# KING COUNTY

## SALES

# BUSINESS PROBLEM

- The stakeholders in King County who are the homeowners are looking for insights on how to increase the estimated value of their houses.
- We were tasked to analyse the King County dataset to provide them with recommendations on ways to increase the value of their houses.

# BUSINESS OBJECTIVE

Using the King County Sales dataset we looked to address the following objectives;

1. How the house design in respect to number of bedrooms, number of bathrooms and number of floors has influence on the sale value of the houses in King County?
2. How the dimensions of the house and lot size have on price of houses in King County?
3. How the combination of the numeric variable with the highest correlation and viable categorical variable influences the price of houses in King county?
4. How the location of the houses influences the price of houses in King county?

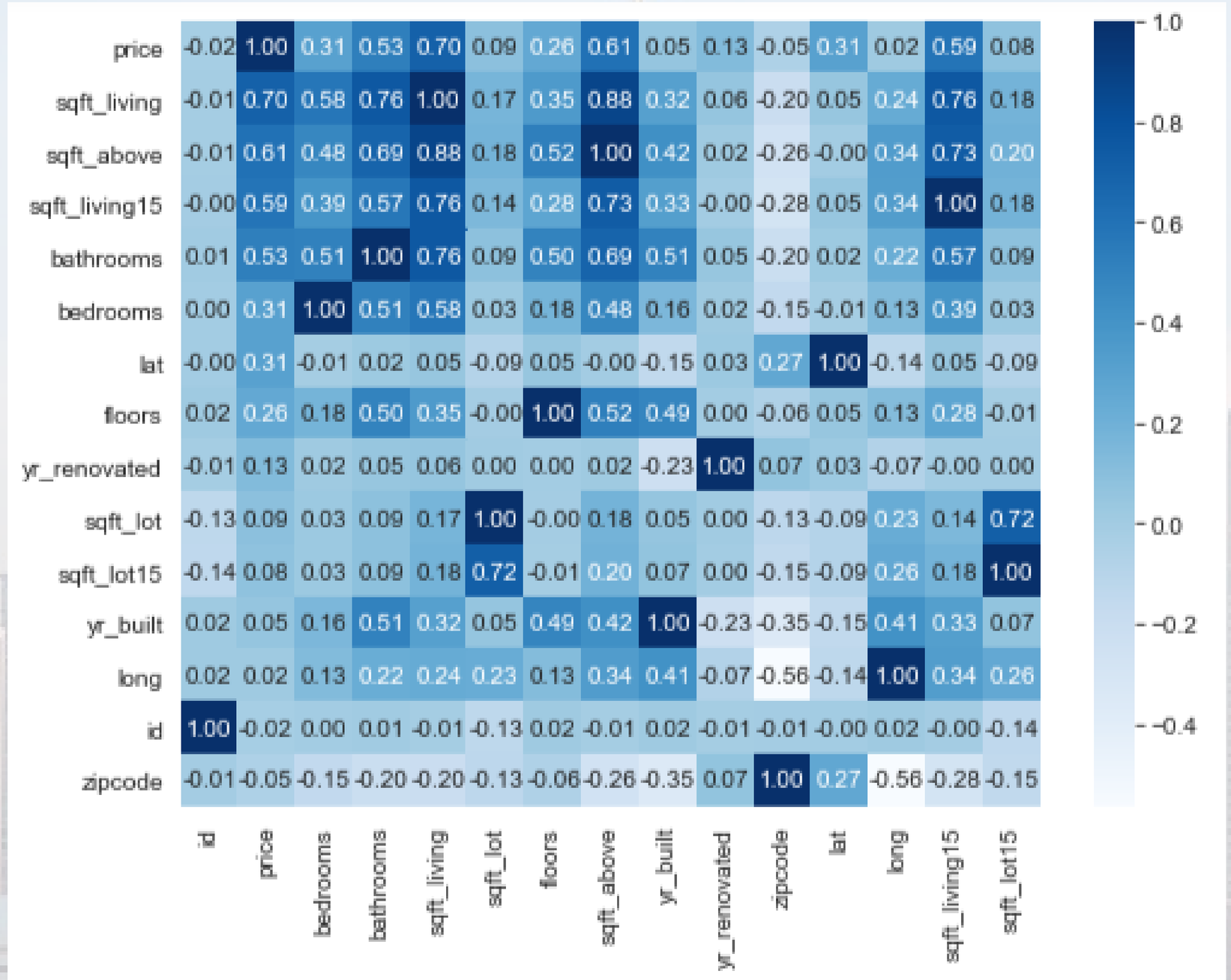
# DATA AND METHODS

We used King County dataset which contained sales from 2014-2015 of 21,597 homes to carry out our analysis.

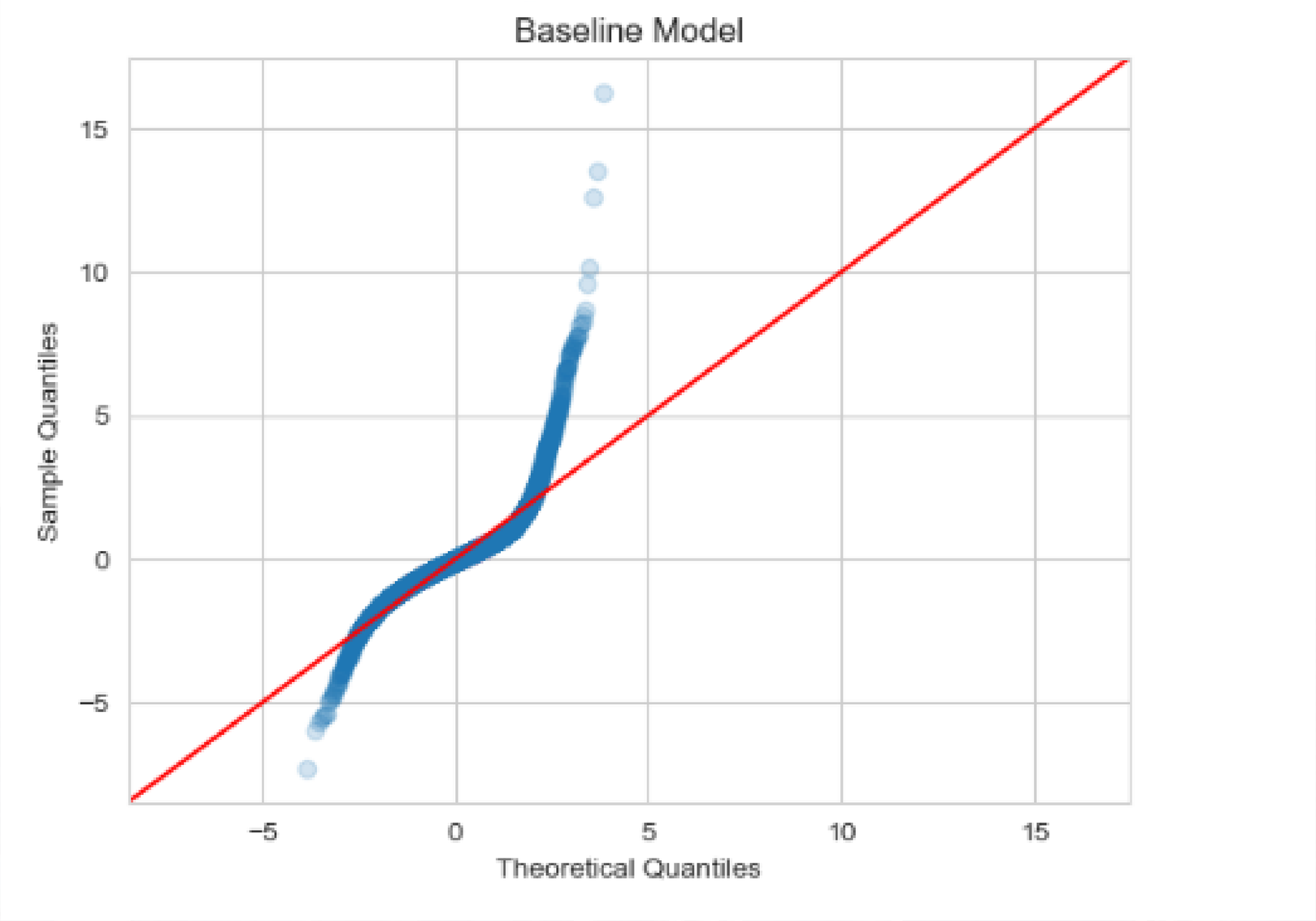
Our methods to analyse the data include;

1. Data cleaning
2. Exploratory data analysis (EDA)
3. Normality testing
4. Hypothesis testing
5. Modeling - simple and multiple linear regression
6. Ridge and Lasso regularization techniques

# RELATIONSHIP OF ALL VARIABLES



# NORMALITY TEST




Our data has heavier tails indicating more extremes thus the data is deviating from normality therefore influencing method choice and exploration.

# HYPOTHESIS TESTING

We conducted a hypothesis testing using waterfront and view ratings where our null and alternative hypotheses were as follows;

- Null hypothesis - Waterfront does not have a significant influence on view ratings
- Alternative hypothesis - Waterfront has a significant influence on view ratings

**Results;**

After conducting a chi-test and ANOVA test we rejected our null hypothesis as results indicated that waterfront had a significant influence on view ratings.

## Objective 1;

## The effect of the house design i.e (number of bedrooms, number of bathrooms and number of floors) have on the sale value of the houses in King County.

King County

OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | price | R-squared: | 0.278 |
| Model: | OLS | Adj. R-squared: | 0.278 |
| Method: | Least Squares | F-statistic: | 2743. |
| Date: | Fri, 08 Sep 2023 | Prob (F-statistic): | 0.00 |
| Time: | 21:04:26 | Log-Likelihood: | -3.0037e+05 |
| No. Observations: | 21345 | AIC: | 6.008e+05 |
| Df Residuals: | 21341 | BIC: | 6.008e+05 |
| Df Model: | 3 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| Intercept | -3.768e+04 | 9492.700 | -3.970 | 0.000 | -5.63e+04 | -1.91e+04 |
| bathrooms | 2.404e+05 | 3756.698 | 63.987 | 0.000 | 2.33e+05 | 2.48e+05 |
| bedrooms | 2.185e+04 | 2815.796 | 7.759 | 0.000 | 1.63e+04 | 2.74e+04 |
| floors | -3272.6132 | 4606.887 | -0.710 | 0.477 | -1.23e+04 | 5757.232 |

| | | | |
|---|---|---|---|
| Omnibus: | 17099.619 | Durbin-Watson: | 1.969 |
| Prob(Omnibus): | 0.000 | Jarque-Bera (JB): | 885044.980 |
| Skew: | 3.464 | Prob(JB): | 0.00 |
| Kurtosis: | 33.776 | Cond. No. | 20.8 |

- In a multiple regression model, bathrooms and bedrooms collectively explain more of the variation in house prices (R-squared: 27.8%) compared to a simple model (R-squared: 9.9%).
- Bathrooms contribute significantly, adding approximately $240,400 per additional bathroom, and bedrooms add about $21,850 each.
- However, the number of floors appears to have no statistically significant impact on house prices (p-value: 0.477), meaning it may not affect prices according to the data.

# Objective 2;
# The effect of dimensions of the house and lot size on the price of houses.

King County

OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | price | R-squared: | 0.503 |
| Model: | OLS | Adj. R-squared: | 0.503 |
| Method: | Least Squares | F-statistic: | 3603. |
| Date: | Fri, 08 Sep 2023 | Prob (F-statistic): | 0.00 |
| Time: | 21:04:45 | Log-Likelihood: | -2.9638e+05 |
| No. Observations: | 21345 | AIC: | 5.928e+05 |
| Df Residuals: | 21338 | BIC: | 5.928e+05 |
| Df Model: | 6 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| Intercept | -1.026e+05 | 5462.508 | -18.786 | 0.000 | -1.13e+05 | -9.19e+04 |
| sqft_living | 230.6043 | 20.011 | 11.524 | 0.000 | 191.380 | 269.828 |
| sqft_lot | 0.0798 | 0.062 | 1.296 | 0.195 | -0.041 | 0.200 |
| sqft_above | 3.9167 | 20.097 | 0.195 | 0.845 | -35.474 | 43.308 |
| sqft_basement | 39.4588 | 19.990 | 1.974 | 0.048 | 0.276 | 78.641 |
| sqft_living15 | 76.9778 | 4.071 | 18.907 | 0.000 | 68.998 | 84.958 |
| sqft_lot15 | -0.7910 | 0.094 | -8.417 | 0.000 | -0.975 | -0.607 |

| | | | |
|---|---|---|---|
| Omnibus: | 15309.267 | Durbin-Watson: | 1.988 |
| Prob(Omnibus): | 0.000 | Jarque-Bera (JB): | 670696.606 |
| Skew: | 2.960 | Prob(JB): | 0.00 |
| Kurtosis: | 29.816 | Cond. No. | 1.56e+05 |

- In a multiple regression model, R-squared is 50.3%, slightly better than the simple model's 49.2%.
- Square foot of living space (sqft_living) is a strong predictor, adding $230.6 pe square foot. "sqft_living15" increases prices by approximately $76.96 with more living space among nearby neighbors.
- On the flip side, "sqft_lot15" suggests a minor price decrease of about $0.79 with larger lot space among neighbors.
- However, "sqft_above" and "sqft_basement" may not significantly affect house prices with p-values > 0.05 and should be considered carefully or potentially removed in further analysis.

# Objective 3;
# The effect of the numeric variable with highest correlation and the viable categorical variable to prices of the house

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OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | price | R-squared: | 0.582 |
| Model: | OLS | Adj. R-squared: | 0.582 |
| Method: | Least Squares | F-statistic: | 2968. |
| Date: | Fri, 08 Sep 2023 | Prob (F-statistic): | 0.00 |
| Time: | 21:14:23 | Log-Likelihood: | -2.9455e+05 |
| No. Observations: | 21345 | AIC: | 5.891e+05 |
| Df Residuals: | 21334 | BIC: | 5.892e+05 |
| Df Model: | 10 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| const | 1.36e+05 | 5364.116 | 25.347 | 0.000 | 1.25e+05 | 1.46e+05 |
| sqft_living | 157.4288 | 2.799 | 56.243 | 0.000 | 151.942 | 162.915 |
| grade_10 Very Good | 3.817e+05 | 9103.068 | 41.932 | 0.000 | 3.64e+05 | 4e+05 |
| grade_11 Excellent | 6.708e+05 | 1.44e+04 | 46.618 | 0.000 | 6.43e+05 | 6.99e+05 |
| grade_12 Luxury | 1.214e+06 | 2.76e+04 | 43.909 | 0.000 | 1.16e+06 | 1.27e+06 |
| grade_13 Mansion | 2.397e+06 | 6.81e+04 | 35.213 | 0.000 | 2.26e+06 | 2.53e+06 |
| grade_4 Low | -6.941e+04 | 6.38e+04 | -1.089 | 0.276 | -1.94e+05 | 5.56e+04 |
| grade_5 Fair | -4.599e+04 | 1.64e+04 | -2.804 | 0.005 | -7.81e+04 | -1.38e+04 |
| grade_6 Low Average | -2.216e+04 | 6094.474 | -3.637 | 0.000 | -3.41e+04 | -1.02e+04 |
| grade_8 Good | 6.293e+04 | 4208.281 | 14.954 | 0.000 | 5.47e+04 | 7.12e+04 |
| grade_9 Better | 1.858e+05 | 6248.370 | 29.737 | 0.000 | 1.74e+05 | 1.98e+05 |

| | | | |
|---|---|---|---|
| Omnibus: | 13686.863 | Durbin-Watson: | 1.995 |
| Prob(Omnibus): | 0.000 | Jarque-Bera (JB): | 465725.595 |
| Skew: | 2.573 | Prob(JB): | 0.00 |
| Kurtosis: | 25.298 | Cond. No. | 9.54e+04 |

- Grade represent the construction quality of improvements thus a more robust choice for the model as the categorical variable.
- In this multiple regression model, R-squared is 58.2%, an improvement from the baseline's 49.2%.
- The baseline price is approximately $136,000.
- Each extra square foot of living space (sqft_living) raises the estimated price by about $157.43.
- Higher-grade categories (10 to 13) significantly increase prices, with a grade of 13 (Mansion) adding around $2,397,000. But the effect of grade_4 (Low) is uncertain with a high p-value (0.276).

# Objective 4;
# The effect of location with the other variables on price of houses

King County

OLS Regression Results

| | | | |
|---|---|---|---|
| Dep. Variable: | price | R-squared: | 0.801 |
| Model: | OLS | Adj. R-squared: | 0.801 |
| Method: | Least Squares | F-statistic: | 1086. |
| Date: | Fri, 08 Sep 2023 | Prob (F-statistic): | 0.00 |
| Time: | 21:15:25 | Log-Likelihood: | -2.8660e+05 |
| No. Observations: | 21345 | AIC: | 5.734e+05 |
| Df Residuals: | 21265 | BIC: | 5.740e+05 |
| Df Model: | 79 | | |
| Covariance Type: | nonrobust | | |

| | coef | std err | t | P>\|t\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| const | -6.728e+05 | 1.52e+04 | -44.201 | 0.000 | -7.03e+05 | -6.43e+05 |
| age | 1084.6468 | 59.775 | 18.146 | 0.000 | 967.484 | 1201.810 |
| numeric_condition | 2.421e+04 | 1952.656 | 12.399 | 0.000 | 2.04e+04 | 2.8e+04 |
| numeric_grade | 6.462e+04 | 1865.065 | 34.647 | 0.000 | 6.1e+04 | 6.83e+04 |
| sqft_living | 128.2788 | 3.327 | 38.558 | 0.000 | 121.758 | 134.800 |
| bathrooms | 1.067e+04 | 2573.653 | 4.144 | 0.000 | 5621.025 | 1.57e+04 |
| view_rating_numeric | 6.65e+04 | 1964.184 | 33.856 | 0.000 | 6.26e+04 | 7.03e+04 |
| numeric_waterfront | 6.227e+05 | 1.45e+04 | 42.919 | 0.000 | 5.94e+05 | 6.51e+05 |
| sqft_lot | 0.2383 | 0.030 | 8.002 | 0.000 | 0.180 | 0.297 |
| sqft_above | 53.8706 | 3.270 | 16.474 | 0.000 | 47.461 | 60.280 |
| sqft_living15 | 12.4718 | 2.954 | 4.222 | 0.000 | 6.682 | 18.262 |
| zipcode_98002 | 2.576e+04 | 1.47e+04 | 1.757 | 0.079 | -2980.675 | 5.45e+04 |
| zipcode_98003 | -1.582e+04 | 1.32e+04 | -1.199 | 0.231 | -4.17e+04 | 1e+04 |
| zipcode_98004 | 7.656e+05 | 1.29e+04 | 59.353 | 0.000 | 7.4e+05 | 7.91e+05 |
| zipcode_98005 | 2.952e+05 | 1.55e+04 | 18.996 | 0.000 | 2.65e+05 | 3.26e+05 |
| zipcode_98006 | 2.629e+05 | 1.17e+04 | 22.482 | 0.000 | 2.4e+05 | 2.86e+05 |
| zipcode_98007 | 2.292e+05 | 1.65e+04 | 13.893 | 0.000 | 1.97e+05 | 2.62e+05 |

| | |
|---|---|
| Omnibus: | 21318.296 |
| Prob(Omnibus): | 0.000 |
| Skew: | 4.394 |
| Kurtosis: | 77.261 |
| Durbin-Watson: | 1.986 |
| Jarque-Bera (JB): | 4973359.080 |
| Prob(JB): | 0.00 |
| Cond. No. | 2.91e+06 |

- The model generated the highest r-squared of 80.1%. The highest coefficient is zipcode 98004, Bellevue, indicating an increase in house price by $1,330,000.
- However, our regression model showed strong multicollinearity between one or more predictor variables. This can affect the reliability and interpretability of the results.
- We decided to address this issue by using Ridge and Lasso regularization techniques.

# Ridge and Lasso regression techiques

The Ridge and Lasso regression model had an MSE of 0.002478 and 0.002478 respectively indicate that, on average, the squared difference between the predicted values and the actual target values is quite small. This suggests that our Ridge regression model is making reasonably accurate predictions for the given dataset. Smaller MSE (Mean Squared Error) values generally imply better model performance.

# Conclusion

We found that the Ordinary Least Squares (OLS) regression model is highly effective with an impressive R-squared of 0.801, accurately accounting for 80.1% of price variance. We initially dealt with multicollinearity using Ridge and Lasso regularization, which greatly improved model stability. Ridge achieved an R-squared of 0.0025, while Lasso had a low Mean Squared Error (MSE) of 0.0025.
We recommend sticking with the OLS model as it aligns with our goal of a reliable property price predictor, backed by strong performance and regularization techniques. These results enhance our decision-making capabilities.

# Recommendations

1. In relation to house design bathrooms contribute significantly, adding approximately $240,400 per additional bathroom, and bedrooms add about $21,850 each therefore number of bathrooms and bedrooms would be great factors to consider when vouching to increase value of houses.
2. In relation to house dimensions square food of living space (sqft_living) is a strong predictor, adding $230.6 per square foot to house price while square footage of interior housing living space for the nearest 15 neighbors (sqft_living15) increases prices by approximately $76.96 with more living space among nearby neighbors thus sqft_living and sqft_living15 would be great factors to consider in increasing value of houses.
3. Grade and square foot of living space (sqft_living) would be a great combined factor to consider as each extra sqft_living raises the estimated price by about $157.43 while higher-grade categories (10 to 13) significantly increase prices, with a grade of 13 (Mansion) adding around $2,397,000.
4. Location is the best feature to use when looking for insight to increase the value of houses in King County as the model with location and the other variables generated the highest r-squared of 80.1%.  The highest coefficient is zipcode 98004, Bellevue, indicating an increase in house price by $1,330,000.


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