

SOUTHERN METHODIST UNIVERSITY  
MSDS 6371(401)

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## Kaggle Project

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Michael J Wolfe  
Sandesh Ojha  
Carl Walenciak  
Travis Daun

Github Repository

[https://github.com/mjwolfe91/SFDS\\_401\\_Team3\\_Kaggle\\_Project](https://github.com/mjwolfe91/SFDS_401_Team3_Kaggle_Project)

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## 1. INTRODUCTION

Many factors can impact the sale price of residential real estate. In this analysis we will explore various factors that tend to impact home prices by looking at the neighborhood of North Ames, Edwards and Brookside in Ames, Iowa. We will explore factors like above ground living space, neighborhoods and the impact on sales price. At the end of this analysis, we will quantify the relationship between living area and sales price with respect to these neighborhoods.

After examining the impact of above ground living space on sales price for these neighborhoods, we will provide a complex analysis of factors that can be used to determine sales price for all of Ames. While we will use various methods to determine what factors are important for our predictive model, we will test this model on a blind dataset to show how it performs. The results of this model on the test data will be provided to further build the level of confidence for predicting future home sale prices.

## 2. DATA DESCRIPTION

The dataset used for this analysis was retrieved from [www.kaggle.com/c/house-prices-advanced-regression-techniques](http://www.kaggle.com/c/house-prices-advanced-regression-techniques).

**DATA** The data for this evaluation contained 79 explanatory variables describing (almost) every aspect of residential homes in Ames, Iowa. A complete description of these data can be found in Appendix E. The explanatory variables contain both categorical and numeric attributes. Appendix E.1, provides a high level summary of the variables and variable types contained in this dataset.

**PREPROCESSING** The variable `LotFrontage` posed a challenge since it was a continuous numerical variable that contained `NA`. This is because the variable was for the linear feet of street connected to property. In many cases (259 of 1460) this was either unknown or unrecorded. Our team made the decision to convert these `NA` values to 0. We believe this is an acceptable practice since we performed a sensitivity analysis by replacing the `NAs` with values from 0 to 140 (mean value is 70) with no impact on the linear regression model selection process and this factor was not utilized in any of our final models.

**TRAINING** Training of the linear regression models will be done utilizing the `training.csv` data obtained from above. A five fold cross validation will be employed for model selection.

**TESTING** Testing of the linear regression models will be done utilizing the `test.csv` data obtained from above.

**RESULTS** Datafiles containing the test results of the linear regression models can be found in our Github repository at [https://github.com/mjwolfe91/SFDS\\_401\\_Team3\\_Kaggle\\_Project](https://github.com/mjwolfe91/SFDS_401_Team3_Kaggle_Project)

### 3. ANALYSIS QUESTION 1

#### 3.1. Restatement of Problem

**REQUEST** Century 21 Ames only sells houses in the North Ames, Edwards and Brookside neighborhoods and wants an estimate of how the sale price of the house is related to the square footage of the living area of the house. Additionally, Century 21 Ames would like to know if the sale price (and its relationship to square footage) depends on which neighborhood the house is located in. A fit a model will be used to answer this question.

**DELIVERABLE** Provide the estimate (or estimates if it varies by neighborhood) as well as confidence intervals for any estimate(s) you provide. Provide evidence that the model assumptions are met and that any suspicious observations (outliers / influential observations) have been identified and addressed. Finally, a conclusion that quantifies the relationship between living area and sale price with respect to these three neighborhoods.

#### 3.2. Build and Fit the Model

Listing 1 of Appendix C contains the SAS code used to check the assumptions, clean the data, and run the model to determine the best estimate for sale price based on square footage for the North Ames, Edwards, and Brookside neighborhoods. We removed four data points from the original dataset due to being outliers. First sale prices greater than \$300,000 were determined to not be representative of the total population of these three neighborhoods. Second, sale condition was limited to only those that were normal sales. Again we feel that home sales that were not normal sales such as foreclosures, linked properties, and land purchases were not representative of the population of interest.

#### 3.3. Checking Assumptions

##### 3.3.1. Assumptions

**LINEARITY** The linearity assumption is met by the reviewing the scatter plots associated with the data. Fig. B.1 shows a plot of SalePrice vs. GrLivArea and by removing the outliers the linearity assumption is reasonably met.

**CONSTANT VARIANCE** The residual plot, Fig. B.3 resembles somewhat of a random scatter of points around the 0 line, although there is a slight suspicion of non-constant variance judging from the dense cloud around the predicted value of \$130,000. Also shown is the Studentized Residual Plot which is very similar to the residual plot, although this plot identifies potential outlying observations.

**NORMALITY** Based upon the histograms and q-q plots in Fig. B.2 there is no evidence to suggest against normality. Additionally the random scatter associated with the residual plots in Fig. B.3 also support the normality assumption.

**INDEPENDENCE** The independence assumption can be assumed to be maintained since these are all unique sales in a free housing market.

### 3.3.2. Outliers and Influential Points

OUTLIERS / INFLUENTIAL OBSERVATIONS There are distinct outliers that can be seen both in the Cook's D and Outlier and Leverage Diagnostics seen in Fig B.4. By removing the observations that resulted from non-normal sales conditions such as foreclosures and sale prices that were significantly outside the population, the Cook's D and Outlier and Leverage Diagnostics significantly improved. We are confident that the removal of these observations was appropriate since they do not represent the population as a whole. Additionally we are confident that the remaining data does not contain significant outliers or leverage points that need to be addressed further.

The model is a reasonable fit without transformations. The removal of observations not reflective of the population, such as non-normal sale conditions and home sales greater than \$300,000, seems appropriate and enables the required model assumptions to be met.

### 3.3.3. Effect by Neighborhood

MODEL A model was developed to individually look at the neighborhoods of interest to determine if the sale price is impacted by neighborhood. Fig B.5 shows the sales price vs living area by neighborhood. The model shows (Table A.1) that the intercept and slope for Brookside and Edwards do differ from North Ames with statistical significance (p-values: < .0001 and .0077). As such we have determined to choose this model which allows for different intercept and slopes based upon the neighborhood. The resultant model can be seen in Fig B.6.

## 3.4. Model Metrics

Model metrics can be seen in Table A.2.

### 3.4.1. Adj R<sup>2</sup>

ADJUSTED R<sup>2</sup> obtained for this model is 0.53.

### 3.4.2. Internal Press

PRESS obtained by this model is 1.96E11.

## 3.5. Parameters

### 3.5.1. Estimates

The parameter estimates can be seen in Table A.1. With these estimates a separate equation can be written for each neighborhood to predict sale price based on living area.

$$\begin{aligned} SalePrice = & 74982 + 54.93(GrLivArea) - 55776(BrkSide) - 30274(Edwards) + \\ & 33.31(GrLivArea)(BrkSide) + 8.24(GrLivArea)(Edwards) \end{aligned}$$

NORTH AMES

$$SalePrice = 74982 + 54.93(GrLivArea)$$

## EDWARDS

$$\begin{aligned} \text{SalePrice} &= 74982 + 54.93(\text{GrLivArea}) - 30274 + 8.24(\text{GrLivArea}) \\ &= 44708 + 63.17(\text{GrLivArea}) \end{aligned}$$

## BROOKSIDE

$$\begin{aligned} \text{SalePrice} &= 74982 + 54.93(\text{GrLivArea}) - 55776 + 33.31(\text{GrLivArea}) \\ &= 19206 + 88.24(\text{GrLivArea}) \end{aligned}$$

### 3.5.2. Interpretation

$\beta_0$  The intercept in this model provides an estimate (74982) of the sale price of a home in North Ames (reference neighborhood) with a living area of zero. Of course, this is extrapolation and does not have a clear, practical meaning.

$\beta_1$  For each 100 square foot increase in the living area of a home in North Ames, the estimated sale price increases \$54.93.

$\beta_2$  This is the adjustment of the intercept for a home in Brookside with respect to a home in North Ames. For a living area of zero, the home in Brookside has an estimated sale price of \$55,776 less than a home in North Ames.

$\beta_3$  This is the adjustment of the intercept for a home in Edwards with respect to a home in North Ames. For a living area of zero, the home in Edwards has an estimated sale price of \$30,274 less than a home in North Ames.

$\beta_4$  For each 100 square foot increase in the living area of a home in Brookside, the estimated sale price increases \$33 from the change with the home in North Ames.

$\beta_5$  For each 100 square foot increase in the living area of a home in Edwards, the estimated sale price increases \$8 from the change with the home in North Ames.

### 3.5.3. Confidence Intervals

The confidence intervals for the estimates can be seen in Table A.1.

## 3.6. Conclusion

The square feet of above ground living space is a statistically significant factor to use to predict the sale price of homes in the North Ames, Edwards, and Brookside neighborhoods of Ames, Iowa. The existing sale prices of homes in these neighborhoods that are sold, under \$300,000 and underwent a normal sales condition meet all the assumptions required to generate an appropriate linear regression model. We also examined the differences in predicted prices in these neighborhoods and determined that the sale prices of homes in each neighborhood do differ from each other. Homes in North Ames under 1600 square feet are predicted to sell for a higher price compared to the other two neighborhoods. Out of these three neighborhoods, the price per square foot in Brookside increases at the highest rate. 8 Homes greater

than approximately 1000 square feet in Brookside are predicted to sell for higher prices than comparable homes in Edwards. Homes greater than approximately 1600 square feet in Brookside are predicted to sell for higher prices than comparable homes in North Ames. Homes in the Edwards neighborhood are predicted to sell for the lowest price except for homes that are smaller than 1000 square feet.

## 4. ANALYSIS QUESTION 2

### 4.1. Restatement of Problem

Build the most predictive model for sales prices of homes in all of Ames Iowa. This includes all neighborhoods. Your group is limited to only the techniques we have learned in 6371 (no random forests or other methods we have not yet covered). Specifically, you should produce 4 models: one from forward selection, one from backwards elimination, one from stepwise selection, and one that you build custom. The custom model could be one of the three preceding models or one that you build by adding or subtracting variables at your will. Generate an adjusted R<sup>2</sup>, CV Press and Kaggle Score for each of these models and clearly describe which model you feel is the best in terms of being able to predict future sale prices of homes in Ames, Iowa.

### 4.2. Model Selection

#### 4.2.1. Forward

$$\begin{aligned} SalePrice = & -1271664 + 648.153(YearBuilt) + 47.049(TotalBsmtSF) \\ & + 80.004(GrLivArea) - 671551(RoofMatl_ClyTile) \\ & + 62871(BsmtQual_Ex) \end{aligned}$$

The SAS code for the forward model can be found in Listing 2 of Appendix D. The fit diagnostics and residuals by regressors for sale price can be seen in Fig B.8. A scatterplot of the predicted values vs. the sale price using the features obtained by the forward selection model can be seen in Fig B.7.

**LINEARITY** Visual tests support assumptions of linearity. There is no evidence to suggest that these data are not linear based on the scatterplot in Fig B.7.

**CONSTANT VARIANCE** Examining Fig B.8 supports a loose random scatter of points around the origin.

**NORMALITY** Visual analysis of histograms and q-q plots in Fig B.9 suggests normality of the data. Additionally the random cloud scatter plotted in Fig B.8 supports the normality assumption. Left and right leaning trailing tails in the q-q plot does suggest that outliers on both ends may not meet the normality assumption. We will address this in later analysis.

**INDEPENDENCE** Century21 Ames indicated all samples are unique sales in a free housing market, supporting assumptions of independence.

#### OUTLIERS AND INFLUENTIAL POINTS

**OUTLIERS / INFLUENTIAL OBSERVATIONS** There are distinct outliers that can be seen both in the Cook's D and Outlier and Leverage Diagnostics seen in Fig B.10; however, these outliers do not have high enough leverage to engender corrective action.

#### 4.2.2. Backward

$$\begin{aligned} SalePrice = & 120177 + 35.192(BsmtFinSF1) + 85.189(1stFlrSF) \\ & + 59.655(2ndFlrSF) - 120853(OverallQual\_3) \\ & - 110889(OverallQual\_4) - 101945(OverallQual\_5) \\ & - 86980(OverallQual\_6) - 57950(OverallQual\_7) \\ & - 615180(RoofMatl_ClyTile) \end{aligned}$$

The SAS code for the forward model can be found in Listing 3 of Appendix D. The fit diagnostics and residuals by regressors for sale price can be seen in Fig B.12. A scatterplot of the predicted values vs. the sale price using the features obtained by the forward selection model can be seen in Fig B.11.

**LINEARITY** Visual tests of the scatter plots in Fig B.11 meet assumptions of linearity.

**CONSTANT VARIANCE** The residual plots in Fig B.12 support a loose random scatter of points around the origin. The Studentized Residual Plot also supports this assumption while highlighting outlying observations. We will address these in later analysis.

**NORMALITY** Visual analysis of histograms and q-q plots in Fig B.13 suggests normality of the data. Additionally the random cloud scatter plotted in Fig B.12 also support the normality assumption. Left and right leaning trailing tails in the q-q plot does suggest that outliers on both ends may not meet the normality assumption. We will address this in later analysis.

**INDEPENDENCE** Century21 Ames indicated all samples are unique sales in a free housing market, supporting assumptions of independence.

#### OUTLIERS AND INFLUENTIAL POINTS

**OUTLIERS / INFLUENTIAL OBSERVATIONS** There are distinct outliers that can be seen both in the Cook's D and Outlier and Leverage Diagnostics seen in Fig B.14; however, these outliers do not have high enough leverage to engender corrective action.

#### 4.2.3. Stepwise

$$\begin{aligned} SalePrice = & -1271664 + 648.153(YearBuilt) + 47.049(TotalBsmtSF) \\ & + 80.004(GrLivArea) - 671551(RoofMatl_ClyTile) \\ & + 62871(BsmtQual_Ex) \end{aligned}$$

The SAS code for the forward model can be found in Listing 4 of Appendix D. The fit diagnostics and residuals by regressors for sale price can be seen in Fig B.16. A scatterplot of the predicted values vs the sale price using the features obtained by the forward selection model can be seen in Fig B.15.

**LINEARITY** Visual tests of the scatter plots in Fig B.15 meet assumptions of linearity.

**CONSTANT VARIANCE** The residual plots in Fig B.16 support a loose random scatter of points around the origin. The Studentized Residual Plot also supports this assumption while highlighting outlying observations. We will address these in later analysis.

**NORMALITY** Visual analysis of histograms and q-q plots in Fig B.17 suggests normality of the data. Additionally the random cloud scatter plotted in Fig B.16 also support the normality assumption. supports the normality assumption. Left and right leaning trailing tails in the q-q plot does suggest that outliers on both ends may not meet the normality assumption. We will address this in later analysis

**INDEPENDENCE** Century21 Ames indicated all samples are unique sales in a free housing market, supporting assumptions of independence.

#### OUTLIERS AND INFLUENTIAL POINTS

**OUTLIERS / INFLUENTIAL OBSERVATIONS** There are distinct outliers that can be seen both in the Cook's D and Outlier and Leverage Diagnostics seen in Fig B.18; however, these outliers do not have high enough leverage to engender corrective action.

##### 4.2.4. Custom

$$\begin{aligned} SalePrice = & 280051 + (28.48)GrLivArea + (37.54)1stFlrSF + \\ & (38.97)2ndFlrSF - (554.60)Age + (86.1448)RemodFactor + \\ & Neighborhood^* + BldgType^* + SaleCondition^* + \\ & OverallQual^* + OverallCond^* + \\ & HouseStyle^* \end{aligned}$$

(\* Estimates for categorical variables left out for ease of reading. See Table A.17 for more detail.)

The SAS code for the custom model can be found in Listing 5 of Appendix D The fit diagnostics and residuals by regressors for sale price can be seen in Fig B.20. A scatterplot of the predicted values vs the sale price using the features obtained by the forward selection model can be seen in Fig B.19.

**LINEARITY** Visual tests of the scatter plots in Fig B.19 meet assumptions of linearity.

**CONSTANT VARIANCE** The residual plots in Fig B.20 support a loose random scatter of points around the origin. The Studentized Residual Plot also supports this assumption while highlighting outlying observations. We will address these in later analysis.

**NORMALITY** Visual analysis of histograms and q-q plots in Fig B.21 suggests normality of the data. Additionally the random cloud scatter plotted in Fig B.20 also support the normality assumption. supports the normality assumption. Left and right leaning trailing tails in the q-q plot does suggest that outliers on both ends may not meet the normality assumption. We will address this in later analysis

**INDEPENDENCE** Century21 Ames indicated all samples are unique sales in a free housing market, supporting assumptions of independence.

## OUTLIERS AND INFLUENTIAL POINTS

**OUTLIERS / INFLUENTIAL OBSERVATIONS** There are distinct outliers that can be seen both in the Cook's D and Outlier and Leverage Diagnostics seen in Fig B.22; however, these outliers do not have high enough leverage to engender corrective action.

### 4.3. Comparing Competing Models

Predictive Models	Adjusted R <sup>2</sup>	Press	Kaggle Score
Forward	0.7789	2.37E12	0.20306
Backward	0.7846	1.87E12	0.23930
Stepwise	0.7789	2.37E12	0.20306
CUSTOM	0.8456	1.59E12	0.14286

Table 4.1: Analysis Results

### 4.4. Conclusion

Model selection methods such as the forward, stepwise, and backward methods enabled model performance to be improved by reducing the number of factors to those of statistical significance. The best results came from modifying the results of these selection methods with domain specific knowledge to generate a more accurate and powerful model. Each model selection method had various strengths as can be seen in Table 4.1 but the most accurate results came from a combination of methods combined with educated choices for model parameters.

## A. LIST OF TABLES

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Parameter	Estimate		Standard Error	t Value	Pr >  t	95% Confidence Limits	
Intercept	74982.03784	B	5925.64914	12.65	<.0001	63324.70074	86639.37493
GrLivArea100	54.93056	B	4.36399	12.59	<.0001	46.34542	63.51570
Neighborhood_BrkSide	-55776.16653	B	12012.18226	-4.64	<.0001	-79407.34256	-32144.99051
Neighborhood_Edwards	-30273.99848	B	11296.53114	-2.68	0.0077	-52497.29731	-8050.69965
Neighborhood_NAmes	0.00000	B	.	.	.	.	.
GrLivArea*Neighborhood_BrkSide	33.31303	B	9.33444	3.57	0.0004	14.94970	51.67637
GrLivArea*Neighborhood_Edwards	8.24334	B	8.45713	0.97	0.3304	-8.39409	24.88077
GrLivArea*Neighborhood_NAmes	0.00000	B	.	.	.	.	.

Table A.1: Results of Neighborhood Impact on Sales Price.

---

<b>Root MSE</b>	24094
<b>Dependent Mean</b>	137977
<b>R-Square</b>	0.5333
<b>Adj R-Sq</b>	0.5291
<b>AIC</b>	7037.53791
<b>AICC</b>	7037.72196
<b>BIC</b>	6705.63517
<b>C(p)</b>	4.00000
<b>PRESS</b>	1.961216E11
<b>SBC</b>	6718.75845
<b>ASE</b>	573508240

Table A.2: Results of Neighborhood Impact on Sales Price.

---

The GLMSELECT Procedure																
Step	Effect Entered	Forward Selection Summary														Pr > F
		Number Effects In	Model R-Square	Adjusted R-Square	AIC		AICC		BIC		CP		SBC		PRESS	
0	Intercept	1	0.0000	0.0000	32291.6565	32291.6653	30916.9518	26023.1178	30923.8798	8.53501E12	6216310560	8.5396E12	0.00	1.0000		
1	GrLivArea	2	0.5038	0.5034	31332.8678	31332.8853	29956.6544	12224.7250	29970.3144	4.27855E12	3084477950	4.27422E12	1390.02	<.0001		
2	YearBuilt	3	0.6454	0.6449	30874.1151	30874.1444	29496.4868	8347.2758	29516.7850	3.0718E12	2204083788	3.0765E12	546.43	<.0001		
3	BsmtQual_Ex	4	0.7095	0.7089	30602.6871	30602.7310	29223.6955	6593.2177	29250.5803	2.53391E12	1805567590	2.54596E12	301.72	<.0001		
4	RoofMatl_ClyTile	5	0.7375	0.7367	30466.0929	30466.1545	29085.6893	5830.2421	29119.2094	2.27335E12	1631965597	2.535E12	145.31	<.0001		
5	TotalBsmtSF	6	0.7797	0.7789*	30227.3690*	30227.4512*	28845.9016*	4674.2217*	28885.7088*	1.91652E12*	1369166863	2.37142E12*	262.00	<.0001		

\* Optimal Value of Criterion

Table A.3: Forward Selection Model Summary.

---

The GLMSELECT Procedure Selected Model																																							
The selected model is the model at the last step (Step 5).																																							
Effects: Intercept YearBuilt TotalBsmtSF GrLivArea RoofMatl_ClyTile BsmtQual_Ex																																							
<b>Analysis of Variance</b>																																							
<table border="1"> <thead> <tr><th>Source</th><th>DF</th><th>Sum of Squares</th><th>Mean Square</th><th>F Value</th></tr> </thead> <tbody> <tr><td>Model</td><td>5</td><td>6.645434E12</td><td>1.329087E12</td><td>966.48</td></tr> <tr><td>Error</td><td>1365</td><td>1.877128E12</td><td>1375185179</td><td></td></tr> <tr><td>Corrected Total</td><td>1370</td><td>8.522562E12</td><td></td><td></td></tr> </tbody> </table>					Source	DF	Sum of Squares	Mean Square	F Value	Model	5	6.645434E12	1.329087E12	966.48	Error	1365	1.877128E12	1375185179		Corrected Total	1370	8.522562E12																	
Source	DF	Sum of Squares	Mean Square	F Value																																			
Model	5	6.645434E12	1.329087E12	966.48																																			
Error	1365	1.877128E12	1375185179																																				
Corrected Total	1370	8.522562E12																																					
<b>Root MSE</b> 37083																																							
<b>Dependent Mean</b> 185182																																							
<b>R-Square</b> 0.7797																																							
<b>Adj R-Sq</b> 0.7789																																							
<b>AIC</b> 30227																																							
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<b>BIC</b> 28846																																							
<b>C(p)</b> 4674.22175																																							
<b>PRESS</b> 1.916518E12																																							
<b>SBC</b> 28886																																							
<b>ASE</b> 1369166863																																							
<b>CV PRESS</b> 2.371423E12																																							
<b>Parameter Estimates</b>																																							
<table border="1"> <thead> <tr><th>Parameter</th><th>DF</th><th>Estimate</th><th>Standard Error</th><th>t Value</th></tr> </thead> <tbody> <tr><td>Intercept</td><td>1</td><td>-1271664</td><td>73606</td><td>-17.28</td></tr> <tr><td>YearBuilt</td><td>1</td><td>648.152763</td><td>37.758936</td><td>17.17</td></tr> <tr><td>TotalBsmtSF</td><td>1</td><td>47.048875</td><td>2.906695</td><td>16.19</td></tr> <tr><td>GrLivArea</td><td>1</td><td>80.004257</td><td>2.189524</td><td>36.54</td></tr> <tr><td>RoofMatl_ClyTile</td><td>1</td><td>-671551</td><td>39444</td><td>-17.03</td></tr> <tr><td>BsmtQual_Ex</td><td>1</td><td>62871</td><td>4009.622196</td><td>15.68</td></tr> </tbody> </table>					Parameter	DF	Estimate	Standard Error	t Value	Intercept	1	-1271664	73606	-17.28	YearBuilt	1	648.152763	37.758936	17.17	TotalBsmtSF	1	47.048875	2.906695	16.19	GrLivArea	1	80.004257	2.189524	36.54	RoofMatl_ClyTile	1	-671551	39444	-17.03	BsmtQual_Ex	1	62871	4009.622196	15.68
Parameter	DF	Estimate	Standard Error	t Value																																			
Intercept	1	-1271664	73606	-17.28																																			
YearBuilt	1	648.152763	37.758936	17.17																																			
TotalBsmtSF	1	47.048875	2.906695	16.19																																			
GrLivArea	1	80.004257	2.189524	36.54																																			
RoofMatl_ClyTile	1	-671551	39444	-17.03																																			
BsmtQual_Ex	1	62871	4009.622196	15.68																																			

Table A.4: Forward Selection Model Performance.

Your most recent submission				
Name results_fw.csv	Submitted just now	Wait time 2 seconds	Execution time 0 seconds	Score 0.20306
Complete				
Jump to your position on the leaderboard ▾				

Table A.5: Forward Selection Model Performance - Kaggle.

### Regression of Sale Price Using Forward Selection Results

The REG Procedure  
Model: MODEL1  
Dependent Variable: SalePrice

Number of Observations Read	2919
Number of Observations Used	1460
Number of Observations with Missing Values	1459

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	7.204143E12	1.440829E12	1045.51	<.0001
Error	1454	2.003768E12	1378107301		
Corrected Total	1459	9.207911E12			

Root MSE	37123	R-Square	0.7824
Dependent Mean	180921	Adj R-Sq	0.7816
Coeff Var	20.51881		

Parameter Estimates						
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr >  t	95% Confidence Limits
Intercept	1	-1314593	69671	-18.87	<.0001	-1451261 -1177926
YearBuilt	1	671.56397	35.78464	18.77	<.0001	601.36894 741.75901
TotalBsmtSF	1	45.58624	2.82417	16.14	<.0001	40.04635 51.12613
GrLivArea	1	78.17387	2.11050	37.04	<.0001	74.03393 82.31382
RoofMatl_ClyTile	1	-659375	39300	-16.78	<.0001	-736466 -582285
BsmtQual_EX	1	65879	3973.03277	16.58	<.0001	58086 73673

Table A.6: Forward Selection Model 95% Confidence Limits.

---

The GLMSELECT Procedure Selected Model				
The selected model is the model at the last step (Step 581).				
<b>Effects:</b> Intercept BsmtFinSF1 _1stFlrSF _2ndFlrSF OverallQual_3 OverallQual_4 OverallQual_5 OverallQual_6 OverallQual_7 RoofMatl_ClyTile				
<b>Analysis of Variance</b>				
Source	DF	Sum of Squares	Mean Square	F Value
Model	9	6.700172E12	7.444635E11	555.98
Error	1361	1.82239E12	1339008268	
Corrected Total	1370	8.522562E12		
<b>Root MSE</b> 36592 <b>Dependent Mean</b> 185182 <b>R-Square</b> 0.7862 <b>Adj R-Sq</b> 0.7848 <b>AIC</b> 30195 <b>AICC</b> 30195 <b>PRESS</b> 1.869959E12 <b>SBC</b> 28874				
<b>Parameter Estimates</b>				
Parameter	DF	Estimate	Standard Error	t Value
Intercept	1	120177	6171.859488	19.47
BsmtFinSF1	1	35.191793	2.494860	14.11
_1stFlrSF	1	85.189346	3.430542	24.83
_2ndFlrSF	1	59.655197	2.597953	22.96
OverallQual_3	1	-120853	10372	-11.65
OverallQual_4	1	-110889	5142.322601	-21.56
OverallQual_5	1	-101945	3689.034840	-27.63
OverallQual_6	1	-86980	3505.752865	-24.81
OverallQual_7	1	-57950	3401.236685	-17.04
RoofMatl_ClyTile	1	-615180	39362	-15.63

Table A.7: Backward Selection Model Performance.

Your most recent submission
Name results_bw.csv Submitted just now Wait time 0 seconds Execution time 0 seconds Score 0.23930
Complete

Jump to your position on the leaderboard ▾

Table A.8: Backward Selection Model Performance - Kaggle.

### Regression of Sale Price Using Backward Selection Results

The REG Procedure  
Model: MODEL1  
Dependent Variable: SalePrice

Number of Observations Read	2919
Number of Observations Used	1460
Number of Observations with Missing Values	1459

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	7.234662E12	8.038513E11	590.69	<.0001
Error	1450	1.973249E12	1360861622		
Corrected Total	1459	9.207911E12			

Root MSE	36890	R-Square	0.7857
Dependent Mean	180921	Adj R-Sq	0.7844
Coeff Var	20.39001		

Parameter Estimates						
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr >  t	95% Confidence Limits
Intercept	1	114937	5909.53288	19.45	<.0001	103345 126530
BsmtFinSF1	1	36.21019	2.45403	14.76	<.0001	31.39636 41.02402
_1stFlrSF	1	86.75759	3.29659	26.32	<.0001	80.29098 93.22419
_2ndFlrSF	1	59.78139	2.53313	23.60	<.0001	54.81239 64.75039
OQ7	1	-55133	3365.79499	-16.38	<.0001	-61735 -48531
OQ6	1	-85111	3437.23031	-24.76	<.0001	-91853 -78368
OQ5	1	-99775	3584.89690	-27.83	<.0001	-106807 -92743
OQ4	1	-108450	4789.69091	-22.64	<.0001	-117845 -99054
OQ3	1	-121786	8938.50314	-13.62	<.0001	-139320 -104252
RoofMatl_ClyTile	1	-623167	39508	-15.77	<.0001	-700666 -545667

Table A.9: Backward Selection Model 95% Confidence Limits.

The GLMSELECT Procedure															
Stepwise Selection Summary															
Step	Effect Entered	Effect Removed	Number Effects In	Model R-Square	Adjusted R-Square	AIC	AICC	BIC	CP	SBC	PRESS	ASE	CV PRESS	F Value	Pr > F
0	Intercept		1	0.0000	0.0000	32291.6565	32291.6653	30916.9518	26023.1178	30923.8798	8.53501E12	6216310560	8.5396E12	0.00	1.0000
1	GrLivArea		2	0.5038	0.5034	31332.8678	31332.8853	29956.6544	12224.7250	29970.3144	4.27855E12	3084477950	4.27422E12	1390.02	<.0001
2	YearBuilt		3	0.6454	0.6449	30874.1151	30874.1444	29496.4868	8347.2758	29516.7850	3.0718E12	2204083788	3.0765E12	546.43	<.0001
3	BsmtQual_Ex		4	0.7095	0.7089	30602.6871	30602.7310	29223.6955	6593.2177	29250.5803	2.53391E12	1805567590	2.54596E12	301.72	<.0001
4	RoofMatl_ClyTile		5	0.7375	0.7367	30466.0929	30466.1545	29085.6893	5830.2421	29119.2094	2.27335E12	1631965597	2.535E12	145.31	<.0001
5	TotalBsmtSF		6	0.7797	0.7789*	30227.3690*	30227.4512*	28845.9016*	4674.2217*	28885.7088*	1.91652E12*	1369166863	2.37142E12*	262.00	<.0001

\* Optimal Value of Criterion

Table A.10: Stepwise Selection Model Summary.

The GLMSELECT Procedure Selected Model				
The selected model is the model at the last step (Step 5).				
<b>Effects:</b> Intercept YearBuilt TotalBsmtSF GrLivArea RoofMatl_ClyTile BsmtQual_Ex				
<b>Analysis of Variance</b>				
Source	DF	Sum of Squares	Mean Square	F Value
Model	5	6.645434E12	1.329087E12	966.48
Error	1365	1.877128E12	1375185179	
Corrected Total	1370	8.522562E12		
<b>Root MSE</b> 37083 <b>Dependent Mean</b> 185182 <b>R-Square</b> 0.7797 <b>Adj R-Sq</b> 0.7789 <b>AIC</b> 30227 <b>AICC</b> 30227 <b>BIC</b> 28846 <b>C(p)</b> 4674.22175 <b>PRESS</b> 1.916518E12 <b>SBC</b> 28886 <b>ASE</b> 1369166863 <b>CV PRESS</b> 2.371423E12				
<b>Parameter Estimates</b>				
Parameter	DF	Estimate	Standard Error	t Value
Intercept	1	-1271664	73606	-17.28
YearBuilt	1	648.152763	37.758936	17.17
TotalBsmtSF	1	47.048875	2.906695	16.19
GrLivArea	1	80.004257	2.189524	36.54
RoofMatl_ClyTile	1	-671551	39444	-17.03
BsmtQual_Ex	1	62871	4009.622196	15.68

Table A.11: Stepwise Selection Model Performance.

Your most recent submission				
Name results_sw.csv	Submitted just now	Wait time 0 seconds	Execution time 0 seconds	Score 0.20306
Complete				

Jump to your position on the leaderboard ▾

Table A.12: Stepwise Selection Model Performance - Kaggle.

### Regression of Sale Price Using Stepwise Selection Results

The REG Procedure  
Model: MODEL1  
Dependent Variable: SalePrice

Number of Observations Read	2919
Number of Observations Used	1460
Number of Observations with Missing Values	1459

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	7.204143E12	1.440829E12	1045.51	<.0001
Error	1454	2.003768E12	1378107301		
Corrected Total	1459	9.207911E12			

Root MSE	37123	R-Square	0.7824
Dependent Mean	180921	Adj R-Sq	0.7816
Coeff Var	20.51881		

Parameter Estimates						
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr >  t	95% Confidence Limits
Intercept	1	-1314593	69671	-18.87	<.0001	-1451261 -1177926
YearBuilt	1	671.56397	35.78464	18.77	<.0001	601.36894 741.75901
TotalBsmtSF	1	45.58624	2.82417	16.14	<.0001	40.04635 51.12613
GrLivArea	1	78.17387	2.11050	37.04	<.0001	74.03393 82.31382
RoofMatl_ClyTile	1	-659375	39300	-16.78	<.0001	-736466 -582285
BsmtQual_EX	1	65879	3973.03277	16.58	<.0001	58086 73673

Table A.13: Stepwise Selection Model 95% Confidence Limits.

The GLM Procedure		
Class Level Information		
Class	Levels	Values
BsmtQual	5	Ex Fa Gd NA TA
OverallQual	10	1 2 3 4 5 6 7 8 9 10
OverallQual	10	1 2 3 4 5 6 7 8 9 10
OverallCond	9	1 2 3 4 5 6 7 8 9
Neighborhood	25	Birgtn Blueste BrDale BrkSide ClearCr ColigCr Crawfor Edwards Gilbert IDOTRR MeadowV Mitchel NAmes NPkVll NWAmes NoRidge NridgHt OldTown SWISU Sawyer SawyerW Somerst StoneBr Timber Veenker
BldgType	5	1Fam 2fmCon Duplex Twnhs E
SaleCondition	6	Abnrmal AdjLand AllocA Family Normal Partial
HouseStyle	8	1.5Fin 1.5Unf 1Story 2.5Fin 2.5Unf 2Story SFoyer SLvI

Table A.14: Custom Model Summary.

Sum of Residuals	-2.857996E-8
Sum of Squared Residuals	1.3610971E12
Sum of Squared Residuals - Error SS	-0.001220703
PRESS Statistic	1.591527E12
First Order Autocorrelation	0.0370548532
Durbin-Watson D	1.9257432676

Observations	1460
Parameters	63
Error DF	1397
MSE	9.74E8
R-Square	0.8522
Adj R-Square	0.8456

Table A.15: Custom Model Performance.

Your most recent submission						
Name	Submitted	Wait time	Execution time	Score		
results_cust.csv	just now	1 seconds	0 seconds	0.14826		
Complete						
<a href="#">Jump to your position on the leaderboard ▾</a>						

Table A.16: Custom Selection Model Performance - Kaggle.

Parameter	Estimate		Standard Error	t Value	Pr >  t	95% Confidence Limits
Intercept	280051.5334	B	16731.55026	16.74	<.0001	247229.86111 312873.2057
GrLivArea	28.4805		22.27568	1.28	0.2013	-15.2169 72.1779
_1stFlrSF	37.5355		22.48390	1.67	0.0953	-6.5703 81.6414
_2ndFlrSF	38.9688		22.01375	1.77	0.0769	-4.2148 82.1523
Age	-554.6041		79.11740	-7.01	<.0001	-709.8059 -399.4024
Neighborhood Blmgtn	-27921.0696	B	12614.12105	-2.21	0.0270	-52665.7311 -3176.4082
Neighborhood Blueste	-30136.4989	B	24455.60793	-1.23	0.2180	-78110.1736 17837.1757
Neighborhood BrDale	-27897.8279	B	13431.79329	-2.08	0.0380	-54246.4872 -1549.1686
Neighborhood BrkSide	-38284.7780	B	10976.10935	-3.49	0.0005	-59816.2116 -16753.3443
Neighborhood ClearCr	-10017.8246	B	11335.13122	-0.88	0.3770	-32253.5383 12217.8892
Neighborhood CollgCr	-32171.4599	B	10022.62574	-3.21	0.0014	-51832.4795 -12510.4403
Neighborhood Crawfor	-8224.8426	B	10789.78513	-0.76	0.4460	-29390.7708 12941.0856
Neighborhood Edwards	-54540.8116	B	10268.02045	-5.31	<.0001	-74683.2131 -34398.4102
Neighborhood Gilbert	-37181.2191	B	10469.27340	-3.55	0.0004	-57718.4111 -16644.0271
Neighborhood IDOTRR	-47511.5755	B	11523.43169	-4.12	<.0001	-70116.6714 -24906.4796
Neighborhood MeadowV	-42217.2180	B	12999.62383	-3.25	0.0012	-67718.1063 -16716.3298
Neighborhood Mitchel	-37274.1687	B	10638.85321	-3.50	0.0005	-58144.0193 -16404.3182
Neighborhood NAmes	-40699.1158	B	9901.17363	-4.11	<.0001	-60121.8872 -21276.3443
Neighborhood NPkVill	-19221.0611	B	14513.00144	-1.32	0.1856	-47690.6870 9248.5648
Neighborhood NWAmes	-40998.6151	B	10288.77702	-3.98	<.0001	-61181.7340 -20815.4963
Neighborhood NoRidge	19161.1306	B	10983.05174	1.74	0.0813	-2383.9216 40706.1829
Neighborhood NridgHt	6011.2647	B	10491.11626	0.57	0.5667	-14568.7757 26591.3050
Neighborhood OldTown	-51172.5973	B	10674.78366	-4.79	<.0001	-72112.9313 -30232.2633
Neighborhood SWISU	-47071.4102	B	12192.57577	-3.86	0.0001	-70989.1417 -23153.6787
Neighborhood Sawyer	-43902.9445	B	10376.43305	-4.23	<.0001	-64258.0150 -23547.8740
Neighborhood SawyerW	-32493.5672	B	10473.18608	-3.10	0.0020	-53038.4346 -11948.6998
Neighborhood Somerst	-19868.6343	B	10384.72232	-1.91	0.0559	-40239.9656 502.6969
Neighborhood StoneBr	20168.8349	B	11608.63619	1.74	0.0825	-2603.4036 42941.0734
Neighborhood Timber	-19026.7762	B	10867.50062	-1.75	0.0802	-40345.1560 2291.6037
Neighborhood Veenker	0.0000	B	.	.	.	.
BldgType 1Fam	22937.9043	B	4097.83269	5.60	<.0001	14899.3353 30976.4733
BldgType 2fmCon	20754.2946	B	7308.48497	2.84	0.0046	6417.5060 35091.0832
Blotter_District	2260.0550	B	6161.65000	0.36	0.7450	15000.5547 40248.0000

Table A.17: Custom Model 95% Confidence Limits.

## B. LIST OF FIGURES

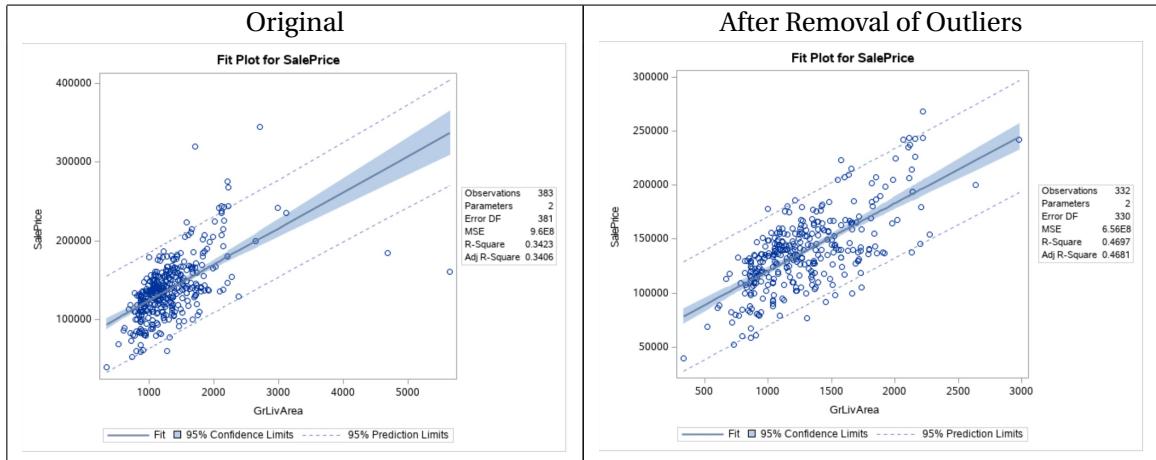


Figure B.1: Simple Linear Regression Models.

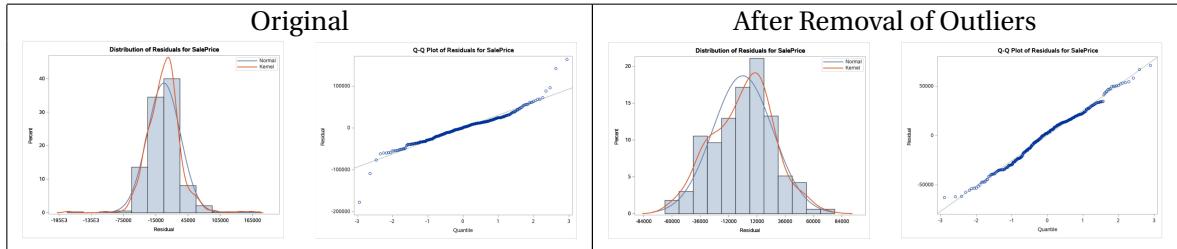


Figure B.2: Normality Plots.

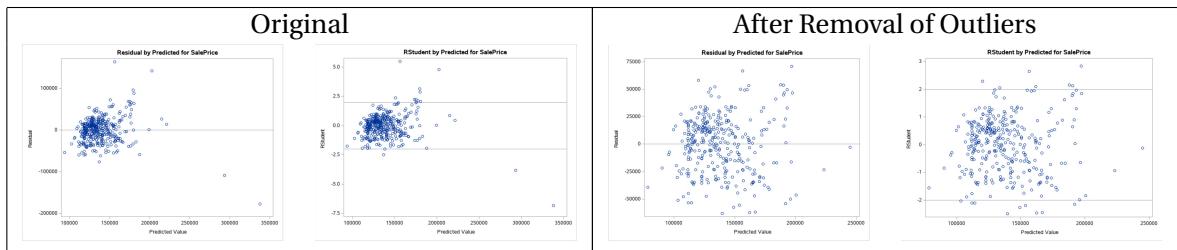


Figure B.3: Residual Plots.

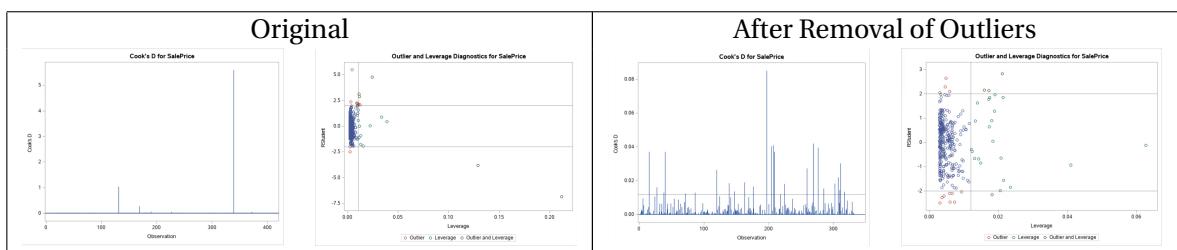


Figure B.4: Influential Point Plots.

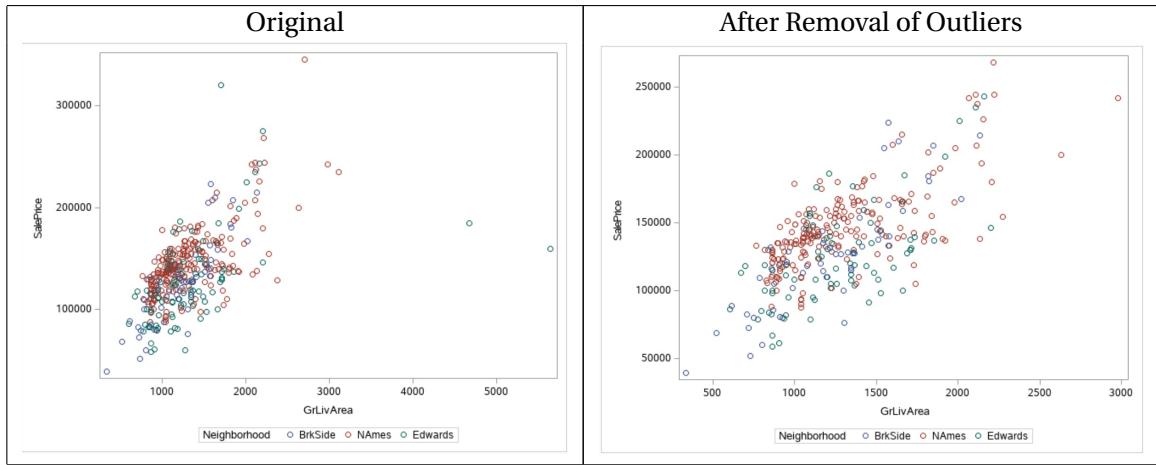


Figure B.5: Scatterplot of Sale Prices vs Living Area by Neighborhood.

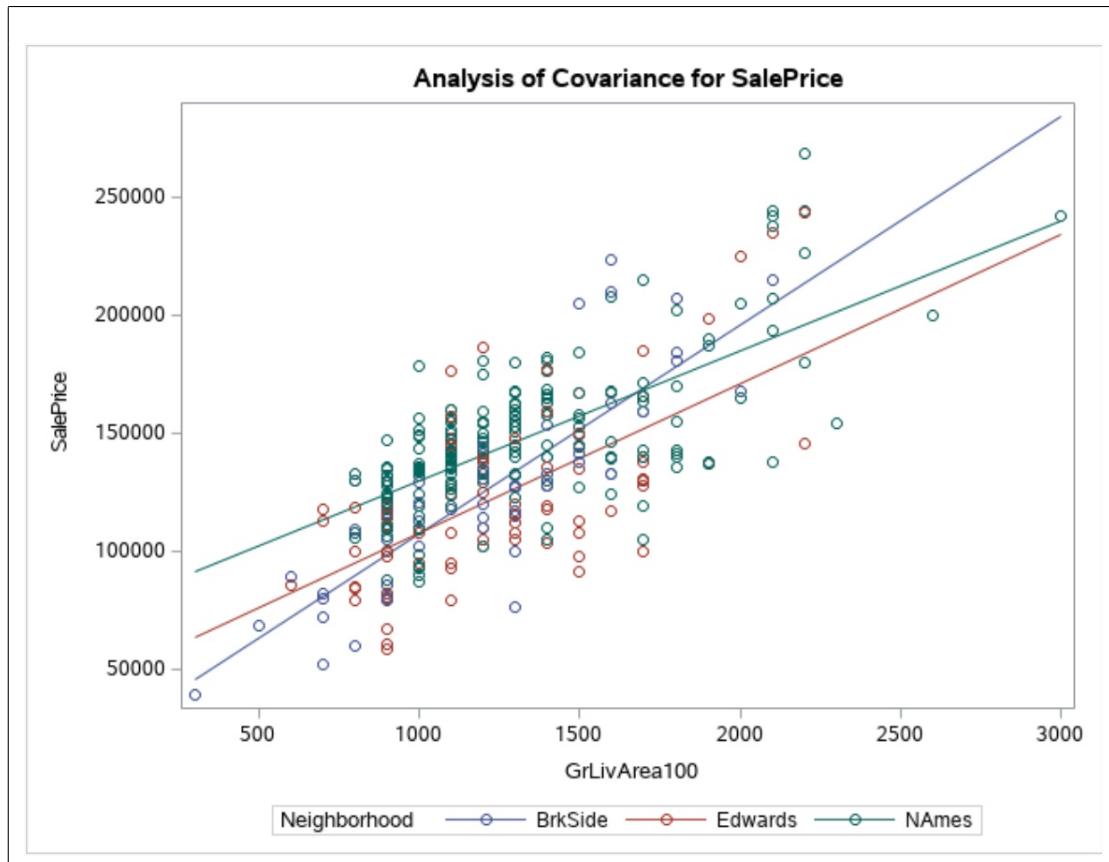


Figure B.6: Linear Regression Model by Neighborhood.

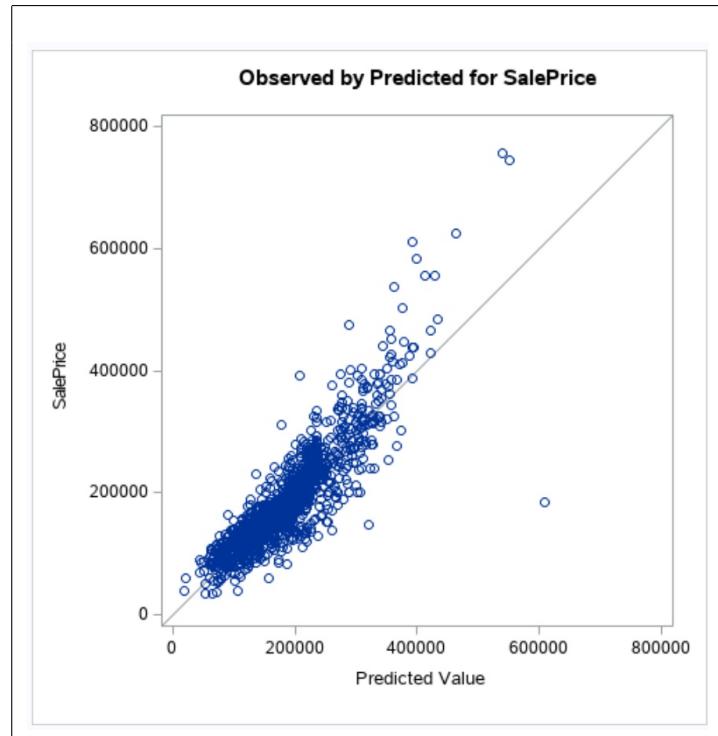


Figure B.7: Scatter Plot Forward Selection Model.

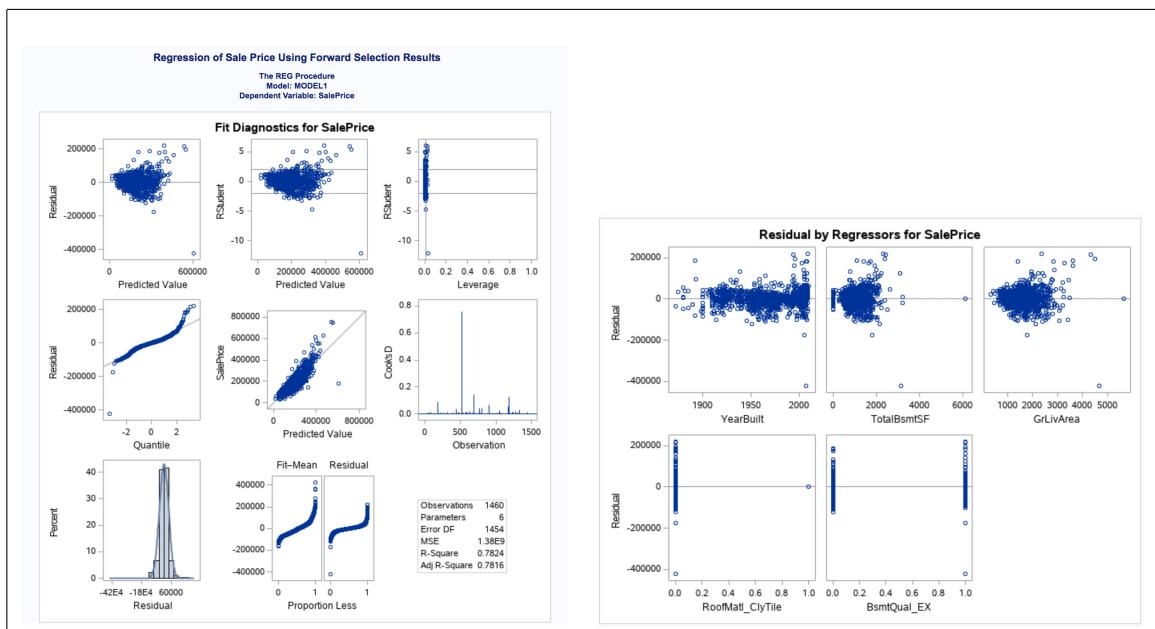


Figure B.8: Plots for Forward Selection Model.

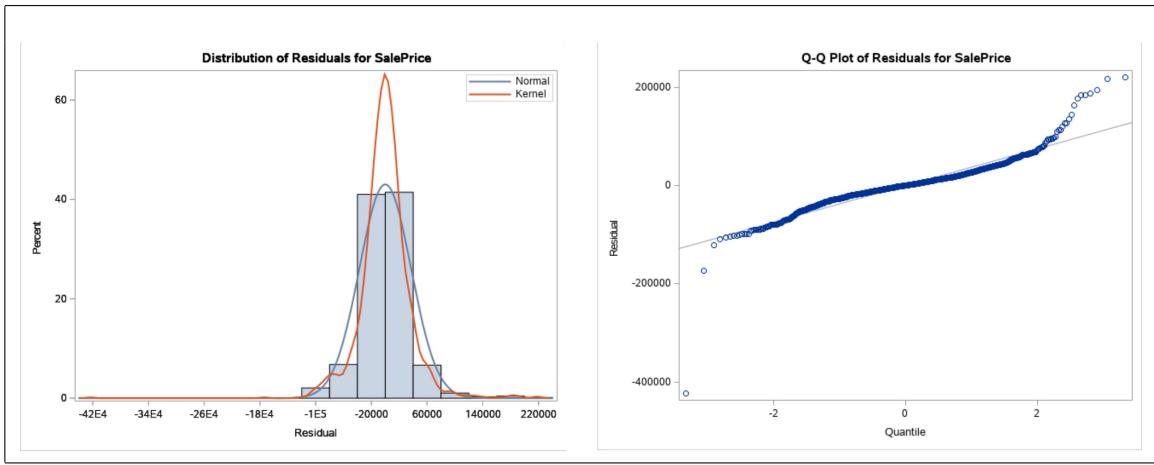


Figure B.9: Normality Plots for Forward Selection Model.

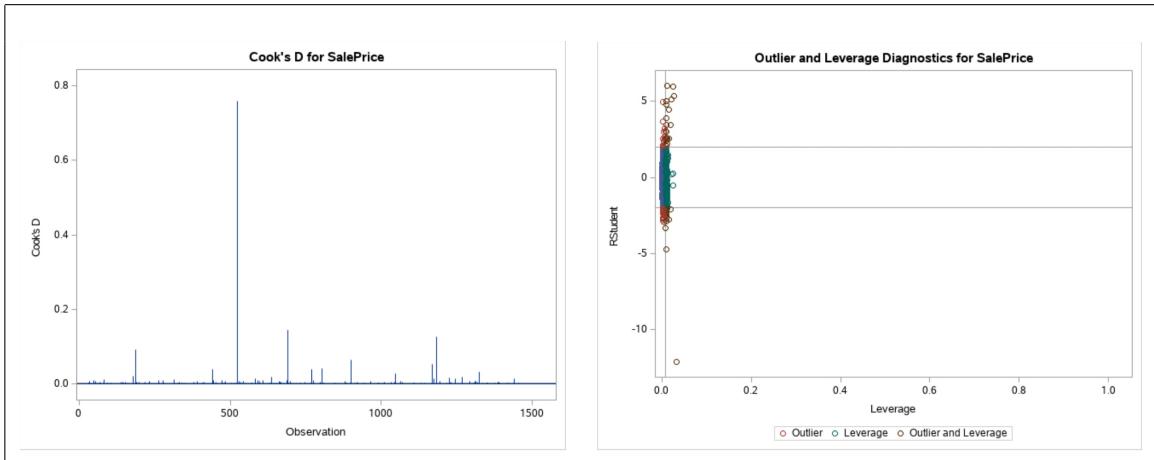


Figure B.10: Influential Point Plots for Forward Selection Model.

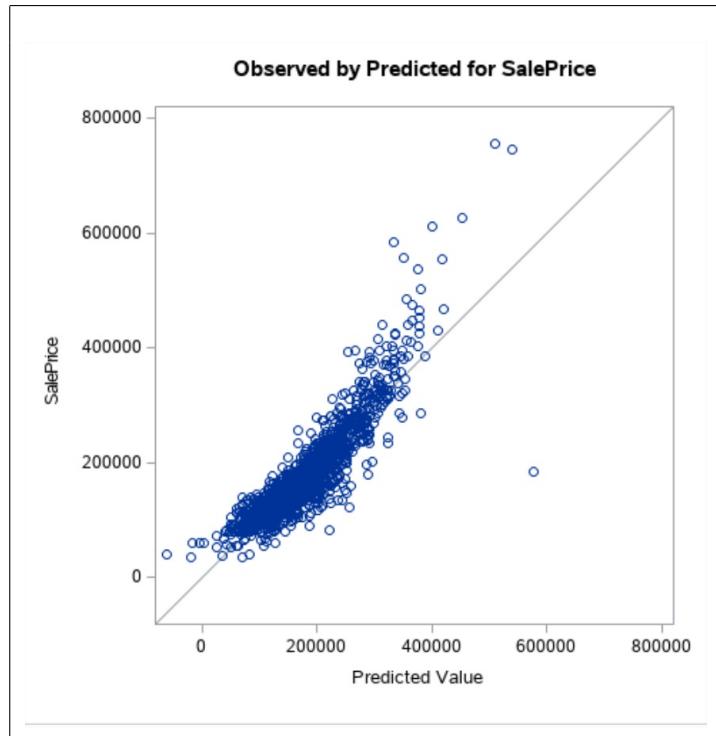


Figure B.11: Scatter Plot Backward Selection Model.

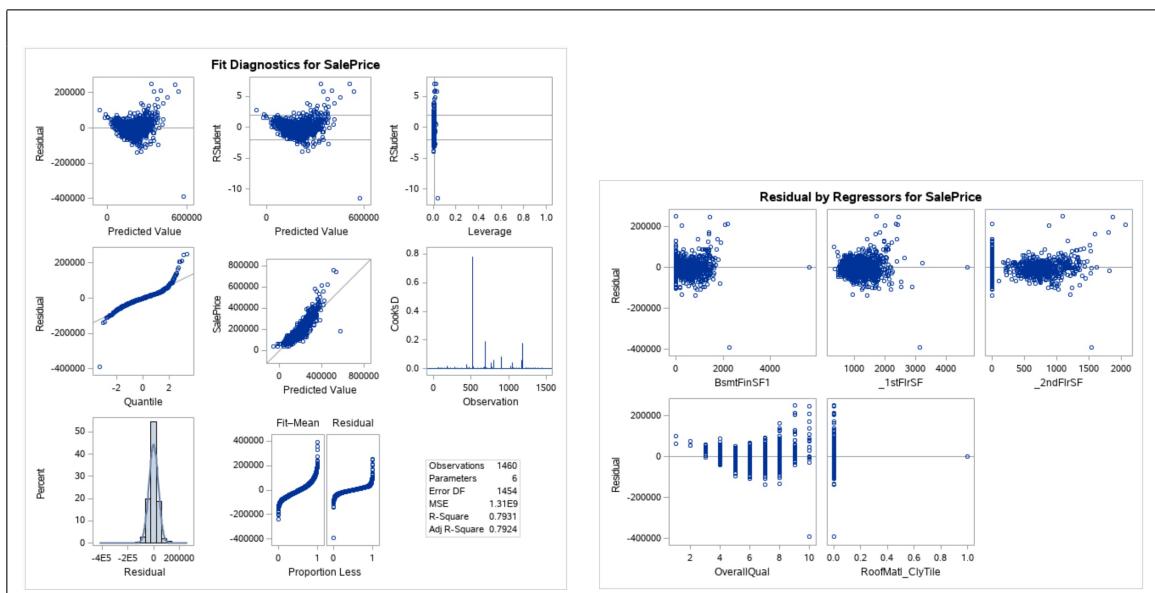


Figure B.12: Plots for Backward Selection Model.

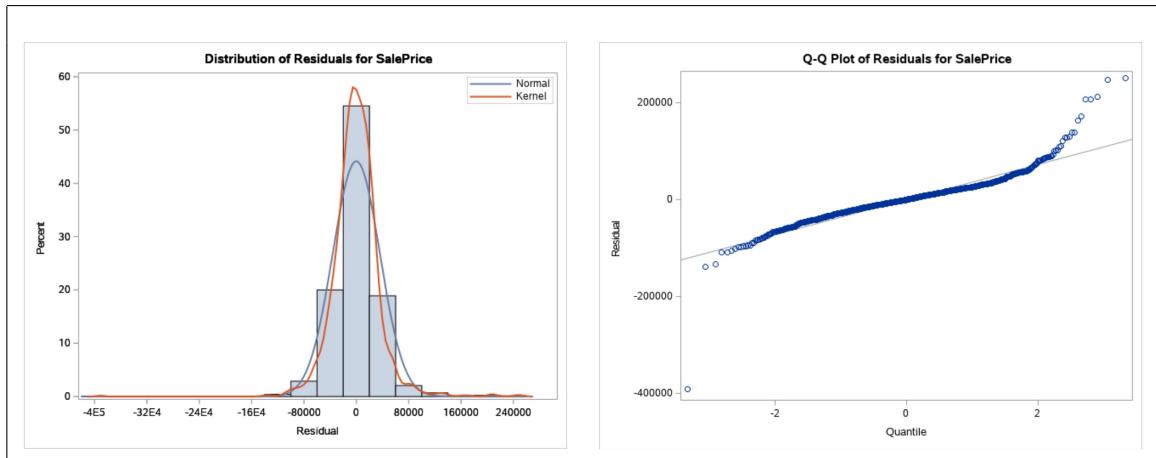


Figure B.13: Normality Plots for Backward Selection Model.

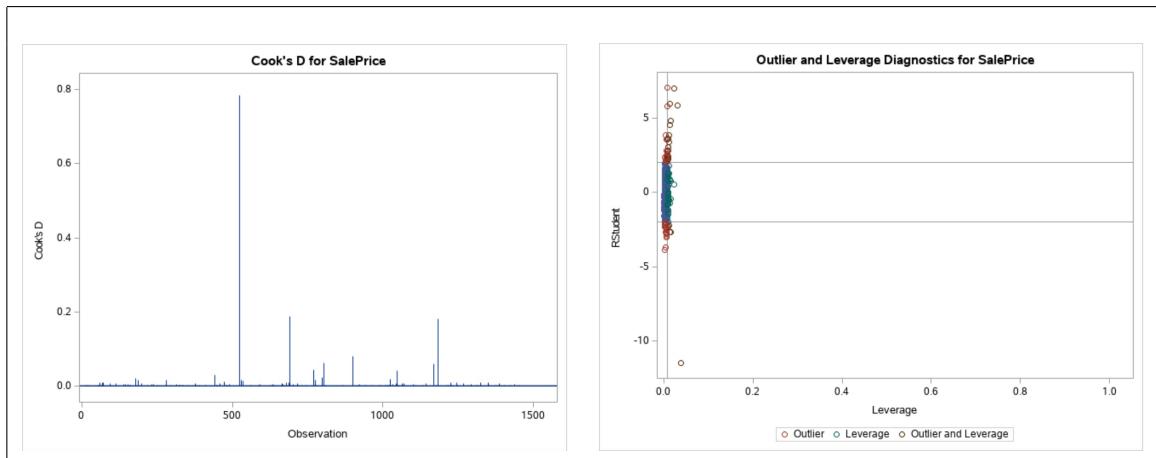


Figure B.14: Influential Point Plots for Backward Selection Model.

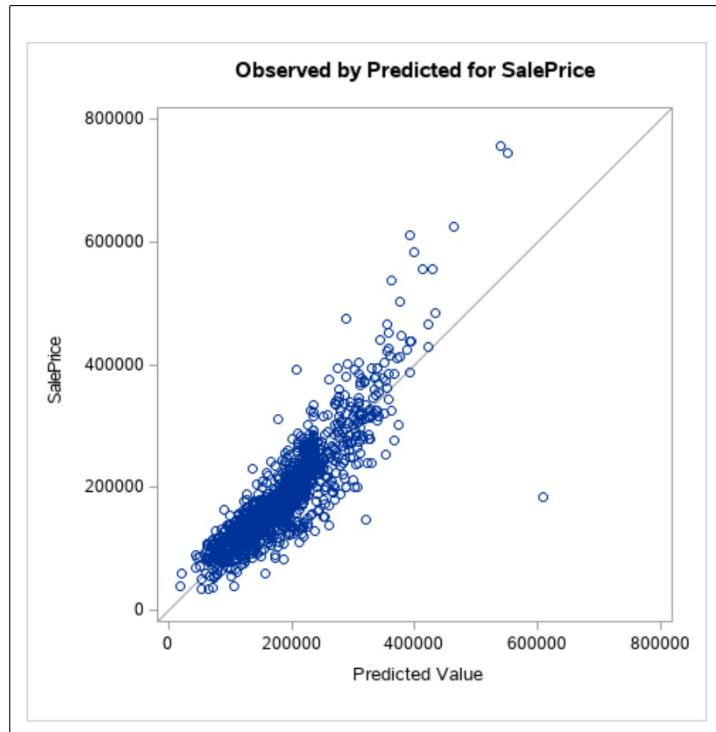


Figure B.15: Scatter Plot Stepwise Selection Model.

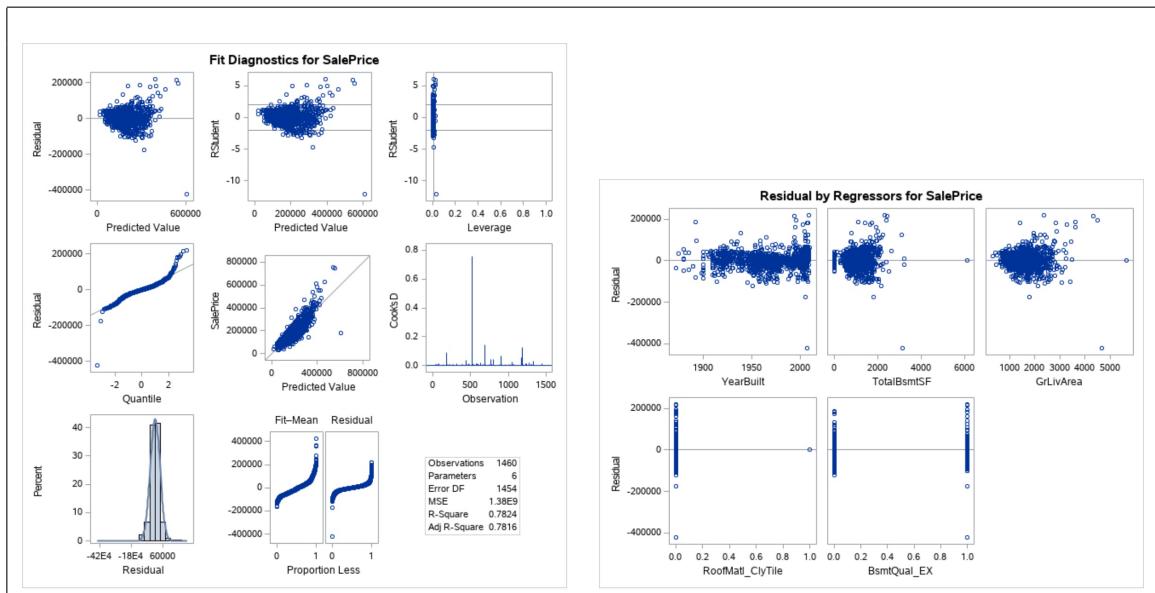


Figure B.16: Plots for Stepwise Selection Model.

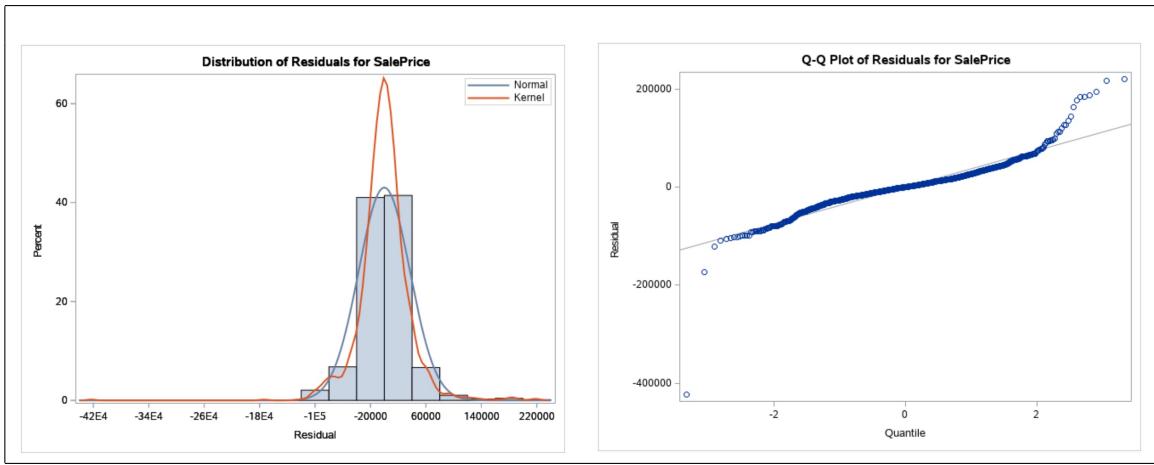


Figure B.17: Normality Plots for Stepwise Selection Model.

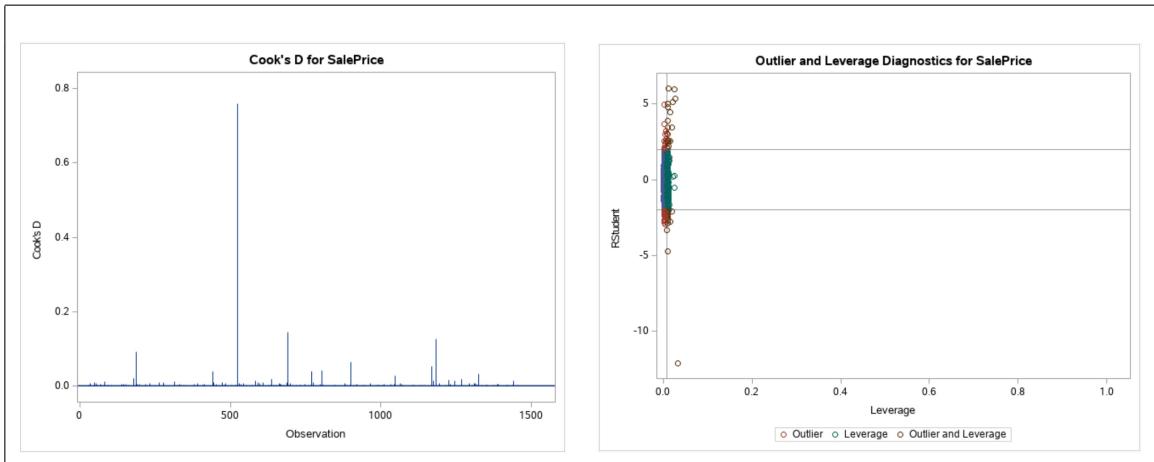


Figure B.18: Influential Point Plots for Stepwise Selection Model.

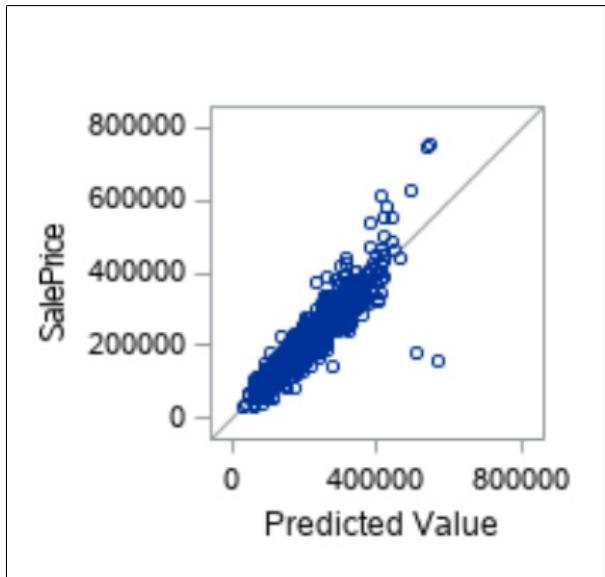


Figure B.19: Scatter Plot Custom Model.

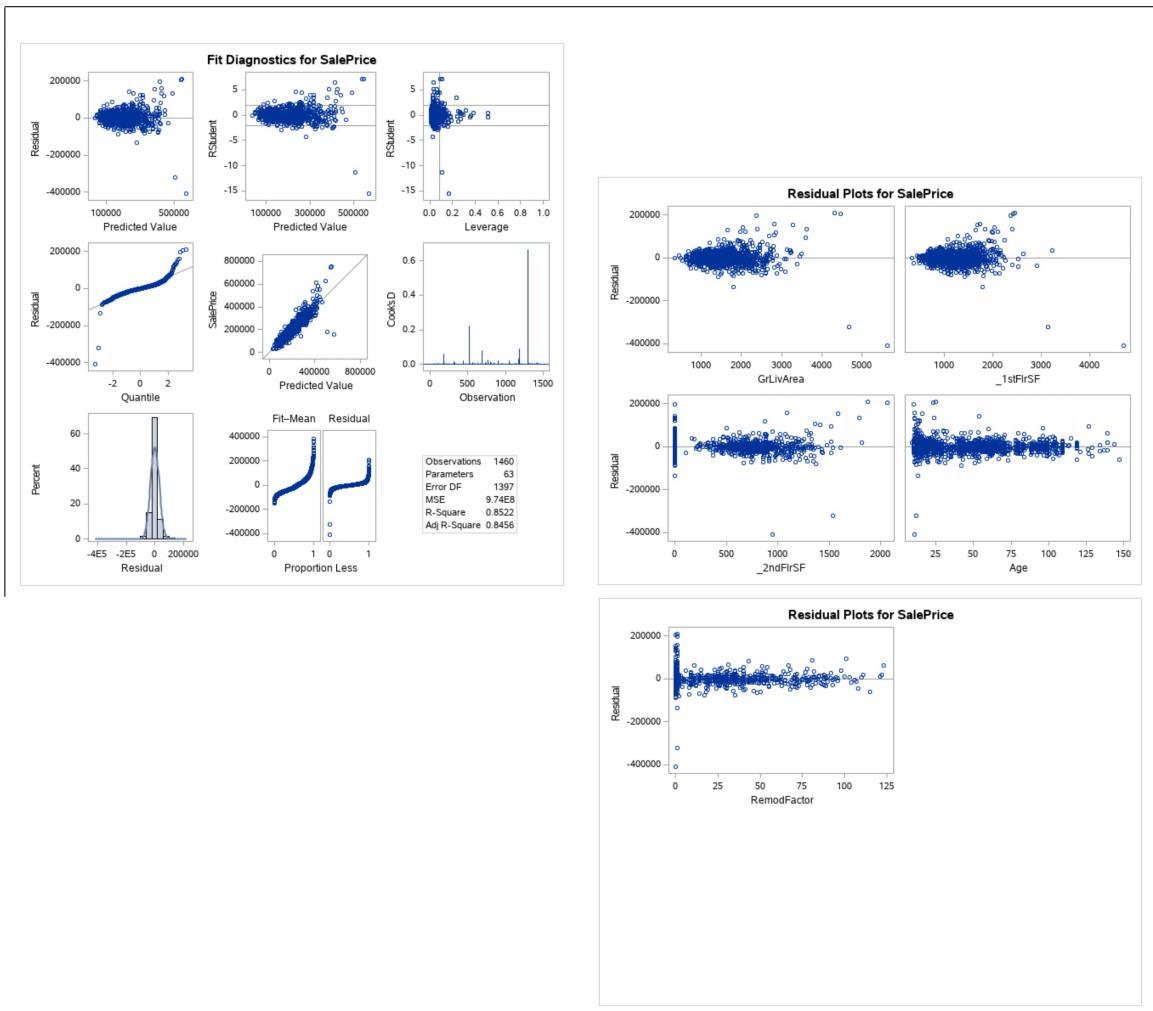


Figure B.20: Plots for Custom Selection Model.

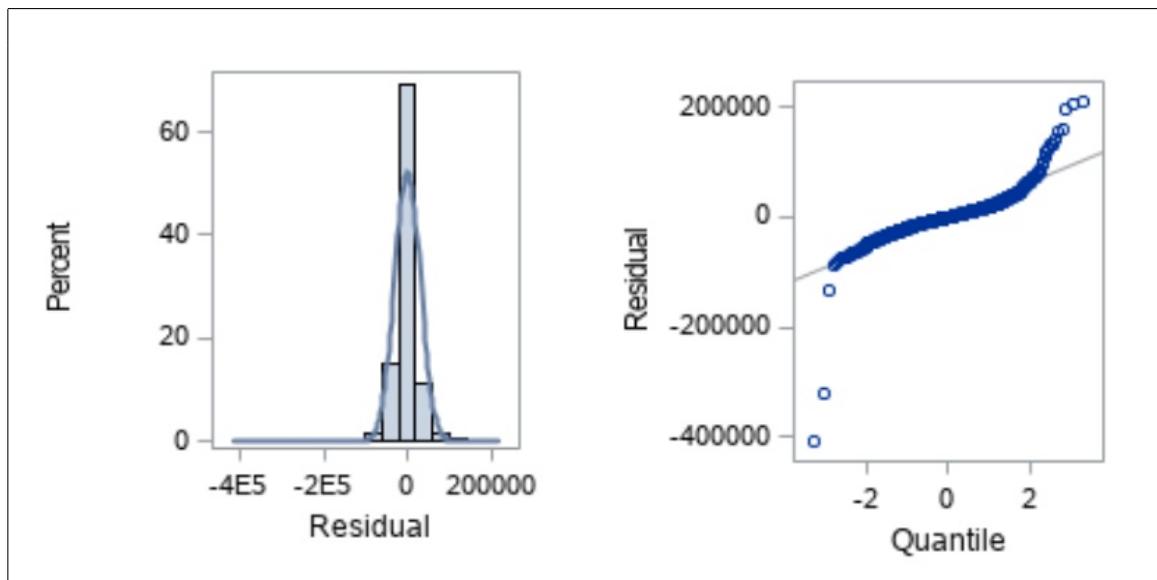


Figure B.21: Normality Plots for Custom Selection Model.

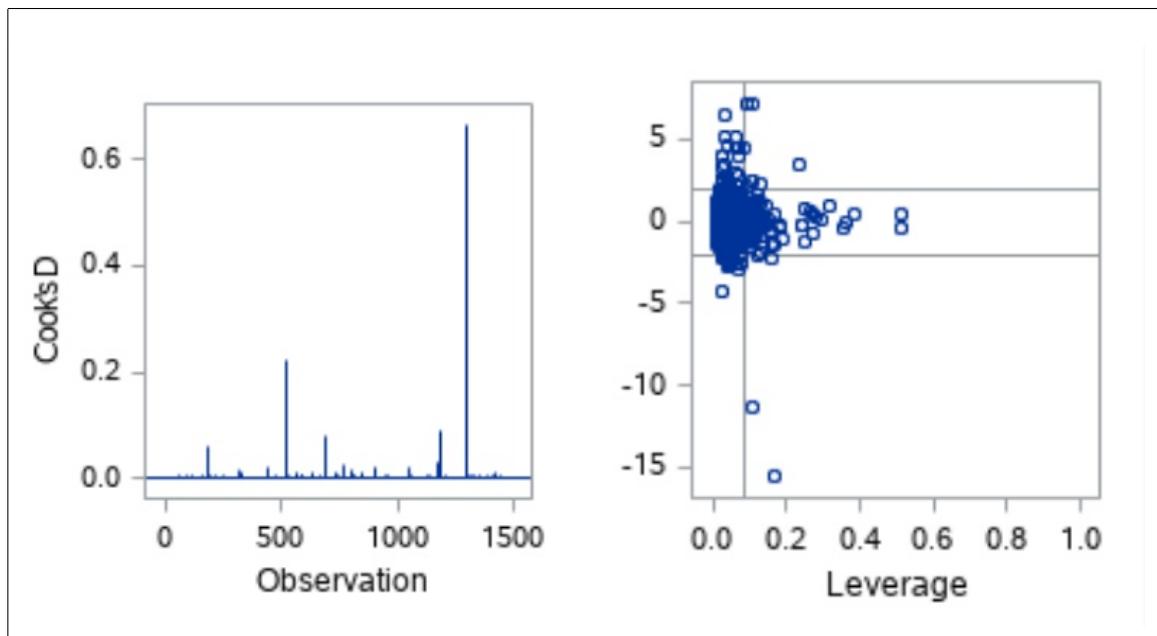


Figure B.22: Influential Point Plots for Custom Selection Model.

## C. SOURCE CODE FOR ANALYSIS 1

Listing 1: Analysis 1 SAS Code.

```
1 *-----*  
2 | Import train.csv |  
3 | Set REFFILE for train.csv |  
4 *-----*;  
5  
6 * FILENAME REFFILE '/home/mwolfe0/train.csv';  
7 FILENAME REFFILE  
8 '/folders/myfolders/MSDS6371/GroupProject/Datasets/train.csv';  
9  
10 PROC IMPORT DATAFILE=REFFILE DBMS=CSV REPLACE OUT=TRAIN;  
11 GETNAMES=YES;  
12 RUN;  
13  
14 *-----*  
15 | Subset the data to only include homes sold in the |  
16 | neighborhoods of interest - NAmes, BrkSide, and Edwards |  
17 | Round the gross living area to the nearest 100 SF |  
18 | Keep only the variables of Neighborhood, GrLivArea, |  
19 | and SalePrice in the dataset |  
20 *-----*;  
21  
22 DATA HOMES1;  
23 SET TRAIN (KEEP=Neighborhood GrLivArea SalePrice);  
24 IF Neighborhood EQ "NAmes" |  
25 Neighborhood EQ "BrkSide" |  
26 Neighborhood EQ "Edwards";  
27 GrLivArea100 = ROUND(GrLivArea, 100); /*FLOOR(GrLivArea);*/  
28 RUN;  
29  
30 *-----*  
31 | Descriptive statistics on the HOMES1 dataset for |  
32 | GrLivArea and SalePrice |  
33 *-----*;  
34  
35 PROC UNIVARIATE DATA=HOMES1;  
36 CLASS Neighborhood;  
37 VAR GrLivArea SalePrice;  
38 RUN;  
39  
40 *-----*  
41 | Scatter plot of sale prices in the three neighborhoods |  
42 | vs Gross Living Area |  
43 *-----*;  
44  
45 PROC SGPLOT DATA=HOMES1;  
46 SCATTER X=GrLivArea Y=SalePrice /GROUP=Neighborhood;  
47 RUN;
```

```

48 |
49 *-----*
50 | Regression model of homes in the three neighborhoods |
51 | combined for Sale Price based on Gross Living Area |
52 | to check assumptions on the data in these three |
53 | neighborhoods |
54 *-----*;
55
56 PROC REG DATA=HOMES1 PLOTS=ALL;
57     MODEL SalePrice=GrLivArea / CLB;
58     RUN;
59
60 *-----*
61 | Regression model of homes in the three neighborhoods |
62 | using an equal slope model |
63 *-----*;
64
65 PROC GLM DATA=HOMES1;
66     CLASS Neighborhood;
67     MODEL SalePrice=GrLivArea Neighborhood / CLPARM;
68     RUN;
69
70 *-----*
71 | Regression model of homes in the three neighborhoods |
72 | using an equal intercept model (slopes differ) |
73 *-----*;
74
75 PROC GLM DATA=HOMES1;
76     CLASS Neighborhood;
77     MODEL SalePrice=GrLivArea*Neighborhood / CLPARM;
78     RUN;
79
80 *-----*
81 | Regression model of homes in the three neighborhoods |
82 | using a model that allows slopes and intercepts to |
83 | vary |
84 *-----*;
85
86 PROC GLM DATA=HOMES1;
87     CLASS Neighborhood;
88     MODEL SalePrice=Neighborhood GrLivArea*Neighborhood / CLPARM;
89     RUN;
90
91 *-----*
92 | Remove Outliers: |
93 | SaleCondition is not normal (confounding effect on |
94 | prices) |
95 | SalePrice is greater than 300,000 since they are not |
96 | representative of the overall population in these |
97 | three neighborhoods. |

```

```

98 | Keep only the variables of Neighboorhood, GrLivArea,      |
99 | and SalePrice in the dataset                                |
100 *-----*;                                                 |
101
102 DATA HOMES2;
103 SET TRAIN (KEEP=Neighborhood GrLivArea SalePrice SaleCondition);
104 IF Neighborhood EQ "NAmes" |
105   Neighborhood EQ "BrkSide" |
106   Neighborhood EQ "Edwards";
107 IF SalePrice LT 300000;
108 IF SaleCondition EQ "Normal";
109 GrLivArea100 = ROUND(GrLivArea, 100);
110 RUN;
111
112 *-----*;
113 | Descriptive statistics on the HOMES1 dataset for      |
114 | GrLivArea and SalePrice                                |
115 *-----*;                                                 |
116
117 PROC UNIVARIATE DATA=HOMES2;
118   CLASS Neighborhood;
119   VAR GrLivArea SalePrice;
120 RUN;
121
122 *-----*;
123 | Scatter plot of sale prices in the three neighborhoods |
124 | vs Gross Living Area                                    |
125 *-----*;                                                 |
126
127 PROC SGPLOT DATA=HOMES2;
128   SCATTER X=GrLivArea Y=SalePrice;
129   REG X=GrLivArea Y=SalePrice;
130 RUN;
131
132 PROC SGPLOT DATA=HOMES2;
133   SCATTER X=GrLivArea Y=SalePrice / GROUP=Neighborhood;
134 RUN;
135
136 *-----*;
137 | Regression model of homes in the three neighborhoods  |
138 | using a model that allows slopes and intercepts to  |
139 | vary                                                 |
140 | Output 95% confidence limit for parameter estimates |
141 *-----*;                                                 |
142
143 PROC REG DATA=HOMES2 PLOTS=ALL;
144   MODEL SalePrice=GrLivArea / CLB;
145   RUN;
146
147 *-----*;

```

```

148 | Regression model of homes in the three neighborhoods |
149 | using an equal slope model |
150 *-----*;
151
152 PROC GLM DATA=HOMES2;
153   CLASS Neighborhood;
154   MODEL SalePrice=GrLivArea Neighborhood / CLPARM;
155   RUN;
156
157 *-----*
158 | Regression model of homes in the three neighborhoods |
159 | using an equal intercept model (slopes differ) |
160 *-----*;
161
162 PROC GLM DATA=HOMES2;
163   CLASS Neighborhood;
164   MODEL SalePrice=GrLivArea*Neighborhood / CLPARM;
165   RUN;
166
167 *-----*
168 | Regression model of homes in the three neighborhoods |
169 | using a model that allows slopes and intercepts to |
170 | vary |
171 *-----*;
172
173 PROC GLM DATA=HOMES2;
174   CLASS Neighborhood;
175   MODEL SalePrice=Neighborhood GrLivArea*Neighborhood / CLPARM;
176   RUN;
177
178
179 *-----*
180 | Alternate Method with interaction terms |
181 |
182 | Keep only the variables of Neighboorhood, GrLivArea , |
183 | and SalePrice in the dataset |
184 | d1 = NAmes, d2 = BrkSide , Control = Edwards |
185 *-----*;
186
187 DATA HOMES3;
188 SET TRAIN (KEEP=Neighborhood GrLivArea SalePrice SaleCondition);
189 IF Neighborhood EQ "NAmes" |
190   Neighborhood EQ "BrkSide" |
191   Neighborhood EQ "Edwards";
192 IF SalePrice LT 300000;
193 IF SaleCondition EQ "Normal";
194 GrLivArea100 = ROUND(GrLivArea, 100);
195 IF Neighborhood = 'NAmes' THEN d1 = 1; ELSE d1=0;
196 IF Neighborhood = 'BrkSide' THEN d2 = 1; ELSE d2=0;
197           int1 = d1*GrLivArea100; int2 = d2*GrLivArea100;

```

```

198 RUN;
199
200 *-----*
201 | Plots to check assumptions |
202 | d1 = NAmes, d2 = BrkSide , Control = Edwards |
203 *-----*;
204
205 PROC SGPLOT DATA=HOMES3;
206 HISTOGRAM GrLivArea100 ;
207 DENSITY GrLivArea100/TYPE=NORMAL;
208 TITLE "Histogram of Gross Living Area in NAmes, BrkSide , and Edwards";
209 RUN;
210
211 PROC SGPLOT DATA=HOMES3;
212 SCATTER X=GrLivArea100 Y=SalePrice ;
213 TITLE "Gross Living Area vs Sale Price in NAmes, BrkSide , and Edwards";
214 RUN;
215
216 PROC REG DATA=HOMES3 PLOT=ALL;
217 model SalePrice = GrLivArea100/CLB;
218 RUN;
219
220 *-----*
221 | Run regression model with interaction terms using dummy|
222 | variables |
223 | d1 = NAmes, d2 = BrkSide , Control = Edwards |
224 | Output 95% confidence limit for parameter estimates |
225 *-----*;
226 PROC REG DATA=HOMES3;
227     model SalePrice = GrLivArea100 d1 d2 int1 int2/VIF CLB;
228     title
229         'Regression of Sale Price on Gross Living Area
230             with Interaction Terms';
231     RUN;
232
233 *-----*
234 | center the interaction terms based on the means of |
235 | GrLivArea100 and d1 and d2 to correct for the |
236 | inflated VIF |
237 *-----*;
238
239 PROC MEANS DATA=HOMES3;
240 var GrLivArea100 d1 d2;
241 run;
242
243 DATA center;
244 set HOMES3;
245 cent1 = (GrLivArea100 - 1280.72)*(d1-0.593);
246 cent2 = (GrLivArea100 - 1280.72)*(d2-0.164);
247 RUN;

```

```
248 PROC REG DATA=center PLOTS=ALL;
249 model SalePrice = GrLivArea100 d1 d2 cent1 cent2/VIF CLB;
250 title
251      'Regression of Sale Price on Gross Living Area
252      with Interaction Terms';
253
254 RUN;
255
256 PROC GLM DATA=HOMES3 PLOT=ALL;
257 CLASS Neighborhood;
258 model SalePrice=GrLivArea100|Neighborhood/solution CLPARM;
259 RUN;
260
261 PROC GLMSELECT DATA=HOMES3;
262 CLASS Neighborhood;
263 MODEL SalePrice = GrLivArea Neighborhood
264 / cvmethod=random(5) stats=all;
265 RUN;
```

## D. SOURCE CODE FOR ANALYSIS 2

### D.1. Forward Selection

Listing 2: Forward Selection SAS Code.

```
1 *-----*  
2 | Import train.csv |  
3 | Import test.csv |  
4 | Set REFFILE for train.csv |  
5 | Set REFFILE2 for test.csv |  
6 *-----*;  
7  
8 *FILENAME REFFILE '/home/mwolfe0/train.csv';  
9 *FILENAME REFFILE2 '/home/mwolfe0/test.csv';  
10 FILENAME REFFILE  
11 '/folders/myfolders/MSDS6371/GroupProject/Datasets/train.csv';  
12 FILENAME REFFILE2  
13 '/folders/myfolders/MSDS6371/GroupProject/Datasets/test.csv';  
14  
15 PROC IMPORT DATAFILE=REFFILE DBMS=CSV REPLACE OUT=TRAIN;  
16     GETNAMES=YES;  
17 RUN;  
18  
19 PROC IMPORT DATAFILE=REFFILE2 DBMS=CSV REPLACE OUT=TEST;  
20     GETNAMES=YES;  
21 RUN;  
22  
23 *-----*  
24 | Combine train and test into one datafile HOMES |  
25 *-----*;  
26  
27 DATA HOMES;  
28     SET TRAIN TEST;  
29     IF LotFrontage EQ "NA" THEN LotFrontage = 0;  
30     LotFront = input(LotFrontage, 8.);  
31     drop LotFrontage;  
32     RENAME LotFront=LotFrontage;  
33 RUN;  
34  
35 *-----*  
36 | Code for forward selection |  
37 | Set seed to a constant for model comparison |  
38 | Class variable input with split option to allow |  
39 |     classification variable to be able to enter or |  
40 |     leave the model independently |  
41 | Stop=CV specifies the model will stop when the |  
42 |     predicted residual sum of square is reached with |  
43 |     k-fold cross validation |  
44 | CVMethod specifies how subsets are formed for |  
45 |     cross validation |
```

```

46 | OUTPUT Dataset to RESULTS with the predicted variable |  

47 | based on the final model |  

48 *-----*;  

49  

50 PROC GLMSELECT DATA=HOMES SEED=71669132;  

51 CLASS MSSubClass MSZoning Street Alley LotShape LandContour  

52 Utilities LotConfig LandSlope Neighborhood Condition1  

53 Condition2 BldgType HouseStyle OverallQual OverallCond  

54 RoofMatl Exterior1st Exterior2nd MasVnrArea ExterQual  

55 ExterCond Foundation BsmtQual BsmtExposure BsmtFinType1  

56 BsmtFinType2 Heating HeatingQC CentralAir Electrical  

57 KitchenQual Functional FireplaceQu GarageType  

58 GarageFinish GarageQual GarageCond PavedDrive PoolQC  

59 Fence MiscFeature SaleType SaleCondition RoofStyle  

60 BsmtCond MasVnrType  

61 / split;  

62 MODEL SalePrice= LotArea YearBuilt YearRemodAdd BsmtFinSF1  

63 BsmtFinSF2 BsmtUnfSF TotalBsmtSF _1stFlrSF _2ndFlrSF  

64 LowQualFinSF GrLivArea BsmtFullBath BsmtHalfBath  

65 FullBath HalfBath BedroomAbvGr KitchenAbvGr  

66 TotRmsAbvGrd Fireplaces GarageYrBlt GarageCars  

67 GarageArea WoodDeckSF OpenPorchSF EnclosedPorch  

68 _3SsnPorch ScreenPorch PoolArea MiscVal MoSold YrSold  

69 MSSubClass MSZoning Street Alley LotShape LandContour  

70 Utilities LotConfig LandSlope Neighborhood Condition1  

71 Condition2 BldgType HouseStyle OverallQual OverallCond  

72 RoofMatl Exterior1st Exterior2nd MasVnrArea ExterQual  

73 ExterCond Foundation BsmtQual BsmtExposure BsmtFinType1  

74 BsmtFinType2 Heating HeatingQC CentralAir Electrical  

75 KitchenQual Functional FireplaceQu GarageType  

76 GarageFinish GarageQual GarageCond PavedDrive PoolQC  

77 Fence MiscFeature SaleType SaleCondition LotFrontage  

78 RoofStyle BsmtCond MasVnrType  

79 / selection =forward(stop=CV) cvmethod=random(5) stats=all;  

80 OUTPUT OUT=RESULTS P=PREDICT;  

81 RUN;  

82  

83 *-----*  

84 | Create a datafile RESULTS_FW of predicted values for |  

85 | SalePrice for house id greater than 1460 which |  

86 | is where the Kaggle test set data begins. |  

87 *-----*;  

88  

89 DATA RESULTS_FW;  

90 SET RESULTS;  

91  

92 IF PREDICT > 0 THEN  

93 SalePrice=Predict;  

94  

95 IF PREDICT < 0 THEN

```

## D.2. Backward Selection

**Listing 3:** Backward Selection SAS Code.

```
1 *-----*  
2 | Import train.csv |
```

```

3 | Import test.csv
4 | Set REFFILE for train.csv
5 | Set REFFILE2 for test.csv
6 *-----*;
7
8 *FILENAME REFFILE '/home/mwolfe0/train.csv';
9 *FILENAME REFFILE2 '/home/mwolfe0/test.csv';
10 FILENAME REFFILE
11 '/folders/myfolders/MSDS6371/GroupProject/Datasets/train.csv';
12 FILENAME REFFILE2
13 '/folders/myfolders/MSDS6371/GroupProject/Datasets/test.csv';
14
15 PROC IMPORT DATAFILE=REFFILE DBMS=CSV REPLACE OUT=TRAIN;
16   GETNAMES=YES;
17 RUN;
18
19 PROC IMPORT DATAFILE=REFFILE2 DBMS=CSV REPLACE OUT=TEST;
20   GETNAMES=YES;
21 RUN;
22
23 *-----*;
24 | Combine train and test into one datafile HOMES |;
25 *-----*;
26
27 DATA HOMES;
28   SET TRAIN TEST;
29   IF LotFrontage EQ "NA" THEN LotFrontage = 0;
30   LotFront = input(LotFrontage, 8.);
31   drop LotFrontage;
32   RENAME LotFront=LotFrontage;
33 RUN;
34
35 *-----*;
36 | Code for backward selection |
37 | Set seed to a constant for model comparison |
38 | Class variable input with split option to allow |
39 |   classification variable to be able to enter or |
40 |   leave the model independently |
41 | Stop=10 specifies the model will stop selection at the |
42 |   first step for which the selected model has 10 |
43 |   effects |
44 | CVMethod specifies how subsets are formed for |
45 |   cross validation |
46 | OUTPUT Dataset to RESULTS with the predicted variable |
47 |   based on the final model |
48 *-----*;
49
50 PROC GLMSELECT DATA=HOMES SEED=71669132;
51   CLASS MSSubClass MSZoning Street Alley LotShape LandContour
52     Utilities LotConfig LandSlope Neighborhood Condition1

```

```

53 Condition2 BldgType HouseStyle OverallQual OverallCond
54 RoofMatl Exterior1st Exterior2nd MasVnrArea ExterQual
55 ExterCond Foundation BsmtQual BsmtExposure BsmtFinType1
56 BsmtFinType2 Heating HeatingQC CentralAir Electrical
57 KitchenQual Functional FireplaceQu GarageType
58 GarageFinish GarageQual GarageCond PavedDrive PoolQC
59 Fence MiscFeature SaleType SaleCondition RoofStyle
60 BsmtCond MasVnrType
61 / split;
62 MODEL SalePrice= LotArea YearBuilt YearRemodAdd BsmtFinSF1
63 BsmtFinSF2 BsmtUnfSF TotalBsmtSF _1stFlrSF _2ndFlrSF
64 LowQualFinSF GrLivArea BsmtFullBath BsmtHalfBath
65 FullBath HalfBath BedroomAbvGr KitchenAbvGr
66 TotRmsAbvGrd Fireplaces GarageYrBlt GarageCars
67 GarageArea WoodDeckSF OpenPorchSF EnclosedPorch
68 _3SsnPorch ScreenPorch PoolArea MiscVal MoSold YrSold
69 MSSubClass MSZoning Street Alley LotShape LandContour
70 Utilities LotConfig LandSlope Neighborhood Condition1
71 Condition2 BldgType HouseStyle OverallQual OverallCond
72 RoofMatl Exterior1st Exterior2nd MasVnrArea ExterQual
73 ExterCond Foundation BsmtQual BsmtExposure BsmtFinType1
74 BsmtFinType2 Heating HeatingQC CentralAir Electrical
75 KitchenQual Functional FireplaceQu GarageType
76 GarageFinish GarageQual GarageCond PavedDrive PoolQC
77 Fence MiscFeature SaleType SaleCondition LotFrontage
78 RoofStyle BsmtCond MasVnrType
79 / selection =backward(stop=10) cvmethod=random(5)
80 stats=ADJRSQ stats=PRESS;
81 OUTPUT OUT=RESULTS P=PREDICT;
82 RUN;
83
84 *-----*
85 | Create a datafile RESULTS_BW of predicted values for |
86 | SalePrice for house id greater than 1460 which |
87 | is where the Kaggle test set data begins. |
88 *-----*;
89
90 DATA RESULTS_BW;
91   SET RESULTS;
92
93   IF PREDICT > 0 THEN
94     SalePrice=Predict;
95
96   IF PREDICT < 0 THEN
97     SalePrice=10000;
98   KEEP id SalePrice;
99   WHERE id > 1460;
100 RUN;
101
102 *-----*

```

```

103 | Export a datafile for predicted values for           |
104 | SalePrice for house id greater than 1460 which    |
105 | is where the Kaggle test set data begins.          |
106 *-----*;
107
108 *FILENAME REFFILE3 '/home/mwolfe0/results_bw.csv';
109 FILENAME REFFILE3
110 '/folders/myfolders/MSDS6371/GroupProject/Datasets/results_bw.csv';
111
112 PROC EXPORT DATA=RESULTS_BW FILE=REFFILE3 DBMS=CSV REPLACE;
113 RUN;
114
115 *-----*;
116 | Check model assumptions.                         |
117 *-----*;
118
119
120 DATA HOMES2;
121 SET HOMES (KEEP=BsmtFinSF1 _1stFlrSF _2ndFlrSF OverallQual RoofMatl
122 SalePrice);
123 IF RoofMatl EQ "ClyTile" THEN RoofMatl_ClyTile=1;
124 ELSE RoofMatl_ClyTile=0;
125 IF OverallQual EQ 7 THEN OQ7=1; ELSE OQ7=0;
126 IF OverallQual EQ 6 THEN OQ6=1; ELSE OQ6=0;
127 IF OverallQual EQ 5 THEN OQ5=1; ELSE OQ5=0;
128 IF OverallQual EQ 4 THEN OQ4=1; ELSE OQ4=0;
129 IF OverallQual EQ 3 THEN OQ3=1; ELSE OQ3=0;
130 RUN;
131
132 PROC REG DATA=HOMES2 PLOT=ALL;
133     model SalePrice = BsmtFinSF1 _1stFlrSF _2ndFlrSF
134 OQ7 OQ6 OQ5 OQ4 OQ3 RoofMatl_ClyTile/CLB;
135     title
136     'Regression of Sale Price Using Backward Selection Results';
137     RUN;
138
139 PROC GLM DATA=HOMES2 PLOT=ALL;
140 CLASS OverallQual RoofMatl;
141 MODEL SalePrice = BsmtFinSF1 _1stFlrSF _2ndFlrSF OverallQual|
142     RoofMatl_ClyTile/solution CLPARM;
143 RUN;

```

### D.3. Stepwise Selection

Listing 4: Stepwise Selection SAS Code.

```

1 *-----*;
2 | Import train.csv
3 | Import test.csv
4 | Set REFFILE for train.csv

```

```

5 | Set REFFILE2 for test.csv | |
6 *-----*;
7
8 *FILENAME REFFILE '/home/mwolfe0/train.csv';
9 *FILENAME REFFILE2 '/home/mwolfe0/test.csv';
10 FILENAME REFFILE
11 '/folders/myfolders/MSDS6371/GroupProject/Datasets/train.csv';
12 FILENAME REFFILE2
13 '/folders/myfolders/MSDS6371/GroupProject/Datasets/test.csv';
14
15 PROC IMPORT DATAFILE=REFFILE DBMS=CSV REPLACE OUT=TRAIN;
16   GETNAMES=YES;
17 RUN;
18
19 PROC IMPORT DATAFILE=REFFILE2 DBMS=CSV REPLACE OUT=TEST;
20   GETNAMES=YES;
21 RUN;
22
23 *-----*;
24 | Combine train and test into one datafile HOMES | |
25 *-----*;
26
27 DATA HOMES;
28   SET TRAIN TEST;
29   IF LotFrontage EQ "NA" THEN LotFrontage = 0;
30   LotFront = input(LotFrontage, 8.);
31   drop LotFrontage;
32   RENAME LotFront=LotFrontage;
33 RUN;
34
35 *-----*;
36 | Code for stepwise selection | |
37 | Set seed to a constant for model comparison | |
38 | Class variable input with split option to allow | |
39 |   classification variable to be able to enter or | |
40 |   leave the model independently | |
41 | Stop=CV specifies the model will stop when the | |
42 |   predicted residual sum of square is reached with | |
43 |   k-fold cross validation | |
44 | CVMethod specifies how subsets are formed for | |
45 |   cross validation | |
46 | OUTPUT Dataset to RESULTS with the predicted variable | |
47 |   based on the final model | |
48 *-----*;
49
50 PROC GLMSELECT DATA=HOMES SEED=71669132;
51   CLASS MSSubClass MSZoning Street Alley LotShape LandContour
52     Utilities LotConfig LandSlope Neighborhood Condition1
53     Condition2 BldgType HouseStyle OverallQual OverallCond
54     RoofMatl Exterior1st Exterior2nd MasVnrArea ExterQual

```

```

55   ExterCond Foundation BsmtQual BsmtExposure BsmtFinType1
56   BsmtFinType2 Heating HeatingQC CentralAir Electrical
57   KitchenQual Functional FireplaceQu GarageType
58   GarageFinish GarageQual GarageCond PavedDrive PoolQC
59   Fence MiscFeature SaleType SaleCondition RoofStyle
60   BsmtCond MasVnrType
61   / split;
62   MODEL SalePrice= LotArea YearBuilt YearRemodAdd BsmtFinSF1
63   BsmtFinSF2 BsmtUnfSF TotalBsmtSF _1stFlrSF _2ndFlrSF
64   LowQualFinSF GrLivArea BsmtFullBath BsmtHalfBath
65   FullBath HalfBath BedroomAbvGr KitchenAbvGr
66   TotRmsAbvGrd Fireplaces GarageYrBlt GarageCars
67   GarageArea WoodDeckSF OpenPorchSF EnclosedPorch
68   _3SsnPorch ScreenPorch PoolArea MiscVal MoSold YrSold
69   MSSubClass MSZoning Street Alley LotShape LandContour
70   Utilities LotConfig LandSlope Neighborhood Condition1
71   Condition2 BldgType HouseStyle OverallQual OverallCond
72   RoofMatl Exterior1st Exterior2nd MasVnrArea ExterQual
73   ExterCond Foundation BsmtQual BsmtExposure BsmtFinType1
74   BsmtFinType2 Heating HeatingQC CentralAir Electrical
75   KitchenQual Functional FireplaceQu GarageType
76   GarageFinish GarageQual GarageCond PavedDrive PoolQC
77   Fence MiscFeature SaleType SaleCondition LotFrontage
78   RoofStyle BsmtCond MasVnrType
79   / selection=stepwise(stop=CV) cvmethod=random(5) stats=all;
80   OUTPUT OUT=RESULTS P=PREDICT;
81 RUN;
82
83 *-----*
84 | Create a datafile RESULTS_SW of predicted values for |
85 | SalePrice for house id greater than 1460 which    |
86 | is where the Kaggle test set data begins.          |
87 *-----*;
88
89 DATA RESULTS_SW;
90   SET RESULTS;
91
92   IF PREDICT > 0 THEN
93     SalePrice=Predict;
94
95   IF PREDICT < 0 THEN
96     SalePrice=10000;
97   KEEP id SalePrice;
98   WHERE id > 1460;
99 RUN;
100
101 *-----*
102 | Export a datafile for predicted values for        |
103 | SalePrice for house id greater than 1460 which  |
104 | is where the Kaggle test set data begins.         |

```

```

105 *-----*;
106
107 *FILENAME REFFILE3 '/home/mwolfe0/results_sw.csv';
108 FILENAME REFFILE3
109 '/folders/myfolders/MSDS6371/GroupProject/Datasets/results_sw.csv';
110
111 PROC EXPORT DATA=RESULTS_SW FILE=REFFILE3 DBMS=CSV REPLACE;
112 RUN;
113
114 *-----*
115 | Check model assumptions. |
116 *-----*;
117
118 DATA HOMES2;
119 SET HOMES (KEEP=YearBuilt TotalBsmtSF GrLivArea RoofMatl BsmtQual
120 SalePrice);
121 IF RoofMatl EQ "ClyTile" THEN RoofMatl_ClyTile=1;
122 ELSE RoofMatl_ClyTile=0;
123 IF BsmtQual = 'Ex' THEN BsmtQual_EX = 1;
124 ELSE BsmtQual_EX=0;
125 RUN;
126
127 PROC REG DATA=HOMES2 PLOT=ALL;
128 model SalePrice = YearBuilt TotalBsmtSF GrLivArea
129 RoofMatl_ClyTile BsmtQual_EX/CLB;
130 title
131 'Regression of Sale Price Using Stepwise Selection Results';
132 RUN;
133
134 PROC GLM DATA=HOMES2 PLOT=ALL;
135 CLASS RoofMatl_ BsmtQual;
136 MODEL SalePrice = YearBuilt TotalBsmtSF GrLivArea|
137 RoofMatl_ClyTile BsmtQual_EX/solution CLPARM;
138 RUN;

```

#### D.4. Custom Model

Listing 5: Custom Model SAS Code.

```

1 *-----*
2 | Import train.csv
3 | Import test.csv
4 | Set REFFILE for train.csv
5 | Set REFFILE2 for test.csv
6 *-----*;
7 FILENAME REFFILE
8 '/folders/myfolders/MSDS6371/GroupProject/Datasets/train.csv';
9
10 /* FILENAME REFFILE */
11 /* "C:\Users\cwale\OneDrive\Desktop\SMU\Winter18\StatsFoundation\*/

```

```

12 | Case_Study\Data\train.csv"; */
13 |
14 | /*FILENAME REFFILE2 */
15 | /* "C:\Users\cwale\OneDrive\Desktop\SMU\Winter18\StatsFoundation\
16 | Case_Study\Data\test.csv" */
17 |
18 | FILENAME REFFILE2
19 | '/folders/myfolders/MSDS6371/GroupProject/Datasets/test.csv';
20 |
21 |
22 | PROC IMPORT OUT= WORK.train
23 |           DATAFILE= REFFILE
24 |           DBMS=CSV REPLACE;
25 |           GETNAMES=YES;
26 |           DATAROW=2;
27 | RUN;
28 |
29 | PROC IMPORT OUT= WORK.test
30 |           DATAFILE= REFFILE2
31 |           DBMS=CSV REPLACE;
32 |           GETNAMES=YES;
33 |           DATAROW=2;
34 | RUN;
35 |
36 |
37 | /*PROC IMPORT DATAFILE=REFFILE DBMS=CSV REPLACE OUT=TRAIN;*/
38 | /*      GETNAMES=YES; */
39 | /*RUN; */
40 | /**
41 | /*PROC IMPORT DATAFILE=REFFILE2 DBMS=CSV REPLACE OUT=TEST;*/
42 | /*      GETNAMES=YES; */
43 | /*RUN; */
44 |
45 | DATA HOMES;
46 |     SET TRAIN TEST;
47 |     Age=2019-YearBuilt;
48 |     RemodFactor = YearRemodAdd - YearBuilt;
49 |     Impression=OverallQual + OverallCond/2;
50 | RUN;
51 |
52 | *-----*
53 | | Code for custom GLM model
54 | | NOTE: SAS online "_1st" will not run must change to
55 | |       first same for _2nd
56 | | Code works as is in SAS University Edition
57 | *-----*;
58 | ods graphics on;
59 | PROC GLM DATA=HOMES PLOTS=ALL;
60 |           CLASS BsmtQual OverallQual OverallQual OverallCond
61 |           Neighborhood BldgType SaleCondition HouseStyle;

```

```

62      MODEL SalePrice = GrLivArea _1stFlrSF _2ndFlrSF Age
63      Neighborhood BldgType SaleCondition RemodFactor
64      OverallQual OverallCond HouseStyle/ p clparm
65          TOLERANCE SOLUTION;
66      OUTPUT OUT=RESULTS P=PREDICT;
67      RUN;
68  ods graphics off;
69 /* .148 - GrLivArea _1stFlrSF _2ndFlrSF Age Neighborhood
70 BldgType SaleCondition LotArea RemodFactor OverallQual
71 OverallCond HouseStyle */
72
73
74 DATA RESULTS_CUST;
75     SET RESULTS;
76
77     IF PREDICT > 0 THEN
78         SalePrice=Predict;
79
80     IF PREDICT < 0 THEN
81         SalePrice=10000;
82     KEEP id SalePrice;
83     WHERE id > 1460;
84
85 RUN;
86
87 FILENAME REFFILE3
88     '/folders/myfolders/MSDS6371/GroupProject/Datasets/results_cust.csv';
89 /* FILENAME REFFILE3
90 C:\Users\cwale\OneDrive\Desktop\results_cust.csv */
91
92 PROC EXPORT DATA=RESULTS_CUST FILE=REFFILE3 DBMS=CSV
93     REPLACE;
94
95 RUN;

```

## E. SUMMARY OF DATA

Attribute Type		Description	Features
Categorical (Qualitative)	Nominal	Only provide enough information to distinguish one object from another	MSSubClass, MSZoning, Street, Alley, LotShape, LandContour, Utilities, LotConfig, LandSlope, Neighborhood, Condition1, Condition2, BldgType, HouseStyle, RoofMatl, Exterior1st, Exterior2nd, MasVnrType, Foundation, BsmtExposure, HeatingCentralAir, Electrical, GarageType, GarageFinish PavedDrive, MiscFeature, SaleType, SaleCondition RoofStyle <b>(30 variables)</b>
	Ordinal	Provide enough information to order objects	OverallQual, OverallCond, ExterQual, ExterCond, BsmtQual, BsmtCond, BsmtFinType1, BsmtFinType2, HeatingQC, KitchenQual, Functional, FireplaceQu, GarageQual, GarageCond, PoolQC, Fence <b>(16 variables)</b>
Numeric (Quantitative)	Interval	Interval attributes difference between values are meaningful	YearBuilt, YearRemodAdd, GarageYrBlt, MoSold, YrSold <b>(5 variables)</b>
	Ratio	Differences and ratios are meaningful	LotFrontage, LotArea, BsmtFinSF1, BsmtFinSF2, BsmtUnfSF, TotalBsmtSF, 1stFlrSF, 2ndFlrSF, LowQualFinSF, GrLivArea, BsmtFullBath, MasVnrArea, BsmtHalfBath, FullBath, HalfBath, Bedroom, Kitchen, TotRmsAbvGrd, Fireplaces, GarageCars, GarageArea, WoodDeckSF, OpenPorchSF, EnclosedPorch, 3SsnPorch, ScreenPorch, PoolArea, MiscVal <b>(28 variables)</b>

Table E.1: Summary of Dataset

Classification Variables	
MSSubClass	Identifies the type of dwelling involved in the sale 20 1-STORY 1946 & NEWER ALL STYLES 30 1-STORY 1945 & OLDER 40 1-STORY W/FINISHED ATTIC ALL AGES 45 1-1/2 STORY - UNFINISHED ALL AGES 50 1-1/2 STORY FINISHED ALL AGES 60 2-STORY 1946 & NEWER 70 2-STORY 1945 & OLDER 75 2-1/2 STORY ALL AGES 80 SPLIT OR MULTI-LEVEL 85 SPLIT FOYER 90 DUPLEX - ALL STYLES AND AGES 120 1-STORY PUD (Planned Unit Development) - 1946 & NEWER 150 1-1/2 STORY PUD - ALL AGES 160 2-STORY PUD - 1946 & NEWER 180 PUD - MULTILEVEL - INCL SPLIT LEV/FOYER 190 2 FAMILY CONVERSION - ALL STYLES AND AGES
MSZoning	Identifies the general zoning classification of the sale A Agriculture C Commercial FV Floating Village Residential I Industrial RH Residential High Density RL Residential Low Density RP Residential Low Density Park RM Residential Medium Density
LotFrontage	Linear feet of street connected to property
LotArea	Lot size in square feet
Street	Type of road access to property Grvl Gravel Pave Paved
Alley	Type of alley access to property Grvl Gravel Pave Paved NA No alley access
LotShape	General shape of property Reg Regular IR1 Slightly Irregular IR2 Moderately Irregular IR3 Irregular
LandContour	General shape of property Lvl Near Flat/Level Bnk Banked - Quick and significant rise from street grade to building HLS Hillside - Significant slope from side to side Low Depression

Classification Variables	
Utilities	Identifies the type of dwelling involved in the sale AllPub All public Utilities (E,G,W,& S) NoSewr Electricity, Gas, and Water (Septic Tank) NoSeWa Electricity and Gas Only ELO Electricity only
LotConfig	Lot configuration Inside Inside lot Corner Corner lot CulDSac Cul-de-sac FR2 Frontage on 2 sides of property FR3 Frontage on 3 sides of property
LandSlope	Slope of property Gtl Gentle slope Mod Moderate slope Sev Severe slope
Neighborhood	Physical locations within Ames city limits Blmgtn Bloomington Heights Blueste Bluestem BrDale Briardale BrkSide Brookside ClearCr Clear Creek CollgCr College Creek Crawfor Crawford Edwards Edwards Gilbert Gilbert IDOTRR Iowa DOT and Rail Road MeadowV Meadow Village Mitchel Mitchell NAmes North Ames NoRidge Northridge NPkVill Northpark Villa NridgHt Northridge Heights NWAmes Northwest Ames OldTown Old Town SWISU South & West of Iowa State University Sawyer Sawyer SawyerW Sawyer West Somerst Somerset StoneBr Stone Brook Timber Timberland Veenker Veenker
Condition1	Proximity to various conditions Artery Adjacent to arterial street Feedr Adjacent to feeder street Norm Normal RRNn Within 200' of North-South Railroad RRAn Adjacent to North-South Railroad PosN Near positive off-site feature–park, greenbelt, etc. PosA Adjacent to positive off-site feature RRNe Within 200' of East-West Railroad RRAe Adjacent to East-West Railroad

Classification Variables		
Condition2	Proximity to various conditions (if more than one is present)	
	Artery	Adjacent to arterial street
	Feedr	Adjacent to feeder street
	Norm	Normal
	RRNn	Within 200' of North-South Railroad
	RRAn	Adjacent to North-South Railroad
	PosN	Near positive off-site feature-park, greenbelt, etc.
	PosA	Adjacent to postive off-site feature
	RRNe	Within 200' of East-West Railroad
	RRAe	Adjacent to East-West Railroad
BldgType	Type of dwelling	
	1Fam	Adjacent to arterial street
	2FmCon	Adjacent to feeder street
	Duplx	Normal
	TwnhsE	Normal
	TwnhsI	Normal
HouseStyle	Style of dwelling	
	1Story	One story
	1.5Fin	One and one-half story: 2nd level finished
	1.5Unf	One and one-half story: 2nd level unfinished
	2Story	Two story
	2.5Fin	Two and one-half story: 2nd level finished
	2.5Unf	Two and one-half story: 2nd level unfinished
	SFoyer	Split Foyer
	SLvl	Split Level
OverallQual	Rates the overall material and finish of the house	
	10	Very Excellent
	9	Excellent
	8	Very Good
	7	Good
	6	Above Average
	5	Average
	4	Below Average
	3	Fair
	2	Poor
	1	Very Poor
OverallQual	Rates the overall material and finish of the house	
	10	Very Excellent
	9	Excellent
	8	Very Good
	7	Good
	6	Above Average
	5	Average
	4	Below Average
	3	Fair
	2	Poor
	1	Very Poor

Classification Variables		
YearBuilt	Original construction date	
YearRemodAdd	Remodel date (same as construction date if no remodeling or additions)	
RoofStyle	Type of roof	
	Flat	Flat
	Gable	Gable
	Gambrel	Gabrel (Barn)
	Hip	Hip
	Mansard	Mansard
	Shed	Shed
RoofMatl	Roof material	
	ClyTile	Clay or Tile
	CompShg	Standard (Composite) Shingle
	Membran	Membrane
	Metal	Metal
	Roll	Roll
	Tar&Grv	Gravel & Tar
	WdShake	Wood Shakes
	WdShngl	Wood Shingles
Exterior1st	Exterior covering on house	
	AsbShng	Asbestos Shingles
	AsphShn	Asphalt Shingles
	BrkComm	Brick Common
	BrkFace	Brick Face
	CBlock	Cinder Block
	CemntBd	Cement Board
	HdBoard	Hard Board
	ImStucc	Imitation Stucco
	MetalSd	Metal Siding
	Other	Other
	Plywood	Plywood
	PreCast	PreCast
	Stone	Stone
	Stucco	Stucco
	VinylSd	Vinyl Siding
	Wd Sdng	Wood Siding
	WdShing	Wood Shingles

Classification Variables	
Exterior2nd	Exterior covering on house (if more than one material)
AsbShng	Asbestos Shingles
AsphShn	Asphalt Shingles
BrkComm	Brick Common
BrkFace	Brick Face
CBlock	Cinder Block
CemntBd	Cement Board
HdBoard	Hard Board
ImStucc	Imitation Stucco
MetalSd	Metal Siding
Other	Other
Plywood	Plywood
PreCast	PreCast
Stone	Stone
Stucco	Stucco
VinylSd	Vinyl Siding
Wd Sdng	Wood Siding
WdShing	Wood Shingles
MasVnrType	Masonry veneer type
BrkCmn	Brick Common
BrkFace	Brick Face
CBlock	Cinder Block
None	None
Stone	Stone
MasVnrArea	Masonry veneer area in square feet
ExterQual	Evaluates the quality of the material on the exterior
Ex	Excellent
Gd	Good
TA	Average/Typical
Fa	Fair
Po	Poor
ExterCond	Evaluates the present condition of the material on the exterior
Ex	Excellent
Gd	Good
TA	Average/Typical
Fa	Fair
Po	Poor

Foundation	Type of foundation BrkTil    Brick & Tile CBlock    Cinder Block PConc    Poured Concrete Slab    Slab Stone    Stone Wood    Wood
BsmtQual	Evaluates the height of the basement Ex    Excellent (100+ inches) Gd    Good (90-99 inches) TA    Typical (80-89 inches) Fa    Fair (70-79 inches) Po    Poor (<70 inches) NA    No Basement
BsmtCond	Evaluates the general condition of the basement Ex    Excellent Gd    Good TA    Typical - slight dampness allowed Fa    Fair - dampness or some cracking or settling Po    Poor - Severe cracking, settling, or wetness NA    No Basement
BsmtExposure	Refers to walkout or garden level walls Gd    Good Exposure Av    Average Exposure Av    (split levels or foyers typically score average or above) Mn    Minimum Exposure No    No Exposure NA    No Basement
BsmtFinType1	Rating of basement finished area GLQ    Good Living Quarters ALQ    Average Living Quarters BLQ    Below Average Living Quarters Rec    Average Rec Room LwQ    Low Quality Unf    Unfinished NA    No Basement
BsmtFinSF1	Type 1 finished square feet
BsmtFinType2	Rating of basement finished area (if multiple types) GLQ    Good Living Quarters ALQ    Average Living Quarters BLQ    Below Average Living Quarters Rec    Average Rec Room LwQ    Low Quality Unf    Unfinished NA    No Basement
BsmtFinSF2	Type 2 finished square feet
BsmtUnfSF	Unfinished square feet of basement area
TotalBsmtSF	Total square feet of basement area

Heating	Type of heating
Floor	Floor Furnace
GasA	Gas forced warm air furnace
GasW	Gas hot water or steam heat
Grav	Gravity furnace
OthW	Hot water or steam heat other than gas
Wall	Wall furnace
HeatingQC	Heating quality and condition
Ex	Excellent
Gd	Good
TA	Average/Typical
Fa	Fair
Po	Poor
CentralAir	Central air conditioning
N	No
Y	Yes
Electrical	Electrical system
SBrkr	Standard Circuit Breakers & Romex
FuseA	Fuse Box over 60 AMP and all Romex wiring (Average)
FuseF	60 AMP Fuse Box and mostly Romex wiring (Fair)
FuseP	AMP Fuse Box and mostly knob & tube wiring (poor)
Mix	Mixed
1stFlrSF	First Floor square feet
2ndFlrSF	Second Floor square feet
LowQualFinSF	Low quality finished square feet (all floors)
GrLivArea	Above grade (ground) living area square feet
BsmtFullBath	Basement full bathrooms
BsmtHalfBath	Basement half bathrooms
FullBath	Full bathrooms above grade
HalfBath	Half baths above grade
Bedroom	Bedrooms above grade (does NOT include basement bedrooms)
Kitchen	Kitchens above grade
KitchenQual	Electrical system
Ex	Excellent
Gd	Good
TA	Average/Typical
Fa	Fair
Po	Poor
TotRmsAbvGrd	Total rooms above grade (does not include bathrooms)
Functional	Home functionality (Assume typical unless deductions are warranted)
Typ	Typical Functionality
Min1	Minor Deductions 1
Min2	Minor Deductions 2
Mod	Moderate Deductions
Maj1	Major Deductions 1
Maj2	Major Deductions 2
Sev	Severely Damaged
Sal	Salvage only
Fireplaces	Number of fireplaces

Classification Variables		
FireplaceQu	Electrical system	
	Ex	Excellent - Exceptional Masonry Fireplace
	Gd	Good - Masonry Fireplace in main level
	TA	Average - Prefabricated Fireplace in main living area or Masonry Fireplace in basement
	Fa	Fair - Prefabricated Fireplace in basement
	Po	Poor - Ben Franklin Stove
	NA	No Fireplace
GarageType	Garage location	
	2Types	More than one type of garage
	Attchd	Attached to home
	Basment	Basement Garage
	BuiltIn	Built-In (Garage part of house - typically has room above garage)
	CarPort	Car Port
	Detchd	Detached from home
	NA	No Garage
GarageYrBlt	Year garage was built	
GarageFinish	Interior finish of the garage	
	Fin	Finished
	RFn	Rough Finished
	Unf	Unfinished
	NA	No Garage
GarageCars	Size of garage in car capacity	
GarageArea	Size of garage in square feet	
GarageQual	Garage quality	
	Ex	Excellent
	Gd	Good
	TA	Typical/Average
	Fa	Fair
	Po	Poor
	NA	No Garage
PavedDrive	Paved driveway	
	Y	Paved
	P	Partial Pavement
	N	Dirt/Gravel
WoodDeckSF	Wood deck area in square feet	
OpenPorchSF	Open porch area in square feet	
EnclosedPorch	Enclosed porch area in square feet	
3SsnPorch	Three season porch area in square feet	
ScreenPorch	Screen porch area in square feet	
PoolArea	Pool area in square feet	
PoolQC	Garage quality	
	Ex	Excellent
	Gd	Good
	TA	Typical/Average
	Fa	Fair
	NA	No Pool

Classification Variables		
Fence	Fence quality	
	GdPrv	Good Privacy
	MnPrv	Minimum Privacy
	GdWo	Good Wood
	MnWw	Minimum Wood/Wire
	NA	No Fence
MiscFeature	Miscellaneous feature not covered in other categories	
	Elev	Elevator
	Gar2	2nd Garage (if not described in garage section)
	Othr	Other
	Shed	Shed (over 100 SF)
	TenC	Tennis Court
	NA	None
MiscVal	\$Value of miscellaneous feature	
MoSold	Month Sold (MM)	
YrSold	Year Sold (YYYY)	
SaleType	Type of sale	
	WD	Warranty Deed - Conventional
	CWD	Warranty Deed - Cash
	VWD	Warranty Deed - VA Loan
	New	Home just constructed and sold
	COD	Court Officer Deed/Estate
	Con	Contract 15% Down payment regular terms
	ConLw	Contract Low Down payment and low interest
	ConLI	Contract Low Interest
	ConLD	Contract Low Down
	Oth	Other
SaleCondition	Condition of sale	
	Normal	Normal Sale
	Abnorml	Abnormal Sale - trade, foreclosure, short sale
	AdjLand	Adjoining Land Purchase
	Alloca	Allocation - two linked properties with separate deeds, typically condo with a garage unit
	Family	Sale between family members
	Partial	Home was not completed when last assessed (associated with New Homes)