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README.md

Final Project Submission

- Student name: Jonathan Lee
- Student pace: full time
- Scheduled project review date/time: April 27, 2pm
- Instructor name: James Irving

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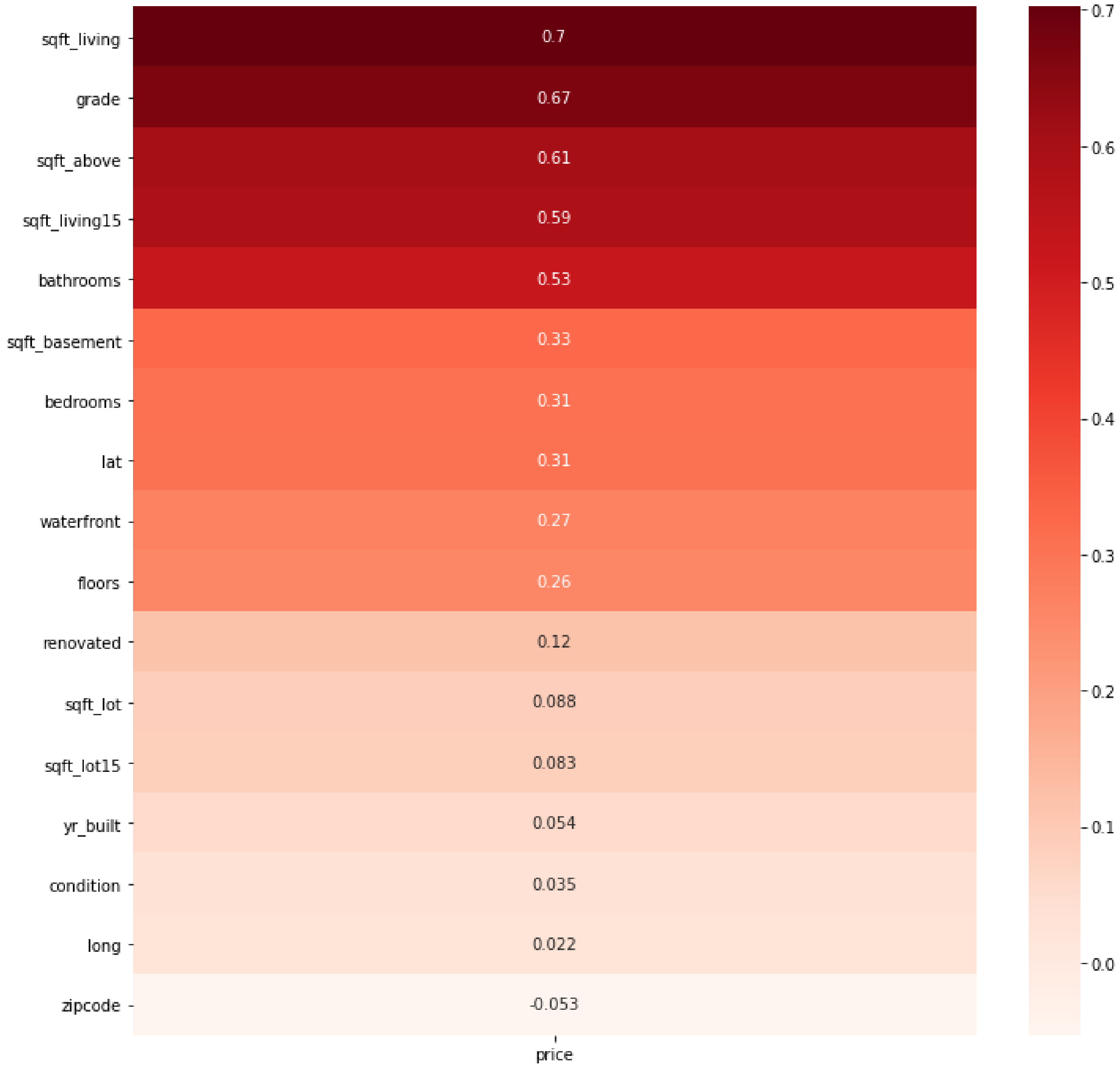
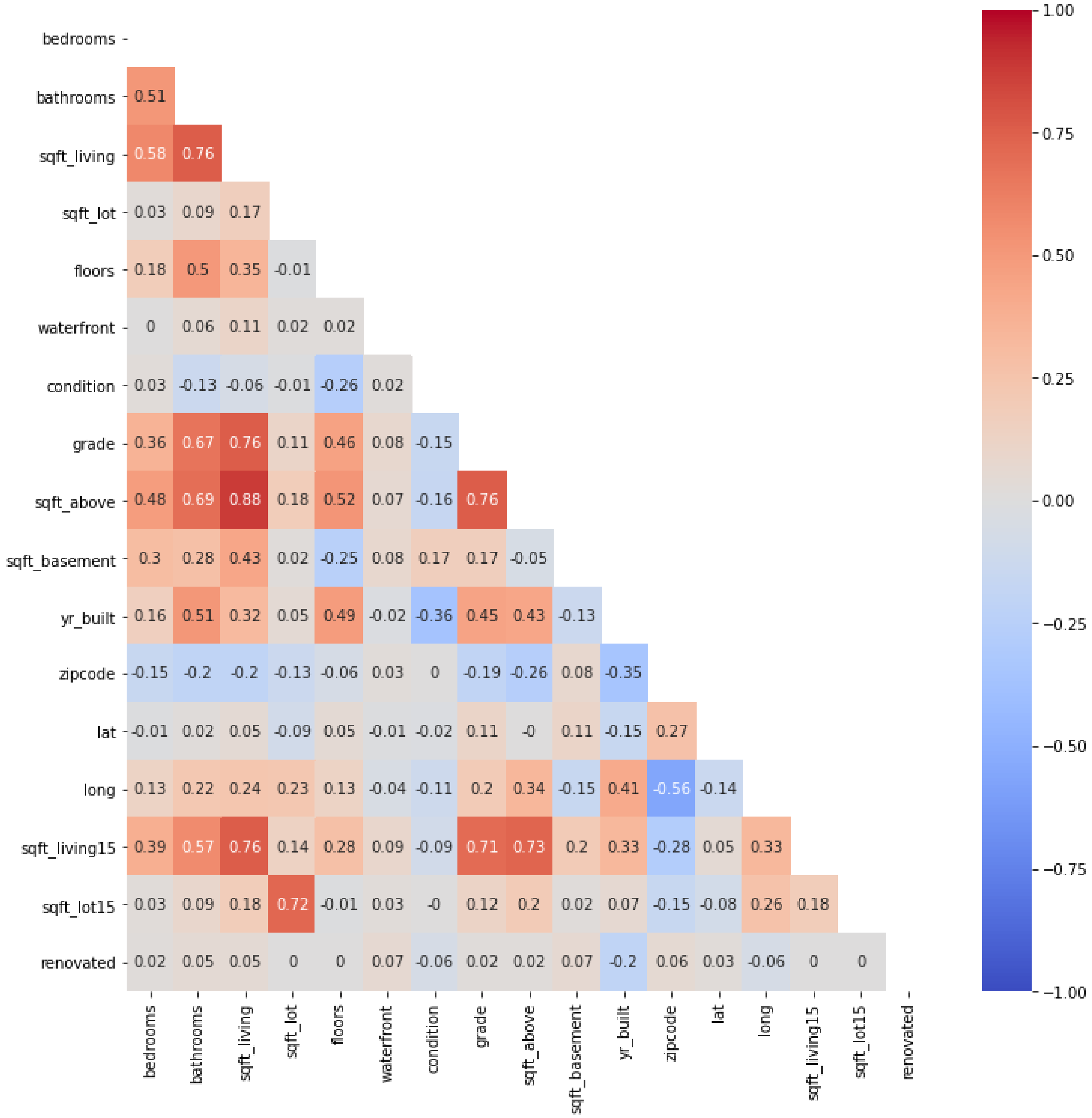
INTRODUCTION

This analysis focuses on creating a multiple regression model based on housing data from King County, Washington. We will work through an exploratory data analysis to clean the data that we have to prepare it for modeling, as well as working through an iterative approach to refining our model. The goal of this analysis is to create a model which explains how different attributes affect the value of a housing property in King County, and to extract specific variables which we can use to recommend to a homeowner in King County how to increase the value of his/her home.

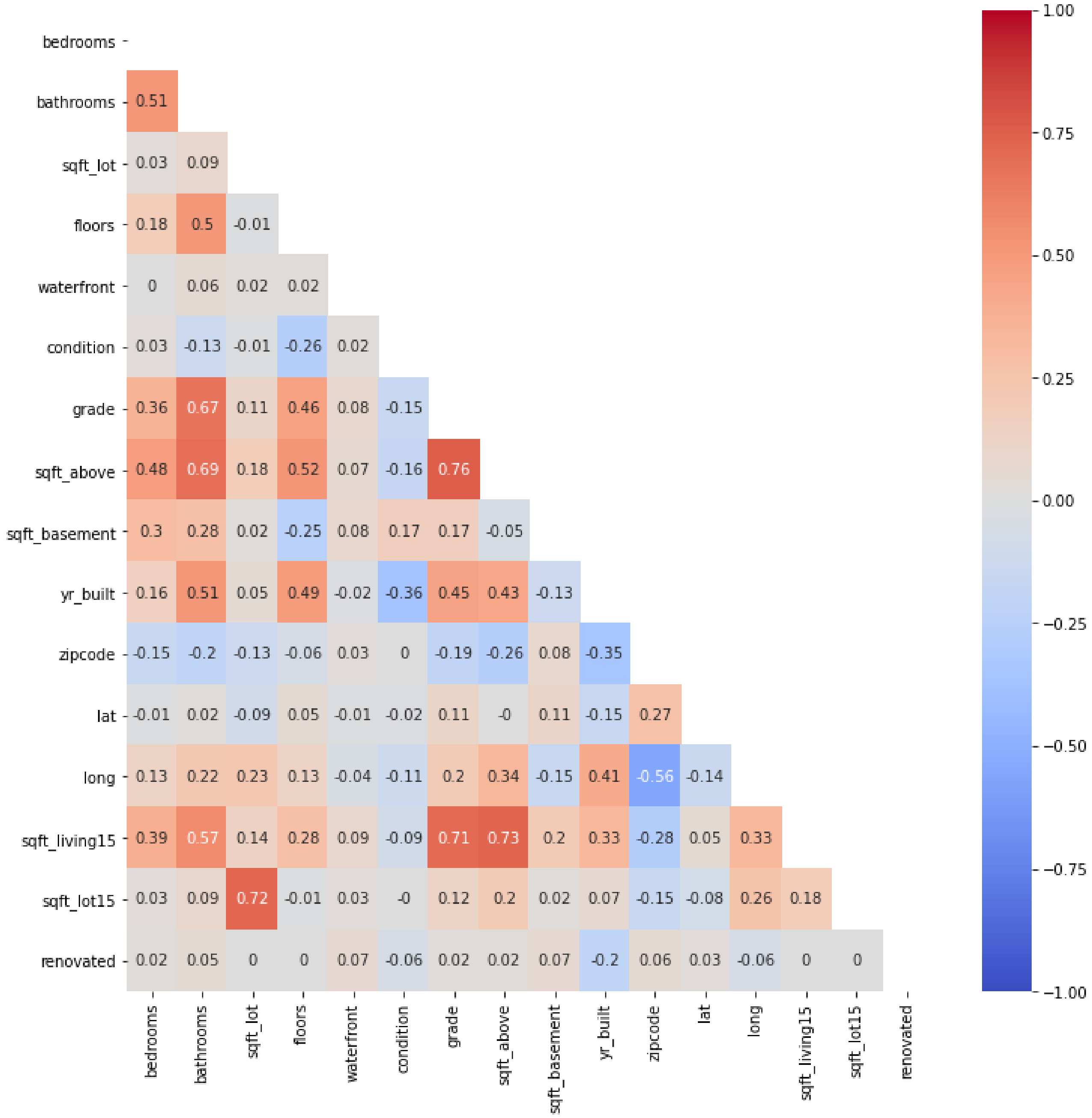
Checking for Correlation and Multicollinearity

The following visualizations help us check for how correlated each column of data is with our target variable 'price' as well as check for multicollinearity


sqft_living
0.7
grade
0.67
sqft_above
0.61
sqft_living15
0.59
bathrooms
0.53
sqft_basement
0.33
bedrooms
0.31
lat
0.31
waterfront
0.27
floors
0.26
renovated
0.12
sqft_lot
0.088
sqft_lot15
0.083
yr_built
0.054
condition
0.035
long
0.022
zipcode
-0.053
price
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0



From the correlation heatmap, we can see that other than 'sqft_living', we do not have any variables that are high enough to remove prior to running our baseline model. We will go ahead and remove 'sqft_living' to address the issue of multicollinearity in our dataset.



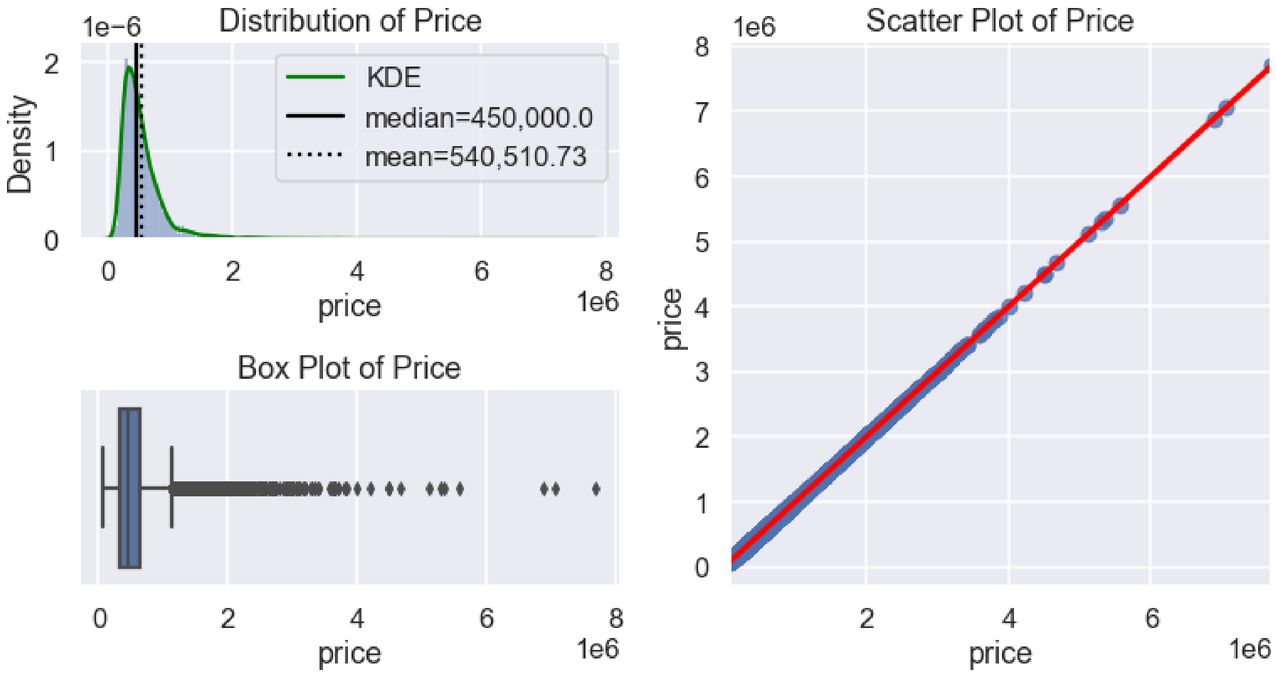
EXPLORE

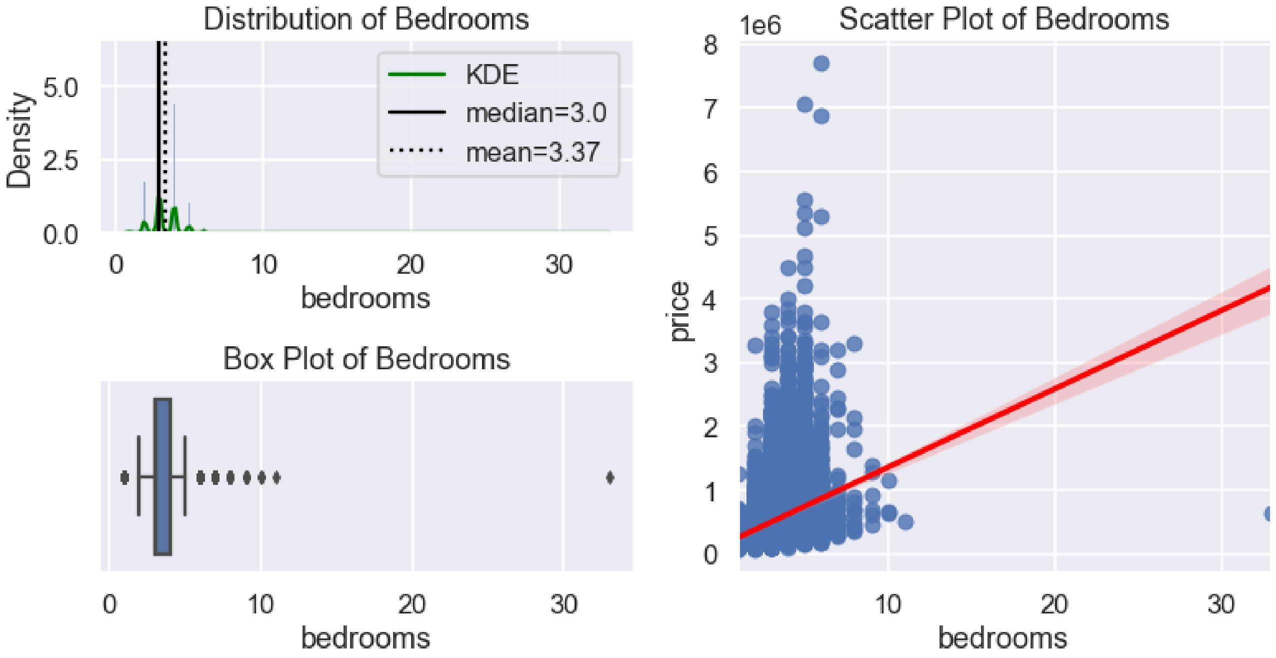
In this section, we will explore the distributions as well as addressing the issue of outliers in each column. We will also be checking to see how much of a linear relationship each variable has with our target variable 'price'.

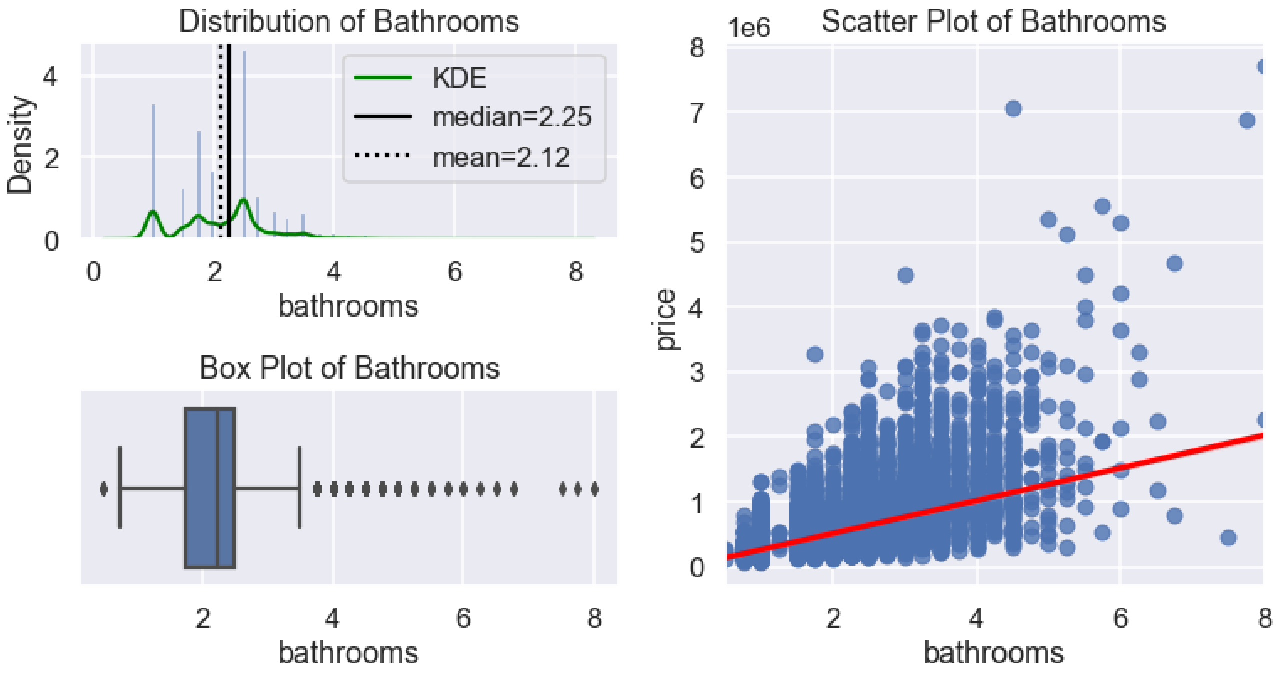
Checking for Normality, Outliers, and Linearity

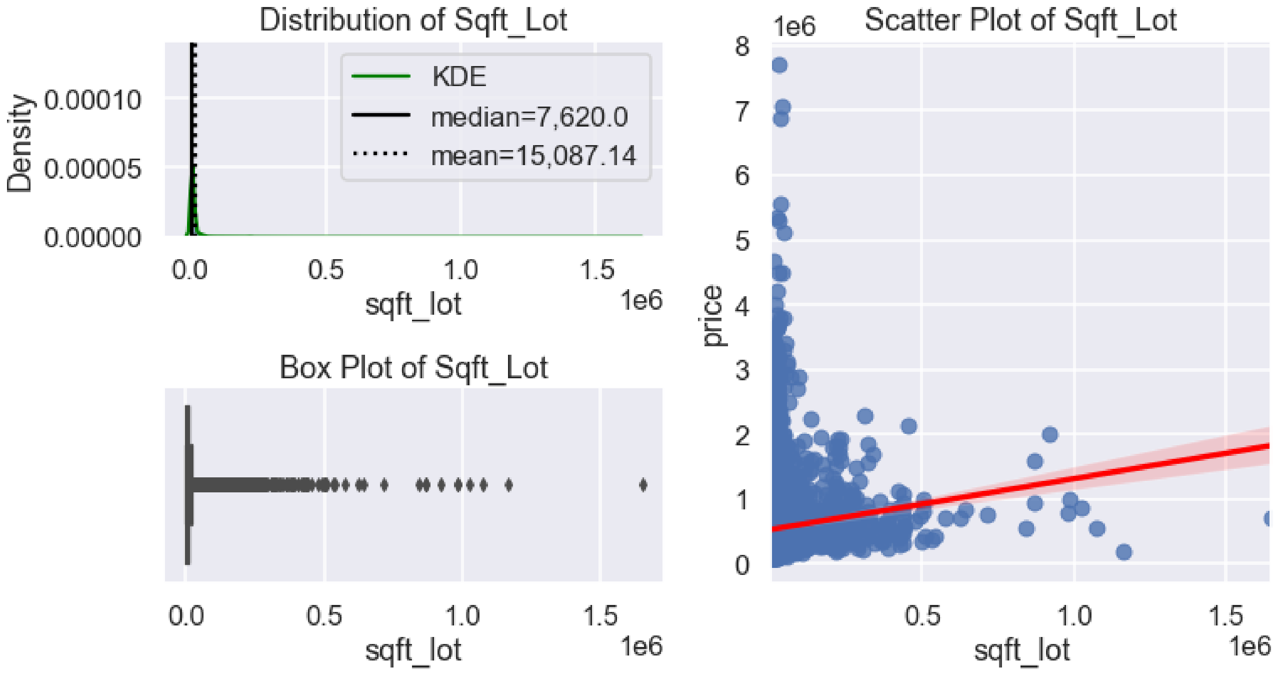
There appear to be some outliers, as in the case of bedrooms where the max number is 33. Although this might be an error in data collection, we will leave the outliers be for now to see how they affect the skew of our data and how our baseline model turns out with what has been provided.

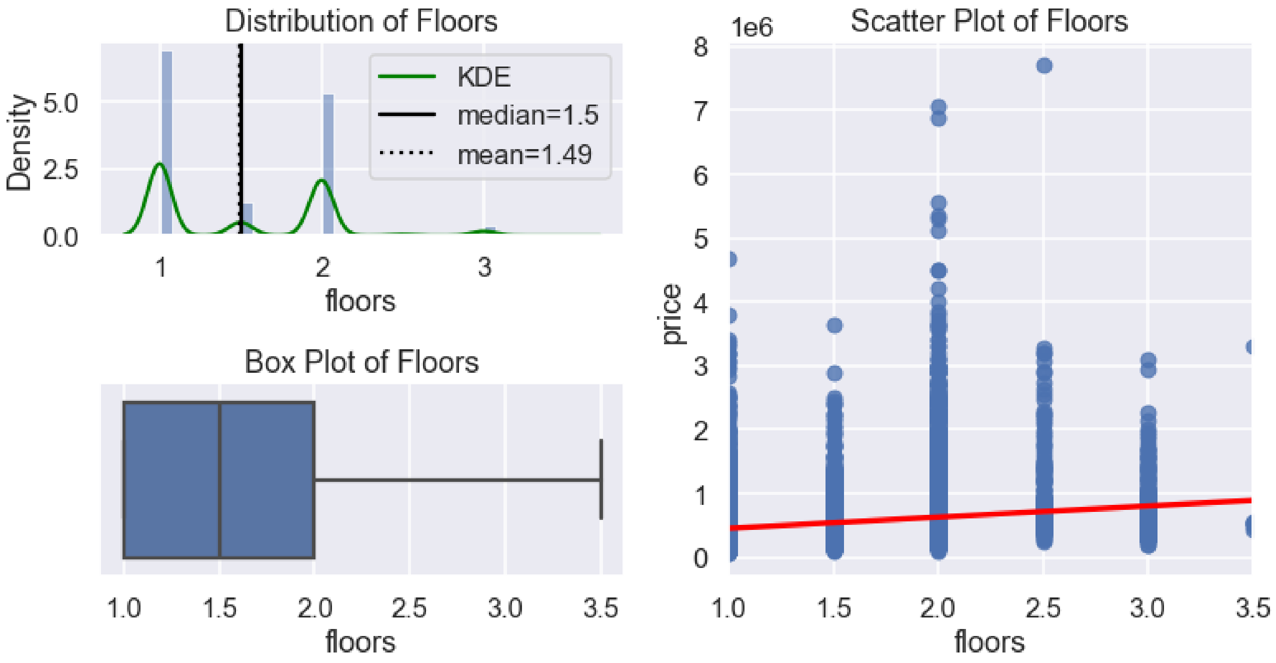
We will proceed to visualize how our data is distributed as well as the linearity of each variable against the price variable.

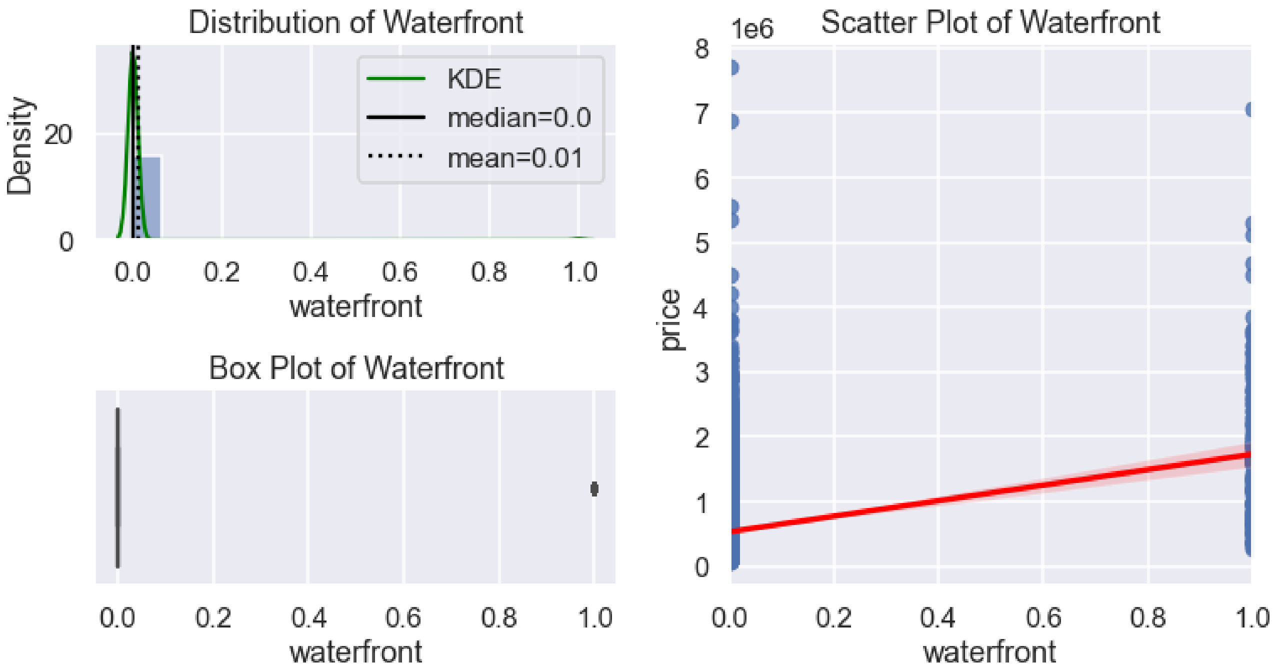


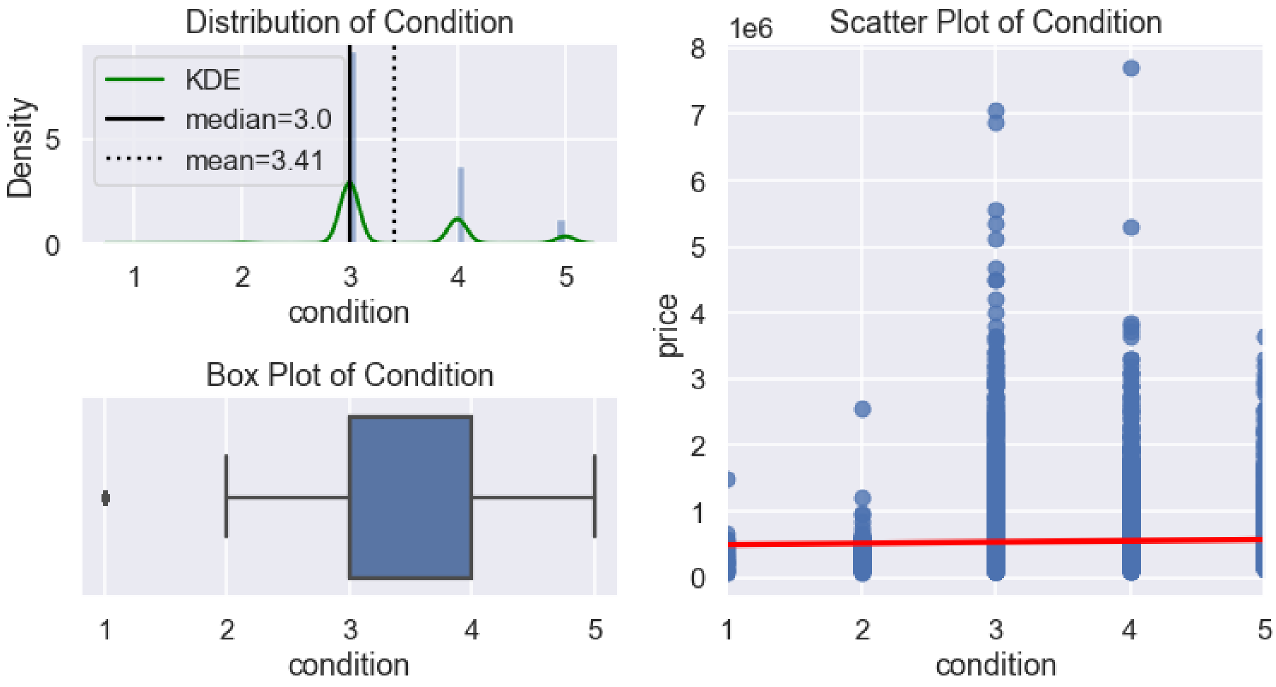


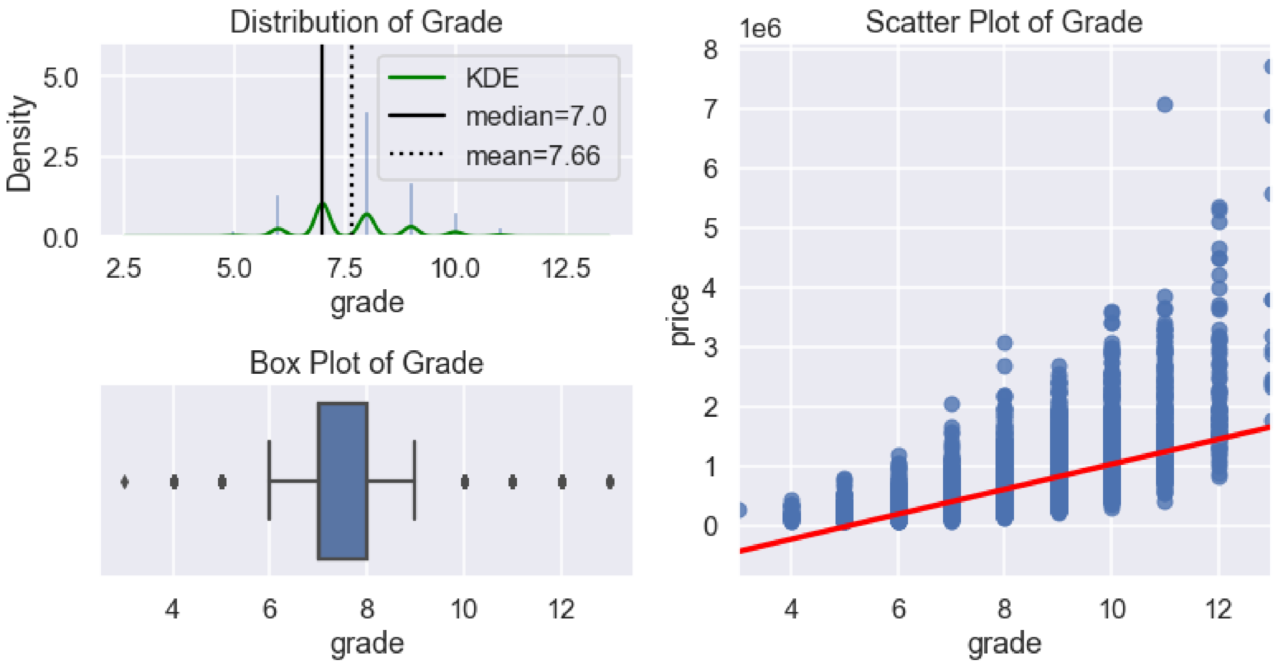

Distribution of Bathrooms
Density
0
2
4
0
2
4
6
8
bathrooms
KDE
median=2.25
mean=2.12
Box Plot of Bathrooms
2
4
6
8
bathrooms
Scatter Plot of Bathrooms
1e6
price
0
1
2
3
4
5
6
7
8
2
4
6
8
bathrooms

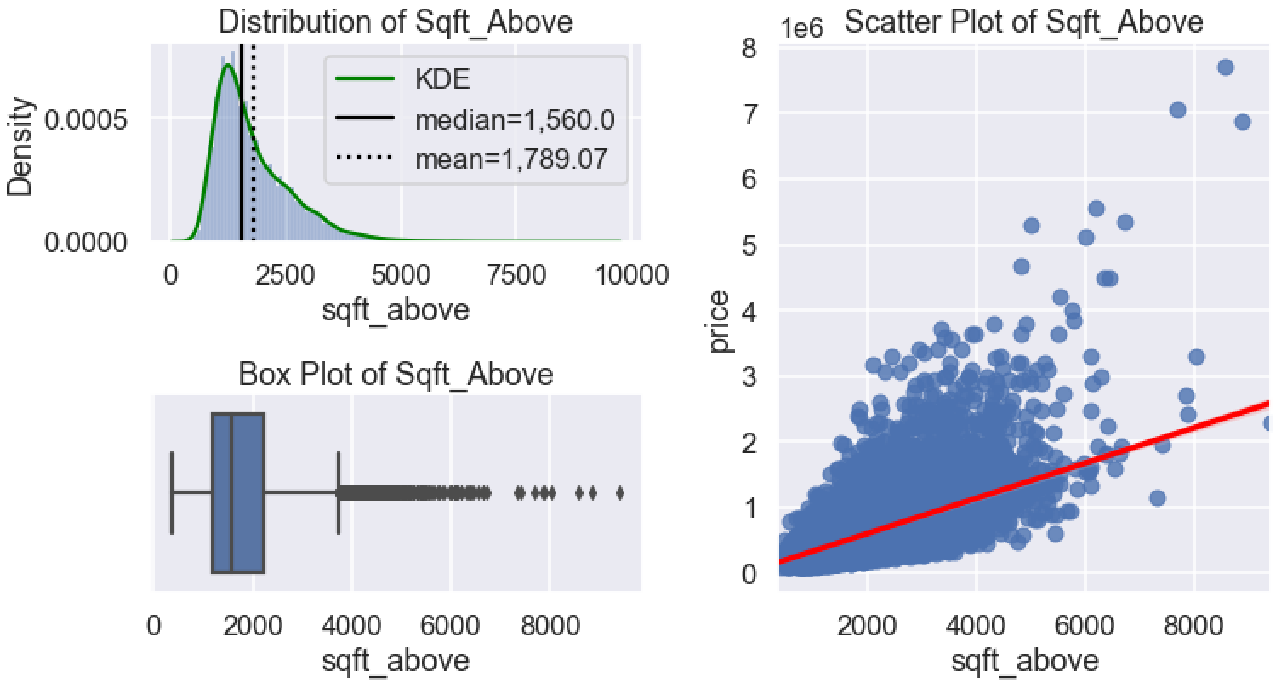

Distribution of Sqft_Lot
Density
0.00000
0.00005
0.00010
0.0
0.5
1.0
1.5
1e6
sqft_lot
KDE
median=7,620.0
mean=15,087.14
Box Plot of Sqft_Lot
0.0
0.5
1.0
1.5
1e6
sqft_lot
Scatter Plot of Sqft_Lot
1e6
price
0
1
2
3
4
5
6
7
8
0.5
1.0
1.5
1e6
sqft_lot

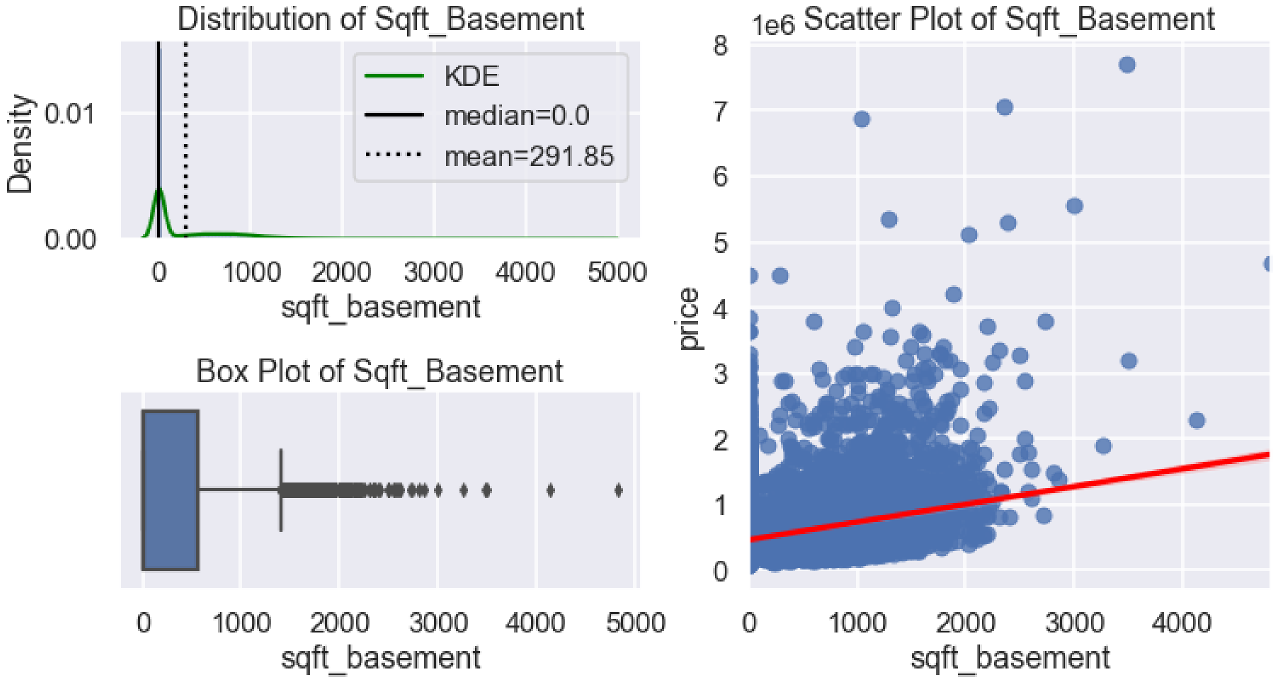

Distribution of Floors
Density
5.0
2.5
0.0
1
2
3
floors
KDE
median=1.5
mean=1.49
Box Plot of Floors
1.0
1.5
2.0
2.5
3.0
3.5
floors
Scatter Plot of Floors
1e6
8
7
6
5
4
3
2
1
0
price
1.0
1.5
2.0
2.5
3.0
3.5
floors

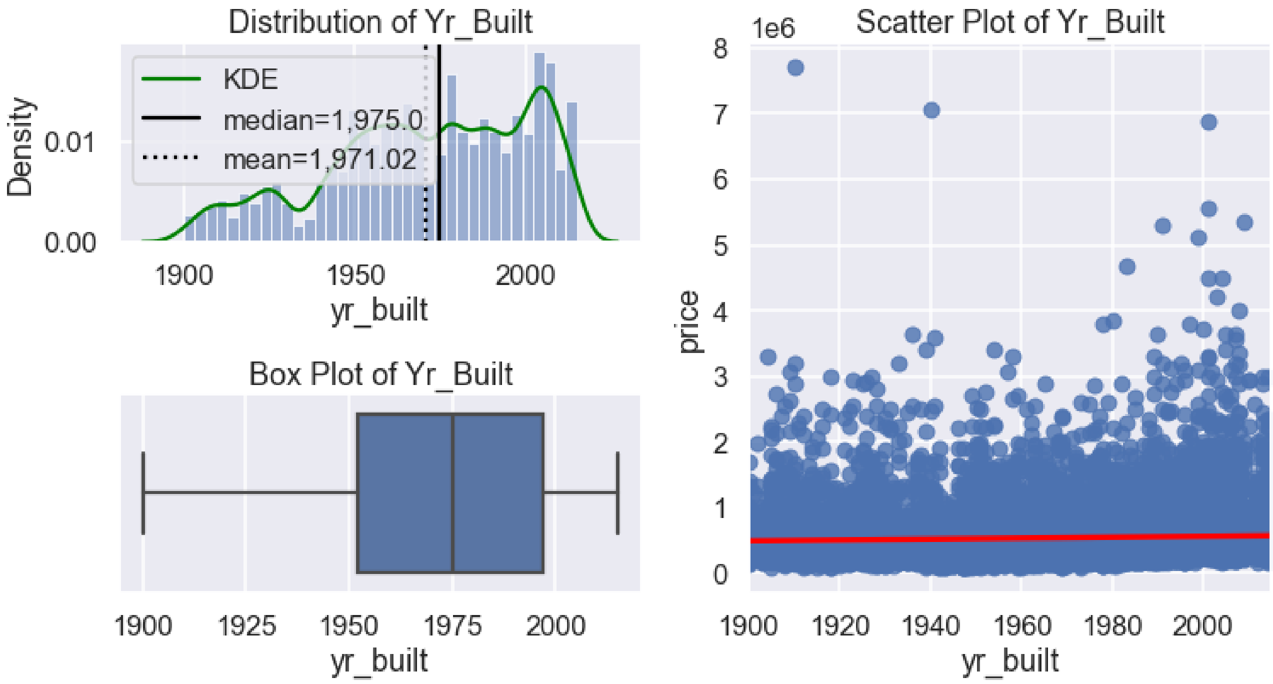

Distribution of Waterfront
Density
20
0
0.0
0.2
0.4
0.6
0.8
1.0
waterfront
KDE
median=0.0
mean=0.01
Box Plot of Waterfront
0.0
0.2
0.4
0.6
0.8
1.0
waterfront
Scatter Plot of Waterfront
1e6
8
7
6
5
4
3
2
1
0
price
0.0
0.2
0.4
0.6
0.8
1.0
waterfront

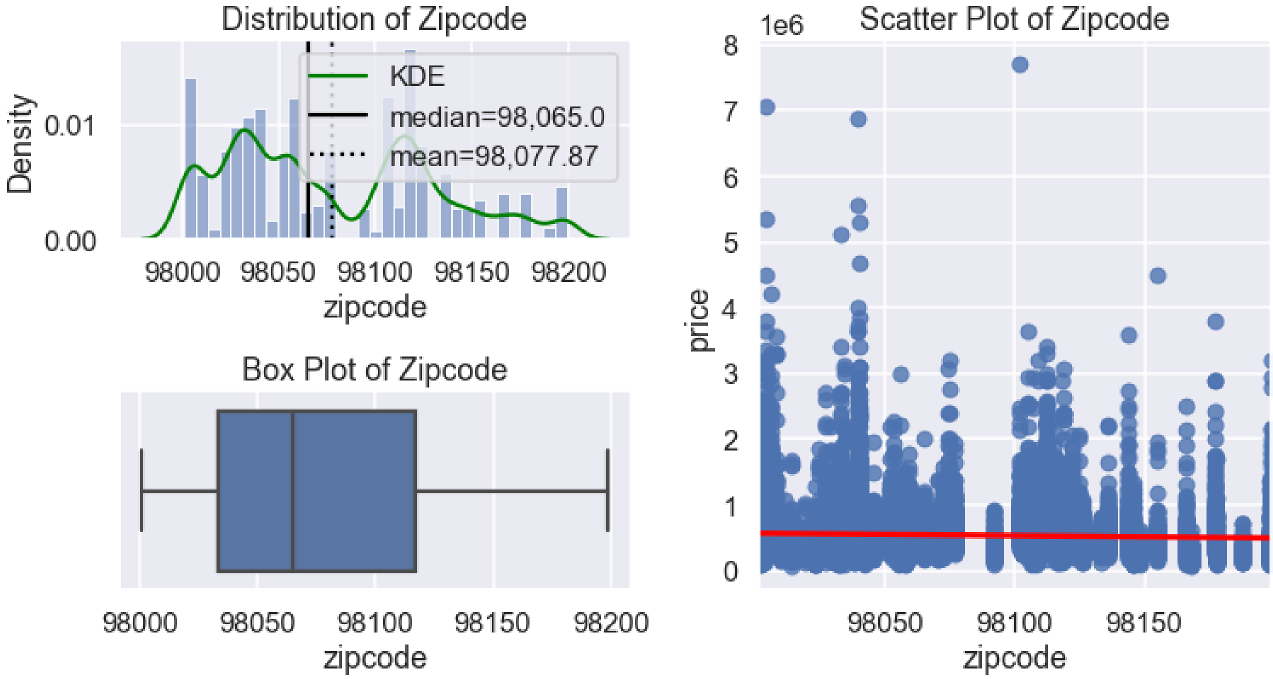

Distribution of Condition
Density
KDE
median=3.0
mean=3.41
0
5
1
2
3
4
5
condition
Box Plot of Condition
1
2
3
4
5
condition
Scatter Plot of Condition
1e6
price
0
1
2
3
4
5
6
7
8
1
2
3
4
5
condition

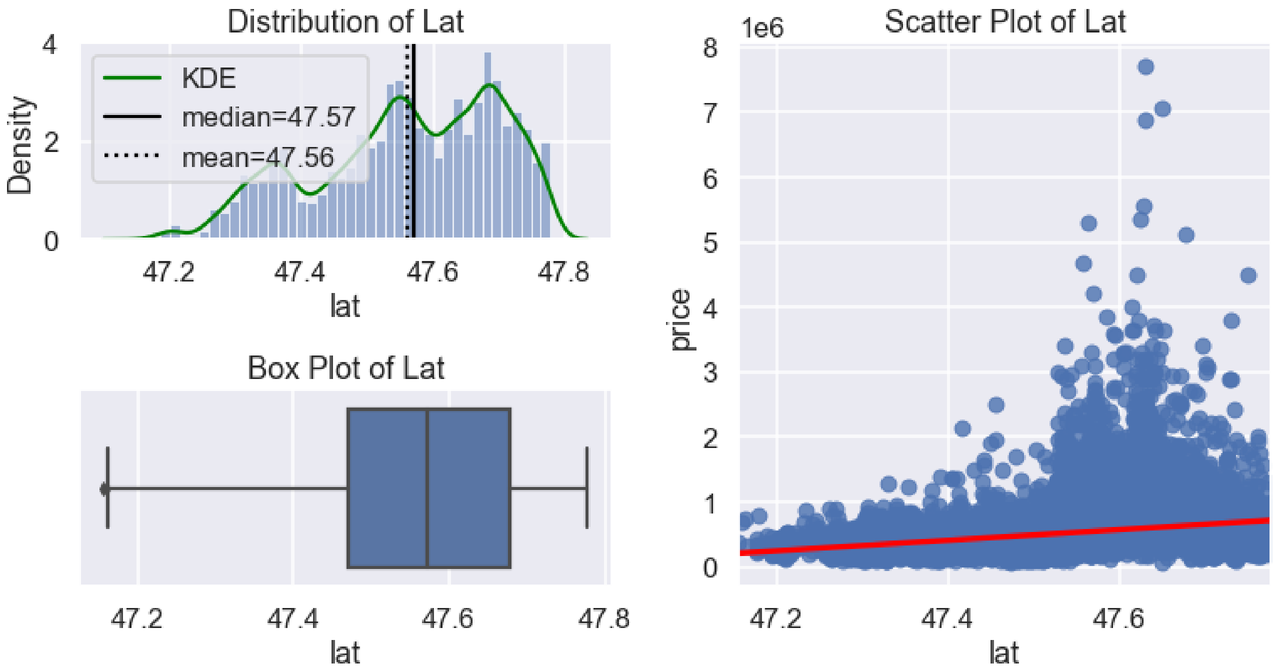

Distribution of Grade
Density
0.0
2.5
5.0
KDE
median=7.0
mean=7.66
2.5
5.0
7.5
10.0
12.5
grade
Box Plot of Grade
4
6
8
10
12
grade
Scatter Plot of Grade
1e6
price
0
1
2
3
4
5
6
7
8
4
6
8
10
12
grade

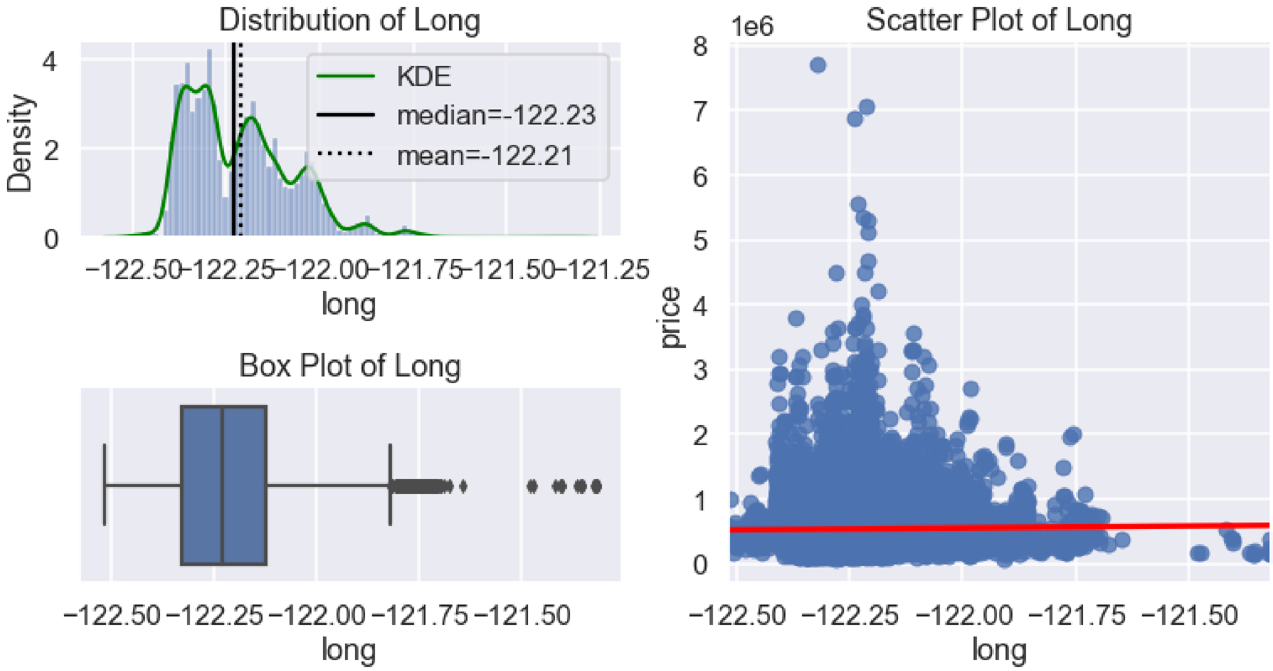

Distribution of Sqft_Above
Density
0.0005
0.0000
0
2500
5000
7500
10000
sqft_above
KDE
median=1,560.0
mean=1,789.07
Box Plot of Sqft_Above
0
2000
4000
6000
8000
sqft_above
1e6
Scatter Plot of Sqft_Above
price
8
7
6
5
4
3
2
1
0
2000
4000
6000
8000
sqft_above

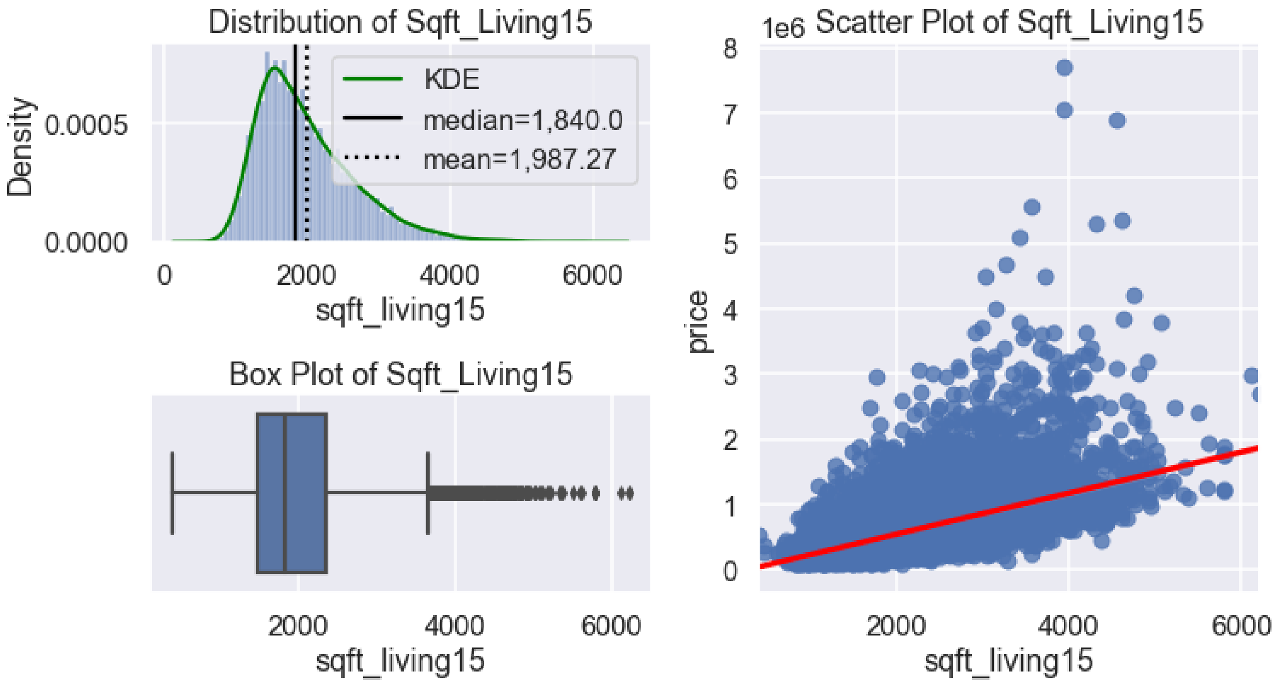

Distribution of Sqft_Basement
Density
0.01
0.00
0
1000
2000
3000
4000
5000
sqft_basement
KDE
median=0.0
mean=291.85
Box Plot of Sqft_Basement
0
1000
2000
3000
4000
5000
sqft_basement
1e6
Scatter Plot of Sqft_Basement
price
8
7
6
5
4
3
2
1
0
0
1000
2000
3000
4000
sqft_basement

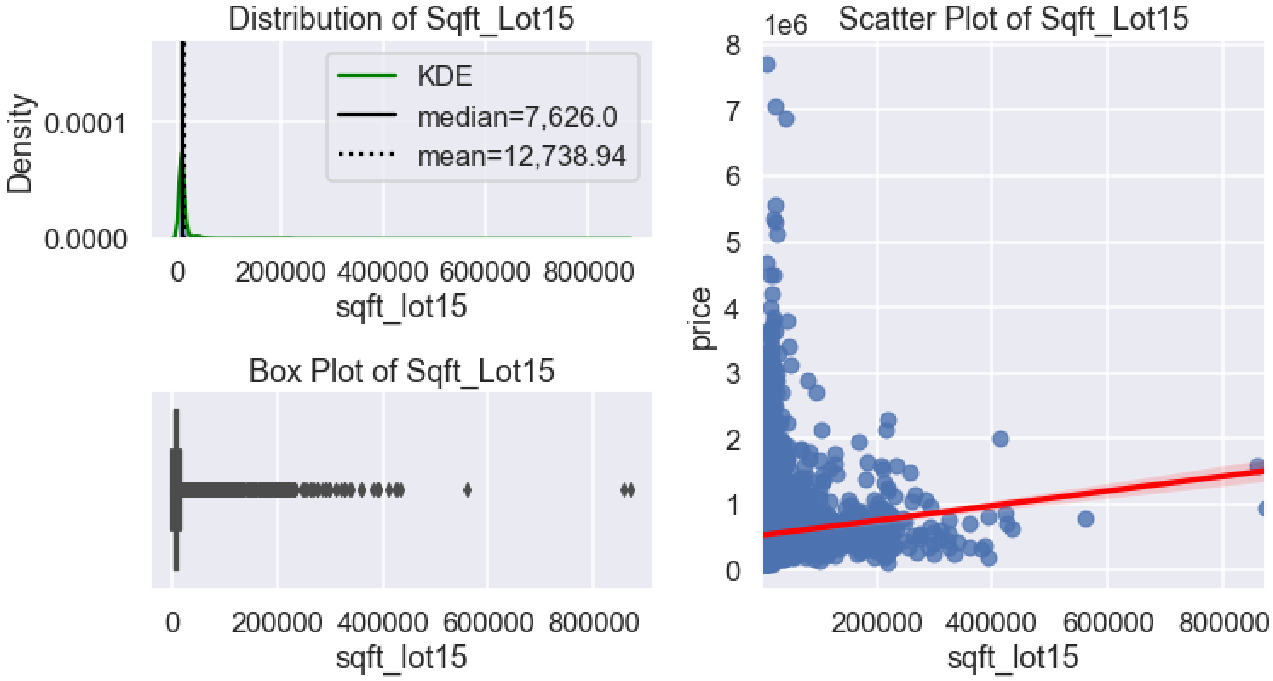

Distribution of Yr_Built
KDE
median=1,975.0
mean=1,971.02
Density
0.01
0.00
1900
1950
2000
yr_built
Box Plot of Yr_Built
1900
1925
1950
1975
2000
yr_built
Scatter Plot of Yr_Built
1e6
8
7
6
5
4
3
2
1
0
price
1900
1920
1940
1960
1980
2000
yr_built

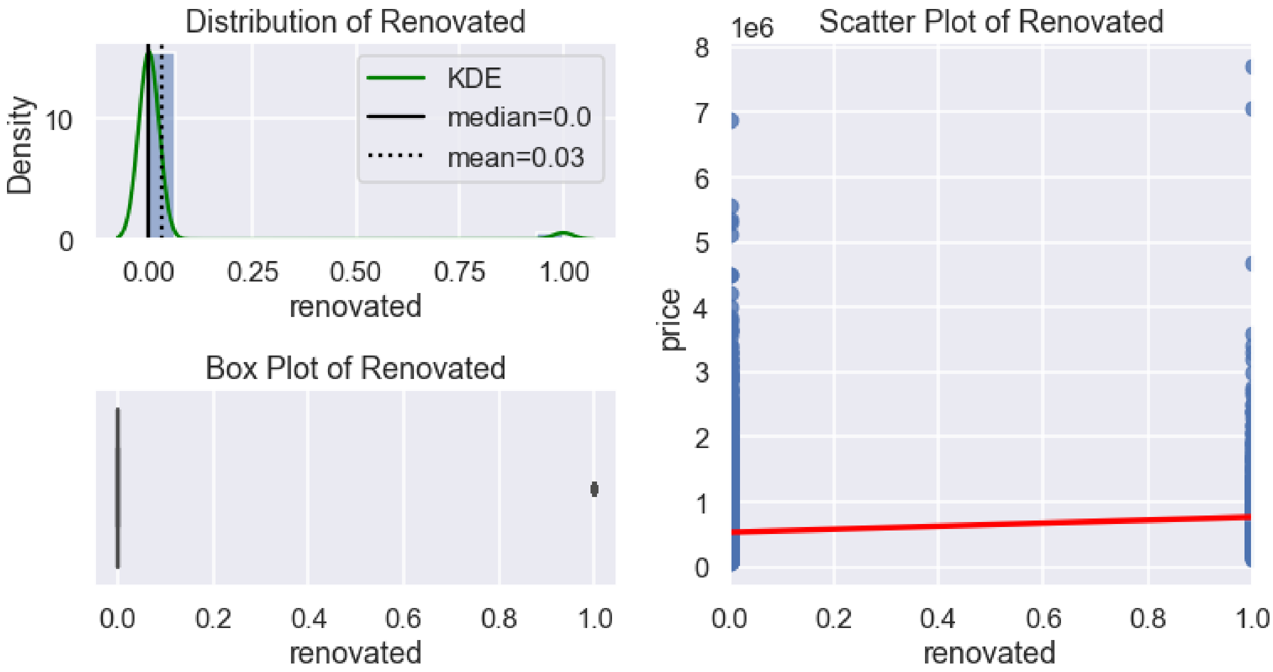

Distribution of Zipcode
KDE
median=98,065.0
mean=98,077.87
Density
0.01
0.00
98000
98050
98100
98150
98200
zipcode
Box Plot of Zipcode
98000
98050
98100
98150
98200
zipcode
Scatter Plot of Zipcode
1e6
8
7
6
5
4
3
2
1
0
price
98050
98100
98150
zipcode


Distribution of Lat
Density
4
2
0
KDE
median=47.57
mean=47.56
47.2
47.4
47.6
47.8
lat
Box Plot of Lat
47.2
47.4
47.6
47.8
lat
Scatter Plot of Lat
1e6
8
7
6
5
4
3
2
1
0
price
47.2
47.4
47.6
lat


Distribution of Long
Density
4
2
0
KDE
median=-122.23
mean=-122.21
−122.50
−122.25
−122.00
−121.75
−121.50
−121.25
long
Box Plot of Long
−122.50
−122.25
−122.00
−121.75
−121.50
long
Scatter Plot of Long
1e6
8
7
6
5
4
3
2
1
0
price
−122.50
−122.25
−122.00
−121.75
−121.50
long


Distribution of Sqft_Living15
Density
0.0005
0.0000
0
2000
4000
6000
sqft_living15
KDE
median=1,840.0
mean=1,987.27
Box Plot of Sqft_Living15
2000
4000
6000
sqft_living15
1e6 Scatter Plot of Sqft_Living15
price
8
7
6
5
4
3
2
1
0
2000
4000
6000
sqft_living15


Distribution of Sqft_Lot15
Density
0.0001
0.0000
0
200000
400000
600000
800000
sqft_lot15
KDE
median=7,626.0
mean=12,738.94
Box Plot of Sqft_Lot15
0
200000
400000
600000
800000
sqft_lot15
1e6 Scatter Plot of Sqft_Lot15
price
8
7
6
5
4
3
2
1
0
200000
400000
600000
800000
sqft_lot15



MODEL

Finally, we have prepared our data enough to be able to run an initial iteration of our multiple regression model! As we create each model, we will include a QQ plot to address the normality of residuals as well as plotting price vs residuals in order to check for homoscedasticity of residuals.

Creating a Baseline Model

OLS Regression Results

Dep. Variable:	price	**R-squared:**	0.793
Model:	OLS	**Adj. R-squared:**	0.792
Method:	Least Squares	**F-statistic:**	1006.
Date:	Thu, 22 Apr 2021	**Prob (F-statistic):**	0.00
Time:	22:29:30	**Log-Likelihood:**	-2.8434e+05
No. Observations:	21143	**AIC:**	5.689e+05
Df Residuals:	21062	**BIC:**	5.695e+05
Df Model:	80		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025
Intercept	-2.693e+07	6.51e+06	-4.140	0.000	-3.97e+07
bedrooms	-2.781e+04	1614.774	-17.224	0.000	-3.1e+04
bathrooms	1.29e+04	2621.916	4.920	0.000	7760.985
sqft_lot	0.2365	0.031	7.642	0.000	0.176
floors	-6.476e+04	3127.358	-20.708	0.000	-7.09e+04
waterfront	8.813e+05	1.46e+04	60.424	0.000	8.53e+05
grade	5.264e+04	1832.891	28.717	0.000	4.9e+04
sqft_above	219.3557	3.115	70.429	0.000	213.251
sqft_basement	157.4838	3.686	42.720	0.000	150.258
lat	1.207e+05	6.69e+04	1.804	0.071	-1.04e+04
long	-1.703e+05	4.83e+04	-3.523	0.000	-2.65e+05
sqft_living15	27.4453	2.985	9.193	0.000	21.594
zipcode_98002	5.715e+04	1.52e+04	3.760	0.000	2.74e+04
zipcode_98003	-1.635e+04	1.37e+04	-1.195	0.232	-4.32e+04
zipcode_98004	7.574e+05	2.47e+04	30.600	0.000	7.09e+05
zipcode_98005	2.806e+05	2.64e+04	10.614	0.000	2.29e+05
zipcode_98006	2.751e+05	2.16e+04	12.709	0.000	2.33e+05
zipcode_98007	2.345e+05	2.73e+04	8.586	0.000	1.81e+05
zipcode_98008	2.612e+05	2.6e+04	10.058	0.000	2.1e+05
zipcode_98010	1.146e+05	2.33e+04	4.917	0.000	6.89e+04
zipcode_98011	6.726e+04	3.38e+04	1.991	0.047	1034.942
zipcode_98014	1.215e+05	3.71e+04	3.277	0.001	4.88e+04
zipcode_98019	7.459e+04	3.67e+04	2.034	0.042	2728.027
zipcode_98022	8.621e+04	2.03e+04	4.253	0.000	4.65e+04
zipcode_98023	-5.151e+04	1.26e+04	-4.093	0.000	-7.62e+04

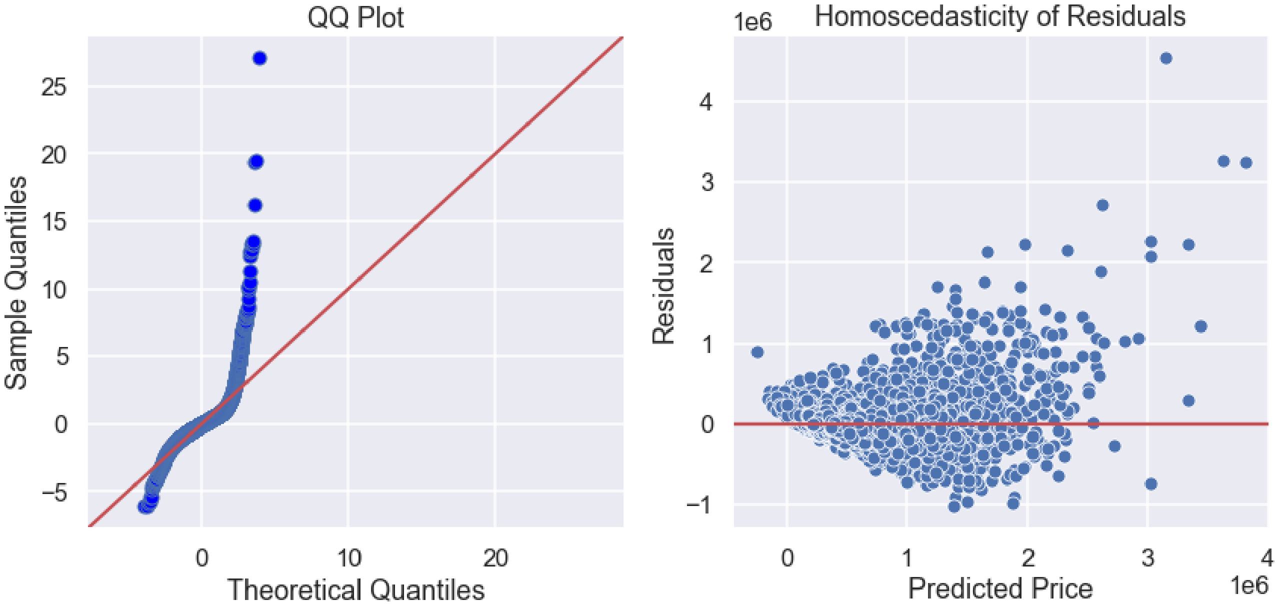
zipcode_98024	1.806e+05	3.27e+04	5.524	0.000	1.17e+05	2
zipcode_98027	1.718e+05	2.23e+04	7.706	0.000	1.28e+05	2
zipcode_98028	6.885e+04	3.28e+04	2.097	0.036	4507.689	1
zipcode_98029	2.212e+05	2.55e+04	8.683	0.000	1.71e+05	2
zipcode_98030	6440.1953	1.5e+04	0.428	0.669	-2.31e+04	3
zipcode_98031	1.687e+04	1.57e+04	1.076	0.282	-1.39e+04	4
zipcode_98032	9181.2935	1.81e+04	0.507	0.612	-2.63e+04	4
zipcode_98033	3.43e+05	2.81e+04	12.190	0.000	2.88e+05	3
zipcode_98034	1.685e+05	3.02e+04	5.583	0.000	1.09e+05	2
zipcode_98038	5.275e+04	1.69e+04	3.115	0.002	1.96e+04	8
zipcode_98039	1.275e+06	3.35e+04	38.079	0.000	1.21e+06	1
zipcode_98040	5.198e+05	2.19e+04	23.764	0.000	4.77e+05	5
zipcode_98042	2.321e+04	1.44e+04	1.615	0.106	-4962.935	5
zipcode_98045	1.575e+05	3.13e+04	5.039	0.000	9.62e+04	2
zipcode_98052	1.962e+05	2.88e+04	6.825	0.000	1.4e+05	2
zipcode_98053	1.611e+05	3.08e+04	5.224	0.000	1.01e+05	2
zipcode_98055	4.754e+04	1.74e+04	2.729	0.006	1.34e+04	8
zipcode_98056	9.953e+04	1.89e+04	5.274	0.000	6.25e+04	1
zipcode_98058	3.033e+04	1.65e+04	1.841	0.066	-1957.843	6
zipcode_98059	7.367e+04	1.86e+04	3.969	0.000	3.73e+04	1
zipcode_98065	1.18e+05	2.88e+04	4.098	0.000	6.15e+04	1
zipcode_98070	-1.88e+04	2.17e+04	-0.867	0.386	-6.13e+04	2
zipcode_98072	1.063e+05	3.36e+04	3.160	0.002	4.03e+04	1
zipcode_98074	1.576e+05	2.72e+04	5.785	0.000	1.04e+05	2
zipcode_98075	1.604e+05	2.62e+04	6.116	0.000	1.09e+05	2
zipcode_98077	7.644e+04	3.5e+04	2.185	0.029	7873.688	1

zipcode_98092	-2.541e+04	1.37e+04	-1.855	0.064	-5.23e+04	1
zipcode_98102	5.076e+05	2.9e+04	17.532	0.000	4.51e+05	5
zipcode_98103	3.306e+05	2.71e+04	12.201	0.000	2.78e+05	3
zipcode_98105	4.71e+05	2.78e+04	16.967	0.000	4.17e+05	5
zipcode_98106	1.245e+05	2.02e+04	6.177	0.000	8.5e+04	1
zipcode_98107	3.323e+05	2.8e+04	11.882	0.000	2.77e+05	3
zipcode_98108	1.132e+05	2.22e+04	5.099	0.000	6.97e+04	1
zipcode_98109	4.99e+05	2.88e+04	17.319	0.000	4.43e+05	5
zipcode_98112	6.152e+05	2.55e+04	24.168	0.000	5.65e+05	6
zipcode_98115	3.155e+05	2.76e+04	11.436	0.000	2.61e+05	3
zipcode_98116	3.002e+05	2.24e+04	13.379	0.000	2.56e+05	3
zipcode_98117	2.948e+05	2.79e+04	10.552	0.000	2.4e+05	3
zipcode_98118	1.769e+05	1.96e+04	9.036	0.000	1.39e+05	2
zipcode_98119	4.967e+05	2.72e+04	18.259	0.000	4.43e+05	5
zipcode_98122	3.457e+05	2.42e+04	14.279	0.000	2.98e+05	3
zipcode_98125	1.726e+05	2.99e+04	5.780	0.000	1.14e+05	2
zipcode_98126	1.959e+05	2.06e+04	9.494	0.000	1.55e+05	2
zipcode_98133	1.233e+05	3.09e+04	3.996	0.000	6.28e+04	1
zipcode_98136	2.492e+05	2.12e+04	11.770	0.000	2.08e+05	2
zipcode_98144	2.904e+05	2.25e+04	12.881	0.000	2.46e+05	3
zipcode_98146	1.078e+05	1.89e+04	5.692	0.000	7.07e+04	1
zipcode_98148	4.939e+04	2.59e+04	1.907	0.057	-1381.603	1
zipcode_98155	1.051e+05	3.21e+04	3.275	0.001	4.22e+04	1
zipcode_98166	6.379e+04	1.73e+04	3.687	0.000	2.99e+04	9
zipcode_98168	6.116e+04	1.83e+04	3.341	0.001	2.53e+04	9
zipcode_98177	1.959e+05	3.22e+04	6.090	0.000	1.33e+05	2

zipcode_98178	4.907e+04	1.89e+04	2.602	0.009	1.21e+04	8
zipcode_98188	3.065e+04	1.95e+04	1.571	0.116	-7588.055	6
zipcode_98198	1.591e+04	1.47e+04	1.079	0.281	-1.3e+04	4
zipcode_98199	3.709e+05	2.65e+04	13.987	0.000	3.19e+05	4

Omnibus:	20092.654	**Durbin-Watson:**	1.985
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	3585946.415
Skew:	4.107	**Prob(JB):**	0.00
Kurtosis:	66.270	**Cond. No.**	2.47e+08

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 2.47e+08. This might indicate that there are strong multicollinearity or other numerical problems.



Removing Outliers to Fulfill Assumptions of Multiple Regressions

We have successfully run our baseline model, and our R2 value isn't too bad! However, we can see from the QQ plot and homoscedasticity plot that we are not fulfilling the assumptions of multiple regression.

We will try to address this issue by removing outliers that lie 1.5 times the IQR below the first quartile and 1.5 times the IQR above the third quartile.

In the 'Explore' section, we saw that we have many outliers several columns. We will proceed to remove outliers from those columns that have extreme outliers, based on our boxplot visualizations.

OLS Regression Results

Dep. Variable:	price	**R-squared:**	0.807
Model:	OLS	**Adj. R-squared:**	0.806
Method:	Least Squares	**F-statistic:**	848.1
Date:	Thu, 22 Apr 2021	**Prob (F-statistic):**	0.00
Time:	22:29:31	**Log-Likelihood:**	-2.0856e+05
No. Observations:	16358	**AIC:**	4.173e+05
Df Residuals:	16277	**BIC:**	4.179e+05
Df Model:	80		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	
Intercept	-2.098e+06	4.45e+06	-0.471	0.638	-1.08e+07	6
bedrooms	-2850.0552	1115.288	-2.555	0.011	-5036.141	-
bathrooms	6959.9481	1611.666	4.318	0.000	3800.906	1
sqft_lot	2.8752	0.276	10.421	0.000	2.334	3
floors	-2.75e+04	1951.375	-14.092	0.000	-3.13e+04	-
waterfront	3.382e+05	1.87e+04	18.087	0.000	3.02e+05	3
grade	3.475e+04	1149.769	30.221	0.000	3.25e+04	3
sqft_above	130.3372	2.348	55.502	0.000	125.734	1
sqft_basement	90.9682	2.638	34.480	0.000	85.797	9
lat	-4.173e+04	4.19e+04	-0.995	0.320	-1.24e+05	4
long	-3.107e+04	3.37e+04	-0.922	0.356	-9.71e+04	3

sqft_living15	34.8750	2.108	16.545	0.000	30.743	3
zipcode_98002	3.279e+04	8193.908	4.001	0.000	1.67e+04	4
zipcode_98003	5708.5590	7433.852	0.768	0.443	-8862.607	2
zipcode_98004	5.463e+05	1.58e+04	34.605	0.000	5.15e+05	5
zipcode_98005	3.521e+05	1.62e+04	21.728	0.000	3.2e+05	3
zipcode_98006	2.942e+05	1.34e+04	21.879	0.000	2.68e+05	3
zipcode_98007	2.793e+05	1.64e+04	17.022	0.000	2.47e+05	3
zipcode_98008	2.716e+05	1.59e+04	17.079	0.000	2.4e+05	3
zipcode_98010	1.052e+05	1.61e+04	6.535	0.000	7.37e+04	1
zipcode_98011	1.656e+05	2.06e+04	8.024	0.000	1.25e+05	2
zipcode_98014	1.37e+05	2.61e+04	5.255	0.000	8.59e+04	1
zipcode_98019	1.15e+05	2.29e+04	5.023	0.000	7.01e+04	1
zipcode_98022	3.168e+04	1.33e+04	2.382	0.017	5610.093	5
zipcode_98023	-1.431e+04	7174.382	-1.995	0.046	-2.84e+04	-
zipcode_98024	1.662e+05	2.45e+04	6.796	0.000	1.18e+05	2
zipcode_98027	2.528e+05	1.46e+04	17.348	0.000	2.24e+05	2
zipcode_98028	1.532e+05	2.01e+04	7.620	0.000	1.14e+05	1
zipcode_98029	2.584e+05	1.6e+04	16.180	0.000	2.27e+05	2
zipcode_98030	1.107e+04	8322.238	1.330	0.184	-5244.964	2
zipcode_98031	2.545e+04	8842.824	2.878	0.004	8117.202	4
zipcode_98032	1.577e+04	9774.747	1.614	0.107	-3384.816	3
zipcode_98033	3.44e+05	1.74e+04	19.733	0.000	3.1e+05	3
zipcode_98034	2.116e+05	1.86e+04	11.375	0.000	1.75e+05	2
zipcode_98038	4.761e+04	1.05e+04	4.525	0.000	2.7e+04	6
zipcode_98039	6.678e+05	3.71e+04	18.020	0.000	5.95e+05	7
zipcode_98040	4.52e+05	1.42e+04	31.871	0.000	4.24e+05	4

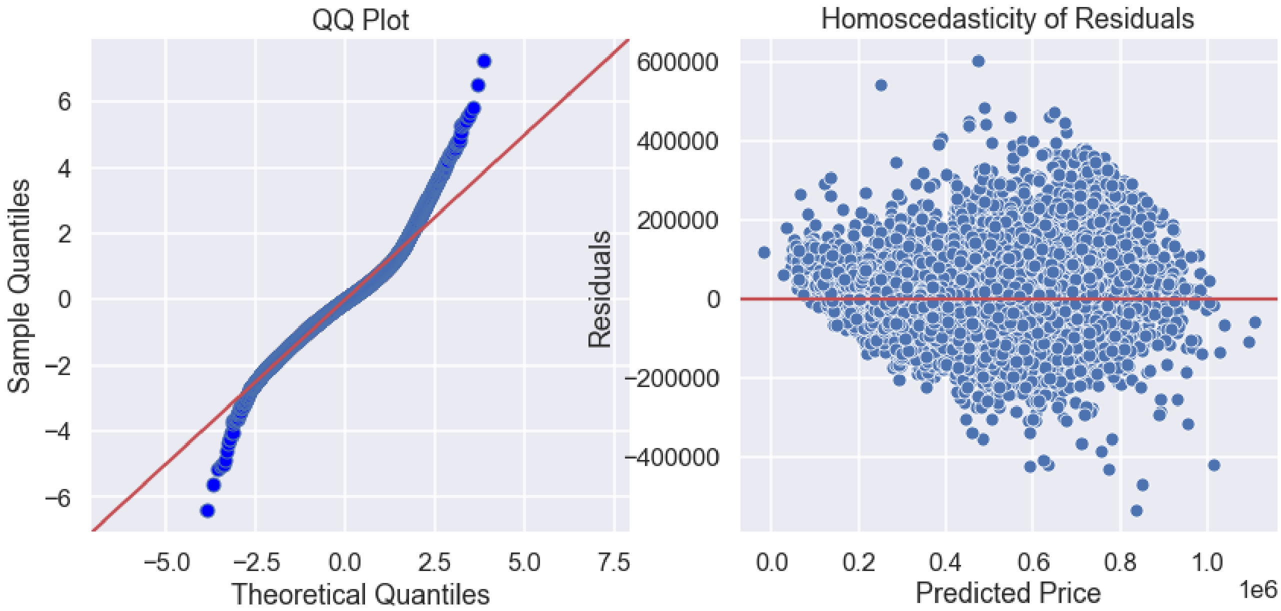
zipcode_98042	2.367e+04	8705.330	2.719	0.007	6610.572	4
zipcode_98045	1.206e+05	2.06e+04	5.851	0.000	8.02e+04	1
zipcode_98052	2.762e+05	1.77e+04	15.598	0.000	2.41e+05	3
zipcode_98053	2.734e+05	2.02e+04	13.520	0.000	2.34e+05	3
zipcode_98055	6.081e+04	1e+04	6.051	0.000	4.11e+04	8
zipcode_98056	1.314e+05	1.12e+04	11.688	0.000	1.09e+05	1
zipcode_98058	5.115e+04	9796.055	5.221	0.000	3.19e+04	7
zipcode_98059	1.02e+05	1.12e+04	9.127	0.000	8.01e+04	1
zipcode_98065	1.585e+05	1.86e+04	8.521	0.000	1.22e+05	1
zipcode_98070	8.554e+04	1.89e+04	4.521	0.000	4.85e+04	1
zipcode_98072	1.76e+05	2.12e+04	8.312	0.000	1.35e+05	2
zipcode_98074	2.267e+05	1.72e+04	13.149	0.000	1.93e+05	2
zipcode_98075	2.514e+05	1.72e+04	14.627	0.000	2.18e+05	2
zipcode_98077	1.773e+05	2.61e+04	6.798	0.000	1.26e+05	2
zipcode_98092	-1.667e+04	7912.858	-2.107	0.035	-3.22e+04	-
zipcode_98102	4.591e+05	1.73e+04	26.564	0.000	4.25e+05	4
zipcode_98103	3.806e+05	1.66e+04	22.896	0.000	3.48e+05	4
zipcode_98105	4.348e+05	1.7e+04	25.507	0.000	4.01e+05	4
zipcode_98106	1.511e+05	1.2e+04	12.608	0.000	1.28e+05	1
zipcode_98107	3.775e+05	1.7e+04	22.229	0.000	3.44e+05	4
zipcode_98108	1.532e+05	1.3e+04	11.825	0.000	1.28e+05	1
zipcode_98109	4.707e+05	1.74e+04	27.075	0.000	4.37e+05	5
zipcode_98112	4.866e+05	1.58e+04	30.810	0.000	4.56e+05	5
zipcode_98115	3.67e+05	1.69e+04	21.701	0.000	3.34e+05	4
zipcode_98116	3.521e+05	1.35e+04	25.985	0.000	3.25e+05	3
zipcode_98117	3.64e+05	1.72e+04	21.192	0.000	3.3e+05	3

zipcode_98118	2.024e+05	1.17e+04	17.309	0.000	1.8e+05	2
zipcode_98119	4.688e+05	1.65e+04	28.358	0.000	4.36e+05	5
zipcode_98122	3.629e+05	1.46e+04	24.918	0.000	3.34e+05	3
zipcode_98125	2.325e+05	1.83e+04	12.722	0.000	1.97e+05	2
zipcode_98126	2.406e+05	1.23e+04	19.517	0.000	2.16e+05	2
zipcode_98133	1.894e+05	1.89e+04	9.994	0.000	1.52e+05	2
zipcode_98136	3.027e+05	1.26e+04	24.041	0.000	2.78e+05	3
zipcode_98144	2.933e+05	1.36e+04	21.592	0.000	2.67e+05	3
zipcode_98146	1.346e+05	1.11e+04	12.104	0.000	1.13e+05	1
zipcode_98148	6.492e+04	1.37e+04	4.744	0.000	3.81e+04	9
zipcode_98155	1.728e+05	1.97e+04	8.771	0.000	1.34e+05	2
zipcode_98166	1.211e+05	1.03e+04	11.763	0.000	1.01e+05	1
zipcode_98168	6.63e+04	1.07e+04	6.195	0.000	4.53e+04	8
zipcode_98177	2.393e+05	1.98e+04	12.090	0.000	2.01e+05	2
zipcode_98178	8.289e+04	1.09e+04	7.593	0.000	6.15e+04	1
zipcode_98188	5.228e+04	1.09e+04	4.790	0.000	3.09e+04	7
zipcode_98198	4.982e+04	8274.755	6.020	0.000	3.36e+04	6
zipcode_98199	4.024e+05	1.63e+04	24.658	0.000	3.7e+05	4

Omnibus:	1839.987	**Durbin-Watson:**	2.005
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	6354.147
Skew:	0.558	**Prob(JB):**	0.00
Kurtosis:	5.842	**Cond. No.**	5.56e+07

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

[2] The condition number is large, 5.56e+07. This might indicate that there are strong multicollinearity or other numerical problems.



Great! We can see that although they are not quite perfect, our QQ plot and homoscedasticity plot look much better. We can see that our R2 value has gone up a bit as well.

Now we want to move on to addressing the nonsignificant P-values in our model. Since a nonsignificant P-value is indicates that our model would be no different than when the respective coefficient is 0, we will go ahead and remove those variables from our model.

OLS Regression Results

Dep. Variable:	price	**R-squared:**	0.806
Model:	OLS	**Adj. R-squared:**	0.806
Method:	Least Squares	**F-statistic:**	869.8
Date:	Thu, 22 Apr 2021	**Prob (F-statistic):**	0.00
Time:	22:29:31	**Log-Likelihood:**	-2.0856e+05
No. Observations:	16358	**AIC:**	4.173e+05
Df Residuals:	16279	**BIC:**	4.179e+05
Df Model:	78		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025

Intercept	-2.73e+05	8978.380	-30.405	0.000	-2.91e+05	-
bedrooms	-2849.0091	1115.274	-2.555	0.011	-5035.068	-
bathrooms	6955.4124	1611.577	4.316	0.000	3796.545	1
sqft_lot	2.8718	0.276	10.409	0.000	2.331	3
floors	-2.748e+04	1951.119	-14.082	0.000	-3.13e+04	-
waterfront	3.385e+05	1.87e+04	18.106	0.000	3.02e+05	3
grade	3.476e+04	1149.100	30.250	0.000	3.25e+04	3
sqft_above	130.3278	2.348	55.500	0.000	125.725	1
sqft_basement	90.9779	2.638	34.486	0.000	85.807	9
sqft_living15	34.8325	2.107	16.528	0.000	30.702	3
zipcode_98002	3.111e+04	7975.317	3.901	0.000	1.55e+04	4
zipcode_98003	6760.4627	7310.504	0.925	0.355	-7568.927	2
zipcode_98004	5.316e+05	9106.136	58.382	0.000	5.14e+05	5
zipcode_98005	3.368e+05	9855.624	34.175	0.000	3.17e+05	3
zipcode_98006	2.802e+05	7147.222	39.199	0.000	2.66e+05	2
zipcode_98007	2.628e+05	9275.845	28.334	0.000	2.45e+05	2
zipcode_98008	2.541e+05	7420.469	34.249	0.000	2.4e+05	2
zipcode_98010	9.676e+04	1.36e+04	7.131	0.000	7.02e+04	1
zipcode_98011	1.45e+05	8316.130	17.434	0.000	1.29e+05	1
zipcode_98014	1.08e+05	1.39e+04	7.790	0.000	8.08e+04	1
zipcode_98019	8.778e+04	8780.990	9.997	0.000	7.06e+04	1
zipcode_98022	2.768e+04	8721.026	3.174	0.002	1.06e+04	4
zipcode_98023	-1.125e+04	6426.804	-1.751	0.080	-2.39e+04	1
zipcode_98024	1.443e+05	1.78e+04	8.107	0.000	1.09e+05	1
zipcode_98027	2.366e+05	7721.041	30.640	0.000	2.21e+05	2
zipcode_98028	1.339e+05	7433.627	18.012	0.000	1.19e+05	1

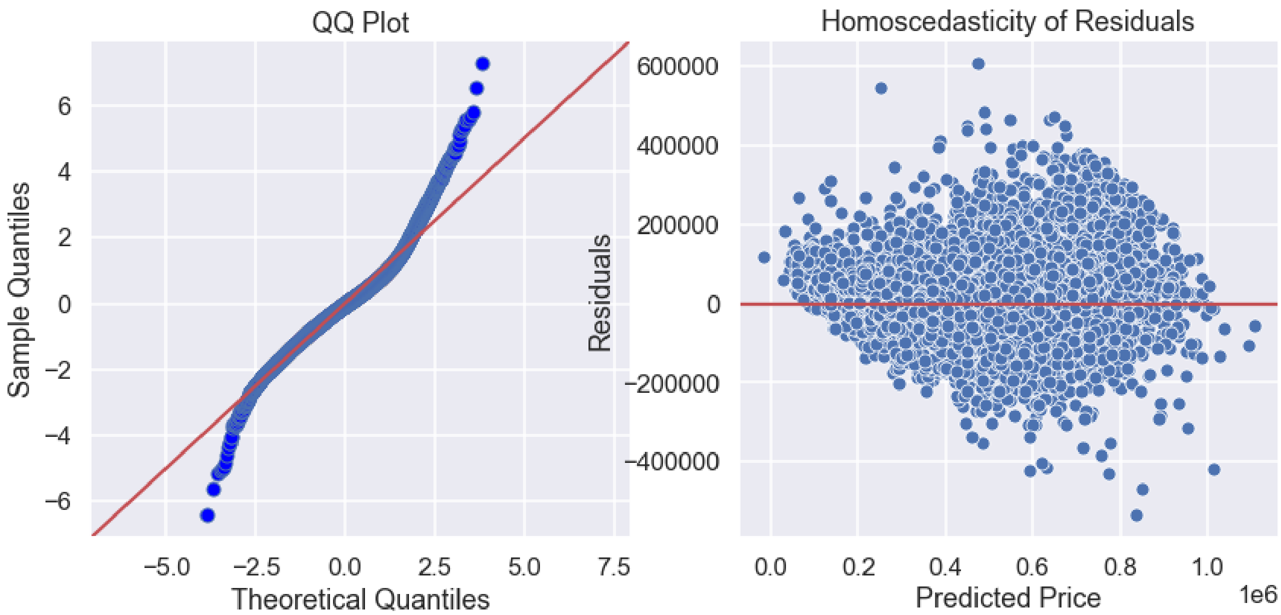
zipcode_98029	2.397e+05	7261.295	33.009	0.000	2.25e+05	2
zipcode_98030	6138.2120	7420.942	0.827	0.408	-8407.648	2
zipcode_98031	1.904e+04	7352.505	2.590	0.010	4630.856	3
zipcode_98032	1.343e+04	9420.742	1.426	0.154	-5032.423	3
zipcode_98033	3.259e+05	6946.511	46.914	0.000	3.12e+05	3
zipcode_98034	1.924e+05	6329.075	30.403	0.000	1.8e+05	2
zipcode_98038	3.808e+04	6374.554	5.974	0.000	2.56e+04	5
zipcode_98039	6.533e+05	3.45e+04	18.938	0.000	5.86e+05	7
zipcode_98040	4.401e+05	9275.468	47.452	0.000	4.22e+05	4
zipcode_98042	1.654e+04	6449.312	2.565	0.010	3897.958	2
zipcode_98045	9.826e+04	8771.005	11.203	0.000	8.11e+04	1
zipcode_98052	2.562e+05	6441.635	39.777	0.000	2.44e+05	2
zipcode_98053	2.497e+05	7924.596	31.508	0.000	2.34e+05	2
zipcode_98055	5.255e+04	7470.196	7.035	0.000	3.79e+04	6
zipcode_98056	1.204e+05	6723.038	17.906	0.000	1.07e+05	1
zipcode_98058	4.178e+04	6661.999	6.272	0.000	2.87e+04	5
zipcode_98059	9.057e+04	6761.772	13.394	0.000	7.73e+04	1
zipcode_98065	1.368e+05	7640.870	17.898	0.000	1.22e+05	1
zipcode_98070	8.72e+04	1.74e+04	5.009	0.000	5.31e+04	1
zipcode_98072	1.537e+05	8855.588	17.355	0.000	1.36e+05	1
zipcode_98074	2.065e+05	7135.626	28.933	0.000	1.92e+05	2
zipcode_98075	2.322e+05	8918.569	26.034	0.000	2.15e+05	2
zipcode_98077	1.529e+05	1.69e+04	9.066	0.000	1.2e+05	1
zipcode_98092	-1.899e+04	7377.054	-2.575	0.010	-3.35e+04	-
zipcode_98102	4.472e+05	1.07e+04	41.757	0.000	4.26e+05	4
zipcode_98103	3.677e+05	6345.370	57.943	0.000	3.55e+05	3

zipcode_98105	4.209e+05	8354.953	50.372	0.000	4.04e+05	4
zipcode_98106	1.443e+05	7015.786	20.573	0.000	1.31e+05	1
zipcode_98107	3.657e+05	7473.143	48.939	0.000	3.51e+05	3
zipcode_98108	1.443e+05	8224.265	17.550	0.000	1.28e+05	1
zipcode_98109	4.596e+05	1.07e+04	42.874	0.000	4.39e+05	4
zipcode_98112	4.742e+05	8524.249	55.627	0.000	4.57e+05	4
zipcode_98115	3.523e+05	6321.102	55.740	0.000	3.4e+05	3
zipcode_98116	3.449e+05	7158.996	48.178	0.000	3.31e+05	3
zipcode_98117	3.517e+05	6393.125	55.010	0.000	3.39e+05	3
zipcode_98118	1.929e+05	6445.325	29.926	0.000	1.8e+05	2
zipcode_98119	4.58e+05	8775.961	52.187	0.000	4.41e+05	4
zipcode_98122	3.514e+05	7434.646	47.260	0.000	3.37e+05	3
zipcode_98125	2.165e+05	6684.149	32.394	0.000	2.03e+05	2
zipcode_98126	2.341e+05	6939.693	33.740	0.000	2.21e+05	2
zipcode_98133	1.739e+05	6376.183	27.274	0.000	1.61e+05	1
zipcode_98136	2.968e+05	7511.155	39.511	0.000	2.82e+05	3
zipcode_98144	2.827e+05	7165.040	39.455	0.000	2.69e+05	2
zipcode_98146	1.294e+05	7342.058	17.621	0.000	1.15e+05	1
zipcode_98148	6.152e+04	1.25e+04	4.912	0.000	3.7e+04	8
zipcode_98155	1.554e+05	6586.017	23.588	0.000	1.42e+05	1
zipcode_98166	1.174e+05	7950.541	14.771	0.000	1.02e+05	1
zipcode_98168	6.001e+04	7585.424	7.912	0.000	4.51e+04	7
zipcode_98177	2.244e+05	7994.410	28.071	0.000	2.09e+05	2
zipcode_98178	7.431e+04	7442.250	9.985	0.000	5.97e+04	8
zipcode_98188	4.692e+04	9296.686	5.047	0.000	2.87e+04	6
zipcode_98198	4.784e+04	7434.966	6.435	0.000	3.33e+04	6

zipcode_98199	3.922e+05	7476.812	52.459	0.000	3.78e+05	4

Omnibus:	1844.788	**Durbin-Watson:**	2.004
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	6380.863
Skew:	0.559	**Prob(JB):**	0.00
Kurtosis:	5.848	**Cond. No.**	5.37e+05

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 5.37e+05. This might indicate that there are
strong multicollinearity or other numerical problems.



iNTERPRET

Now that we have our final model with outliers removed and only significant P-values included, all that's left in our analysis is to scale our model coefficients to determine which coefficients have the largest effect on the variability of housing price. Since there are multiple coefficients for zipcode, we will examine which of the other variables have high coefficients.

We should also note that zipcode, as well as some other variables are ones that we cannot control, and therefore will not be appropriate variables to provide recommendations for changing. However, we will still include those variables as part of our model, as long as they have a high enough coefficient to indicate that they are valid predictors for the value of a house.

Creating a Scaled Model

OLS Regression Results

Dep. Variable:	price	**R-squared:**	0.806
Model:	OLS	**Adj. R-squared:**	0.806
Method:	Least Squares	**F-statistic:**	869.8
Date:	Thu, 22 Apr 2021	**Prob (F-statistic):**	0.00
Time:	22:29:33	**Log-Likelihood:**	-9777.5
No. Observations:	16358	**AIC:**	1.971e+04
Df Residuals:	16279	**BIC:**	2.032e+04
Df Model:	78		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-1.0046	0.027	-37.858	0.000	-1.057	-0.953
bedrooms	-0.0116	0.005	-2.555	0.011	-0.020	-0.003
bathrooms	0.0242	0.006	4.316	0.000	0.013	0.035
sqft_lot	0.0514	0.005	10.409	0.000	0.042	0.061
floors	-0.0790	0.006	-14.082	0.000	-0.090	-0.068
waterfront	0.0640	0.004	18.106	0.000	0.057	0.071
grade	0.1623	0.005	30.250	0.000	0.152	0.173
sqft_above	0.3970	0.007	55.500	0.000	0.383	0.411
sqft_basement	0.1700	0.005	34.486	0.000	0.160	0.180
sqft_living15	0.0908	0.005	16.528	0.000	0.080	0.102

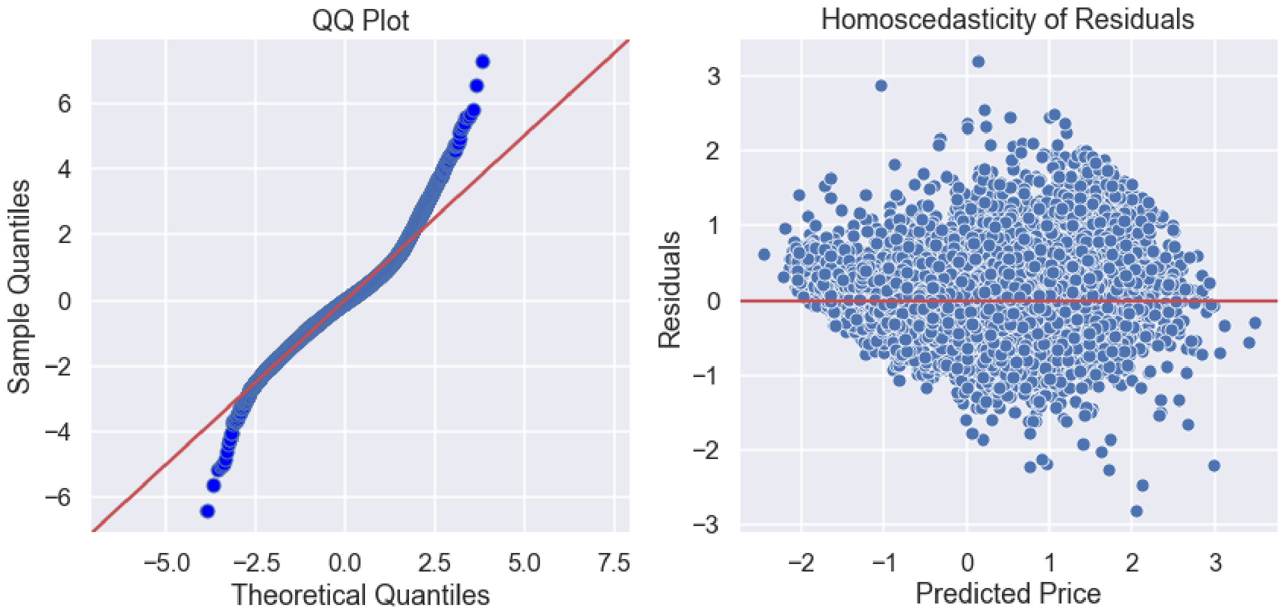
zipcode_98002	0.1642	0.042	3.901	0.000	0.082	0.247
zipcode_98003	0.0357	0.039	0.925	0.355	-0.040	0.111
zipcode_98004	2.8061	0.048	58.382	0.000	2.712	2.900
zipcode_98005	1.7778	0.052	34.175	0.000	1.676	1.880
zipcode_98006	1.4788	0.038	39.199	0.000	1.405	1.553
zipcode_98007	1.3872	0.049	28.334	0.000	1.291	1.483
zipcode_98008	1.3414	0.039	34.249	0.000	1.265	1.418
zipcode_98010	0.5107	0.072	7.131	0.000	0.370	0.651
zipcode_98011	0.7653	0.044	17.434	0.000	0.679	0.851
zipcode_98014	0.5701	0.073	7.790	0.000	0.427	0.714
zipcode_98019	0.4633	0.046	9.997	0.000	0.372	0.554
zipcode_98022	0.1461	0.046	3.174	0.002	0.056	0.236
zipcode_98023	-0.0594	0.034	-1.751	0.080	-0.126	0.007
zipcode_98024	0.7616	0.094	8.107	0.000	0.577	0.946
zipcode_98027	1.2487	0.041	30.640	0.000	1.169	1.329
zipcode_98028	0.7067	0.039	18.012	0.000	0.630	0.784
zipcode_98029	1.2652	0.038	33.009	0.000	1.190	1.340
zipcode_98030	0.0324	0.039	0.827	0.408	-0.044	0.109
zipcode_98031	0.1005	0.039	2.590	0.010	0.024	0.177
zipcode_98032	0.0709	0.050	1.426	0.154	-0.027	0.168
zipcode_98033	1.7202	0.037	46.914	0.000	1.648	1.792
zipcode_98034	1.0157	0.033	30.403	0.000	0.950	1.081
zipcode_98038	0.2010	0.034	5.974	0.000	0.135	0.267
zipcode_98039	3.4485	0.182	18.938	0.000	3.092	3.805
zipcode_98040	2.3232	0.049	47.452	0.000	2.227	2.419
zipcode_98042	0.0873	0.034	2.565	0.010	0.021	0.154

zipcode_98045	0.5187	0.046	11.203	0.000	0.428	0.609
zipcode_98052	1.3525	0.034	39.777	0.000	1.286	1.419
zipcode_98053	1.3179	0.042	31.508	0.000	1.236	1.400
zipcode_98055	0.2774	0.039	7.035	0.000	0.200	0.355
zipcode_98056	0.6354	0.035	17.906	0.000	0.566	0.705
zipcode_98058	0.2205	0.035	6.272	0.000	0.152	0.289
zipcode_98059	0.4780	0.036	13.394	0.000	0.408	0.548
zipcode_98065	0.7218	0.040	17.898	0.000	0.643	0.801
zipcode_98070	0.4602	0.092	5.009	0.000	0.280	0.640
zipcode_98072	0.8112	0.047	17.355	0.000	0.720	0.903
zipcode_98074	1.0897	0.038	28.933	0.000	1.016	1.164
zipcode_98075	1.2255	0.047	26.034	0.000	1.133	1.318
zipcode_98077	0.8072	0.089	9.066	0.000	0.633	0.982
zipcode_98092	-0.1002	0.039	-2.575	0.010	-0.177	-0.024
zipcode_98102	2.3603	0.057	41.757	0.000	2.250	2.471
zipcode_98103	1.9407	0.033	57.943	0.000	1.875	2.006
zipcode_98105	2.2214	0.044	50.372	0.000	2.135	2.308
zipcode_98106	0.7618	0.037	20.573	0.000	0.689	0.834
zipcode_98107	1.9304	0.039	48.939	0.000	1.853	2.008
zipcode_98108	0.7618	0.043	17.550	0.000	0.677	0.847
zipcode_98109	2.4259	0.057	42.874	0.000	2.315	2.537
zipcode_98112	2.5028	0.045	55.627	0.000	2.415	2.591
zipcode_98115	1.8598	0.033	55.740	0.000	1.794	1.925
zipcode_98116	1.8205	0.038	48.178	0.000	1.746	1.895
zipcode_98117	1.8563	0.034	55.010	0.000	1.790	1.922
zipcode_98118	1.0181	0.034	29.926	0.000	0.951	1.085

zipcode_98119	2.4174	0.046	52.187	0.000	2.327	2.508
zipcode_98122	1.8546	0.039	47.260	0.000	1.778	1.932
zipcode_98125	1.1429	0.035	32.394	0.000	1.074	1.212
zipcode_98126	1.2359	0.037	33.740	0.000	1.164	1.308
zipcode_98133	0.9179	0.034	27.274	0.000	0.852	0.984
zipcode_98136	1.5665	0.040	39.511	0.000	1.489	1.644
zipcode_98144	1.4922	0.038	39.455	0.000	1.418	1.566
zipcode_98146	0.6829	0.039	17.621	0.000	0.607	0.759
zipcode_98148	0.3247	0.066	4.912	0.000	0.195	0.454
zipcode_98155	0.8200	0.035	23.588	0.000	0.752	0.888
zipcode_98166	0.6199	0.042	14.771	0.000	0.538	0.702
zipcode_98168	0.3168	0.040	7.912	0.000	0.238	0.395
zipcode_98177	1.1845	0.042	28.071	0.000	1.102	1.267
zipcode_98178	0.3922	0.039	9.985	0.000	0.315	0.469
zipcode_98188	0.2477	0.049	5.047	0.000	0.151	0.344
zipcode_98198	0.2525	0.039	6.435	0.000	0.176	0.329
zipcode_98199	2.0703	0.039	52.459	0.000	1.993	2.148

Omnibus:	1844.788	**Durbin-Watson:**	2.004
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	6380.863
Skew:	0.559	**Prob(JB):**	0.00
Kurtosis:	5.848	**Cond. No.**	122.

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



Selecting Variables to Recommend

Now that we have a scaled model, we can pick out the variables with the highest coefficients. This means that we are selecting variables which have the largest impact on the variability of the value of a house.

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.dataframe thead th {
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	index	coeffs	abs
33	Intercept	-1.004551	1.004551
53	sqft_above	0.397017	0.397017
62	sqft_basement	0.170033	0.170033
64	grade	0.162327	0.162327
68	sqft_living15	0.090830	0.090830
70	floors	-0.078977	0.078977

	index	coeffs	abs
72	waterfront	0.063982	0.063982
74	sqft_lot	0.051372	0.051372
77	bathrooms	0.024169	0.024169
78	bedrooms	-0.011559	0.011559

We can see that aside from the intercept, our coefficients for 'sqft_above', 'sqft_basement', and 'grade' have the most impact on price. Therefore, we will select those variables to interpret and make recommendations to our stakeholder on.

CONCLUSIONS & RECOMMENDATIONS

Key Takeaways

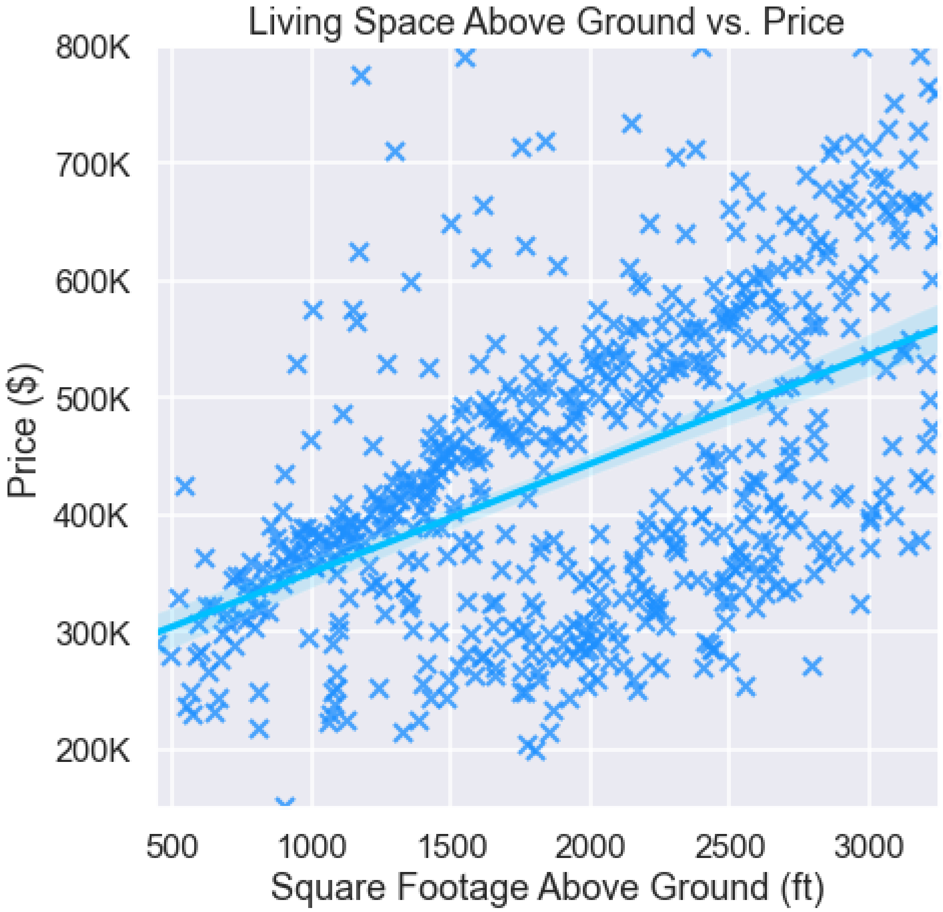
Our final model has an R2 value of 0.806, indicating that with the included variables, the model is capable of explaining 80.6% of the variability in a property's price.

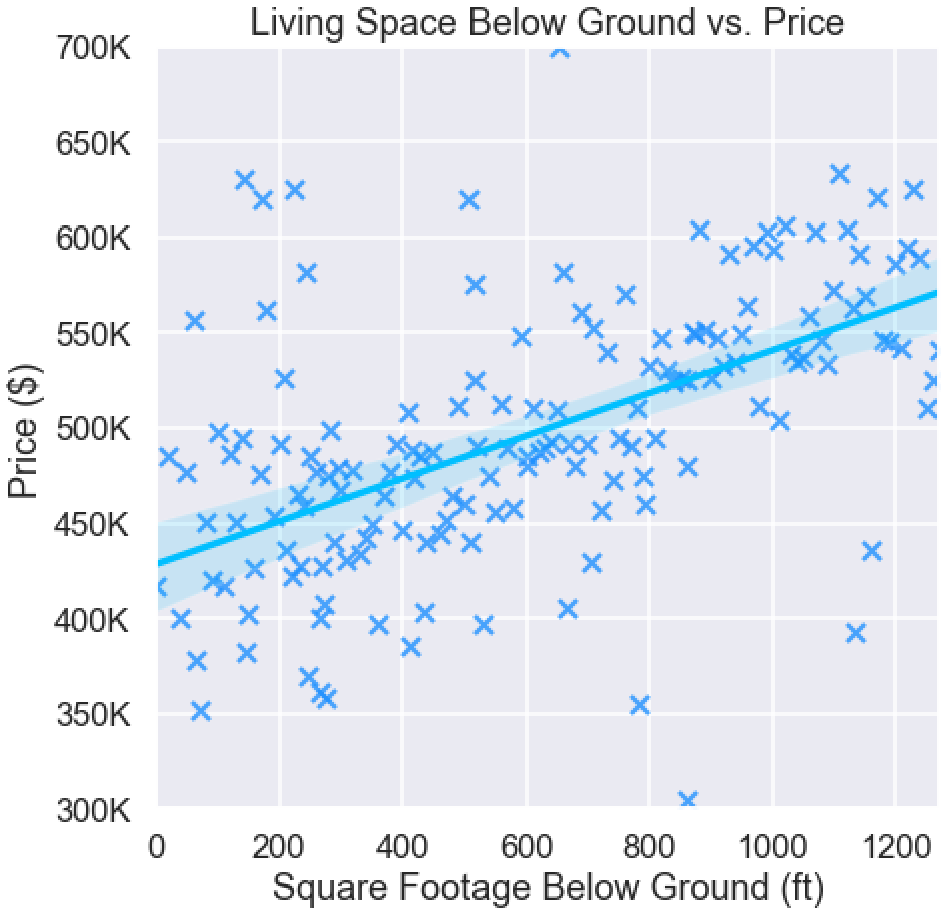
As we can see in our three plots below, there does seem to be a strong linear relationship between price and our three selected variables: living space above ground, living space below ground and grade.

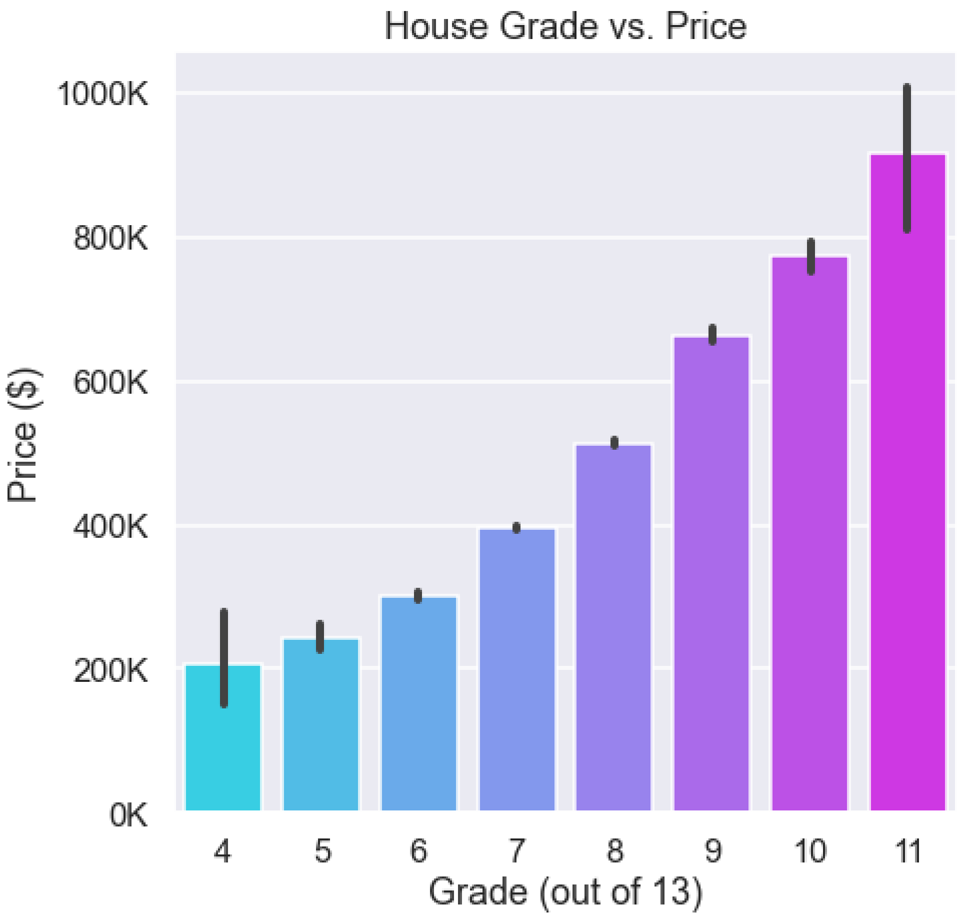
According to our model, for each foot of living space above ground that is increased, we see an increase in property value of approximately $130.33. For each foot of living space below ground that is increased, we see an increase in property value of approximately $90.98. Lastly, when the property grade is increased by 1 point, we see an increase in property value of approximately $34,760.

An idea for future analysis would be to explore what costs would be involved in making these renovations, and to determine whether these recommendations would be cost-effective.

Summary Visualizations


Living Space Above Ground vs. Price
800K
700K
600K
500K
400K
300K
200K
Price ($)
500
1000
1500
2000
2500
3000
Square Footage Above Ground (ft)


Living Space Below Ground vs. Price
700K
650K
600K
550K
500K
450K
400K
350K
300K
Price ($)
0
200
400
600
800
1000
1200
Square Footage Below Ground (ft)



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