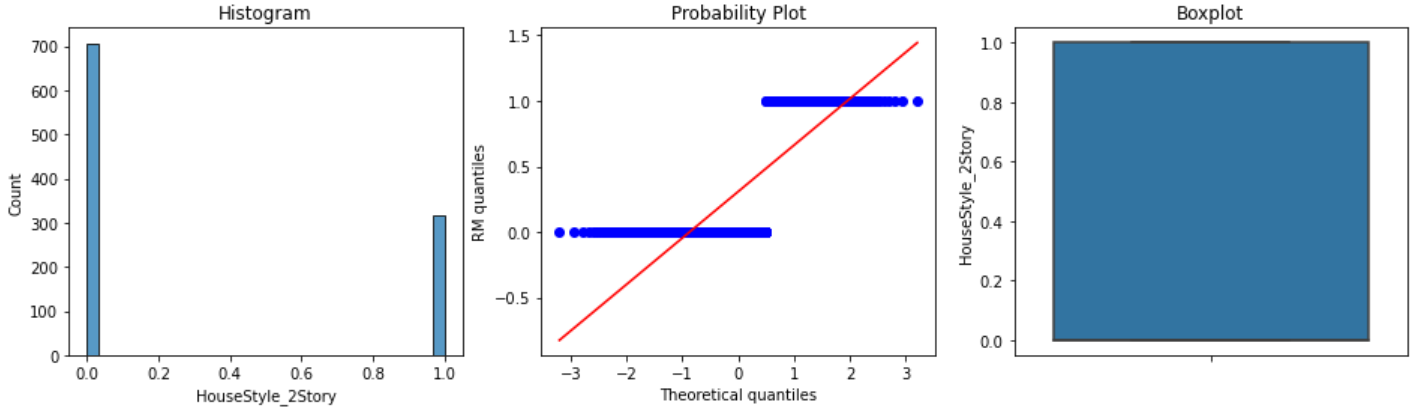
Count
HouseStyle_Rare
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
HouseStyle_Rare


Histogram
Count
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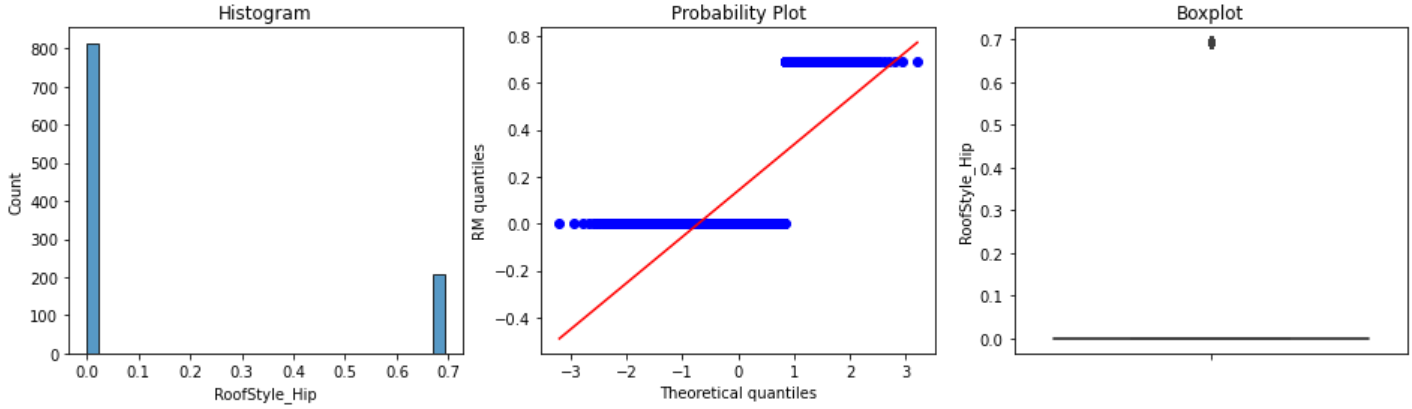
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
HouseStyle_2Story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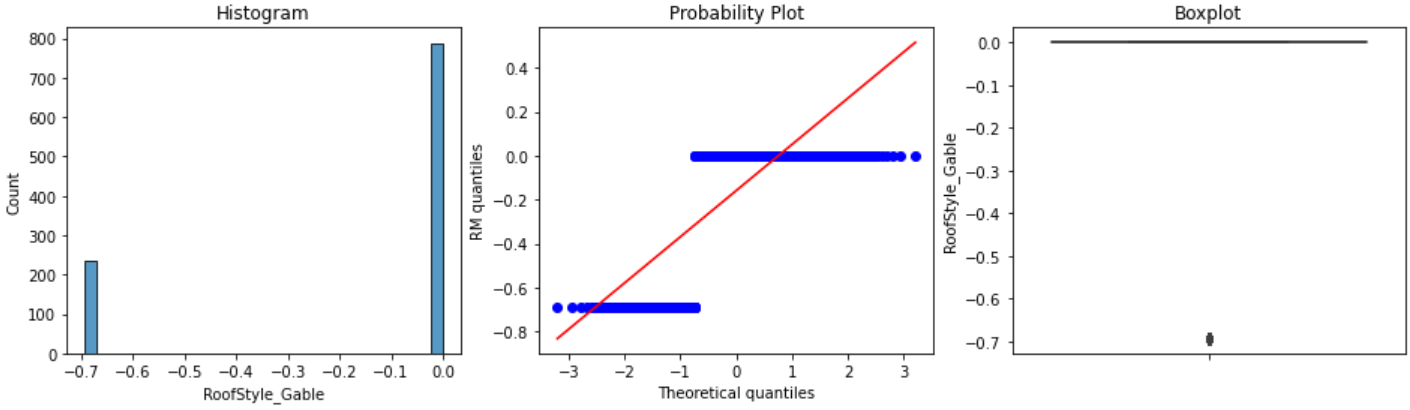
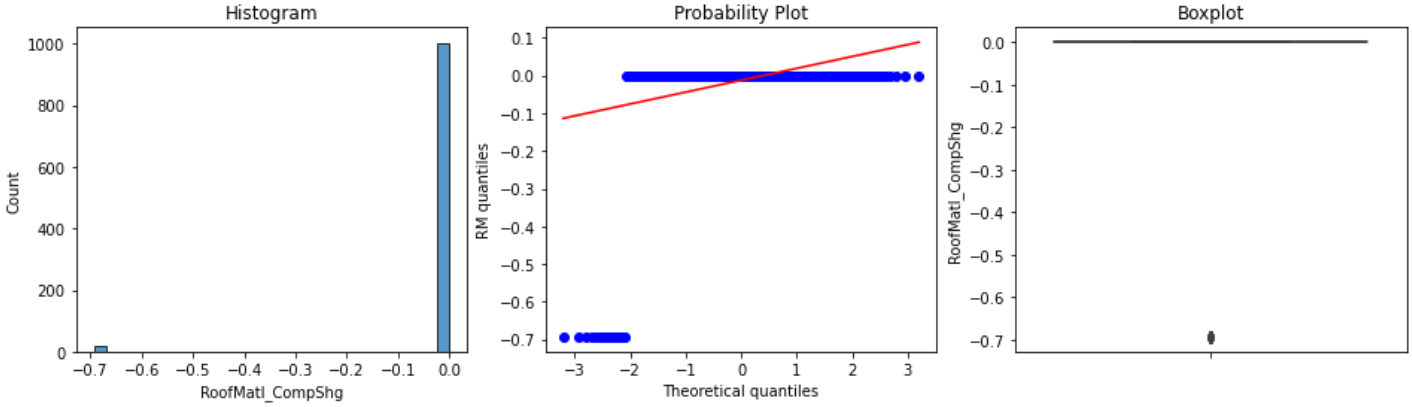
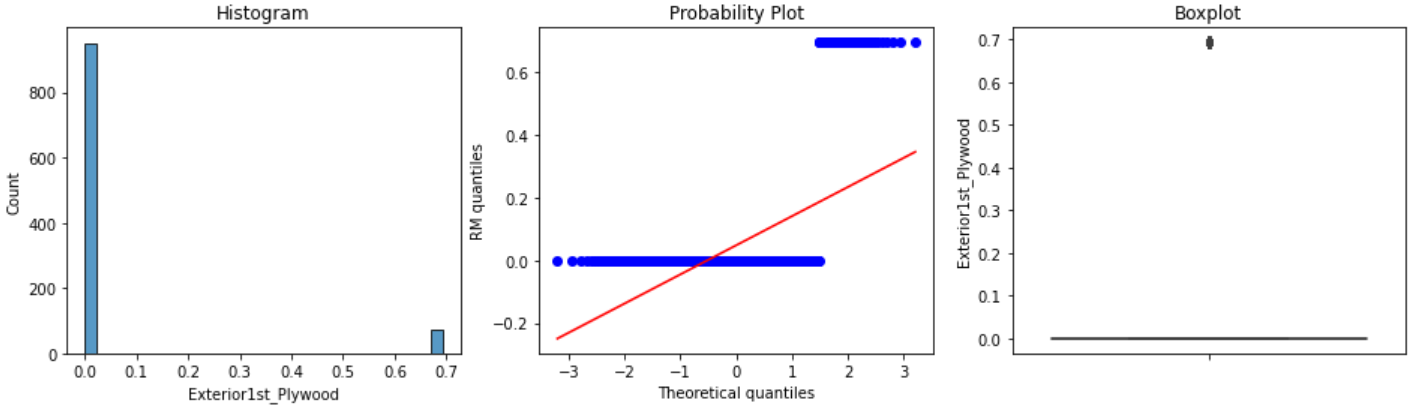
Count
RoofStyle_Hip
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
RoofStyle_Hip


Histogram
Count
RoofStyle_Gable
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
RoofStyle_Gable


Histogram
Count
RoofMatl_CompShg
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
RoofMatl_CompShg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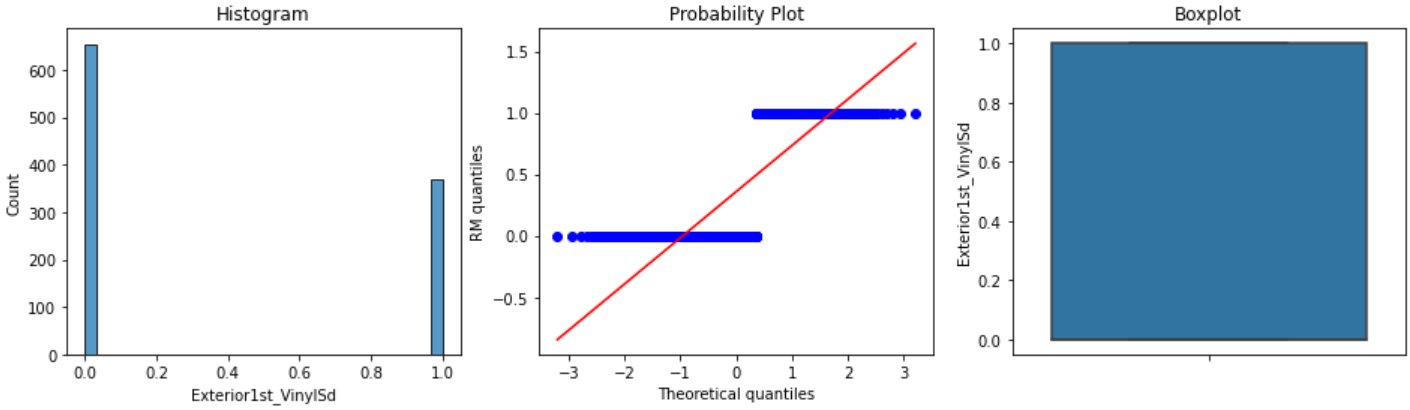
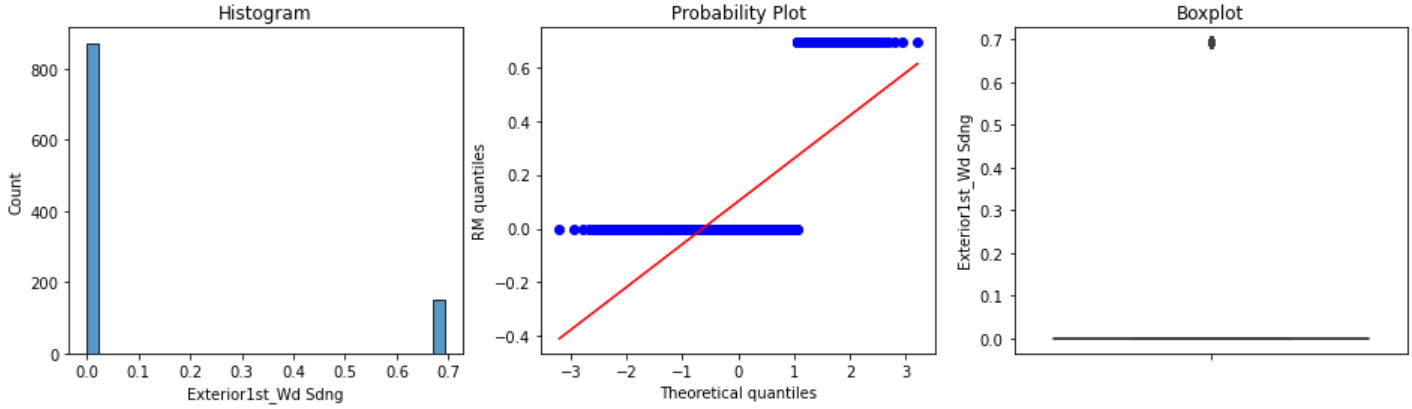
Count
Exterior1st_Plywood
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior1st_Plywood


Histogram
Count
Exterior1st_VinylSd
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior1st_VinylSd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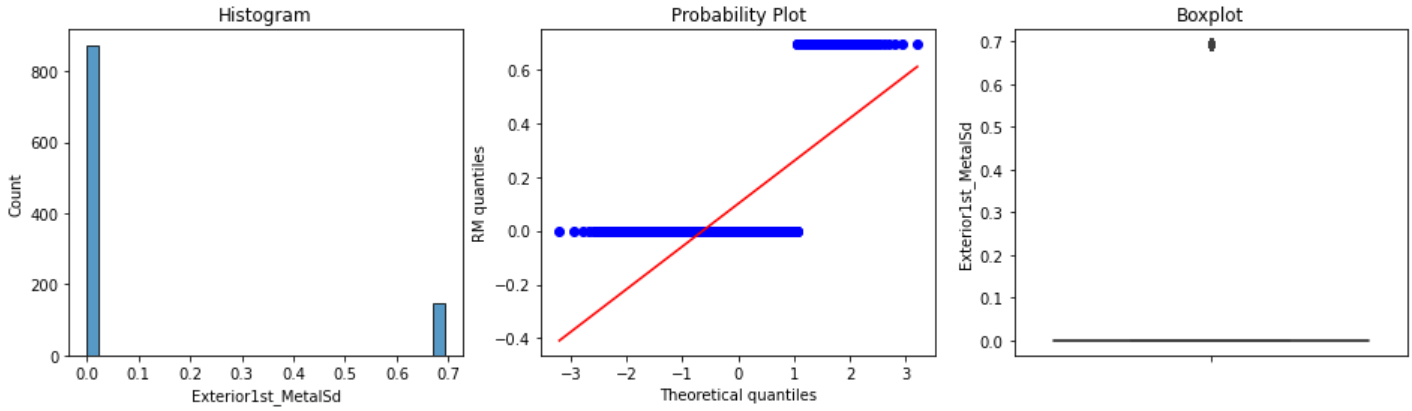
Count
Exterior1st_Wd Sdng
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior1st_Wd Sdng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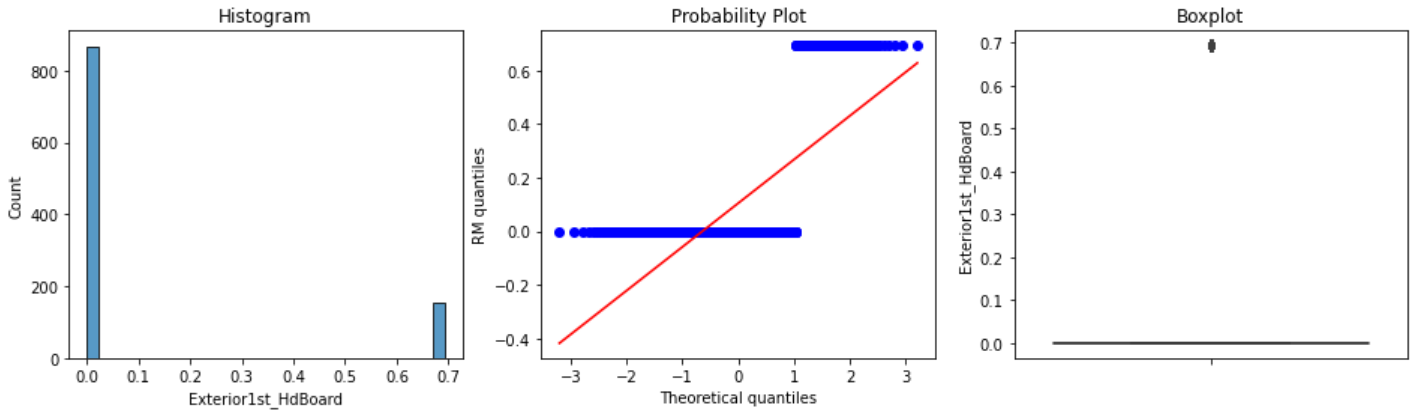
Count
Exterior1st_MetalSd
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior1st_MetalSd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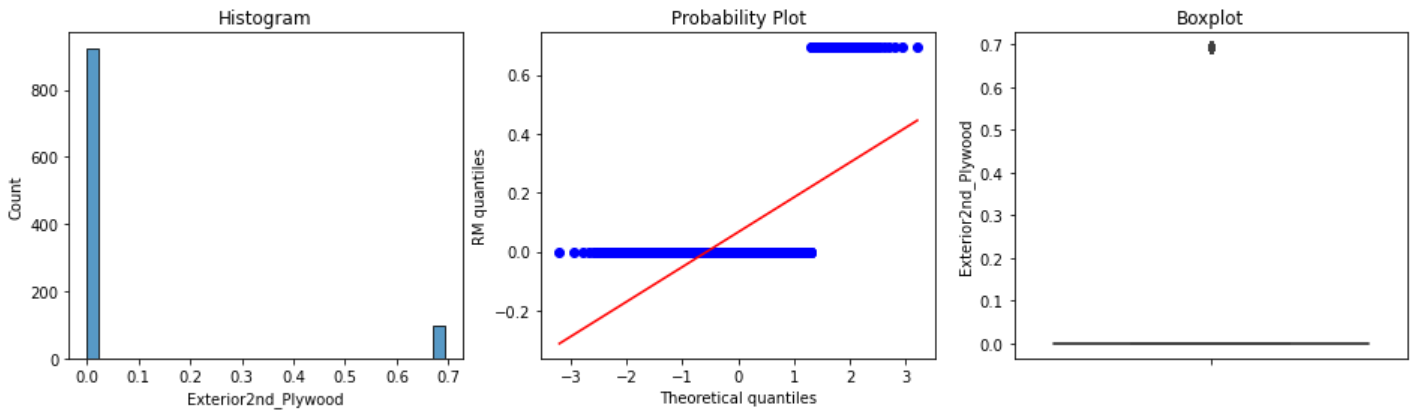
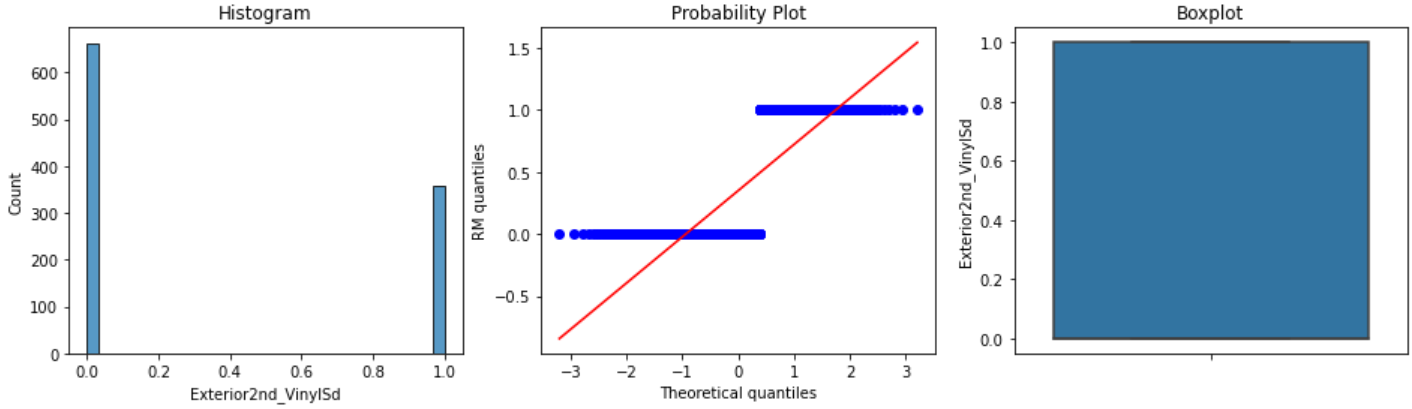
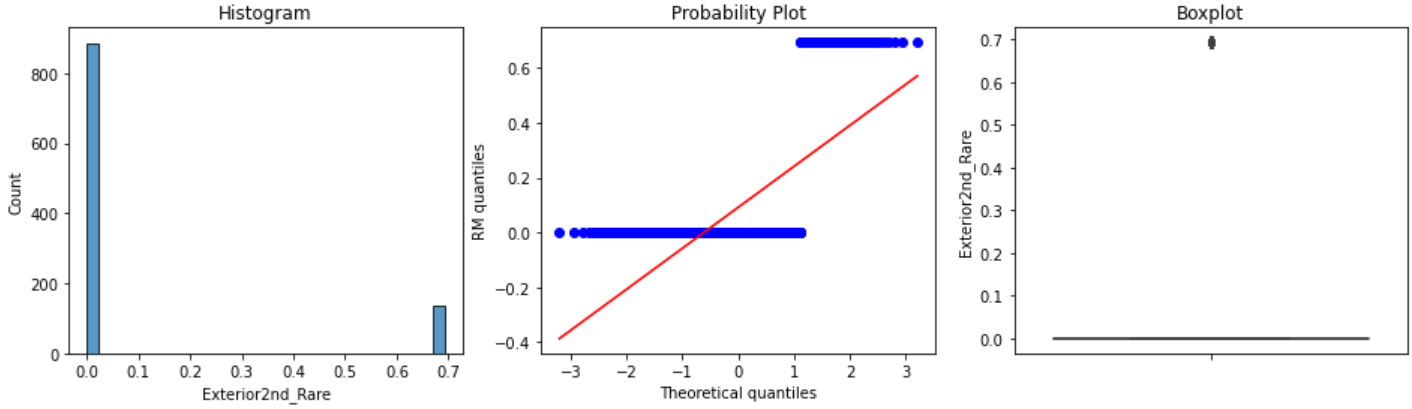
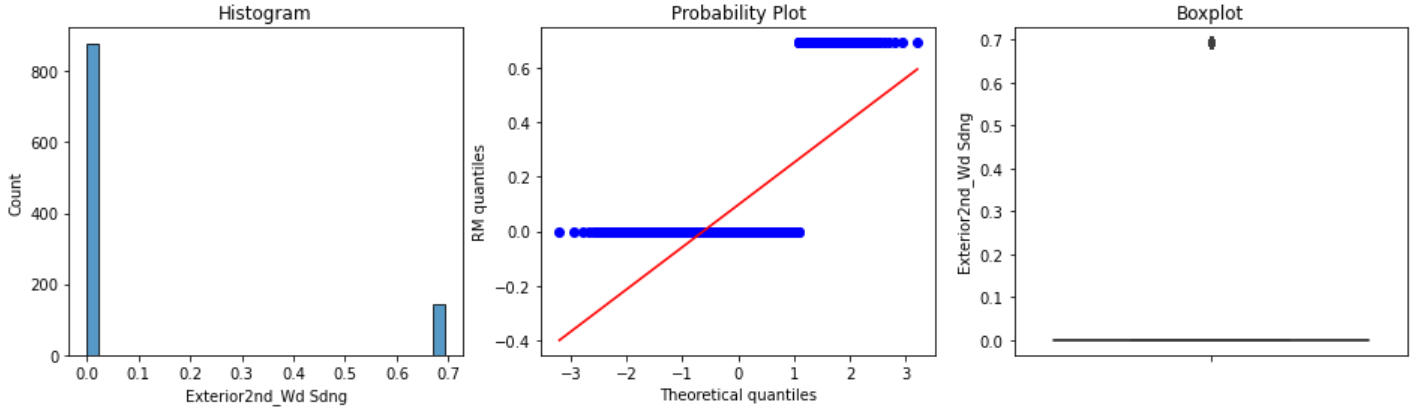
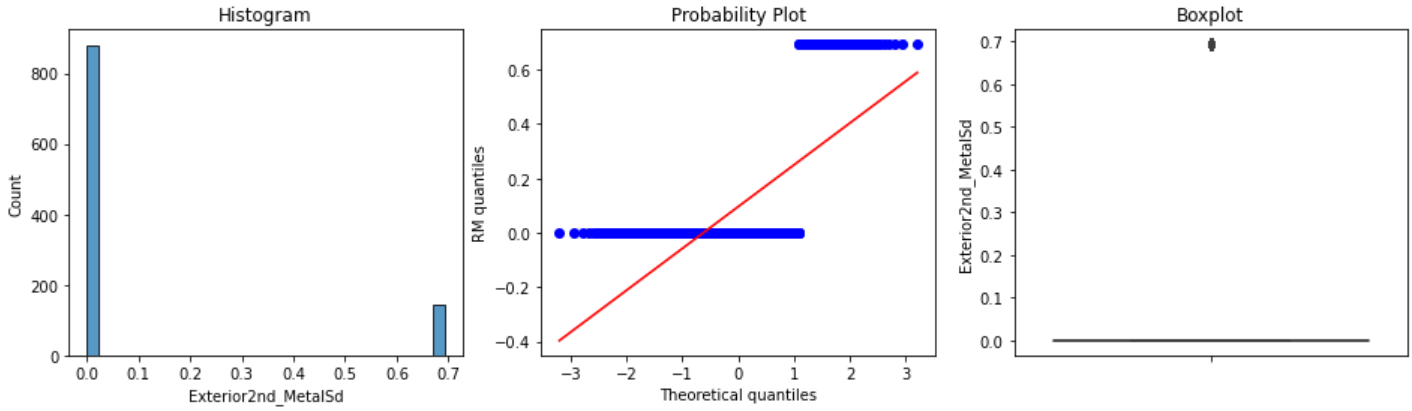
Count
Exterior1st_HdBoard
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior1st_HdBoard

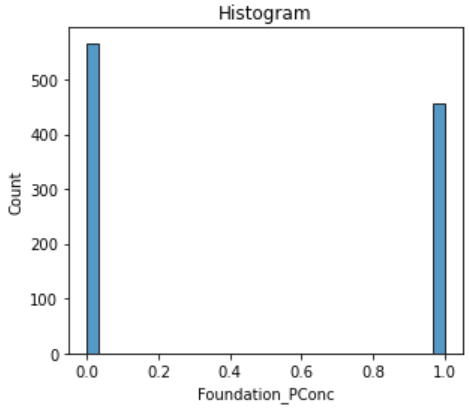

Histogram
Count
Exterior2nd_Plywood
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior2nd_Plywood

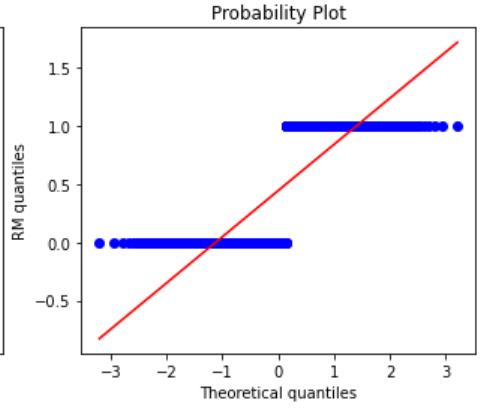

Histogram
Count
Exterior2nd_VinylSd
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior2nd_VinylSd

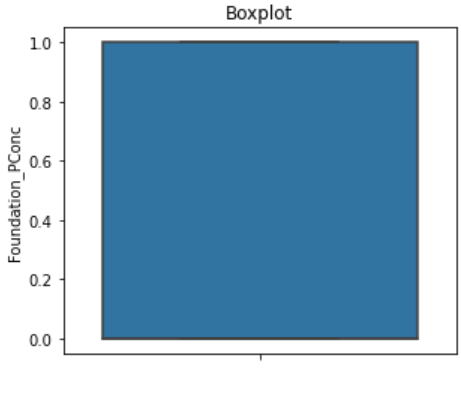

Histogram
Count
Exterior2nd_Rare
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior2nd_Rare

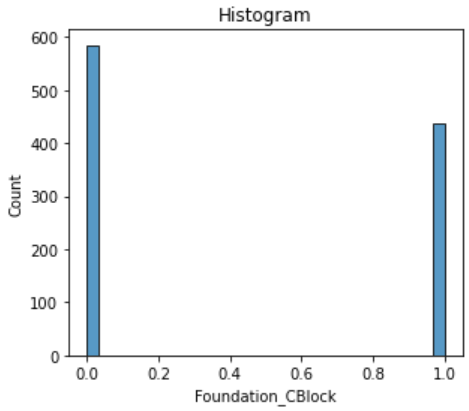

Histogram
Count
Exterior2nd_Wd Sdng
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior2nd_Wd Sdng

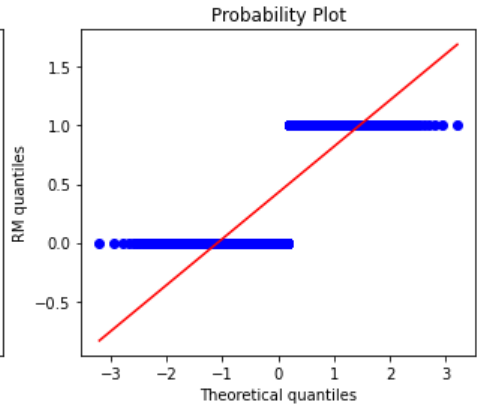

Histogram
Count
Exterior2nd_MetalSd
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Exterior2nd_MetalSd

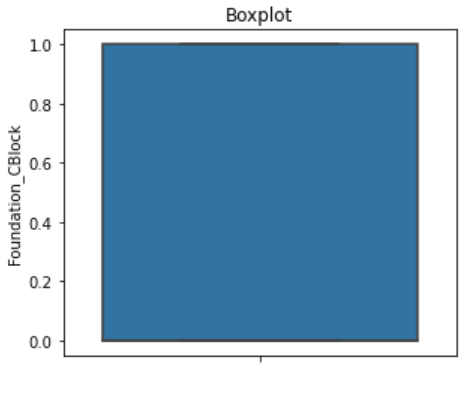

Histogram
Count
Foundation_PConc

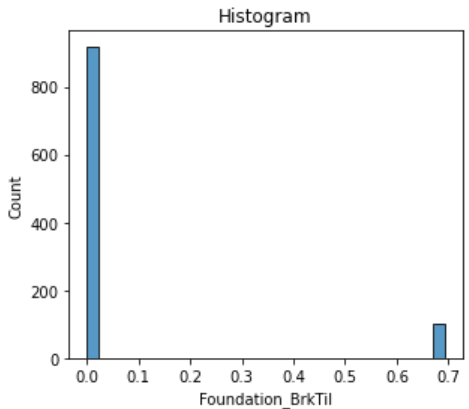

Probability Plot
RM quantiles
Theoretical quantiles

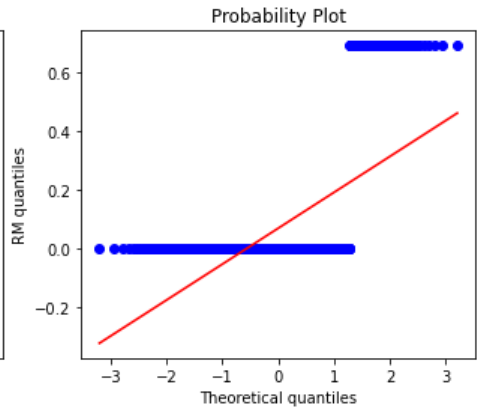

Boxplot
Foundation_PConc

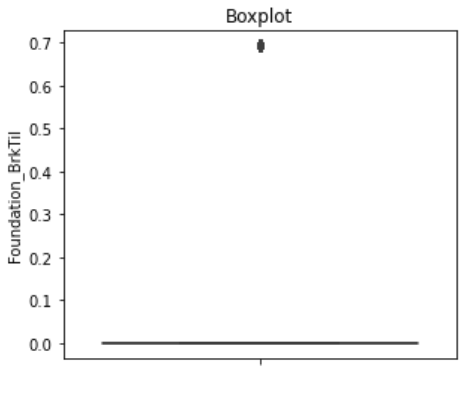

Histogram
Count
Foundation_CBlock

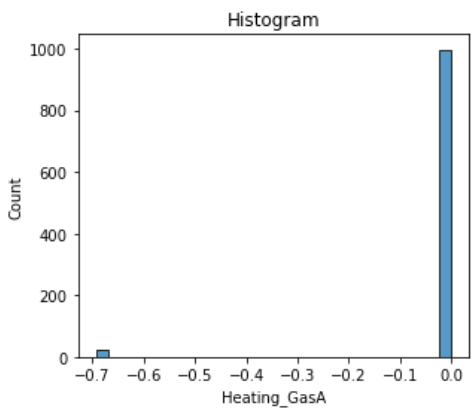

Probability Plot
RM quantiles
Theoretical quantiles

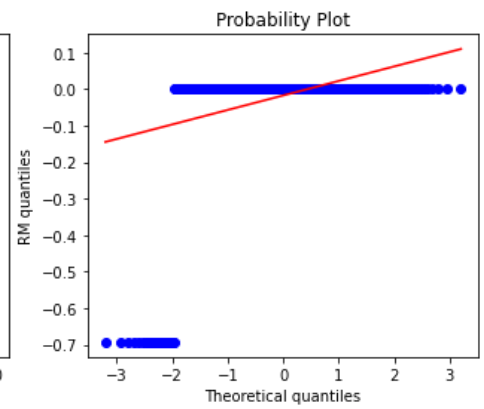

Boxplot
Foundation_CBlock

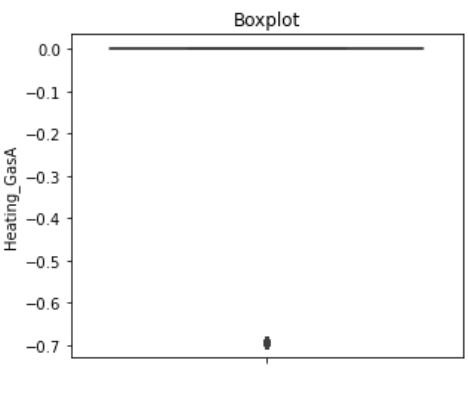

Histogram
Count
Foundation_BrkTil

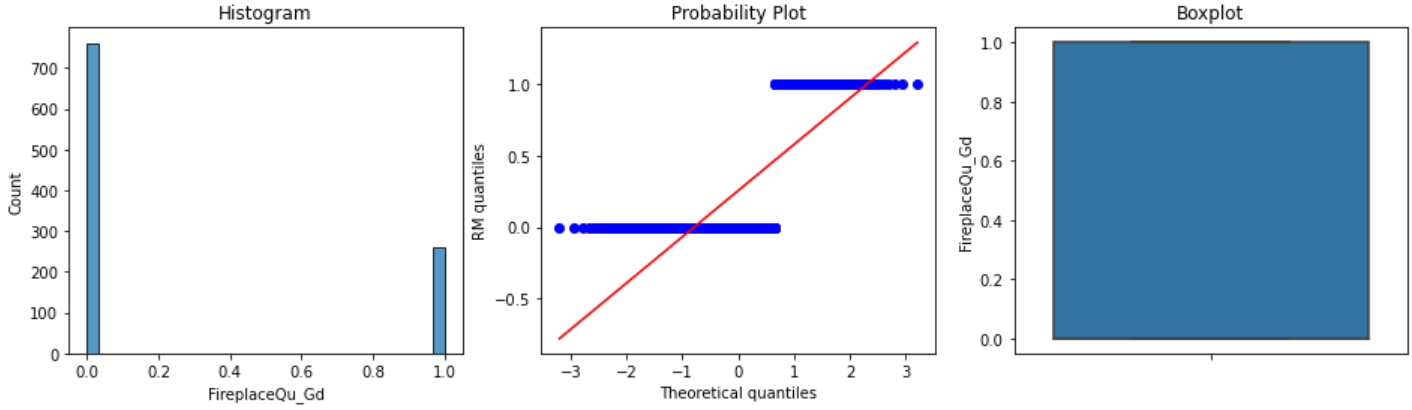

Probability Plot
RM quantiles
Theoretical quantiles

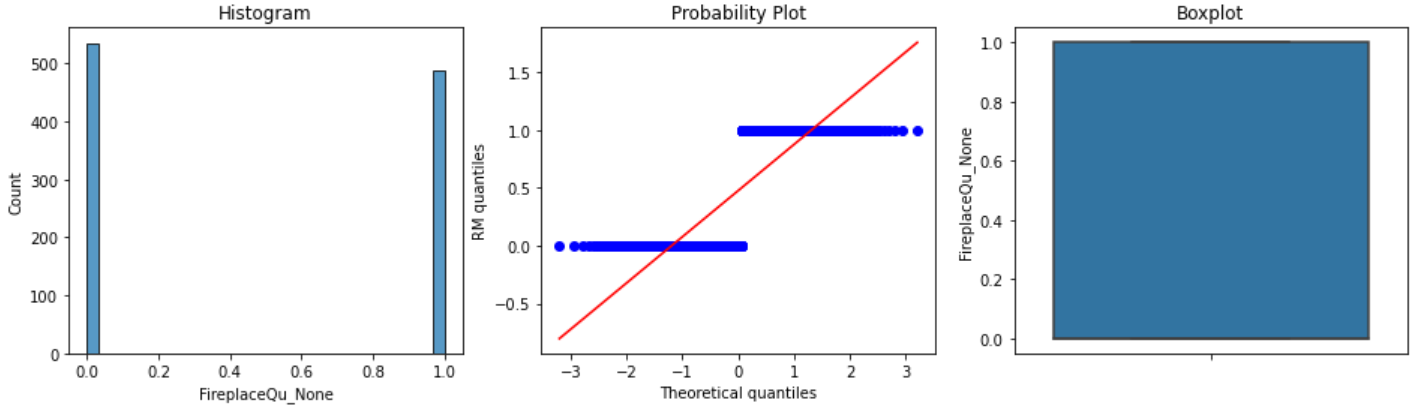

Boxplot
Foundation_BrkTil

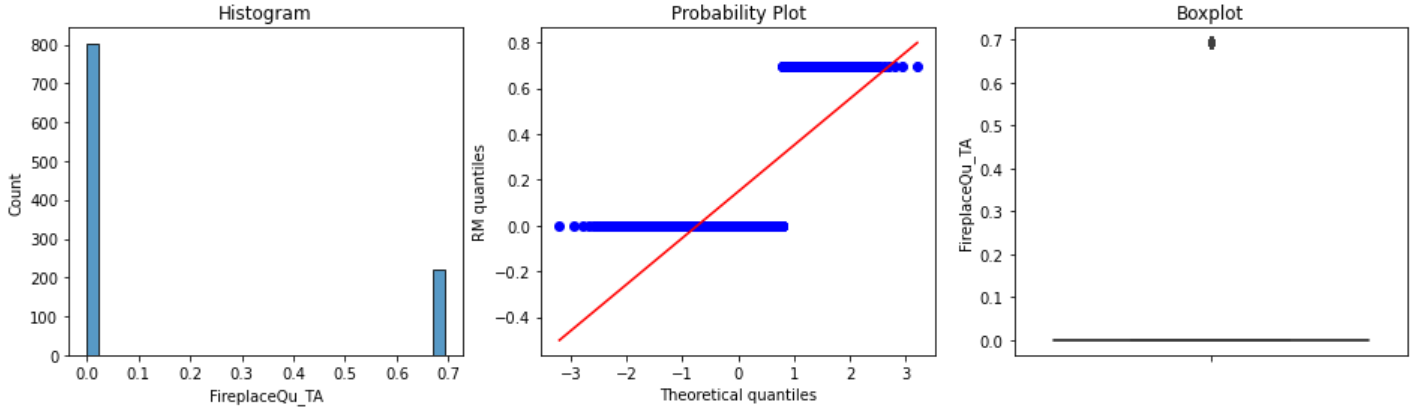

Histogram
Count
Heating_GasA

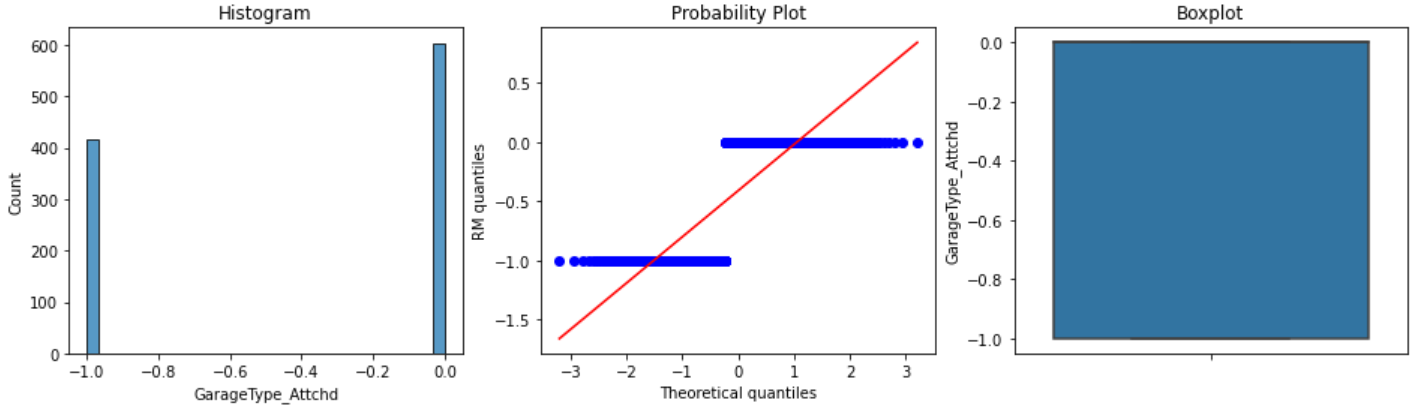

Probability Plot
RM quantiles
Theoretical quantiles

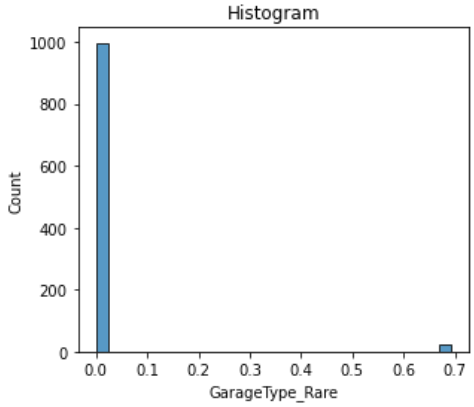

Boxplot
Heating_GasA

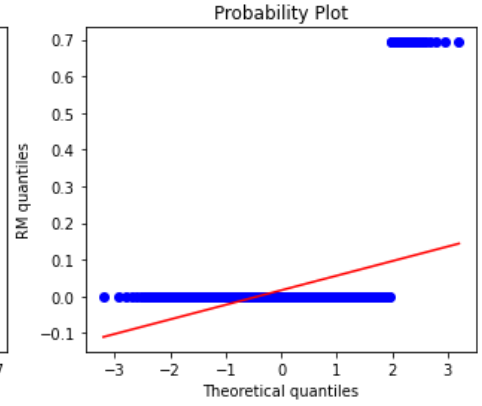

Histogram
Count
FireplaceQu_Gd
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
FireplaceQu_Gd

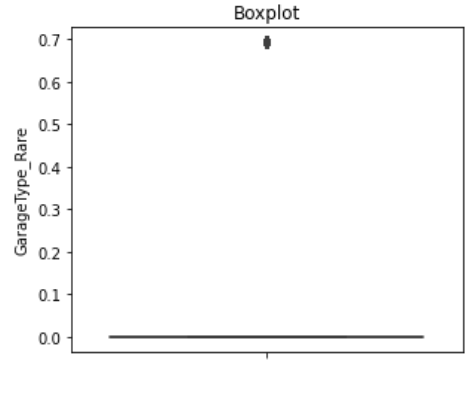

Histogram
Count
FireplaceQu_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
FireplaceQu_None

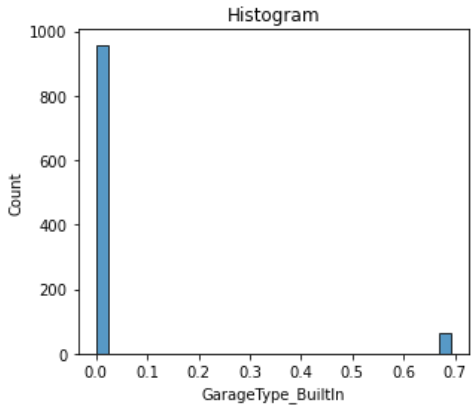

Histogram
Count
FireplaceQu_TA
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
FireplaceQu_TA

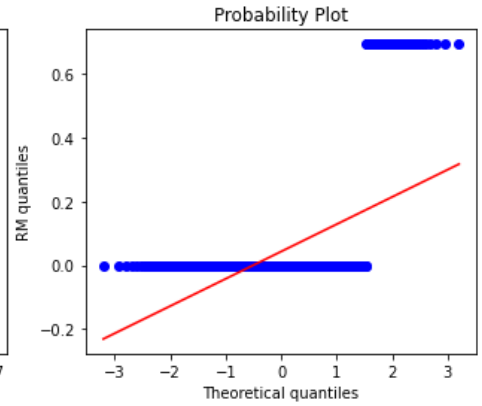

Histogram
Count
GarageType_Attchd
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
GarageType_Attchd

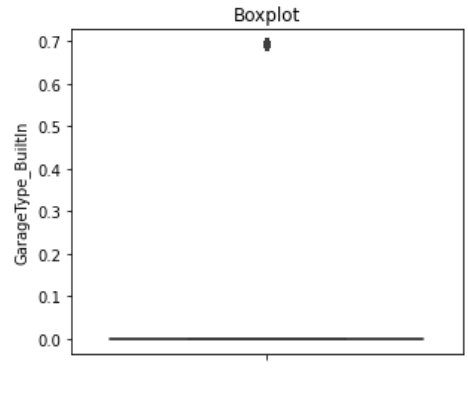

Histogram
Count
GarageType_Rare

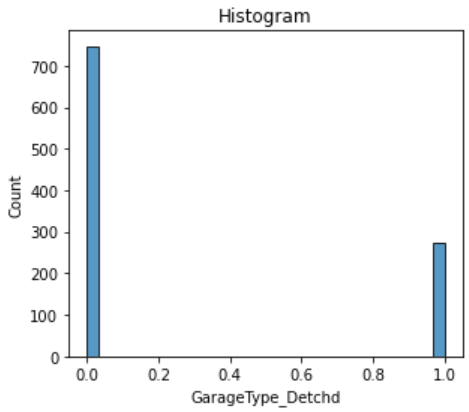

Probability Plot
RM quantiles
Theoretical quantiles

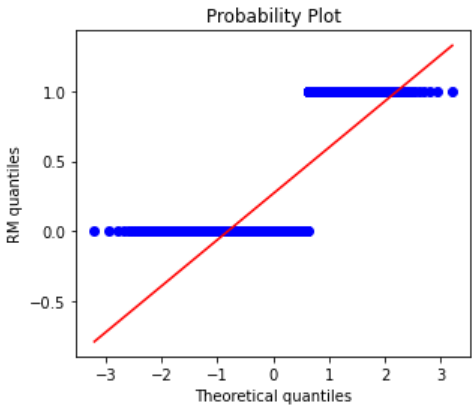

Boxplot
GarageType_Rare

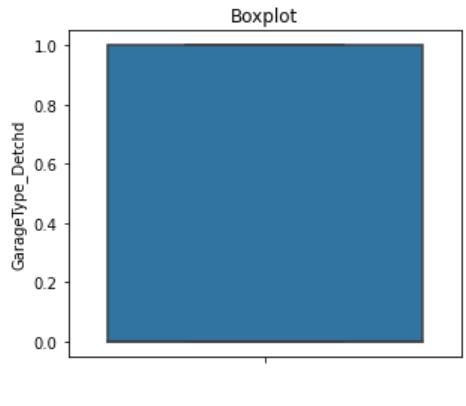

Histogram
Count
GarageType_BuiltIn

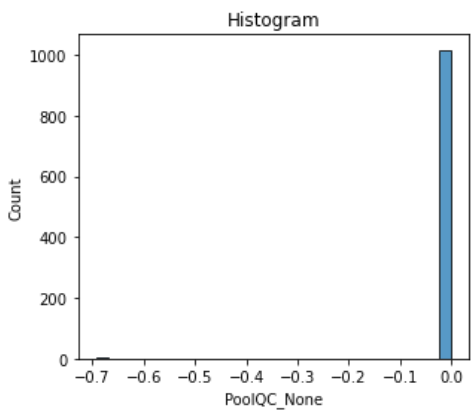

Probability Plot
RM quantiles
Theoretical quantiles

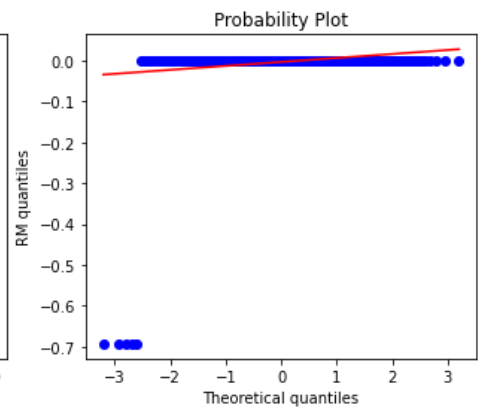

Boxplot
GarageType_BuiltIn

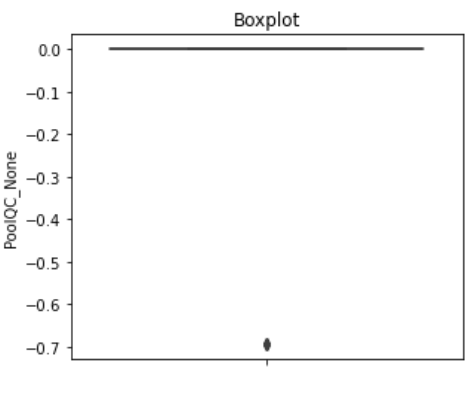

Histogram
Count
GarageType_Detchd

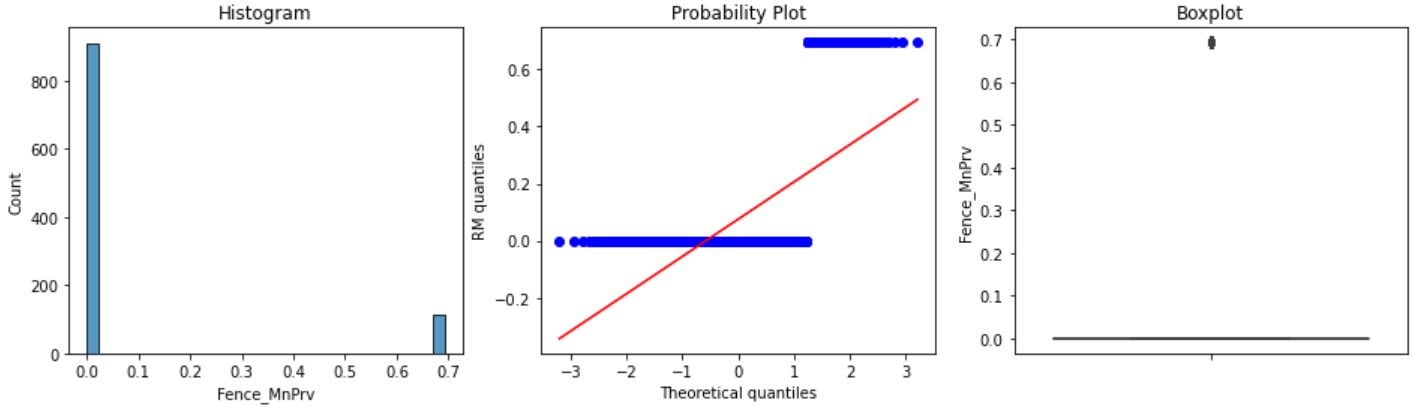

Probability Plot
RM quantiles
Theoretical quantiles

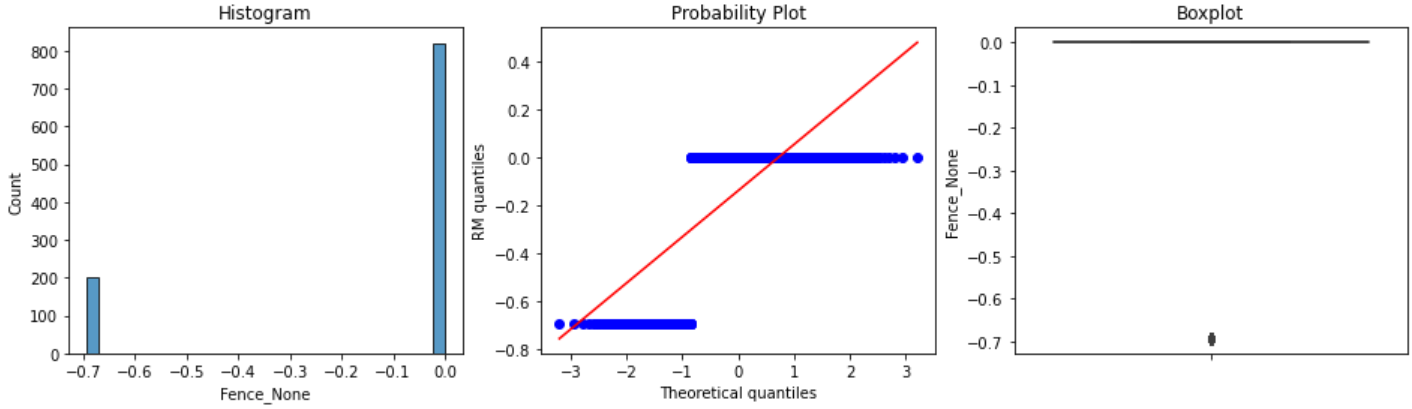

Boxplot
GarageType_Detchd

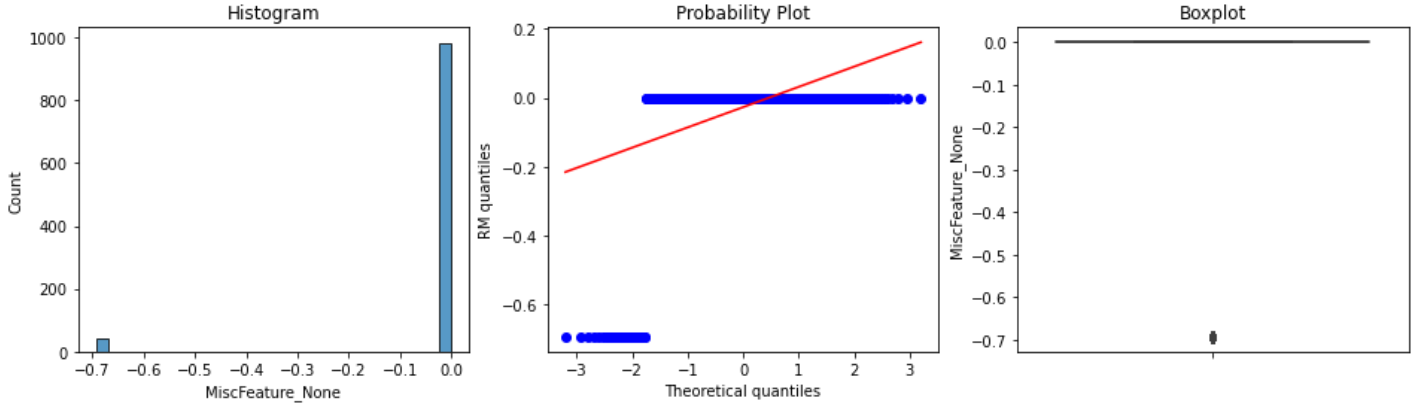

Histogram
Count
PoolQC_None

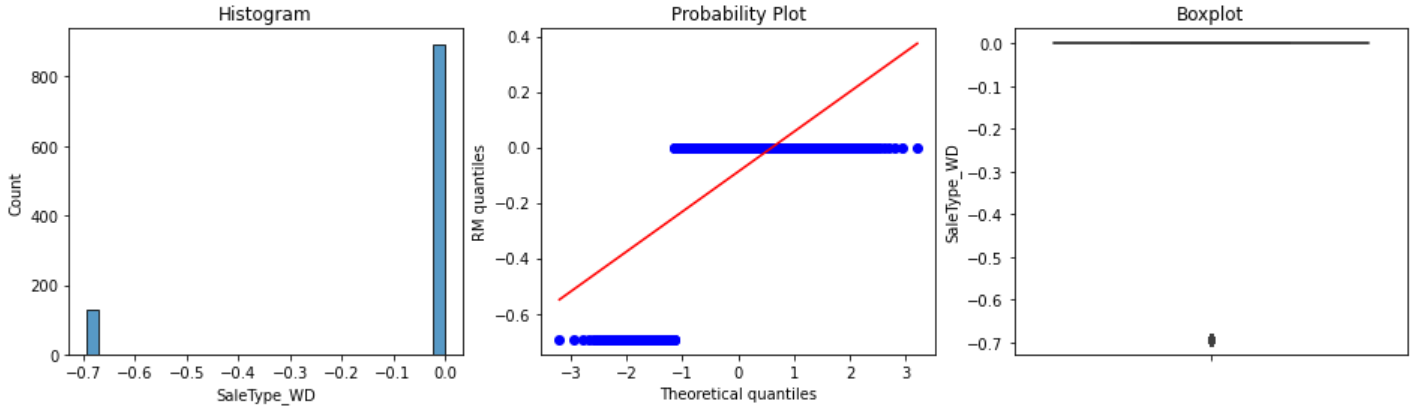

Probability Plot
RM quantiles
Theoretical quantiles

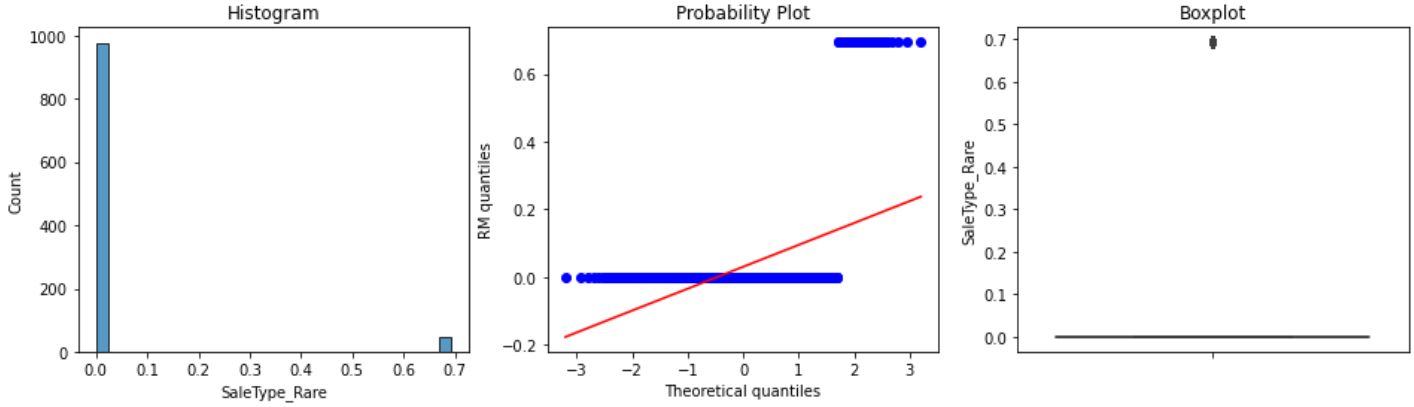

Boxplot
PoolQC_None

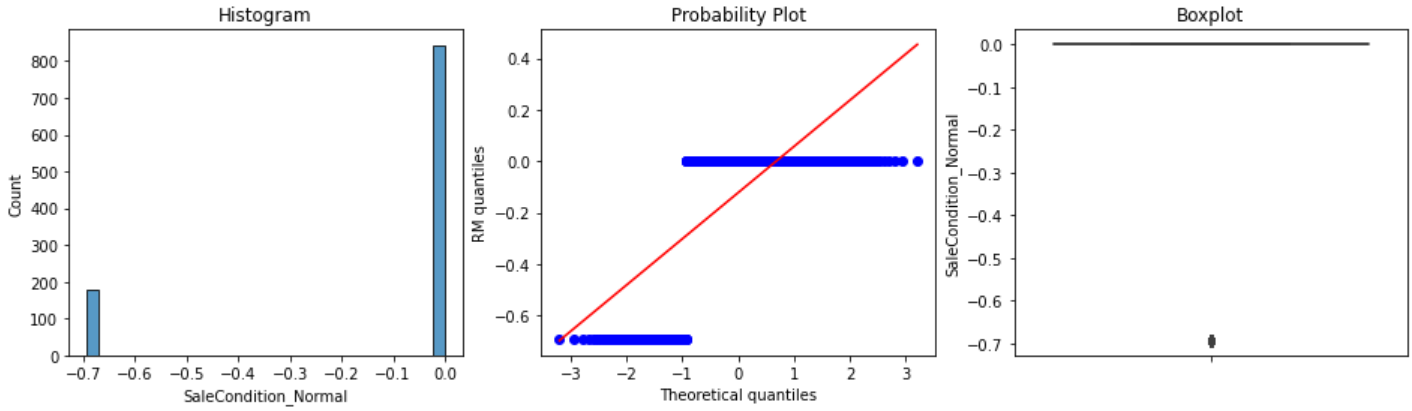

Histogram
Count
Fence_MnPrv
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Fence_MnPrv

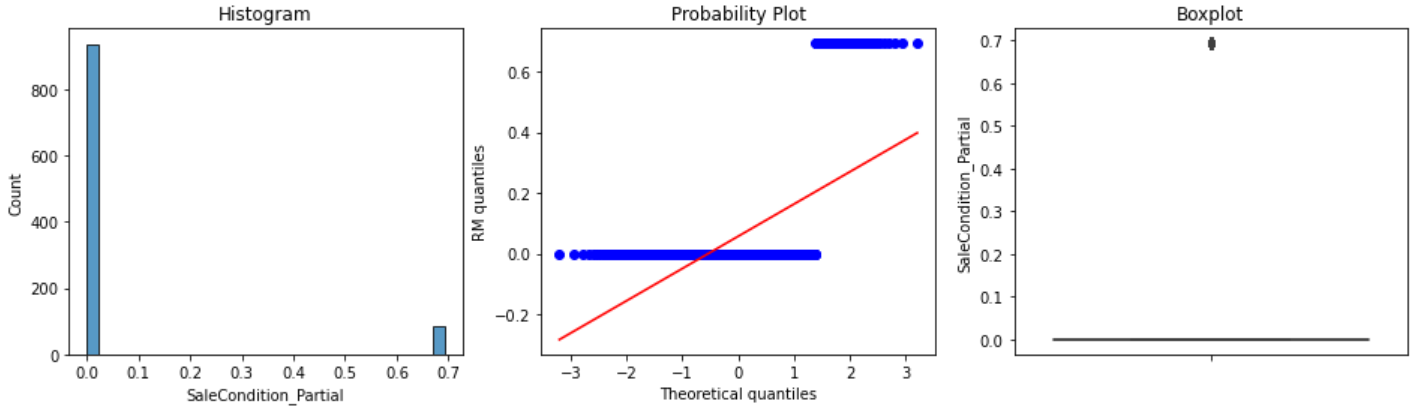

Histogram
Count
Fence_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
Fence_None

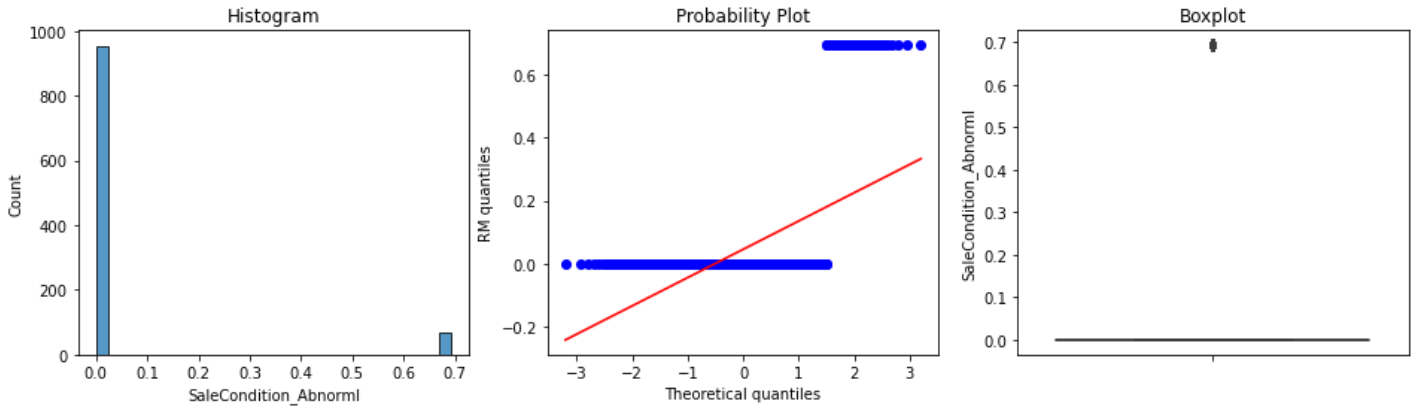

Histogram
Count
MiscFeature_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MiscFeature_None

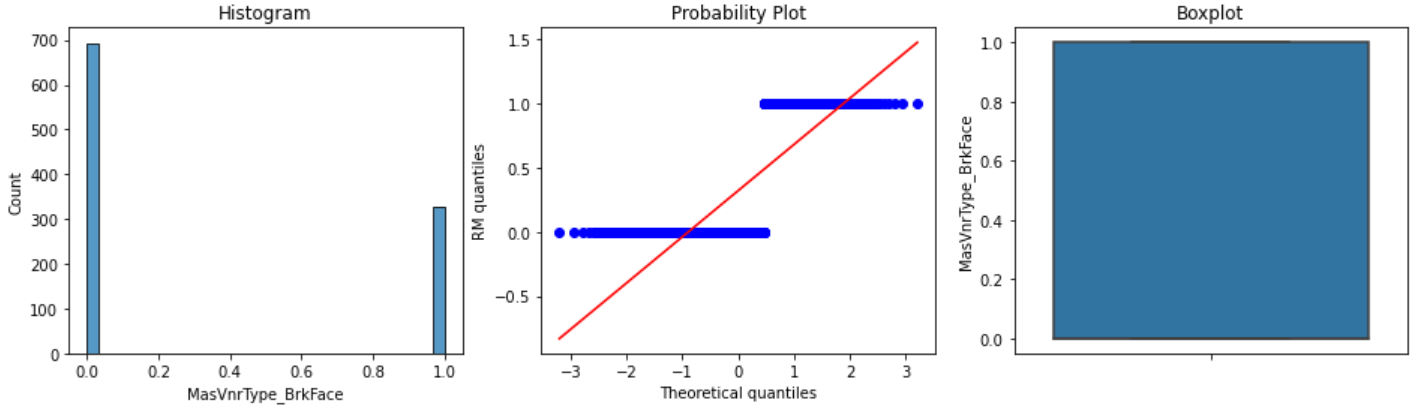

Histogram
Count
SaleType_WD
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleType_WD

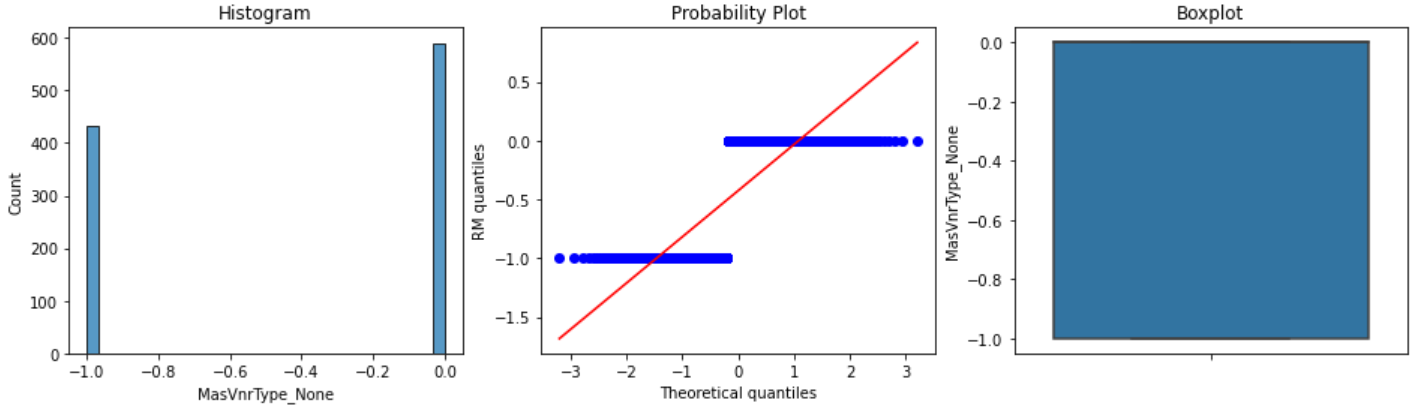

Histogram
Count
SaleType_Rare
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleType_Rare

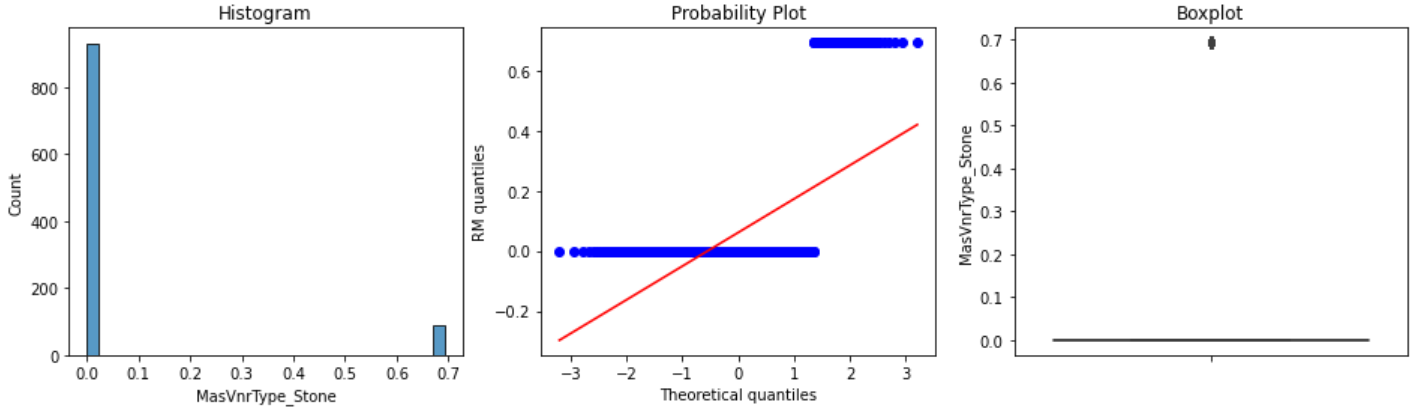

Histogram
Count
SaleCondition_Normal
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleCondition_Normal

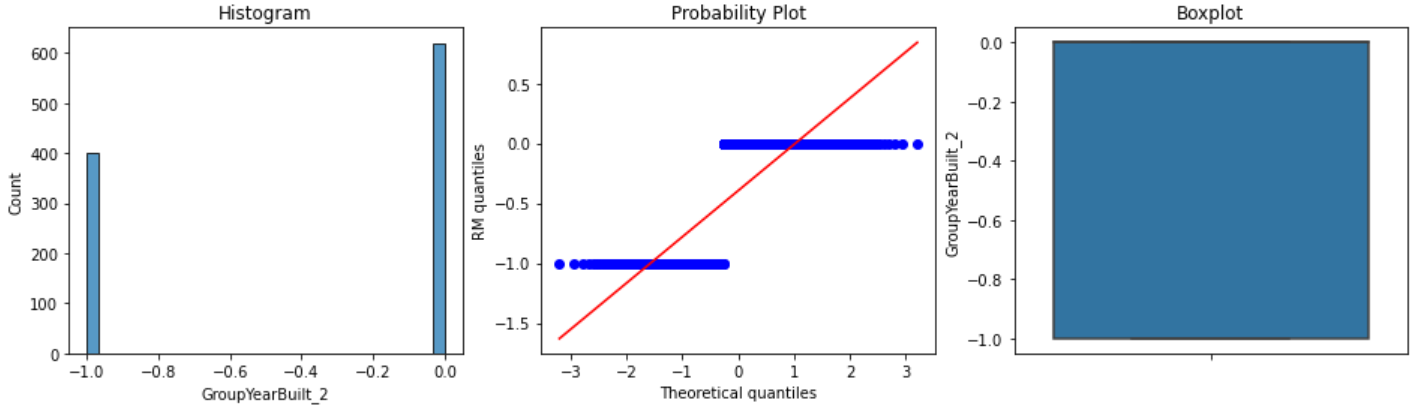

Histogram
Count
SaleCondition_Partial
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleCondition_Partial

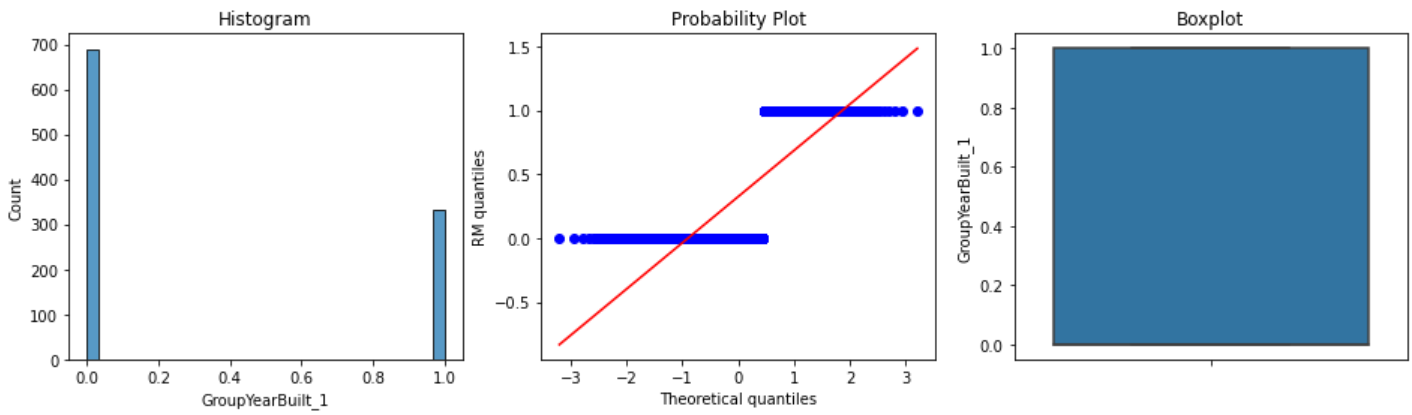

Histogram
Count
SaleCondition_Abnorml
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
SaleCondition_Abnorml


Histogram
Count
MasVnrType_BrkFace
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MasVnrType_BrkFace


Histogram
Count
MasVnrType_None
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MasVnrType_None


Histogram
Count
MasVnrType_Stone
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
MasVnrType_Stone


Histogram
Count
GroupYearBuilt_2
Probability Plot
RM quantiles
Theoretical quantiles
Boxplot
GroupYearBuilt_2



Feature Selection

before do the next process of built model for prediction, we need to select some feature that most useful for our prediction and before do the process of feature selection we'll compare score of dataset before/after by use the neg_mean_squared_error with the less score show the import of model preformance

In [263…

```
model=GradientBoostingRegressor()

def score_dataset(X, y, model):
    log_y = np.log(y)

    score = cross_val_score(
        model, X, log_y, cv=5, scoring="neg_mean_squared_error",
    )
    score = -1 * score.mean()
    score = np.sqrt(score)
    return score
```

In [263…

```
score_dataset(X_train, y_train, model)
```

Out[263…

```
0.14289960519051648
```

we'll check the feature that contain constant value and will remove it to improve model performance

In [264…

```
quasi_constant=[]
for col in X_train.columns:
    predominant=(X_train[col].value_counts()/np.float(
        len(X_train))).sort_values(ascending=False).values[0]

    if predominant>0.95:
        quasi_constant.append(col)

len(quasi_constant)
```

Out[264…

```
15
```

As we notice that there are 15 features that constain the constant values, then we remove those from our dataset

In [264…

```
quasi_constant
```

Out[264…

```
['Utilities',
 'LowQualFinSF',
```

```
 'KitchenAbvGr',
 'ThirdSsnPorch ',
 'PoolArea',
 'MiscVal',
 'Lotsize',
 'Street_Pave',
 'Condition2_Norm',
 'RoofMatl_CompShg',
 'Heating_GasA',
 'GarageType_Rare',
 'PoolQC_None',
 'MiscFeature_None',
 'SaleType_Rare']
```

In [264…

```
for col in quasi_constant:
    predo=X_train[col].value_counts()/np.float(len(X_train))
    print(predo)
```

```
 0.000000    0.999022
-0.693147    0.000978
Name: Utilities, dtype: float64
0.000000    0.981409
4.394449    0.002935
3.988984    0.000978
4.976734    0.000978
6.161207    0.000978
6.177944    0.000978
5.973810    0.000978
5.968708    0.000978
6.246107    0.000978
6.350886    0.000978
5.986452    0.000978
5.459586    0.000978
5.327876    0.000978
5.953243    0.000978
6.042633    0.000978
4.795791    0.000978
6.242223    0.000978
5.888878    0.000978
Name: LowQualFinSF, dtype: float64
 0.000000    0.953033
 0.405465    0.045988
-0.693147    0.000978
Name: KitchenAbvGr, dtype: float64
0.000000    0.983366
5.379897    0.001957
5.129899    0.001957
5.771441    0.000978
6.011267    0.000978
4.875197    0.000978
5.283204    0.000978
5.198497    0.000978
5.673323    0.000978
5.505332    0.000978
5.036953    0.000978
5.209486    0.000978
4.976734    0.000978
4.948760    0.000978
6.232448    0.000978
5.720312    0.000978
Name: ThirdSsnPorch , dtype: float64
0.000000    0.995108
6.320768    0.000978
6.175867    0.000978
```

```
6.240276    0.000978
6.253829    0.000978
6.605298    0.000978
Name: PoolArea, dtype: float64
0.000000    0.960861
5.993961    0.007828
6.216606    0.006849
6.552508    0.004892
6.111467    0.003914
7.601402    0.003914
7.090910    0.001957
6.175867    0.001957
8.160804    0.000978
7.170888    0.000978
9.024131    0.000978
5.860786    0.000978
6.431331    0.000978
7.048386    0.000978
7.244942    0.000978
7.824446    0.000978
Name: MiscVal, dtype: float64
 0.000000    0.994129
 0.405465    0.001957
-0.693147    0.001957
 0.693147    0.001957
Name: Lotsize, dtype: float64
 0.000000    0.996086
-0.693147    0.003914
Name: Street_Pave, dtype: float64
 0.000000    0.991194
-0.693147    0.008806
Name: Condition2_Norm, dtype: float64
 0.000000    0.981409
-0.693147    0.018591
Name: RoofMatl_CompShg, dtype: float64
 0.000000    0.975538
-0.693147    0.024462
Name: Heating_GasA, dtype: float64
0.000000    0.975538
0.693147    0.024462
Name: GarageType_Rare, dtype: float64
 0.000000    0.995108
-0.693147    0.004892
Name: PoolQC_None, dtype: float64
 0.000000    0.960861
-0.693147    0.039139
Name: MiscFeature_None, dtype: float64
0.000000    0.955969
0.693147    0.044031
Name: SaleType_Rare, dtype: float64
```

In [264…

```
X_train.drop(labels=quasi_constant,axis=1,inplace=True)
X_test.drop(labels=quasi_constant,axis=1,inplace=True)
df_test.drop(labels=quasi_constant,axis=1,inplace=True)
```

In [264…

```
score_dataset(X_train, y_train, model)
```

Out[264…

```
0.14358262553369477
```

The performance after remove some constant feature, a bit increase

check some feature duplicate

In [264…

```
def find_dupl(data):
    duplic_dic={}
    duplic_list=[]

    for i in range(0, len(data.columns)):
        col1=data.columns[i]
        if col1 not in duplic_list:
            duplic_dic[col1]=[]
            for col2 in data.columns[i+1:]:
                if data[col1].equals(data[col2]):
                    duplic_dic[col1].append(col2)
                    duplic_list.append(col2)

    return duplic_list, duplic_dic
```

In [264…

```
find_dupl(X_train)
```

Out[264…

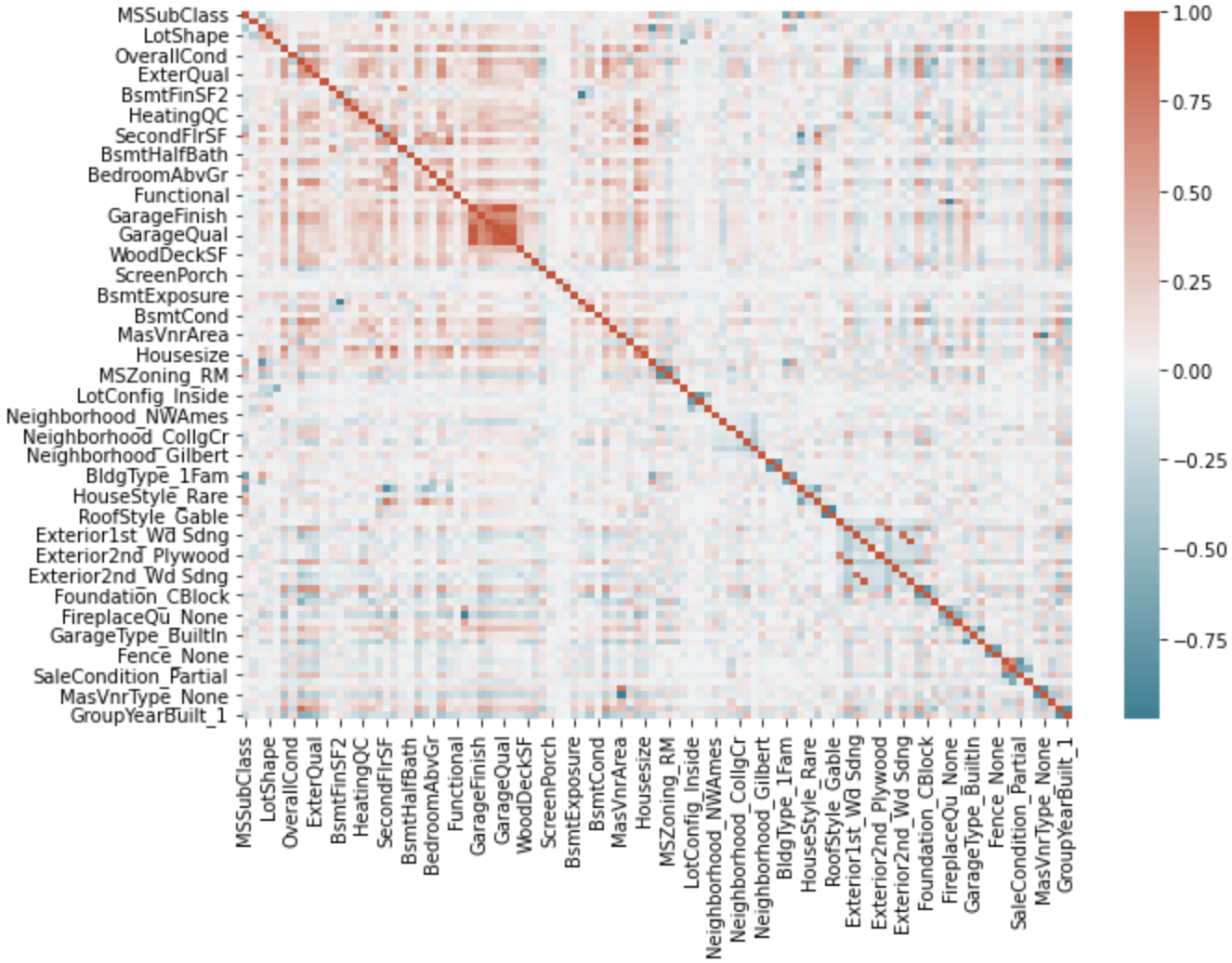
```
([],
 {'MSSubClass': [],
  'LotFrontage': [],
  'LotArea': [],
  'LotShape': [],
  'LandSlope': [],
  'OverallQual': [],
  'OverallCond': [],
  'YearBuilt': [],
  'YearRemodAdd': [],
  'ExterQual': [],
  'ExterCond': [],
  'BsmtFinSF1': [],
  'BsmtFinSF2': [],
  'BsmtUnfSF': [],
  'TotalBsmtSF': [],
  'HeatingQC': [],
  'CentralAir': [],
  'FirstFlrSF': [],
  'SecondFlrSF': [],
  'GrLivArea': [],
  'BsmtFullBath': [],
  'BsmtHalfBath': [],
  'FullBath': [],
  'HalfBath': [],
  'BedroomAbvGr': [],
  'KitchenQual': [],
  'TotRmsAbvGrd': [],
  'Functional': [],
  'Fireplaces': [],
  'GarageYrBlt': [],
  'GarageFinish': [],
  'GarageCars': [],
  'GarageArea': [],
  'GarageQual': [],
  'GarageCond': [],
  'PavedDrive': [],
  'WoodDeckSF': [],
  'OpenPorchSF': [],
  'EnclosedPorch': [],
  'ScreenPorch': [],
  'MoSold': [],
  'YrSold': [],
  'BsmtExposure': [],
  'BsmtFinType2': [],
  'BsmtFinType1': [],
```

```
'BsmtCond': [],
'BsmtQual': [],
'Electrical': [],
'MasVnrArea': [],
'Remodel': [],
'TotalSF': [],
'Housesize': [],
'TotalPerLot': [],
'MSZoning_RL': [],
'MSZoning_RM': [],
'Alley_None': [],
'LandContour_Lvl': [],
'LotConfig_Inside': [],
'LotConfig_Corner': [],
'LotConfig_CulDSac': [],
'Neighborhood_NWAmes': [],
'Neighborhood_Edwards': [],
'Neighborhood_Somerst': [],
'Neighborhood_CollgCr': [],
'Neighborhood_NAmes': [],
'Neighborhood_Rare': [],
'Neighborhood_Gilbert': [],
'Condition1_Norm': [],
'Condition1_Rare': [],
'BldgType_1Fam': [],
'BldgType_TwnhsE': [],
'HouseStyle_1Story': [],
'HouseStyle_Rare': [],
'HouseStyle_2Story': [],
'RoofStyle_Hip': [],
'RoofStyle_Gable': [],
'Exterior1st_Plywood': [],
'Exterior1st_VinylSd': [],
'Exterior1st_Wd Sdng': [],
'Exterior1st_MetalSd': [],
'Exterior1st_HdBoard': [],
'Exterior2nd_Plywood': [],
'Exterior2nd_VinylSd': [],
'Exterior2nd_Rare': [],
'Exterior2nd_Wd Sdng': [],
'Exterior2nd_MetalSd': [],
'Foundation_PConc': [],
'Foundation_CBlock': [],
'Foundation_BrkTil': [],
'FireplaceQu_Gd': [],
'FireplaceQu_None': [],
'FireplaceQu_TA': [],
'GarageType_Attchd': [],
'GarageType_BuiltIn': [],
'GarageType_Detchd': [],
'Fence_MnPrv': [],
'Fence_None': [],
'SaleType_WD': [],
'SaleCondition_Normal': [],
'SaleCondition_Partial': [],
'SaleCondition_Abnorml': [],
'MasVnrType_BrkFace': [],
'MasVnrType_None': [],
'MasVnrType_Stone': [],
'GroupYearBuilt_2': [],
'GroupYearBuilt_1': []})
```

Check correlation of dataset

In [264…
```
correlation= X_train.corr(method='pearson')
cmap=sns.diverging_palette(220,20,as_cmap=True)
fig,ax=plt.subplots(figsize=(10,7))
sns.heatmap(correlation,cmap=cmap)
```

Out[264…
```
<AxesSubplot:>
```



Next we'll compare the 3 method for select feature and find the best one

- Lasso that we'll filter out the feature that 0 coefficient
- RFE with Gradientboosting that we'll filter out the feature that 0 coefficient
- RFE with Randomforest that we'll filter out the feature that 0 coefficient

In [264…
```
lcv = LassoCV()
lcv.fit(X_train,y_train)
print('Optimal alpha = {0:.3f}'.format(lcv.alpha_))


r_squared = lcv.score(X_test,y_test)
print('The model explains {0:.1%} of the test set variance'.format(r_squared))

lcv_mask = lcv.coef_!=0
print('{} features out of {} selected'.format(sum(lcv_mask), len(lcv_mask)))
```

```
Optimal alpha = 1510.256
The model explains 76.9% of the test set variance
28 features out of 106 selected
```

In [265…
```
rfe_gb = RFE(estimator=GradientBoostingRegressor(),
```

```
            n_features_to_select=15, step=10, verbose=1)
rfe_gb.fit(X_train, y_train)

r_squared = rfe_gb.score(X_test, y_test)
print('The model can explain {0:.1%} of the variance in the test set'.format(r_squared))

gb_mask = rfe_gb.support_!=0
```

```
Fitting estimator with 106 features.
Fitting estimator with 96 features.
Fitting estimator with 86 features.
Fitting estimator with 76 features.
Fitting estimator with 66 features.
Fitting estimator with 56 features.
Fitting estimator with 46 features.
Fitting estimator with 36 features.
Fitting estimator with 26 features.
Fitting estimator with 16 features.
The model can explain 90.8% of the variance in the test set
```

In [265…

```
rfe_rf = RFE(estimator=RandomForestRegressor(),
             n_features_to_select=15,step=3,verbose=1)
rfe_rf.fit(X_train, y_train)

r_squared = rfe_rf.score(X_test, y_test)
print('The model can explain {0:.1%} of the variance in the test set'.format(r_squared))

rf_mask = rfe_rf.support_
```

```
Fitting estimator with 106 features.
Fitting estimator with 103 features.
Fitting estimator with 100 features.
Fitting estimator with 97 features.
Fitting estimator with 94 features.
Fitting estimator with 91 features.
Fitting estimator with 88 features.
Fitting estimator with 85 features.
Fitting estimator with 82 features.
Fitting estimator with 79 features.
Fitting estimator with 76 features.
Fitting estimator with 73 features.
Fitting estimator with 70 features.
Fitting estimator with 67 features.
Fitting estimator with 64 features.
Fitting estimator with 61 features.
Fitting estimator with 58 features.
Fitting estimator with 55 features.
Fitting estimator with 52 features.
Fitting estimator with 49 features.
Fitting estimator with 46 features.
Fitting estimator with 43 features.
Fitting estimator with 40 features.
Fitting estimator with 37 features.
Fitting estimator with 34 features.
Fitting estimator with 31 features.
Fitting estimator with 28 features.
Fitting estimator with 25 features.
Fitting estimator with 22 features.
Fitting estimator with 19 features.
Fitting estimator with 16 features.
The model can explain 91.1% of the variance in the test set
```

After compare we'll use Gradientboosting that has the best score 91.5% with remain 15 features by set mark to filter out the unuseful feature out from dataset

In [265…
```
X_train=X_train.loc[:,gb_mask]
X_test=X_test.loc[:,gb_mask]
df_test=df_test.loc[:,gb_mask]
```

modeling

Compare model for select the best algorithm that can generate the best score for this dataset by use model 'RandomForestRegressor','LinearRegression','Ridge','GradientBoostingRegressor'

In [265…
```
model_pipeline=[]
model_pipeline.append(RandomForestRegressor())
model_pipeline.append(LinearRegression())
model_pipeline.append(Ridge())
model_pipeline.append(GradientBoostingRegressor())
```

In [265…
```
model_list=('RandomForestRegressor','LinearRegression','Ridge','GradientBoostingRegressor'
mae_list=[]
r2score_list=[]
for model in model_pipeline:
    model.fit(X_train,y_train)
    pred=model.predict(X_test)
    mae_list.append(mean_absolute_error(y_test,pred))
    r2score_list.append(r2_score(y_test,pred))
```

In [265…
```
result_model=pd.DataFrame({'Model':model_list,'MAE':mae_list,'R2_score':r2score_list})
result_model
```

Out[265…

	Model	MAE	R2_score
0	RandomForestRegressor	15763.699338	0.905089
1	LinearRegression	32650.489071	0.701703
2	Ridge	32555.247073	0.702795
3	GradientBoostingRegressor	16197.976410	0.911617

The best algorithm is the GradientBoostingRegressor that can generate the score 91.016% and the next algorithm is RandomForestRegressor that score is 90.779%

Hyperparameter tuning

For increasing the performance model we'll tuning hyperparameter for randomforest and GradientBoosting by using random_grid method that will random the hyperparameter that we select and find the best score from random hyperparameter

In [265…
```
model= RandomForestRegressor(random_state=42,criterion='mse')

n_estimators=[int(x) for x in np.linspace(start=200, stop= 2000, num=10)]
max_features= ['auto', 'sqrt']
max_depth=[int(x) for x in np.linspace(10,110, num=11)]
max_depth.append(None)
min_samples_split=[2,5,10]
min_samples_leaf=[1,2,4]
bootstrap=[True, False]
```

In [265…

```
random_grid={'n_estimators':n_estimators,'max_features':max_features,
             'max_depth':max_depth,
             'min_samples_split':min_samples_split,
             'min_samples_leaf':min_samples_leaf,
             'bootstrap':bootstrap}
```

In [265…

```
random=RandomizedSearchCV(estimator=model,
                          param_distributions=random_grid,
                          n_iter=100,cv=3, verbose=2,
                          random_state=42,n_jobs=-1)
```

In [265…

```
random.get_params
```

Out[265…

```
<bound method BaseEstimator.get_params of RandomizedSearchCV(cv=3,
                   estimator=RandomForestRegressor(criterion='mse',
                                                   random_state=42),
                   n_iter=100, n_jobs=-1,
                   param_distributions={'bootstrap': [True, False],
                                        'max_depth': [10, 20, 30, 40, 50, 60,
                                                      70, 80, 90, 100, 110,
                                                      None],
                                        'max_features': ['auto', 'sqrt'],
                                        'min_samples_leaf': [1, 2, 4],
                                        'min_samples_split': [2, 5, 10],
                                        'n_estimators': [200, 400, 600, 800,
                                                         1000, 1200, 1400, 1600,
                                                         1800, 2000]},
                   random_state=42, verbose=2)>
```

In [266…

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

```
Fitting 3 folds for each of 100 candidates, totalling 300 fits
/Users/wittawatmuangkot/opt/anaconda3/lib/python3.9/site-packages/sklearn/ensemble/_fores
t.py:396: FutureWarning: Criterion 'mse' was deprecated in v1.0 and will be removed in ver
sion 1.2. Use `criterion='squared_error'` which is equivalent.
  warn(
/Users/wittawatmuangkot/opt/anaconda3/lib/python3.9/site-packages/sklearn/ensemble/_fores
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```
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```

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sion 1.2. Use `criterion='squared_error'` which is equivalent.
  warn(
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```

```
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/Users/wittawatmuangkot/opt/anaconda3/lib/python3.9/site-packages/sklearn/ensemble/_fores
t.py:396: FutureWarning: Criterion 'mse' was deprecated in v1.0 and will be removed in ver
sion 1.2. Use `criterion='squared_error'` which is equivalent.
  warn(
```

Out[266…

```
RandomizedSearchCV(cv=3,
                   estimator=RandomForestRegressor(criterion='mse',
                                                   random_state=42),
                   n_iter=100, n_jobs=-1,
                   param_distributions={'bootstrap': [True, False],
                                        'max_depth': [10, 20, 30, 40, 50, 60,
                                                      70, 80, 90, 100, 110,
                                                      None],
                                        'max_features': ['auto', 'sqrt'],
                                        'min_samples_leaf': [1, 2, 4],
                                        'min_samples_split': [2, 5, 10],
                                        'n_estimators': [200, 400, 600, 800,
                                                         1000, 1200, 1400, 1600,
                                                         1800, 2000]},
                   random_state=42, verbose=2)
```

In [266…

```
random.best_params_
```

Out[266…
```
{'n_estimators': 1600,
 'min_samples_split': 5,
 'min_samples_leaf': 1,
 'max_features': 'sqrt',
 'max_depth': 70,
 'bootstrap': False}
```

In [266…
```
def evaluation_model(model, X_test, y_test):
    pred=model.predict(X_test)
    errors=abs(pred-y_test)
    avg_error=100*np.mean(errors/y_test)
    acc=100-avg_error
    print('AVG Error : {:0.4f} degrees'.format(np.mean(errors)))
    print('Accuracy : {:.2f}'.format(acc))
    return acc
```

In [266…
```
base_model=RandomForestRegressor(n_estimators=10, random_state=42)
base_model.fit(X_train,y_train)
evaluation_model(base_model,X_test,y_test)
```

```
AVG Error : 16963.7537 degrees
Accuracy : 89.82
```
Out[266…
```
89.8161520581492
```

In [266…
```
best_random=random.best_estimator_
evaluation_model(best_random,X_test,y_test)
```

```
AVG Error : 17107.9342 degrees
Accuracy : 89.53
```
Out[266…
```
89.53067760271445
```

In [266…
```
best_random.fit(X_train,y_train)
```

Out[266…
```
RandomForestRegressor(bootstrap=False, criterion='mse', max_depth=70,
                      max_features='sqrt', min_samples_split=5,
                      n_estimators=1600, random_state=42)
```

In [266…
```
pred=best_random.predict(X_test)
r_score=r2_score(y_test,pred)
r_score
```

Out[266…
```
0.8906265037236445
```

In [266…
```
param={
    "n_estimators":[1,2,5,10,20,50,100,200,500],
    "max_leaf_nodes":[2,5,10,20,50,100],
    "learning_rate":loguniform(0.01,1)
    }
random_cv=RandomizedSearchCV(
    GradientBoostingRegressor(),param_distributions=param,
    scoring='neg_mean_absolute_error',n_iter=20,
    random_state=42,n_jobs=2
)
random_cv.fit(X_train,y_train)
```

```
[CV] END bootstrap=True, max_depth=30, max_features=sqrt, min_samples_leaf=1, min_samples_
split=5, n_estimators=400; total time=   0.7s
[CV] END bootstrap=False, max_depth=30, max_features=auto, min_samples_leaf=4, min_samples
```

```
_split=2, n_estimators=2000; total time=   7.9s
[CV] END bootstrap=False, max_depth=10, max_features=auto, min_samples_leaf=4, min_samples
_split=5, n_estimators=1800; total time=   7.2s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=2, min_samples
_split=10, n_estimators=800; total time=   1.4s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=1, min_samples_
split=2, n_estimators=1000; total time=   1.9s
[CV] END bootstrap=False, max_depth=110, max_features=auto, min_samples_leaf=2, min_sample
s_split=10, n_estimators=1800; total time=   7.2s
[CV] END bootstrap=True, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples_
split=5, n_estimators=1400; total time=   2.4s
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=1400; total time=   2.5s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=5, n_estimators=1000; total time=   1.6s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=5, n_estimators=1000; total time=   1.7s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=2, n_estimators=1200; total time=   2.0s
[CV] END bootstrap=False, max_depth=20, max_features=sqrt, min_samples_leaf=4, min_samples
_split=10, n_estimators=1200; total time=   1.9s
[CV] END bootstrap=False, max_depth=50, max_features=sqrt, min_samples_leaf=2, min_samples
_split=2, n_estimators=800; total time=   1.5s
[CV] END bootstrap=True, max_depth=50, max_features=sqrt, min_samples_leaf=4, min_samples_
split=10, n_estimators=800; total time=   1.2s
[CV] END bootstrap=True, max_depth=90, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=1800; total time=   2.7s
[CV] END bootstrap=True, max_depth=60, max_features=sqrt, min_samples_leaf=2, min_samples_
split=2, n_estimators=1000; total time=   1.6s
[CV] END bootstrap=True, max_depth=60, max_features=sqrt, min_samples_leaf=2, min_samples_
split=2, n_estimators=1000; total time=   1.8s
[CV] END bootstrap=True, max_depth=90, max_features=sqrt, min_samples_leaf=4, min_samples_
split=10, n_estimators=400; total time=   0.6s
[CV] END bootstrap=True, max_depth=90, max_features=auto, min_samples_leaf=2, min_samples_
split=2, n_estimators=2000; total time=   6.7s
[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=2000; total time=   8.0s
[CV] END bootstrap=False, max_depth=60, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=600; total time=   0.9s
[CV] END bootstrap=True, max_depth=80, max_features=auto, min_samples_leaf=2, min_samples_
split=2, n_estimators=1800; total time=   6.3s
[CV] END bootstrap=True, max_depth=50, max_features=sqrt, min_samples_leaf=1, min_samples_
split=2, n_estimators=200; total time=   0.4s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=400; total time=   0.5s
[CV] END bootstrap=False, max_depth=None, max_features=auto, min_samples_leaf=2, min_sampl
es_split=10, n_estimators=1200; total time=   5.4s
[CV] END bootstrap=False, max_depth=10, max_features=auto, min_samples_leaf=4, min_samples
_split=2, n_estimators=1800; total time= 2.5min
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=1400; total time=   2.7s
[CV] END bootstrap=True, max_depth=60, max_features=sqrt, min_samples_leaf=2, min_samples_
split=5, n_estimators=1800; total time=   4.4s
[CV] END bootstrap=True, max_depth=90, max_features=auto, min_samples_leaf=1, min_samples_
split=5, n_estimators=1600; total time=   8.6s
[CV] END bootstrap=True, max_depth=80, max_features=auto, min_samples_leaf=4, min_samples_
split=5, n_estimators=200; total time=   0.6s
[CV] END bootstrap=False, max_depth=60, max_features=auto, min_samples_leaf=4, min_samples
_split=2, n_estimators=2000; total time=   8.5s
[CV] END bootstrap=True, max_depth=100, max_features=sqrt, min_samples_leaf=4, min_samples
_split=10, n_estimators=800; total time=   1.4s
[CV] END bootstrap=True, max_depth=110, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=600; total time=   1.0s
[CV] END bootstrap=True, max_depth=40, max_features=sqrt, min_samples_leaf=1, min_samples_
split=5, n_estimators=800; total time=   1.5s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=4, min_samples
```

```
_split=2, n_estimators=600; total time=   1.0s
[CV] END bootstrap=False, max_depth=40, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=400; total time=   1.7s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=2, n_estimators=2000; total time=   3.8s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=1, min_samples_
split=5, n_estimators=2000; total time=   3.7s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=4, min_samples
_split=5, n_estimators=800; total time=   1.2s
[CV] END bootstrap=False, max_depth=100, max_features=sqrt, min_samples_leaf=2, min_sample
s_split=5, n_estimators=1000; total time=   1.8s
[CV] END bootstrap=False, max_depth=60, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=600; total time=   1.1s
[CV] END bootstrap=False, max_depth=10, max_features=auto, min_samples_leaf=4, min_samples
_split=5, n_estimators=1800; total time=   6.8s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=2, min_samples
_split=10, n_estimators=800; total time=   1.4s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=2, min_samples
_split=10, n_estimators=800; total time=   1.4s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=1, min_samples_
split=2, n_estimators=1000; total time=   1.9s
[CV] END bootstrap=False, max_depth=110, max_features=auto, min_samples_leaf=2, min_sample
s_split=10, n_estimators=1800; total time=   8.0s
[CV] END bootstrap=True, max_depth=None, max_features=auto, min_samples_leaf=2, min_sample
s_split=2, n_estimators=1800; total time=   6.3s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=2, n_estimators=1200; total time=   2.1s
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split=2, n_estimators=1200; total time=   2.2s
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_split=10, n_estimators=1200; total time=   2.0s
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s_split=5, n_estimators=800; total time=   1.5s
[CV] END bootstrap=True, max_depth=90, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=1800; total time=   2.7s
[CV] END bootstrap=True, max_depth=None, max_features=auto, min_samples_leaf=2, min_sample
s_split=5, n_estimators=800; total time=   2.7s
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split=2, n_estimators=800; total time=   1.2s
[CV] END bootstrap=True, max_depth=110, max_features=sqrt, min_samples_leaf=1, min_samples
_split=2, n_estimators=1000; total time=   2.0s
[CV] END bootstrap=False, max_depth=110, max_features=sqrt, min_samples_leaf=2, min_sample
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_split=2, n_estimators=1800; total time=   9.8s
[CV] END bootstrap=False, max_depth=None, max_features=sqrt, min_samples_leaf=2, min_sampl
es_split=5, n_estimators=1400; total time=   2.4s
[CV] END bootstrap=True, max_depth=10, max_features=auto, min_samples_leaf=1, min_samples_
split=5, n_estimators=1600; total time=   5.5s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=1400; total time=   5.6s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=1, min_samples_
split=10, n_estimators=1600; total time=   3.9s
[CV] END bootstrap=True, max_depth=70, max_features=auto, min_samples_leaf=2, min_samples_
split=2, n_estimators=1400; total time= 2.4min
[CV] END bootstrap=False, max_depth=60, max_features=auto, min_samples_leaf=2, min_samples
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[CV] END bootstrap=False, max_depth=90, max_features=sqrt, min_samples_leaf=2, min_samples
_split=10, n_estimators=400; total time=   1.4s
[CV] END bootstrap=True, max_depth=None, max_features=sqrt, min_samples_leaf=1, min_sample
s_split=10, n_estimators=1600; total time=   3.8s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples_
split=5, n_estimators=1000; total time=   1.9s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=600; total time=   1.9s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=4, min_samples
```

```
_split=5, n_estimators=1000; total time=   3.1s
[CV] END bootstrap=False, max_depth=70, max_features=sqrt, min_samples_leaf=4, min_samples
_split=5, n_estimators=800; total time=   1.4s
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_split=10, n_estimators=600; total time=   1.0s
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split=2, n_estimators=1600; total time=   2.8s
[CV] END bootstrap=False, max_depth=None, max_features=sqrt, min_samples_leaf=4, min_sampl
es_split=5, n_estimators=2000; total time=   3.4s
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_split=2, n_estimators=1000; total time=   5.1s
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split=5, n_estimators=400; total time=   0.7s
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_split=2, n_estimators=2000; total time=   8.2s
[CV] END bootstrap=True, max_depth=70, max_features=auto, min_samples_leaf=4, min_samples_
split=10, n_estimators=400; total time=   1.1s
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split=10, n_estimators=400; total time=   1.2s
[CV] END bootstrap=False, max_depth=90, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=800; total time=   1.6s
[CV] END bootstrap=False, max_depth=10, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=2000; total time=   3.3s
[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=4, min_samples
_split=2, n_estimators=1800; total time=   7.7s
[CV] END bootstrap=False, max_depth=70, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=1600; total time=   3.2s
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s_split=2, n_estimators=1800; total time=   6.3s
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s_split=10, n_estimators=2000; total time=   7.8s
[CV] END bootstrap=False, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples
_split=10, n_estimators=800; total time=   1.2s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=5, n_estimators=1200; total time=   2.0s
[CV] END bootstrap=True, max_depth=60, max_features=sqrt, min_samples_leaf=2, min_samples_
split=2, n_estimators=1000; total time=   1.7s
[CV] END bootstrap=True, max_depth=10, max_features=auto, min_samples_leaf=4, min_samples_
split=5, n_estimators=200; total time=   0.5s
[CV] END bootstrap=True, max_depth=90, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=800; total time=   1.1s
[CV] END bootstrap=True, max_depth=110, max_features=sqrt, min_samples_leaf=1, min_samples
_split=2, n_estimators=1000; total time=   2.0s
[CV] END bootstrap=False, max_depth=70, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=1200; total time=   1.8s
[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=2000; total time=   7.8s
[CV] END bootstrap=False, max_depth=30, max_features=auto, min_samples_leaf=4, min_samples
_split=5, n_estimators=1000; total time=   3.9s
[CV] END bootstrap=True, max_depth=10, max_features=auto, min_samples_leaf=1, min_samples_
split=5, n_estimators=1600; total time=   5.5s
[CV] END bootstrap=True, max_depth=80, max_features=sqrt, min_samples_leaf=2, min_samples_
split=10, n_estimators=1400; total time=   2.1s
[CV] END bootstrap=False, max_depth=80, max_features=auto, min_samples_leaf=4, min_samples
_split=10, n_estimators=1000; total time=   3.5s
[CV] END bootstrap=True, max_depth=None, max_features=auto, min_samples_leaf=2, min_sample
s_split=10, n_estimators=1600; total time=   7.5s
[CV] END bootstrap=True, max_depth=70, max_features=auto, min_samples_leaf=2, min_samples_
split=2, n_estimators=1400; total time= 2.4min
[CV] END bootstrap=False, max_depth=20, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=800; total time=   2.1s
[CV] END bootstrap=False, max_depth=90, max_features=auto, min_samples_leaf=1, min_samples
_split=5, n_estimators=400; total time=   2.5s
[CV] END bootstrap=True, max_depth=90, max_features=auto, min_samples_leaf=1, min_samples_
split=5, n_estimators=1600; total time=   8.6s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples_
```

```
split=5, n_estimators=1000; total time=   1.7s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=4, min_samples
_split=5, n_estimators=1000; total time=   3.3s
[CV] END bootstrap=False, max_depth=None, max_features=auto, min_samples_leaf=2, min_sampl
es_split=10, n_estimators=800; total time=   3.6s
[CV] END bootstrap=True, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=1600; total time=   3.0s
[CV] END bootstrap=True, max_depth=40, max_features=sqrt, min_samples_leaf=1, min_samples_
split=5, n_estimators=800; total time=   1.5s
[CV] END bootstrap=True, max_depth=40, max_features=auto, min_samples_leaf=4, min_samples_
split=2, n_estimators=600; total time=   1.9s
[CV] END bootstrap=False, max_depth=100, max_features=auto, min_samples_leaf=4, min_sample
s_split=5, n_estimators=200; total time=   0.8s
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[CV] END bootstrap=True, max_depth=40, max_features=auto, min_samples_leaf=2, min_samples_
split=10, n_estimators=2000; total time=   4.1s
[CV] END bootstrap=True, max_depth=30, max_features=sqrt, min_samples_leaf=1, min_samples_
split=5, n_estimators=400; total time=   0.7s
[CV] END bootstrap=False, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples
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[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=4, min_samples_
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s_split=5, n_estimators=1000; total time=   1.9s
[CV] END bootstrap=False, max_depth=10, max_features=auto, min_samples_leaf=4, min_samples
_split=5, n_estimators=1800; total time=   6.8s
[CV] END bootstrap=False, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples
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[CV] END bootstrap=False, max_depth=70, max_features=auto, min_samples_leaf=2, min_samples
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[CV] END bootstrap=False, max_depth=110, max_features=auto, min_samples_leaf=2, min_sample
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s_split=10, n_estimators=2000; total time=   8.1s
[CV] END bootstrap=False, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples
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[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=1, min_samples
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[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=400; total time=   0.6s
[CV] END bootstrap=False, max_depth=None, max_features=auto, min_samples_leaf=2, min_sampl
es_split=10, n_estimators=1200; total time=   5.5s
[CV] END bootstrap=False, max_depth=10, max_features=auto, min_samples_leaf=4, min_samples
_split=2, n_estimators=1800; total time= 2.5min
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples
```

```
_split=2, n_estimators=1400; total time=   2.9s
[CV] END bootstrap=True, max_depth=60, max_features=sqrt, min_samples_leaf=2, min_samples_
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[CV] END bootstrap=True, max_depth=90, max_features=auto, min_samples_leaf=1, min_samples_
split=5, n_estimators=1600; total time=   8.3s
[CV] END bootstrap=True, max_depth=80, max_features=auto, min_samples_leaf=4, min_samples_
split=5, n_estimators=200; total time=   0.7s
[CV] END bootstrap=False, max_depth=60, max_features=auto, min_samples_leaf=4, min_samples
_split=2, n_estimators=2000; total time=   8.6s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples_
split=10, n_estimators=1000; total time=   1.8s
[CV] END bootstrap=False, max_depth=None, max_features=sqrt, min_samples_leaf=4, min_sampl
es_split=5, n_estimators=2000; total time=   3.4s
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[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=1, min_samples_
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[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=4, min_samples
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[CV] END bootstrap=False, max_depth=100, max_features=sqrt, min_samples_leaf=2, min_sample
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[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=1, min_samples
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[CV] END bootstrap=False, max_depth=90, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=800; total time=   1.5s
[CV] END bootstrap=False, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples
_split=5, n_estimators=1600; total time=   2.8s
[CV] END bootstrap=False, max_depth=70, max_features=auto, min_samples_leaf=2, min_samples
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[CV] END bootstrap=True, max_depth=80, max_features=auto, min_samples_leaf=1, min_samples_
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[CV] END bootstrap=True, max_depth=80, max_features=auto, min_samples_leaf=1, min_samples_
split=5, n_estimators=600; total time=   2.1s
[CV] END bootstrap=False, max_depth=70, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=1600; total time=   3.3s
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=1400; total time=   2.6s
[CV] END bootstrap=False, max_depth=40, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=1400; total time=   7.9s
[CV] END bootstrap=False, max_depth=50, max_features=sqrt, min_samples_leaf=2, min_samples
_split=2, n_estimators=800; total time=   1.7s
[CV] END bootstrap=False, max_depth=100, max_features=sqrt, min_samples_leaf=1, min_sample
s_split=5, n_estimators=800; total time=   1.5s
[CV] END bootstrap=True, max_depth=90, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=1800; total time=   2.7s
[CV] END bootstrap=True, max_depth=None, max_features=auto, min_samples_leaf=2, min_sample
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[CV] END bootstrap=True, max_depth=60, max_features=sqrt, min_samples_leaf=2, min_samples_
split=10, n_estimators=600; total time=   0.9s
[CV] END bootstrap=False, max_depth=90, max_features=auto, min_samples_leaf=2, min_samples
_split=5, n_estimators=200; total time=   0.9s
[CV] END bootstrap=True, max_depth=90, max_features=auto, min_samples_leaf=2, min_samples_
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[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=4, min_samples
_split=10, n_estimators=1000; total time=   3.6s
[CV] END bootstrap=False, max_depth=30, max_features=auto, min_samples_leaf=4, min_samples
_split=5, n_estimators=1000; total time=   3.8s
[CV] END bootstrap=False, max_depth=60, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=600; total time=   0.9s
[CV] END bootstrap=True, max_depth=80, max_features=auto, min_samples_leaf=2, min_samples_
split=2, n_estimators=1800; total time=   6.3s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=400; total time=   0.7s
[CV] END bootstrap=False, max_depth=80, max_features=auto, min_samples_leaf=4, min_samples
_split=10, n_estimators=1000; total time=   4.3s
[CV] END bootstrap=True, max_depth=None, max_features=auto, min_samples_leaf=2, min_sample
```

```
s_split=10, n_estimators=1600; total time= 2.4min
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_split=10, n_estimators=1000; total time=   2.7s
[CV] END bootstrap=False, max_depth=60, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=2000; total time=  11.8s
[CV] END bootstrap=True, max_depth=100, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=2000; total time=   4.9s
[CV] END bootstrap=True, max_depth=80, max_features=auto, min_samples_leaf=4, min_samples_
split=5, n_estimators=200; total time=   0.7s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=600; total time=   2.1s
[CV] END bootstrap=False, max_depth=None, max_features=auto, min_samples_leaf=2, min_sampl
es_split=10, n_estimators=800; total time=   3.6s
[CV] END bootstrap=False, max_depth=40, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=600; total time=   1.1s
[CV] END bootstrap=True, max_depth=100, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=400; total time=   0.8s
[CV] END bootstrap=True, max_depth=100, max_features=sqrt, min_samples_leaf=4, min_samples
_split=10, n_estimators=800; total time=   1.4s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples_
split=10, n_estimators=1000; total time=   1.8s
[CV] END bootstrap=True, max_depth=40, max_features=auto, min_samples_leaf=4, min_samples_
split=2, n_estimators=600; total time=   2.0s
[CV] END bootstrap=False, max_depth=40, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=400; total time=   1.6s
[CV] END bootstrap=False, max_depth=100, max_features=auto, min_samples_leaf=4, min_sample
s_split=5, n_estimators=200; total time=   1.0s
[CV] END bootstrap=True, max_depth=40, max_features=auto, min_samples_leaf=2, min_samples_
split=10, n_estimators=2000; total time=   5.5s
[CV] END bootstrap=False, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples
_split=5, n_estimators=1200; total time=   2.2s
[CV] END bootstrap=False, max_depth=30, max_features=auto, min_samples_leaf=4, min_samples
_split=2, n_estimators=2000; total time=   8.2s
[CV] END bootstrap=True, max_depth=70, max_features=auto, min_samples_leaf=4, min_samples_
split=10, n_estimators=400; total time=   1.3s
[CV] END bootstrap=False, max_depth=90, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=800; total time=   1.6s
[CV] END bootstrap=False, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples
_split=5, n_estimators=1600; total time=   2.7s
[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=4, min_samples
_split=2, n_estimators=1800; total time=   7.1s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=1800; total time=   3.1s
[CV] END bootstrap=False, max_depth=70, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=1600; total time=   3.2s
[CV] END bootstrap=False, max_depth=None, max_features=sqrt, min_samples_leaf=1, min_sampl
es_split=2, n_estimators=400; total time=   0.9s
[CV] END bootstrap=False, max_depth=40, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=1400; total time=   7.7s
[CV] END bootstrap=False, max_depth=20, max_features=sqrt, min_samples_leaf=4, min_samples
_split=10, n_estimators=1200; total time=   2.0s
[CV] END bootstrap=False, max_depth=100, max_features=sqrt, min_samples_leaf=1, min_sample
s_split=5, n_estimators=800; total time=   1.5s
[CV] END bootstrap=False, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples
_split=10, n_estimators=800; total time=   1.2s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=800; total time=   3.2s
[CV] END bootstrap=True, max_depth=10, max_features=auto, min_samples_leaf=4, min_samples_
split=5, n_estimators=200; total time=   0.6s
[CV] END bootstrap=True, max_depth=60, max_features=sqrt, min_samples_leaf=2, min_samples_
split=10, n_estimators=600; total time=   0.9s
[CV] END bootstrap=True, max_depth=90, max_features=sqrt, min_samples_leaf=4, min_samples_
split=10, n_estimators=400; total time=   0.6s
[CV] END bootstrap=True, max_depth=90, max_features=auto, min_samples_leaf=2, min_samples_
split=2, n_estimators=2000; total time=   7.0s
[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=4, min_samples
```

```
_split=10, n_estimators=1000; total time=   3.6s
[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=4, min_samples
_split=10, n_estimators=1000; total time=   4.0s
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[CV] END bootstrap=True, max_depth=10, max_features=auto, min_samples_leaf=1, min_samples_
split=5, n_estimators=1600; total time=   5.3s
[CV] END bootstrap=True, max_depth=80, max_features=sqrt, min_samples_leaf=2, min_samples_
split=10, n_estimators=1400; total time=   2.1s
[CV] END bootstrap=False, max_depth=None, max_features=auto, min_samples_leaf=2, min_sampl
es_split=10, n_estimators=1200; total time=   5.9s
[CV] END bootstrap=False, max_depth=10, max_features=auto, min_samples_leaf=4, min_samples
_split=2, n_estimators=1800; total time= 2.5min
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples
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[CV] END bootstrap=True, max_depth=60, max_features=sqrt, min_samples_leaf=2, min_samples_
split=5, n_estimators=1800; total time=   4.6s
[CV] END bootstrap=False, max_depth=90, max_features=sqrt, min_samples_leaf=2, min_samples
_split=10, n_estimators=400; total time=   1.1s
[CV] END bootstrap=False, max_depth=90, max_features=sqrt, min_samples_leaf=2, min_samples
_split=10, n_estimators=400; total time=   1.5s
[CV] END bootstrap=True, max_depth=None, max_features=sqrt, min_samples_leaf=1, min_sample
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split=5, n_estimators=1000; total time=   1.9s
[CV] END bootstrap=False, max_depth=60, max_features=auto, min_samples_leaf=4, min_samples
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split=10, n_estimators=1000; total time=   1.9s
[CV] END bootstrap=True, max_depth=110, max_features=sqrt, min_samples_leaf=1, min_samples
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split=2, n_estimators=600; total time=   1.9s
[CV] END bootstrap=False, max_depth=40, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=400; total time=   1.9s
[CV] END bootstrap=True, max_depth=40, max_features=auto, min_samples_leaf=2, min_samples_
split=10, n_estimators=2000; total time=   5.6s
[CV] END bootstrap=False, max_depth=10, max_features=sqrt, min_samples_leaf=2, min_samples
_split=5, n_estimators=1200; total time=   2.2s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=1600; total time=   2.5s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=4, min_samples
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[CV] END bootstrap=False, max_depth=60, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=600; total time=   1.1s
[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=1, min_samples
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[CV] END bootstrap=False, max_depth=10, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=2000; total time=   3.3s
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_split=5, n_estimators=600; total time=   2.8s
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split=2, n_estimators=1000; total time=   2.3s
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split=5, n_estimators=600; total time=   2.0s
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[CV] END bootstrap=True, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples_
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[CV] END bootstrap=False, max_depth=None, max_features=sqrt, min_samples_leaf=1, min_sampl
es_split=2, n_estimators=400; total time=   0.9s
[CV] END bootstrap=False, max_depth=None, max_features=sqrt, min_samples_leaf=1, min_sampl
es_split=2, n_estimators=400; total time=   0.9s
[CV] END bootstrap=False, max_depth=40, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=1400; total time=   8.3s
[CV] END bootstrap=False, max_depth=50, max_features=sqrt, min_samples_leaf=2, min_samples
```

```
_split=2, n_estimators=800; total time=   1.5s
[CV] END bootstrap=True, max_depth=50, max_features=sqrt, min_samples_leaf=4, min_samples_
split=10, n_estimators=800; total time=   1.3s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=5, n_estimators=1200; total time=   1.9s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=800; total time=   3.1s
[CV] END bootstrap=True, max_depth=90, max_features=sqrt, min_samples_leaf=4, min_samples_
split=10, n_estimators=400; total time=   0.6s
[CV] END bootstrap=False, max_depth=90, max_features=auto, min_samples_leaf=2, min_samples
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[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples
_split=10, n_estimators=400; total time=   0.6s
[CV] END bootstrap=False, max_depth=70, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=1200; total time=   1.8s
[CV] END bootstrap=False, max_depth=20, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=1800; total time=  10.3s
[CV] END bootstrap=False, max_depth=None, max_features=sqrt, min_samples_leaf=2, min_sampl
es_split=5, n_estimators=1400; total time=   2.3s
[CV] END bootstrap=True, max_depth=80, max_features=auto, min_samples_leaf=2, min_samples_
split=2, n_estimators=1800; total time=   6.2s
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split=10, n_estimators=1400; total time=   2.2s
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split=10, n_estimators=1600; total time=   2.4s
[CV] END bootstrap=True, max_depth=None, max_features=auto, min_samples_leaf=2, min_sample
s_split=10, n_estimators=1600; total time=   7.9s
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=1000; total time= 2.4min
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=1000; total time=   2.0s
[CV] END bootstrap=False, max_depth=20, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=800; total time=   1.5s
[CV] END bootstrap=False, max_depth=20, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=800; total time=   2.1s
[CV] END bootstrap=False, max_depth=90, max_features=auto, min_samples_leaf=1, min_samples
_split=5, n_estimators=400; total time=   2.4s
[CV] END bootstrap=False, max_depth=90, max_features=auto, min_samples_leaf=1, min_samples
_split=5, n_estimators=400; total time=   3.0s
[CV] END bootstrap=True, max_depth=None, max_features=sqrt, min_samples_leaf=1, min_sample
s_split=10, n_estimators=1600; total time=   4.2s
[CV] END bootstrap=True, max_depth=100, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=2000; total time=   4.2s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=4, min_samples
_split=5, n_estimators=1000; total time=   3.1s
[CV] END bootstrap=False, max_depth=70, max_features=sqrt, min_samples_leaf=4, min_samples
_split=5, n_estimators=800; total time=   1.3s
[CV] END bootstrap=False, max_depth=40, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=600; total time=   1.0s
[CV] END bootstrap=True, max_depth=100, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=400; total time=   0.8s
[CV] END bootstrap=True, max_depth=100, max_features=sqrt, min_samples_leaf=4, min_samples
_split=10, n_estimators=800; total time=   1.4s
[CV] END bootstrap=True, max_depth=110, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=600; total time=   1.2s
[CV] END bootstrap=True, max_depth=40, max_features=sqrt, min_samples_leaf=1, min_samples_
split=5, n_estimators=800; total time=   1.6s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=600; total time=   1.0s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=600; total time=   0.9s
[CV] END bootstrap=False, max_depth=100, max_features=auto, min_samples_leaf=4, min_sample
s_split=5, n_estimators=200; total time=   0.9s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=2, n_estimators=2000; total time=   3.8s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=1, min_samples_
```

```
split=5, n_estimators=2000; total time=   3.6s
[CV] END bootstrap=True, max_depth=10, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=1600; total time=   2.3s
[CV] END bootstrap=False, max_depth=60, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=600; total time=   1.0s
[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=1000; total time=   5.9s
[CV] END bootstrap=False, max_depth=10, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=2000; total time=   3.1s
[CV] END bootstrap=False, max_depth=50, max_features=auto, min_samples_leaf=4, min_samples
_split=2, n_estimators=1800; total time=   7.2s
[CV] END bootstrap=False, max_depth=30, max_features=sqrt, min_samples_leaf=1, min_samples
_split=10, n_estimators=1800; total time=   3.4s
[CV] END bootstrap=True, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples_
split=5, n_estimators=1400; total time=   2.3s
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=1400; total time=   2.6s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=5, n_estimators=1000; total time=   1.8s
[CV] END bootstrap=False, max_depth=100, max_features=auto, min_samples_leaf=4, min_sample
s_split=10, n_estimators=2000; total time=   7.6s
[CV] END bootstrap=True, max_depth=50, max_features=sqrt, min_samples_leaf=4, min_samples_
split=10, n_estimators=800; total time=   1.2s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=2, min_samples_
split=5, n_estimators=1200; total time=   2.0s
[CV] END bootstrap=True, max_depth=None, max_features=auto, min_samples_leaf=2, min_sample
s_split=5, n_estimators=800; total time=   2.6s
[CV] END bootstrap=True, max_depth=60, max_features=sqrt, min_samples_leaf=2, min_samples_
split=10, n_estimators=600; total time=   0.9s
[CV] END bootstrap=False, max_depth=90, max_features=auto, min_samples_leaf=2, min_samples
_split=5, n_estimators=200; total time=   0.9s
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples
_split=10, n_estimators=400; total time=   0.6s
[CV] END bootstrap=False, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples
_split=10, n_estimators=400; total time=   0.5s
[CV] END bootstrap=False, max_depth=70, max_features=sqrt, min_samples_leaf=4, min_samples
_split=2, n_estimators=1200; total time=   1.7s
[CV] END bootstrap=False, max_depth=20, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=1800; total time=  10.4s
[CV] END bootstrap=False, max_depth=None, max_features=sqrt, min_samples_leaf=2, min_sampl
es_split=5, n_estimators=1400; total time=   2.5s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=1400; total time=   5.8s
[CV] END bootstrap=True, max_depth=50, max_features=sqrt, min_samples_leaf=1, min_samples_
split=2, n_estimators=200; total time=   0.5s
[CV] END bootstrap=False, max_depth=80, max_features=auto, min_samples_leaf=4, min_samples
_split=10, n_estimators=1000; total time=   3.7s
[CV] END bootstrap=True, max_depth=20, max_features=sqrt, min_samples_leaf=1, min_samples_
split=10, n_estimators=1600; total time=   4.4s
[CV] END bootstrap=True, max_depth=70, max_features=auto, min_samples_leaf=2, min_samples_
split=2, n_estimators=1400; total time= 2.4min
[CV] END bootstrap=False, max_depth=60, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=2000; total time=  12.3s
[CV] END bootstrap=True, max_depth=100, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=2000; total time=   4.7s
[CV] END bootstrap=True, max_depth=100, max_features=auto, min_samples_leaf=2, min_samples
_split=10, n_estimators=600; total time=   2.0s
[CV] END bootstrap=False, max_depth=None, max_features=auto, min_samples_leaf=2, min_sampl
es_split=10, n_estimators=800; total time=   3.3s
[CV] END bootstrap=False, max_depth=70, max_features=sqrt, min_samples_leaf=4, min_samples
_split=5, n_estimators=800; total time=   1.3s
[CV] END bootstrap=True, max_depth=100, max_features=sqrt, min_samples_leaf=1, min_samples
_split=5, n_estimators=400; total time=   0.8s
[CV] END bootstrap=True, max_depth=80, max_features=sqrt, min_samples_leaf=4, min_samples_
split=2, n_estimators=1600; total time=   3.1s
[CV] END bootstrap=False, max_depth=None, max_features=sqrt, min_samples_leaf=4, min_sampl
```

```
es_split=5, n_estimators=2000; total time=   3.4s
[CV] END bootstrap=False, max_depth=10, max_features=auto, min_samples_leaf=1, min_samples
_split=2, n_estimators=1000; total time=   5.1s
```

Out[266…
```
RandomizedSearchCV(estimator=GradientBoostingRegressor(), n_iter=20, n_jobs=2,
                   param_distributions={'learning_rate': <scipy.stats._distn_infrastructur
e.rv_frozen object at 0x7fb52cc0baf0>,
                                        'max_leaf_nodes': [2, 5, 10, 20, 50,
                                                           100],
                                        'n_estimators': [1, 2, 5, 10, 20, 50,
                                                         100, 200, 500]},
                   random_state=42, scoring='neg_mean_absolute_error')
```

In [266…
```
random_cv.best_params_
```

Out[266…
```
{'learning_rate': 0.06170217483403151,
 'max_leaf_nodes': 20,
 'n_estimators': 200}
```

In [266…
```
model_gb=random_cv.best_estimator_
model_gb.fit(X_train,y_train)
pred=model_gb.predict(X_test)
r_score=r2_score(y_test,pred)
print('model score is : {}'.format(r_score))
```

```
model score is : 0.9177315048254759
```

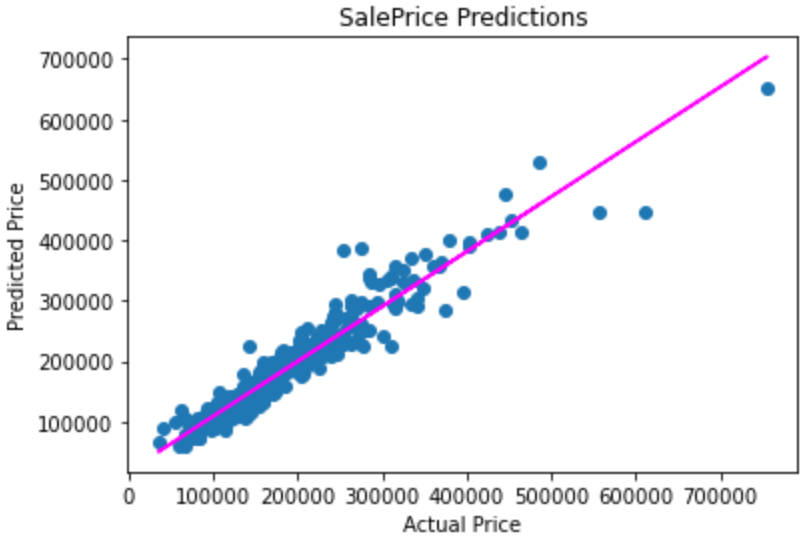
In [267…
```
mae=mean_absolute_error(pred,y_test)
print('Mean absolute error is : {}'.format(mae))
```

```
Mean absolute error is : 15759.847600190216
```

We got the best score from GradientBoostingRegressor after tuning hyperparameter at 91.44% and Mean absolute error at 15724.85 that conclusion that the prediction prices from this model can have the average error around +/- 15724.85 from actual housing prices.

Fit linear line model to visualize model fit to dataset

In [267…
```
plt.scatter(y_test, pred)
plt.xlabel('Actual Price')
plt.ylabel('Predicted Price')
plt.title('SalePrice Predictions')
z = np.polyfit(y_test, pred, 1)
p = np.poly1d(z)
plt.plot(y_test,p(y_test), color='magenta')
plt.show()
```



Save model and use model for predict df_test dataset

In [267…

```
import joblib
filename = './SalePrice.pkl'
joblib.dump(model_gb, filename)
```

Out[267…

```
['./SalePrice.pkl']
```

In [267…

```
loaded_model = joblib.load(filename)
predict_data=df_test

result = loaded_model.predict(predict_data)
np.round(result[1:10],2)
```

Out[267…

```
array([174419.48, 164961.46, 191638.79, 186202.93, 163503.83, 178241.23,
       172441.81, 163785.16, 107116.81])
```