

Regression Analysis of the Ames, Iowa Dataset

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1 Introduction

Ramsey and Schafer^[3] CWR Update Test

2 Ames, Iowa Data Set

The Ames, Iowa Data Set describes the sale of individual residential properties from 2006-2010 in Ames, Iowa^[1]. The data was retrieved from the dataset hosting site Kaggle, where it is listed under a machine learning competition named *House Prices: Advanced Regression Techniques*^[2]. The data is comprised of 37 numeric features, 43 non-numeric features and an observation index split between a training set and a testing set, which contain 1460 and 1459 observations, respectively. The response variable (**SalePrice**) is only provided for the training set. The output of a model on the test set can be submitted to the Kaggle competition for scoring the performance of the model in terms of RMSE. The first analysis models property sale prices (**SalePrice**) as the response of living room area (**GrLivArea**) of the property and neighborhood (**Neighborhood**) where it is located. **Add some details on the question 2 variables?**

3 Analysis Question I

3.1 Question of Interest

Century 21 has commissioned an analysis of this data to determine how the sale price of property is related to living room area of the property in the Edwards, Northwest Ames, and Brookside neighborhoods of Ames, IA.

3.2 Modeling

Linear regression will be used to model sale price as a response of the living room area. From the initial exploratory data analysis, it was determined that sale prices should be log-transformed to meet the model assumptions for linearity (see section 5.1), thus improving our models fit and reducing standard error. Additionally, two observations were removed as they appeared to be from a different population than the other observations in the dataset (see section 5.2); therefore, analysis only considers properties with living rooms less than 3500 sq. ft. in area.

We will consider two models: the logarithm of sale price as the response of living room area (1), the reduced model, and the logarithm of sale price as the response of living room area accounting for differences in the three neighborhood of interest (Brookside, Northwest Ames, and Edwards) where Edwards will be used as the reference (2), the full model. An extra sums of square (ESS) test will be used to verify that the addition of **Neighborhood** improves the model.

Reduced Model

$$\mu\{\log(\text{SalePrice})\} = \beta_0 + \beta_1(\text{LivingRoomArea}) \quad (1)$$

Full Model

$$\begin{aligned} \mu\{\log(\text{SalePrice})\} = & \beta_0 + \beta_1(\text{LivingRoomArea}) + \beta_2(\text{Brookside}) + \beta_3(\text{NorthwestAmes}) + \\ & \beta_3(\text{Brookside})(\text{LivingRoomArea}) + \beta_4(\text{NorthwestAmes})(\text{LivingRoomArea}) \end{aligned} \quad (2)$$

The ESS test provides convincing evidence that the interaction terms are useful for the model (p-value < 0.0001); thus, we will continue with the full model.

```
## Analysis of Variance Table
##
## Model 1: log(SalePrice) ~ (GrLivArea) + Neighborhood_BrkSide + Neighborhood_NAmes
## Model 2: log(SalePrice) ~ (GrLivArea) + Neighborhood_BrkSide + Neighborhood_NAmes +
##      (GrLivArea) * Neighborhood_BrkSide + (GrLivArea) * Neighborhood_NAmes
##   Res.Df    RSS Df Sum of Sq    F    Pr(>F)
## 1      377 14.824
## 2      375 13.441   2    1.3834 19.299 1.053e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.3 Model Assumptions Assessment

The following assessments for model assumptions are made based on Figure 1 and Figure 3:

- The residuals of the model appear to be approximately normally distributed based on the QQ plot of the residuals and histogram of the residuals, suggesting the assumption of normality is met.
- No patterns are evident in the scatter plots of residuals and studentized residuals vs predicted value, suggesting the assumption of constant variance is met.
- While some observations appear to be influential and have high leverage, removing these observations does not have a significant impact on the result of the model fit.
- Based on the scatter plot of the log transform of **SalePrice** vs **GrLivArea**, it appears that a linear model is reasonable (see section 5.1).

The sampling procedure is not known. We will assume the independence assumption is met.

3.4 Comparing Competing Models

The two models were trained and validated on the training dataset using 10-fold cross validation. The table below summarizes the performance of the models with RMSE, adjusted R^2 , and PRESS. These results show that the full model is an improvement over the reduced model, which is consistent with the result of the ESS test.

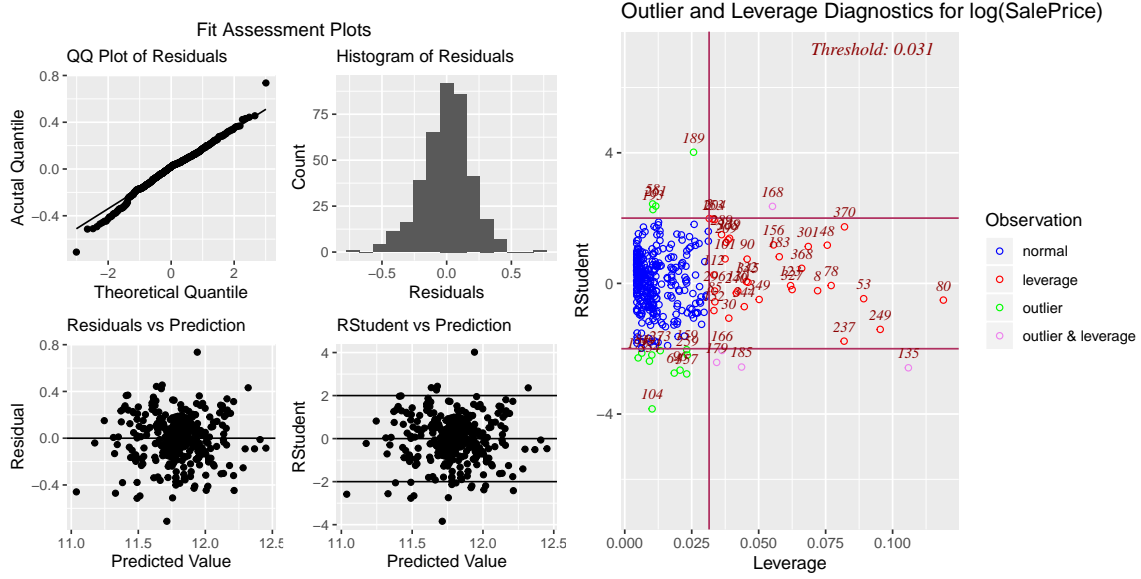


Figure 1: Diagnostic Plots

Model	RMSE	CV.Press	Adjusted.R.Squared
Full Model	0.1906429	12.46260	0.5321848
Reduced Model	0.1972251	13.33804	0.4731396

3.5 Parameters

The following table summerizes the parameter estimates for the full model.

Parameter	Estimate	CI.Lower	CI.Upper
Intercept	11.0254845	10.8861855	11.1647836
GrLivArea	0.0005387	0.0004324	11.1647836
Neighborhood_BrkSide	-0.2338906	-0.4468114	-0.0209698
Neighborhood_NAmes	0.4178562	0.2558923	0.5798200
GrLivArea:Neighborhood_BrkSide	0.0001996	0.0000336	0.0003656
GrLivArea:Neighborhood_NAmes	-0.0002145	-0.0003366	-0.0000924

Where Intercept is β_0 , GrLivArea is β_1 , Neighborhood_BrkSide is β_2 , Neighborhood_NAmes is β_3 , GrLivArea:Neighborhood_BrkSide is β_4 , and GrLivArea:Neighborhood_NAmes is β_5

3.6 Model Interpretation

We estimate that for increase in 100 sq. ft., there is associated multiplicative increase in median price of

- 1.055 for the Edwards neighborhood with a 95% confidence interval of [1.044 , 1.066]
- 1.033 for the Northwest Ames neighborhood with a 95% confidence interval of [1.026 , 1.040]
- 1.077 for the Brookside neighborhood with a 95% confidence interval of [1.063 , 1.090]

Since the sampling procedure is not known and this is an observational study, the results only apply to this data.

3.7 Conclusion

In response to the analysis commissioned by Century 21, the log transform of property sale price was modeled as a linear response to the property living room area for residential properties in Ames, IA. It was determined that it was necessary to include interaction terms to allow for the influence of neighborhood on sale price. Based on the model, there is strong evidence of an associated multiplicative increase in median sale price for an increase in living room area (p-value < 0.0001, overall F-test).

4 Analysis Question II

4.1 Question of Interest

Century 21 has commissioned a second analysis using the same data set, expanded to include as many of the 80 total features, plus the index split, as required to determine the sale price of residential properties across all neighborhoods of Ames, Iowa, beyond only the three - Edwards, Northwest Ames, and Brookside - previously commissioned for analysis.

4.2 Modeling

Restatement of Problem

Through analyzing our variable selection and cross-validation processes - along with our nascent domain knowledge of residential real estate - we ultimately arrived at a multiple linear regression model featuring 11 linear predictor variables and three interaction terms. Specifically, our variable selection process included direct analysis of a correlation plot and a correlation matrix as well as performing forward selection, backward elimination, and stepwise regression. Because many variables contained zeroes that were significant to the factor (for example, bathrooms), we elected to perform logarithmic transformation only to variable **LotArea**, representative of the area of the real estate lot.

In addition to the transformation of **LotArea**, we imputed NA values for 19 variables using a combination of the Data Dictionary provided by Century 21 as well as our domain knowledge.

Type of selection

Forward Selection

Forward selection is a variable selection methodology that begins with a constant mean and adds explanatory variables one-by-one until no further additional predictor variables significantly improve the model's fit. This employs the "F-to-enter" method from the extra-sum-of-squares F-statistic. This was the first method we employed. For this process, we provided the test a starting model with no predictor variables and a model from which terms can be selected, which included all predictor variables available. The process worked forward with selecting one parameter. The suggested model is output below.

```
# Initial Model - Forward Selection
model2.forward.Start <- lm(log(SalePrice)~1,data = train2)
```

```
# All Variables Model - Forward Selection
```

```
model2.Allvar <- lm(log(SalePrice) ~ Id + MSSubClass + MSZoning + LotFrontage + LotArea + Street +
  Alley + LotShape + LandContour + Utilities + LotConfig + LandSlope +
  Neighborhood + Condition1 + Condition2 + BldgType + HouseStyle + OverallQual +
  OverallCond + YearBuilt + YearRemodAdd + RoofStyle + RoofMatl + Exterior1st +
  Exterior2nd + MasVnrType + MasVnrArea + ExterQual + ExterCond + Foundation +
  BsmtQual + BsmtCond + BsmtExposure + BsmtFinType1 + BsmtFinSF1 + BsmtFinType2
+ BsmtFinSF2 + BsmtUnfSF + TotalBsmtSF + Heating + HeatingQC + CentralAir +
  Electrical + `1stFlrSF` + `2ndFlrSF` + LowQualFinSF + GrLivArea + BsmtFullBath
+ BsmtHalfBath + FullBath + HalfBath + BedroomAbvGr + KitchenAbvGr + KitchenQual
+ TotRmsAbvGrd + Functional + Fireplaces + FireplaceQu + GarageType +
  GarageYrBlt + GarageFinish + GarageCars + GarageArea + GarageQual + GarageCond
+ PavedDrive + WoodDeckSF + OpenPorchSF + EnclosedPorch + `3SsnPorch` +
  ScreenPorch + PoolArea + PoolQC + Fence + MiscFeature + MiscVal + MoSold +
  YrSold + SaleType + SaleCondition, data = train2
)
```

```
model2.Forward <- stepAIC(model2.forward.Start, direction = "forward", trace = F, scope = formula(model2.Allvar))
```

```
summary(model2.Forward)
```

```
##
```

```
## Call:
```

```
## lm(formula = log(SalePrice) ~ OverallQual + Neighborhood + GrLivArea +
##   BsmtFinType1 + GarageCars + OverallCond + RoofMatl + TotalBsmtSF +
##   YearBuilt + LotArea + Condition2 + MSZoning + BsmtUnfSF +
##   SaleCondition + Functional + CentralAir + Condition1 + KitchenQual +
##   Fireplaces + Exterior1st + Heating + ScreenPorch + YearRemodAdd +
##   BsmtQual + PoolQC + Foundation + KitchenAbvGr + SaleType +
##   GarageArea + HeatingQC + BsmtExposure + EnclosedPorch + WoodDeckSF +
##   LotConfig + Street + BsmtFullBath + PoolArea + LandSlope +
##   GarageCond + HalfBath + FullBath + TotRmsAbvGrd + `3SsnPorch` +
##   ExterCond + GarageQual + GarageYrBlt + Utilities, data = train2)
```

```
##
```

```
## Residuals:
```

```
##      Min       1Q   Median       3Q      Max
## -0.72243 -0.04585  0.00175  0.05406  0.72243
```

```
##
```

```
## Coefficients: (2 not defined because of singularities)
```

```
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      1.156e+00  9.003e-01   1.284 0.199342
## OverallQual       4.534e-02  4.267e-03  10.625 < 2e-16 ***
## NeighborhoodBlueste -1.828e-02  8.177e-02  -0.224 0.823149
```

## NeighborhoodBrDale	-6.383e-02	4.388e-02	-1.455	0.146044	
## NeighborhoodBrkSide	1.077e-02	3.669e-02	0.294	0.769178	
## NeighborhoodClearCr	-1.217e-02	3.774e-02	-0.322	0.747241	
## NeighborhoodCollgCr	-4.672e-02	2.923e-02	-1.599	0.110164	
## NeighborhoodCrawfor	8.022e-02	3.486e-02	2.301	0.021539	*
## NeighborhoodEdwards	-1.037e-01	3.226e-02	-3.215	0.001337	**
## NeighborhoodGilbert	-4.801e-02	3.121e-02	-1.538	0.124258	
## NeighborhoodIDOTRR	-4.462e-02	4.267e-02	-1.046	0.295897	
## NeighborhoodMeadowV	-1.632e-01	4.637e-02	-3.520	0.000446	***
## NeighborhoodMitchel	-9.451e-02	3.349e-02	-2.822	0.004844	**
## NeighborhoodNames	-5.862e-02	3.138e-02	-1.868	0.061937	.
## NeighborhoodNoRidge	1.077e-02	3.408e-02	0.316	0.752018	
## NeighborhoodNPkVill	-1.274e-02	4.704e-02	-0.271	0.786616	
## NeighborhoodNridgHt	3.664e-02	3.044e-02	1.204	0.228936	
## NeighborhoodNWAmes	-6.179e-02	3.293e-02	-1.877	0.060793	.
## NeighborhoodOldTown	-5.731e-02	3.739e-02	-1.533	0.125636	
## NeighborhoodSawyer	-5.556e-02	3.313e-02	-1.677	0.093742	.
## NeighborhoodSawyerW	-4.766e-02	3.233e-02	-1.474	0.140677	
## NeighborhoodSomerst	8.423e-03	3.675e-02	0.229	0.818755	
## NeighborhoodStoneBr	8.120e-02	3.506e-02	2.316	0.020696	*
## NeighborhoodSWISU	-2.141e-02	3.892e-02	-0.550	0.582229	
## NeighborhoodTimber	-3.348e-02	3.364e-02	-0.995	0.319801	
## NeighborhoodVeenker	-9.409e-03	4.540e-02	-0.207	0.835861	
## GrLivArea	2.140e-04	1.608e-05	13.311	< 2e-16	***
## BsmtFinType1ALQ	-5.270e-02	1.096e-01	-0.481	0.630830	
## BsmtFinType1BLQ	-6.157e-02	1.096e-01	-0.562	0.574543	
## BsmtFinType1GLQ	-4.235e-02	1.098e-01	-0.386	0.699892	
## BsmtFinType1LwQ	-7.859e-02	1.100e-01	-0.715	0.474988	
## BsmtFinType1Rec	-6.949e-02	1.097e-01	-0.634	0.526454	
## BsmtFinType1Unf	-7.221e-02	1.092e-01	-0.661	0.508643	
## GarageCars	2.050e-02	9.942e-03	2.062	0.039387	*
## OverallCond	3.719e-02	3.726e-03	9.982	< 2e-16	***
## RoofMatlCompShg	2.517e+00	1.986e-01	12.671	< 2e-16	***
## RoofMatlMembran	2.730e+00	2.311e-01	11.815	< 2e-16	***
## RoofMatlMetal	2.592e+00	2.307e-01	11.236	< 2e-16	***
## RoofMatlRoll	2.562e+00	2.283e-01	11.223	< 2e-16	***
## RoofMatlTar&Grv	2.496e+00	2.042e-01	12.228	< 2e-16	***
## RoofMatlWdShake	2.542e+00	2.055e-01	12.371	< 2e-16	***
## RoofMatlWdShngl	2.545e+00	2.023e-01	12.585	< 2e-16	***
## TotalBsmtSF	1.477e-04	1.523e-05	9.694	< 2e-16	***
## YearBuilt	2.039e-03	3.156e-04	6.458	1.49e-10	***
## LotArea	8.909e-02	1.000e-02	8.908	< 2e-16	***
## Condition2Feedr	7.729e-02	9.623e-02	0.803	0.422021	

## Condition2Norm	4.081e-02	8.255e-02	0.494	0.621127	
## Condition2PosA	2.971e-01	1.541e-01	1.929	0.053972	.
## Condition2PosN	-8.390e-01	1.171e-01	-7.163	1.31e-12	***
## Condition2RR Ae	-1.399e-01	1.347e-01	-1.039	0.299064	
## Condition2RR An	-8.032e-02	1.343e-01	-0.598	0.549881	
## Condition2RR Nn	-1.358e-02	1.146e-01	-0.119	0.905654	
## MSZoningFV	4.209e-01	5.158e-02	8.160	7.82e-16	***
## MSZoningRH	4.154e-01	5.135e-02	8.089	1.37e-15	***
## MSZoningRL	4.019e-01	4.368e-02	9.203	< 2e-16	***
## MSZoningRM	3.711e-01	4.088e-02	9.078	< 2e-16	***
## BsmtUnfSF	-5.325e-05	1.291e-05	-4.123	3.97e-05	***
## SaleConditionAdjLand	1.243e-01	5.779e-02	2.150	0.031734	*
## SaleConditionAlloca	4.331e-02	3.720e-02	1.164	0.244486	
## SaleConditionFamily	1.532e-02	2.691e-02	0.569	0.569387	
## SaleConditionNormal	7.074e-02	1.268e-02	5.580	2.93e-08	***
## SaleConditionPartial	-5.574e-02	6.543e-02	-0.852	0.394473	
## FunctionalMaj2	-2.367e-01	5.882e-02	-4.024	6.05e-05	***
## FunctionalMin1	4.359e-02	3.581e-02	1.217	0.223685	
## FunctionalMin2	4.480e-02	3.535e-02	1.267	0.205325	
## FunctionalMod	-4.948e-02	4.315e-02	-1.147	0.251792	
## FunctionalSev	-2.619e-01	1.175e-01	-2.229	0.025995	*
## FunctionalTyp	7.740e-02	3.052e-02	2.536	0.011340	*
## CentralAirY	6.380e-02	1.591e-02	4.011	6.38e-05	***
## Condition1Feedr	4.539e-02	2.158e-02	2.103	0.035674	*
## Condition1Norm	8.223e-02	1.785e-02	4.608	4.47e-06	***
## Condition1PosA	4.391e-02	4.284e-02	1.025	0.305519	
## Condition1PosN	8.746e-02	3.193e-02	2.739	0.006243	**
## Condition1RR Ae	-4.912e-02	3.987e-02	-1.232	0.218225	
## Condition1RR An	4.088e-02	2.981e-02	1.371	0.170510	
## Condition1RR Ne	2.394e-02	7.837e-02	0.305	0.760077	
## Condition1RR Nn	8.546e-02	5.481e-02	1.559	0.119156	
## KitchenQualFa	-5.620e-02	2.582e-02	-2.177	0.029690	*
## KitchenQualGd	-5.437e-02	1.439e-02	-3.779	0.000165	***
## KitchenQualTA	-5.434e-02	1.644e-02	-3.306	0.000973	***
## Fireplaces	2.164e-02	5.782e-03	3.743	0.000190	***
## Exterior1stAsphShn	3.372e-02	1.122e-01	0.301	0.763724	
## Exterior1stBrkComm	-1.500e-01	8.675e-02	-1.729	0.084059	.
## Exterior1stBrkFace	8.658e-02	3.098e-02	2.795	0.005271	**
## Exterior1stCBlock	-2.912e-02	1.110e-01	-0.262	0.793151	
## Exterior1stCemntBd	3.653e-02	3.249e-02	1.124	0.261090	
## Exterior1stHdBoard	4.786e-03	2.832e-02	0.169	0.865811	
## Exterior1stImStucc	1.779e-03	1.091e-01	0.016	0.986992	
## Exterior1stMetalSd	3.256e-02	2.735e-02	1.190	0.234082	

## Exterior1stPlywood	1.015e-02	2.972e-02	0.342	0.732706	
## Exterior1stStone	-1.733e-02	8.554e-02	-0.203	0.839534	
## Exterior1stStucco	4.550e-02	3.497e-02	1.301	0.193459	
## Exterior1stVinylSd	2.773e-02	2.759e-02	1.005	0.315019	
## Exterior1stWd Sdng	2.130e-03	2.740e-02	0.078	0.938050	
## Exterior1stWdShing	1.068e-02	3.421e-02	0.312	0.754861	
## HeatingGasA	1.306e-01	1.138e-01	1.147	0.251487	
## HeatingGasW	2.122e-01	1.171e-01	1.812	0.070189	.
## HeatingGrav	-2.092e-02	1.230e-01	-0.170	0.864987	
## HeatingOthW	1.733e-01	1.388e-01	1.248	0.212090	
## HeatingWall	1.888e-01	1.291e-01	1.462	0.143934	
## ScreenPorch	2.478e-04	5.473e-05	4.527	6.52e-06	***
## YearRemodAdd	7.768e-04	2.340e-04	3.319	0.000929	***
## BsmtQualEx	5.017e-02	1.753e-02	2.862	0.004274	**
## BsmtQualFa	1.652e-02	2.069e-02	0.799	0.424585	
## BsmtQualGd	7.765e-03	1.067e-02	0.728	0.466730	
## BsmtQualTA	NA	NA	NA	NA	
## PoolQCFa	-1.186e-01	1.182e-01	-1.003	0.316025	
## PoolQCGd	8.872e-02	1.413e-01	0.628	0.530171	
## PoolQCNone	9.036e-01	4.108e-01	2.200	0.027989	*
## FoundationCBlock	1.872e-02	1.369e-02	1.367	0.171852	
## FoundationPConc	3.742e-02	1.498e-02	2.497	0.012637	*
## FoundationSlab	-2.317e-03	4.301e-02	-0.054	0.957042	
## FoundationStone	1.037e-01	4.668e-02	2.222	0.026426	*
## FoundationWood	-1.163e-01	6.419e-02	-1.812	0.070191	.
## KitchenAbvGr	-5.693e-02	1.724e-02	-3.302	0.000985	***
## SaleTypeCon	4.102e-02	7.839e-02	0.523	0.600868	
## SaleTypeConLD	1.264e-01	4.199e-02	3.011	0.002654	**
## SaleTypeConLI	-3.210e-02	5.071e-02	-0.633	0.526833	
## SaleTypeConLw	1.291e-02	5.215e-02	0.248	0.804473	
## SaleTypeCWD	5.621e-02	5.681e-02	0.989	0.322668	
## SaleTypeNew	1.558e-01	6.784e-02	2.297	0.021787	*
## SaleTypeOth	5.535e-02	6.437e-02	0.860	0.390039	
## SaleTypeWD	-1.896e-02	1.830e-02	-1.036	0.300280	
## GarageArea	1.014e-04	3.410e-05	2.974	0.002993	**
## HeatingQCFa	-3.036e-02	2.005e-02	-1.514	0.130261	
## HeatingQCGd	-2.151e-02	9.049e-03	-2.377	0.017589	*
## HeatingQCPo	-4.834e-02	1.141e-01	-0.424	0.671941	
## HeatingQCTA	-3.692e-02	8.979e-03	-4.112	4.18e-05	***
## BsmtExposureAv	6.546e-02	1.039e-01	0.630	0.528649	
## BsmtExposureGd	1.043e-01	1.043e-01	1.000	0.317348	
## BsmtExposureMn	6.107e-02	1.041e-01	0.586	0.557645	
## BsmtExposureNo	5.632e-02	1.037e-01	0.543	0.587153	


```

## EnclosedPorch      1.198e-04  5.360e-05   2.236 0.025549 *
## WoodDeckSF         6.805e-05  2.572e-05   2.646 0.008240 **
## LotConfigCulDSac   1.137e-02  1.372e-02   0.829 0.407341
## LotConfigFR2       -4.420e-02  1.748e-02  -2.529 0.011562 *
## LotConfigFR3       -9.740e-02  5.591e-02  -1.742 0.081705 .
## LotConfigInside    -1.580e-02  7.682e-03  -2.057 0.039888 *
## StreetPave         1.106e-01  4.844e-02   2.284 0.022545 *
## BsmtFullBath       2.162e-02  8.120e-03   2.663 0.007845 **
## PoolArea           1.679e-03  7.539e-04   2.228 0.026072 *
## LandSlopeMod       1.755e-02  1.515e-02   1.158 0.247052
## LandSlopeSev      -7.623e-02  3.792e-02  -2.011 0.044573 *
## GarageCondFa       1.826e-01  1.443e-01   1.265 0.205988
## GarageCondGd       2.152e-01  1.480e-01   1.454 0.146055
## GarageCondNone     -7.047e-02  7.739e-02  -0.911 0.362683
## GarageCondPo       3.425e-01  1.551e-01   2.208 0.027399 *
## GarageCondTA       2.231e-01  1.426e-01   1.564 0.117963
## HalfBath           2.271e-02  8.330e-03   2.726 0.006496 **
## FullBath           1.935e-02  9.364e-03   2.066 0.039000 *
## TotRmsAbvGrd       6.493e-03  3.671e-03   1.769 0.077166 .
## `3SsnPorch`       1.477e-04  9.884e-05   1.494 0.135342
## ExterCondFa       -6.253e-02  7.903e-02  -0.791 0.429005
## ExterCondGd       -5.048e-02  7.515e-02  -0.672 0.501919
## ExterCondPo       -6.132e-02  1.365e-01  -0.449 0.653358
## ExterCondTA       -2.644e-02  7.504e-02  -0.352 0.724688
## GarageQualFa      -3.025e-01  1.229e-01  -2.461 0.013967 *
## GarageQualGd      -2.405e-01  1.255e-01  -1.916 0.055587 .
## GarageQualNone           NA           NA           NA           NA
## GarageQualPo      -3.614e-01  1.519e-01  -2.379 0.017502 *
## GarageQualTA      -2.645e-01  1.212e-01  -2.183 0.029243 *
## GarageYrBlt       -4.060e-04  2.587e-04  -1.569 0.116882
## UtilitiesNoSeWa   -1.608e-01  1.094e-01  -1.471 0.141567

```

```
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
```

```
## Residual standard error: 0.1028 on 1299 degrees of freedom
```

```
## Multiple R-squared:  0.941, Adjusted R-squared:  0.9337
```

```
## F-statistic: 129.5 on 160 and 1299 DF, p-value: < 2.2e-16
```

```
model2.Forward$anova
```

```
## Stepwise Model Path
```

```
## Analysis of Deviance Table
```

```
##
```

```
## Initial Model:
```

```

## log(SalePrice) ~ 1
##
## Final Model:
## log(SalePrice) ~ OverallQual + Neighborhood + GrLivArea + BsmtFinType1 +
##   GarageCars + OverallCond + RoofMatl + TotalBsmtSF + YearBuilt +
##   LotArea + Condition2 + MSZoning + BsmtUnfSF + SaleCondition +
##   Functional + CentralAir + Condition1 + KitchenQual + Fireplaces +
##   Exterior1st + Heating + ScreenPorch + YearRemodAdd + BsmtQual +
##   PoolQC + Foundation + KitchenAbvGr + SaleType + GarageArea +
##   HeatingQC + BsmtExposure + EnclosedPorch + WoodDeckSF + LotConfig +
##   Street + BsmtFullBath + PoolArea + LandSlope + GarageCond +
##   HalfBath + FullBath + TotRmsAbvGrd + `3SsnPorch` + ExterCond +
##   GarageQual + GarageYrBlt + Utilities
##
##
##           Step Df      Deviance Resid. Df Resid. Dev      AIC
## 1
## 2   + OverallQual  1 155.46203888      1458    77.33862 -4285.477
## 3   + Neighborhood 24  20.64653490      1434    56.69209 -4690.893
## 4     + GrLivArea  1  14.83069906      1433    41.86139 -5131.669
## 5   + BsmtFinType1  6   4.03327119      1427    37.82811 -5267.583
## 6     + GarageCars  1   3.26135246      1426    34.56676 -5397.217
## 7     + OverallCond  1   2.68083808      1425    31.88592 -5513.079
## 8       + RoofMatl  7   2.27800530      1418    29.60792 -5607.299
## 9     + TotalBsmtSF  1   2.90424457      1417    26.70367 -5756.030
## 10    + YearBuilt   1   1.54304245      1416    25.16063 -5840.930
## 11     + LotArea    1   1.79077988      1415    23.36985 -5946.728
## 12    + Condition2  7   1.46488205      1408    21.90497 -6027.238
## 13     + MSZoning   4   0.95147479      1404    20.95350 -6084.074
## 14     + BsmtUnfSF  1   0.67072280      1403    20.28277 -6129.573
## 15 + SaleCondition  5   0.84137276      1398    19.44140 -6181.429
## 16     + Functional  6   0.73550628      1392    18.70589 -6225.735
## 17     + CentralAir  1   0.46022681      1391    18.24567 -6260.106
## 18     + Condition1  8   0.53482973      1383    17.71084 -6287.542
## 19    + KitchenQual  3   0.37132218      1380    17.33951 -6312.477
## 20     + Fireplaces  1   0.26880260      1379    17.07071 -6333.288
## 21    + Exterior1st 14   0.54350008      1365    16.52721 -6352.528
## 22       + Heating   5   0.27522498      1360    16.25199 -6367.046
## 23    + ScreenPorch  1   0.15569020      1359    16.09630 -6379.100
## 24 + YearRemodAdd   1   0.15411911      1358    15.94218 -6391.146
## 25     + BsmtQual    3   0.18403447      1355    15.75814 -6402.098
## 26       + PoolQC    3   0.15215182      1352    15.60599 -6410.264
## 27    + Foundation   5   0.18551221      1347    15.42048 -6417.723

```

## 28	+ KitchenAbvGr	1	0.10252599	1346	15.31795	-6425.463
## 29	+ SaleType	8	0.24240360	1338	15.07555	-6432.752
## 30	+ GarageArea	1	0.09371674	1337	14.98183	-6439.856
## 31	+ HeatingQC	4	0.15007917	1333	14.83175	-6446.555
## 32	+ BsmtExposure	4	0.13705578	1329	14.69470	-6452.109
## 33	+ EnclosedPorch	1	0.06780557	1328	14.62689	-6456.862
## 34	+ WoodDeckSF	1	0.06736739	1327	14.55953	-6461.602
## 35	+ LotConfig	4	0.11722845	1323	14.44230	-6465.405
## 36	+ Street	1	0.05761598	1322	14.38468	-6469.241
## 37	+ BsmtFullBath	1	0.05359166	1321	14.33109	-6472.690
## 38	+ PoolArea	1	0.04846687	1320	14.28262	-6475.636
## 39	+ LandSlope	2	0.06762462	1318	14.21500	-6478.565
## 40	+ GarageCond	5	0.12893599	1313	14.08606	-6481.869
## 41	+ HalfBath	1	0.04484913	1312	14.04121	-6484.525
## 42	+ FullBath	1	0.04414227	1311	13.99707	-6487.122
## 43	+ TotRmsAbvGrd	1	0.02713930	1310	13.96993	-6487.955
## 44	+ `3SsnPorch`	1	0.02428567	1309	13.94565	-6488.496
## 45	+ ExterCond	4	0.07902859	1305	13.86662	-6488.793
## 46	+ GarageQual	4	0.08008028	1301	13.78654	-6489.249
## 47	+ GarageYrBlt	1	0.02479572	1300	13.76174	-6489.877
## 48	+ Utilities	1	0.02288193	1299	13.73886	-6490.307

```
final.Forward.Model <- lm(log(SalePrice) ~ OverallQual + Neighborhood + GrLivArea + BsmtFinType1 +
  GarageCars + OverallCond + RoofMatl + TotalBsmtSF + YearBuilt +
  LotArea + Condition2 + MSZoning + BsmtUnfSF + SaleCondition +
  Functional + CentralAir + Condition1 + KitchenQual + Fireplaces +
  Exterior1st + Heating + ScreenPorch + YearRemodAdd + BsmtQual +
  PoolQC + Foundation + KitchenAbvGr + SaleType + GarageArea +
  HeatingQC + BsmtExposure + EnclosedPorch + WoodDeckSF + LotConfig +
  Street + BsmtFullBath + PoolArea + LandSlope + GarageCond +
  HalfBath + FullBath + TotRmsAbvGrd + `3SsnPorch` + ExterCond +
  GarageQual + GarageYrBlt + Utilities, data = train2
)
```

Backward Elimination

Backward elimination is a variable selection methodology that begins with all possible predictor variables and works backward, eliminating variables using all possible combinations until only the best for the fit are provided. This employs the “F-to-remove” method from the extra-sum-of-squares F-statistic. For this process, we provided the test a model with all available predictor variables from which insignificant variables were eliminated. The output is as follows below.

```
##
## Call:
## lm(formula = log(SalePrice) ~ MSZoning + LotArea + Street + LotConfig +
```

```

## LandSlope + Neighborhood + Condition1 + Condition2 + OverallQual +
## OverallCond + YearBuilt + YearRemodAdd + RoofMatl + Exterior1st +
## ExterCond + Foundation + BsmtQual + BsmtExposure + BsmtFinSF1 +
## BsmtFinSF2 + BsmtUnfSF + Heating + HeatingQC + CentralAir +
## `1stFlrSF` + `2ndFlrSF` + LowQualFinSF + BsmtFullBath + FullBath +
## HalfBath + KitchenAbvGr + KitchenQual + TotRmsAbvGrd + Functional +
## Fireplaces + GarageCars + GarageArea + GarageQual + GarageCond +
## WoodDeckSF + EnclosedPorch + `3SsnPorch` + ScreenPorch +
## PoolArea + PoolQC + SaleType + SaleCondition, data = train2)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.73120 -0.04561  0.00172  0.05490  0.73120
##
## Coefficients: (1 not defined because of singularities)
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    4.266e-01  8.405e-01   0.508 0.611822
## MSZoningFV      4.232e-01  5.158e-02   8.205 5.48e-16 ***
## MSZoningRH      4.156e-01  5.135e-02   8.092 1.33e-15 ***
## MSZoningRL      4.046e-01  4.366e-02   9.267 < 2e-16 ***
## MSZoningRM      3.720e-01  4.087e-02   9.102 < 2e-16 ***
## LotArea        8.957e-02  9.910e-03   9.038 < 2e-16 ***
## StreetPave     1.092e-01  4.837e-02   2.257 0.024168 *
## LotConfigCulDSac 8.514e-03  1.366e-02   0.623 0.533289
## LotConfigFR2    -4.098e-02  1.747e-02  -2.346 0.019108 *
## LotConfigFR3    -9.211e-02  5.588e-02  -1.648 0.099509 .
## LotConfigInside -1.436e-02  7.645e-03  -1.878 0.060599 .
## LandSlopeMod     1.609e-02  1.517e-02   1.060 0.289200
## LandSlopeSev    -7.893e-02  3.793e-02  -2.081 0.037631 *
## NeighborhoodBlueste -1.262e-02  8.181e-02  -0.154 0.877419
## NeighborhoodBrDale -6.156e-02  4.393e-02  -1.401 0.161392
## NeighborhoodBrkSide 1.229e-02  3.675e-02   0.335 0.738051
## NeighborhoodClearCr -8.026e-03  3.819e-02  -0.210 0.833565
## NeighborhoodCollgCr -4.798e-02  2.940e-02  -1.632 0.102904
## NeighborhoodCrawfor 8.246e-02  3.486e-02   2.366 0.018151 *
## NeighborhoodEdwards -1.052e-01  3.244e-02  -3.242 0.001218 **
## NeighborhoodGilbert -5.301e-02  3.135e-02  -1.691 0.091071 .
## NeighborhoodIDOTRR -3.864e-02  4.270e-02  -0.905 0.365690
## NeighborhoodMeadowV -1.558e-01  4.615e-02  -3.376 0.000758 ***
## NeighborhoodMitchel -9.347e-02  3.359e-02  -2.782 0.005472 **
## NeighborhoodNames  -5.696e-02  3.145e-02  -1.811 0.070346 .
## NeighborhoodNoRidge 1.011e-02  3.435e-02   0.294 0.768597
## NeighborhoodNPkVill -3.641e-03  4.683e-02  -0.078 0.938041

```

## NeighborhoodNridgHt	3.511e-02	3.064e-02	1.146	0.252054	
## NeighborhoodNWAmes	-5.784e-02	3.292e-02	-1.757	0.079192	.
## NeighborhoodOldTown	-5.305e-02	3.751e-02	-1.414	0.157462	
## NeighborhoodSawyer	-5.567e-02	3.318e-02	-1.678	0.093665	.
## NeighborhoodSawyerW	-4.701e-02	3.243e-02	-1.450	0.147364	
## NeighborhoodSomerst	7.367e-03	3.683e-02	0.200	0.841496	
## NeighborhoodStoneBr	8.119e-02	3.514e-02	2.311	0.021015	*
## NeighborhoodSWISU	-1.314e-02	3.927e-02	-0.335	0.738011	
## NeighborhoodTimber	-4.081e-02	3.363e-02	-1.214	0.225115	
## NeighborhoodVeenker	-1.408e-02	4.534e-02	-0.311	0.756160	
## Condition1Feedr	4.537e-02	2.158e-02	2.103	0.035651	*
## Condition1Norm	8.266e-02	1.781e-02	4.640	3.83e-06	***
## Condition1PosA	4.460e-02	4.303e-02	1.036	0.300227	
## Condition1PosN	8.432e-02	3.194e-02	2.640	0.008387	**
## Condition1RR Ae	-4.973e-02	3.993e-02	-1.245	0.213264	
## Condition1RR An	3.845e-02	2.969e-02	1.295	0.195581	
## Condition1RR Ne	2.909e-02	7.831e-02	0.371	0.710405	
## Condition1RR Nn	8.423e-02	5.477e-02	1.538	0.124342	
## Condition2Feedr	6.606e-02	9.613e-02	0.687	0.492029	
## Condition2Norm	2.643e-02	8.243e-02	0.321	0.748548	
## Condition2PosA	2.720e-01	1.537e-01	1.769	0.077131	.
## Condition2PosN	-8.582e-01	1.170e-01	-7.334	3.92e-13	***
## Condition2RR Ae	-1.247e-01	1.347e-01	-0.926	0.354563	
## Condition2RR An	-9.775e-02	1.343e-01	-0.728	0.466739	
## Condition2RR Nn	-2.677e-02	1.143e-01	-0.234	0.814942	
## OverallQual	4.580e-02	4.226e-03	10.838	< 2e-16	***
## OverallCond	3.795e-02	3.678e-03	10.319	< 2e-16	***
## YearBuilt	2.027e-03	3.084e-04	6.574	7.05e-11	***
## YearRemodAdd	7.533e-04	2.328e-04	3.236	0.001242	**
## RoofMatlCompShg	2.588e+00	1.971e-01	13.133	< 2e-16	***
## RoofMatlMembran	2.815e+00	2.313e-01	12.172	< 2e-16	***
## RoofMatlMetal	2.664e+00	2.294e-01	11.611	< 2e-16	***
## RoofMatlRoll	2.643e+00	2.256e-01	11.718	< 2e-16	***
## RoofMatlTar&Grv	2.576e+00	2.029e-01	12.697	< 2e-16	***
## RoofMatlWdShake	2.608e+00	2.047e-01	12.739	< 2e-16	***
## RoofMatlWdShngl	2.619e+00	2.007e-01	13.049	< 2e-16	***
## Exterior1stAsphShn	2.942e-02	1.129e-01	0.261	0.794465	
## Exterior1stBrkComm	-1.445e-01	8.688e-02	-1.664	0.096402	.
## Exterior1stBrkFace	9.118e-02	3.097e-02	2.945	0.003292	**
## Exterior1stCBlock	-1.595e-02	1.107e-01	-0.144	0.885434	
## Exterior1stCemntBd	3.761e-02	3.241e-02	1.161	0.246001	
## Exterior1stHdBoard	8.831e-03	2.824e-02	0.313	0.754530	
## Exterior1stImStucc	1.300e-03	1.092e-01	0.012	0.990507	

## Exterior1stMetalSd	3.632e-02	2.737e-02	1.327	0.184723	
## Exterior1stPlywood	1.240e-02	2.968e-02	0.418	0.676177	
## Exterior1stStone	-2.733e-03	8.633e-02	-0.032	0.974753	
## Exterior1stStucco	4.735e-02	3.477e-02	1.362	0.173503	
## Exterior1stVinylSd	3.047e-02	2.761e-02	1.104	0.269907	
## Exterior1stWd Sdng	4.887e-03	2.736e-02	0.179	0.858277	
## Exterior1stWdShing	1.371e-02	3.417e-02	0.401	0.688369	
## ExterCondFa	-6.467e-02	7.898e-02	-0.819	0.413026	
## ExterCondGd	-5.206e-02	7.505e-02	-0.694	0.487999	
## ExterCondPo	-6.700e-02	1.369e-01	-0.489	0.624675	
## ExterCondTA	-2.915e-02	7.494e-02	-0.389	0.697347	
## FoundationCBBlock	1.752e-02	1.366e-02	1.282	0.200095	
## FoundationPConc	3.701e-02	1.497e-02	2.472	0.013555	*
## FoundationSlab	-2.874e-03	4.305e-02	-0.067	0.946783	
## FoundationStone	1.067e-01	4.661e-02	2.288	0.022287	*
## FoundationWood	-1.198e-01	6.406e-02	-1.870	0.061658	.
## BsmtQualEx	-2.908e-02	1.117e-01	-0.260	0.794559	
## BsmtQualFa	-6.214e-02	1.116e-01	-0.557	0.577654	
## BsmtQualGd	-6.800e-02	1.107e-01	-0.614	0.539034	
## BsmtQualTA	-7.552e-02	1.102e-01	-0.685	0.493427	
## BsmtExposureAv	7.904e-02	1.039e-01	0.760	0.447130	
## BsmtExposureGd	1.170e-01	1.044e-01	1.121	0.262442	
## BsmtExposureMn	7.427e-02	1.042e-01	0.713	0.476110	
## BsmtExposureNo	6.757e-02	1.038e-01	0.651	0.515072	
## BsmtFinSF1	1.557e-04	1.985e-05	7.845	9.00e-15	***
## BsmtFinSF2	1.206e-04	2.533e-05	4.763	2.12e-06	***
## BsmtUnfSF	8.636e-05	1.877e-05	4.602	4.60e-06	***
## HeatingGasA	1.307e-01	1.140e-01	1.147	0.251499	
## HeatingGasW	2.143e-01	1.171e-01	1.830	0.067509	.
## HeatingGrav	-2.660e-02	1.232e-01	-0.216	0.829129	
## HeatingOthW	1.609e-01	1.387e-01	1.160	0.246275	
## HeatingWall	1.894e-01	1.293e-01	1.464	0.143413	
## HeatingQCFA	-2.893e-02	2.005e-02	-1.443	0.149300	
## HeatingQCGd	-2.236e-02	9.056e-03	-2.469	0.013670	*
## HeatingQCPo	-4.023e-02	1.137e-01	-0.354	0.723556	
## HeatingQCTA	-3.656e-02	8.978e-03	-4.072	4.94e-05	***
## CentralAirY	6.087e-02	1.587e-02	3.835	0.000132	***
## `1stFlrSF`	2.238e-04	2.272e-05	9.850	< 2e-16	***
## `2ndFlrSF`	2.162e-04	1.685e-05	12.833	< 2e-16	***
## LowQualFinSF	1.297e-04	6.816e-05	1.902	0.057393	.
## BsmtFullBath	2.738e-02	7.869e-03	3.479	0.000520	***
## FullBath	1.824e-02	9.390e-03	1.943	0.052277	.
## HalfBath	2.186e-02	8.739e-03	2.501	0.012497	*

## KitchenAbvGr	-5.919e-02	1.726e-02	-3.428	0.000626	***
## KitchenQualFa	-5.581e-02	2.585e-02	-2.159	0.031019	*
## KitchenQualGd	-5.422e-02	1.441e-02	-3.762	0.000176	***
## KitchenQualTA	-5.442e-02	1.643e-02	-3.311	0.000954	***
## TotRmsAbvGrd	6.363e-03	3.677e-03	1.730	0.083815	.
## FunctionalMaj2	-2.252e-01	5.885e-02	-3.826	0.000137	***
## FunctionalMin1	4.374e-02	3.574e-02	1.224	0.221224	
## FunctionalMin2	4.267e-02	3.545e-02	1.204	0.228910	
## FunctionalMod	-5.044e-02	4.325e-02	-1.166	0.243773	
## FunctionalSev	-2.672e-01	1.174e-01	-2.277	0.022965	*
## FunctionalTyp	7.897e-02	3.060e-02	2.581	0.009962	**
## Fireplaces	2.138e-02	5.793e-03	3.691	0.000233	***
## GarageCars	2.013e-02	9.945e-03	2.024	0.043127	*
## GarageArea	8.607e-05	3.289e-05	2.617	0.008978	**
## GarageQualFa	-3.258e-01	1.274e-01	-2.557	0.010681	*
## GarageQualGd	-2.733e-01	1.307e-01	-2.091	0.036747	*
## GarageQualNone	-7.169e-02	7.735e-02	-0.927	0.354153	
## GarageQualPo	-3.830e-01	1.558e-01	-2.459	0.014073	*
## GarageQualTA	-2.944e-01	1.261e-01	-2.334	0.019758	*
## GarageCondFa	2.199e-01	1.488e-01	1.477	0.139890	
## GarageCondGd	2.534e-01	1.534e-01	1.653	0.098652	.
## GarageCondNone	NA	NA	NA	NA	
## GarageCondPo	3.811e-01	1.595e-01	2.389	0.017040	*
## GarageCondTA	2.579e-01	1.472e-01	1.753	0.079892	.
## WoodDeckSF	6.553e-05	2.561e-05	2.559	0.010601	*
## EnclosedPorch	1.192e-04	5.379e-05	2.217	0.026793	*
## `3SsnPorch`	1.523e-04	9.865e-05	1.544	0.122869	
## ScreenPorch	2.403e-04	5.450e-05	4.409	1.12e-05	***
## PoolArea	1.583e-03	7.561e-04	2.093	0.036509	*
## PoolQCFa	-1.379e-01	1.187e-01	-1.162	0.245592	
## PoolQCGd	7.035e-02	1.415e-01	0.497	0.619033	
## PoolQCNone	8.269e-01	4.132e-01	2.001	0.045570	*
## SaleTypeCon	4.728e-02	7.847e-02	0.603	0.546873	
## SaleTypeConLD	1.297e-01	4.196e-02	3.091	0.002037	**
## SaleTypeConLI	-3.534e-02	5.079e-02	-0.696	0.486647	
## SaleTypeConLw	2.282e-02	5.216e-02	0.438	0.661784	
## SaleTypeCWD	6.391e-02	5.687e-02	1.124	0.261366	
## SaleTypeNew	1.574e-01	6.784e-02	2.321	0.020462	*
## SaleTypeOth	5.663e-02	6.433e-02	0.880	0.378874	
## SaleTypeWD	-1.480e-02	1.822e-02	-0.812	0.416828	
## SaleConditionAdjLand	1.275e-01	5.783e-02	2.205	0.027595	*
## SaleConditionAlloca	3.651e-02	3.738e-02	0.977	0.328772	
## SaleConditionFamily	9.440e-03	2.690e-02	0.351	0.725671	

## 1				1207	12.84597	-6404.415
## 2	- GrLivArea	0	0.0000000000	1207	12.84597	-6404.415
## 3	- TotalBsmtSF	0	0.0000000000	1207	12.84597	-6404.415
## 4	- MiscFeature	4	0.0071184283	1211	12.85309	-6411.607
## 5	- BldgType	4	0.0090739655	1215	12.86217	-6418.576
## 6	- Exterior2nd	14	0.1907005136	1229	13.05287	-6425.088
## 7	- FireplaceQu	5	0.0330714087	1234	13.08594	-6431.394
## 8	- ExterQual	3	0.0058939959	1237	13.09183	-6436.737
## 9	- Electrical	4	0.0280797229	1241	13.11991	-6441.608
## 10	- BsmtFinType2	6	0.0660817875	1247	13.18599	-6446.273
## 11	- BsmtFinType1	5	0.0628798476	1252	13.24887	-6449.328
## 12	- RoofStyle	5	0.0646479063	1257	13.31352	-6452.221
## 13	- LotShape	3	0.0295479478	1260	13.34307	-6454.984
## 14	- GarageFinish	2	0.0105103125	1262	13.35358	-6457.834
## 15	- GarageType	5	0.0697782736	1267	13.42336	-6460.225
## 16	- MasVnrType	3	0.0309574363	1270	13.45432	-6462.862
## 17	- MiscVal	1	0.0001161084	1271	13.45443	-6464.849
## 18	- Alley	2	0.0187499370	1273	13.47318	-6466.816
## 19	- HouseStyle	7	0.1103233581	1280	13.58351	-6468.910
## 20	- Fence	4	0.0540626339	1284	13.63757	-6471.110
## 21	- BsmtCond	3	0.0340658341	1287	13.67163	-6473.468
## 22	- LotFrontage	1	0.0004633675	1288	13.67210	-6475.419
## 23	- BedroomAbvGr	1	0.0020604596	1289	13.67416	-6477.199
## 24	- YrSold	1	0.0026936553	1290	13.67685	-6478.911
## 25	- BsmtHalfBath	1	0.0031955268	1291	13.68005	-6480.570
## 26	- OpenPorchSF	1	0.0039191081	1292	13.68397	-6482.152
## 27	- MoSold	1	0.0036593326	1293	13.68763	-6483.761
## 28	- PavedDrive	2	0.0240231991	1295	13.71165	-6485.201
## 29	- Id	1	0.0064771694	1296	13.71813	-6486.512
## 30	- MSSubClass	1	0.0110326193	1297	13.72916	-6487.338
## 31	- MasVnrArea	1	0.0122577100	1298	13.74142	-6488.035
## 32	- LandContour	3	0.0519387656	1301	13.79336	-6488.527
## 33	- Utilities	1	0.0144669027	1302	13.80782	-6488.996
## 34	- GarageYrBlt	1	0.0168317755	1303	13.82465	-6489.218

Stepwise Regression

Stepwise regression is a variable selection methodology that performs one step of forward selection for each step of backward elimination. The steps are repeated, concurrently, until no further predictor variables can be added or removed. This is the third model approach we used. The suggested model is output below.

```
##
## Call:
## lm(formula = log(SalePrice) ~ OverallQual + Neighborhood + GrLivArea +
##      GarageCars + OverallCond + RoofMatl + TotalBsmtSF + YearBuilt +
```

```

##      LotArea + Condition2 + MSZoning + BsmtUnfSF + SaleCondition +
##      Functional + CentralAir + Condition1 + KitchenQual + Fireplaces +
##      Exterior1st + Heating + ScreenPorch + YearRemodAdd + BsmtQual +
##      PoolQC + Foundation + KitchenAbvGr + SaleType + GarageArea +
##      HeatingQC + BsmtExposure + EnclosedPorch + WoodDeckSF + LotConfig +
##      Street + BsmtFullBath + PoolArea + LandSlope + GarageCond +
##      HalfBath + FullBath + BsmtFinSF1 + TotRmsAbvGrd + `3SsnPorch` +
##      LandContour, data = train2)
##
## Residuals:
##      Min        1Q    Median        3Q        Max
## -0.71707 -0.04587  0.00185  0.05454  0.71707
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.628e-01  8.307e-01   0.316  0.751757
## OverallQual       4.637e-02  4.227e-03  10.969 < 2e-16 ***
## NeighborhoodBlueste -2.465e-02  8.165e-02  -0.302  0.762785
## NeighborhoodBrDale  -6.171e-02  4.379e-02  -1.409  0.159041
## NeighborhoodBrkSide   6.700e-03  3.647e-02   0.184  0.854280
## NeighborhoodClearCr  -8.921e-03  3.795e-02  -0.235  0.814179
## NeighborhoodCollgCr  -5.029e-02  2.928e-02  -1.717  0.086143 .
## NeighborhoodCrawfor   6.945e-02  3.517e-02   1.975  0.048484 *
## NeighborhoodEdwards  -1.073e-01  3.234e-02  -3.317  0.000936 ***
## NeighborhoodGilbert  -5.637e-02  3.129e-02  -1.801  0.071875 .
## NeighborhoodIDOTRR   -4.823e-02  4.256e-02  -1.133  0.257396
## NeighborhoodMeadowV  -1.566e-01  4.609e-02  -3.398  0.000700 ***
## NeighborhoodMitchel  -9.832e-02  3.345e-02  -2.939  0.003350 **
## NeighborhoodNames    -6.297e-02  3.150e-02  -1.999  0.045854 *
## NeighborhoodNoRidge   5.874e-03  3.410e-02   0.172  0.863265
## NeighborhoodNPkVill  -5.852e-03  4.680e-02  -0.125  0.900505
## NeighborhoodNridgHt   3.175e-02  3.050e-02   1.041  0.298177
## NeighborhoodNWAmes   -6.507e-02  3.294e-02  -1.975  0.048435 *
## NeighborhoodOldTown  -5.963e-02  3.740e-02  -1.595  0.111041
## NeighborhoodSawyer   -6.145e-02  3.321e-02  -1.850  0.064491 .
## NeighborhoodSawyerW  -4.722e-02  3.236e-02  -1.459  0.144711
## NeighborhoodSomerst   2.308e-03  3.681e-02   0.063  0.950024
## NeighborhoodStoneBr   7.817e-02  3.529e-02   2.215  0.026911 *
## NeighborhoodSWISU    -1.710e-02  3.921e-02  -0.436  0.662860
## NeighborhoodTimber    -4.740e-02  3.398e-02  -1.395  0.163222
## NeighborhoodVeenker  -2.386e-02  4.528e-02  -0.527  0.598316
## GrLivArea         2.169e-04  1.607e-05  13.499 < 2e-16 ***
## GarageCars         2.234e-02  9.923e-03   2.251  0.024556 *

```

## OverallCond	3.802e-02	3.528e-03	10.775	< 2e-16	***
## RoofMatlCompShg	2.545e+00	1.974e-01	12.897	< 2e-16	***
## RoofMatlMembran	2.796e+00	2.315e-01	12.081	< 2e-16	***
## RoofMatlMetal	2.634e+00	2.298e-01	11.459	< 2e-16	***
## RoofMatlRoll	2.624e+00	2.255e-01	11.637	< 2e-16	***
## RoofMatlTar&Grv	2.534e+00	2.030e-01	12.481	< 2e-16	***
## RoofMatlWdShake	2.566e+00	2.047e-01	12.540	< 2e-16	***
## RoofMatlWdShngl	2.626e+00	2.005e-01	13.094	< 2e-16	***
## TotalBsmtSF	1.264e-04	2.166e-05	5.836	6.74e-09	***
## YearBuilt	2.063e-03	3.066e-04	6.728	2.56e-11	***
## LotArea	9.191e-02	9.973e-03	9.215	< 2e-16	***
## Condition2Feedr	4.557e-02	9.422e-02	0.484	0.628716	
## Condition2Norm	1.326e-02	8.074e-02	0.164	0.869596	
## Condition2PosA	3.137e-01	1.351e-01	2.322	0.020378	*
## Condition2PosN	-8.621e-01	1.154e-01	-7.471	1.44e-13	***
## Condition2RRAE	-1.362e-01	1.337e-01	-1.018	0.308692	
## Condition2RRAN	-1.054e-01	1.333e-01	-0.791	0.429086	
## Condition2RRNN	-6.525e-02	1.135e-01	-0.575	0.565507	
## MSZoningFV	4.235e-01	5.188e-02	8.162	7.64e-16	***
## MSZoningRH	4.134e-01	5.173e-02	7.990	2.93e-15	***
## MSZoningRL	4.022e-01	4.401e-02	9.139	< 2e-16	***
## MSZoningRM	3.694e-01	4.113e-02	8.982	< 2e-16	***
## BsmtUnfSF	-3.551e-05	2.021e-05	-1.757	0.079124	.
## SaleConditionAdjLand	1.198e-01	5.765e-02	2.078	0.037943	*
## SaleConditionAlloca	3.942e-02	3.767e-02	1.046	0.295553	
## SaleConditionFamily	6.711e-03	2.696e-02	0.249	0.803487	
## SaleConditionNormal	7.036e-02	1.265e-02	5.561	3.25e-08	***
## SaleConditionPartial	-4.825e-02	6.557e-02	-0.736	0.461915	
## FunctionalMaj2	-2.377e-01	5.797e-02	-4.100	4.38e-05	***
## FunctionalMin1	4.812e-02	3.561e-02	1.352	0.176764	
## FunctionalMin2	4.509e-02	3.522e-02	1.280	0.200704	
## FunctionalMod	-6.051e-02	4.225e-02	-1.432	0.152286	
## FunctionalSev	-2.881e-01	1.172e-01	-2.458	0.014100	*
## FunctionalTyp	7.996e-02	3.033e-02	2.636	0.008482	**
## CentralAirY	5.903e-02	1.581e-02	3.734	0.000196	***
## Condition1Feedr	3.994e-02	2.141e-02	1.866	0.062287	.
## Condition1Norm	8.078e-02	1.761e-02	4.588	4.91e-06	***
## Condition1PosA	4.221e-02	4.274e-02	0.987	0.323595	
## Condition1PosN	8.479e-02	3.173e-02	2.672	0.007636	**
## Condition1RRAE	-5.594e-02	3.992e-02	-1.401	0.161322	
## Condition1RRAN	4.035e-02	2.955e-02	1.366	0.172313	
## Condition1RRNE	2.782e-02	7.838e-02	0.355	0.722736	
## Condition1RRNN	9.338e-02	5.484e-02	1.703	0.088835	.

## KitchenQualFa	-5.884e-02	2.563e-02	-2.295	0.021878	*
## KitchenQualGd	-5.425e-02	1.434e-02	-3.783	0.000162	***
## KitchenQualTA	-5.542e-02	1.636e-02	-3.388	0.000725	***
## Fireplaces	2.301e-02	5.734e-03	4.013	6.32e-05	***
## Exterior1stAsphShn	2.427e-02	1.125e-01	0.216	0.829181	
## Exterior1stBrkComm	-1.476e-01	8.588e-02	-1.719	0.085839	.
## Exterior1stBrkFace	9.226e-02	3.100e-02	2.976	0.002971	**
## Exterior1stCBlock	-7.147e-03	1.107e-01	-0.065	0.948547	
## Exterior1stCemntBd	3.946e-02	3.240e-02	1.218	0.223470	
## Exterior1stHdBoard	1.009e-02	2.820e-02	0.358	0.720593	
## Exterior1stImStucc	3.089e-04	1.093e-01	0.003	0.997746	
## Exterior1stMetalSd	3.739e-02	2.735e-02	1.367	0.171865	
## Exterior1stPlywood	1.277e-02	2.969e-02	0.430	0.667113	
## Exterior1stStone	6.297e-03	8.555e-02	0.074	0.941337	
## Exterior1stStucco	4.070e-02	3.450e-02	1.180	0.238335	
## Exterior1stVinylSd	3.115e-02	2.753e-02	1.132	0.258031	
## Exterior1stWd Sdng	8.055e-03	2.739e-02	0.294	0.768739	
## Exterior1stWdShing	1.778e-02	3.418e-02	0.520	0.603060	
## HeatingGasA	1.127e-01	1.137e-01	0.992	0.321602	
## HeatingGasW	1.954e-01	1.167e-01	1.674	0.094313	.
## HeatingGrav	-5.024e-02	1.230e-01	-0.408	0.682993	
## HeatingOthW	1.192e-01	1.382e-01	0.862	0.388672	
## HeatingWall	1.765e-01	1.291e-01	1.367	0.171888	
## ScreenPorch	2.541e-04	5.369e-05	4.734	2.44e-06	***
## YearRemodAdd	7.722e-04	2.306e-04	3.349	0.000833	***
## BsmtQualEx	-4.385e-02	1.109e-01	-0.396	0.692489	
## BsmtQualFa	-7.601e-02	1.109e-01	-0.685	0.493211	
## BsmtQualGd	-8.122e-02	1.098e-01	-0.740	0.459607	
## BsmtQualTA	-8.766e-02	1.094e-01	-0.801	0.423203	
## PoolQCFa	-1.172e-01	1.181e-01	-0.993	0.321097	
## PoolQCGd	8.973e-02	1.413e-01	0.635	0.525401	
## PoolQCNone	8.888e-01	4.096e-01	2.170	0.030201	*
## FoundationCBlock	2.000e-02	1.356e-02	1.474	0.140696	
## FoundationPConc	3.890e-02	1.482e-02	2.624	0.008796	**
## FoundationSlab	-8.396e-03	4.292e-02	-0.196	0.844928	
## FoundationStone	9.513e-02	4.570e-02	2.082	0.037570	*
## FoundationWood	-1.108e-01	6.433e-02	-1.722	0.085350	.
## KitchenAbvGr	-5.446e-02	1.725e-02	-3.156	0.001635	**
## SaleTypeCon	5.404e-02	7.851e-02	0.688	0.491375	
## SaleTypeConLD	1.292e-01	4.152e-02	3.113	0.001892	**
## SaleTypeConLI	-3.118e-02	5.069e-02	-0.615	0.538650	
## SaleTypeConLw	2.957e-02	5.213e-02	0.567	0.570658	
## SaleTypeCWD	6.911e-02	5.694e-02	1.214	0.225061	

```

## SaleTypeNew      1.504e-01  6.792e-02  2.214 0.027004 *
## SaleTypeOth      6.342e-02  6.436e-02  0.985 0.324670
## SaleTypeWD       -1.282e-02  1.813e-02 -0.707 0.479555
## GarageArea       8.816e-05  3.280e-05  2.687 0.007291 **
## HeatingQCFa      -2.500e-02  2.009e-02 -1.244 0.213590
## HeatingQCGd      -2.231e-02  9.037e-03 -2.469 0.013680 *
## HeatingQCPo      -3.208e-02  1.139e-01 -0.282 0.778255
## HeatingQCTA      -3.356e-02  8.943e-03 -3.752 0.000183 ***
## BsmtExposureAv    8.136e-02  1.041e-01  0.782 0.434479
## BsmtExposureGd    1.167e-01  1.045e-01  1.117 0.264225
## BsmtExposureMn    7.635e-02  1.043e-01  0.732 0.464419
## BsmtExposureNo    6.941e-02  1.039e-01  0.668 0.504291
## EnclosedPorch     1.334e-04  5.358e-05  2.489 0.012928 *
## WoodDeckSF        5.686e-05  2.553e-05  2.227 0.026095 *
## LotConfigCulDSac  1.019e-02  1.367e-02  0.745 0.456363
## LotConfigFR2     -3.814e-02  1.747e-02 -2.183 0.029218 *
## LotConfigFR3     -8.344e-02  5.585e-02 -1.494 0.135386
## LotConfigInside   -1.146e-02  7.623e-03 -1.504 0.132870
## StreetPave        1.101e-01  4.836e-02  2.277 0.022944 *
## BsmtFullBath      2.550e-02  7.871e-03  3.240 0.001227 **
## PoolArea          1.648e-03  7.516e-04  2.192 0.028562 *
## LandSlopeMod       2.918e-02  1.702e-02  1.714 0.086763 .
## LandSlopeSev      -5.733e-02  3.955e-02 -1.450 0.147387
## GarageCondFa      -9.532e-02  7.822e-02 -1.219 0.223224
## GarageCondGd      -4.292e-02  8.396e-02 -0.511 0.609282
## GarageCondNone    -7.425e-02  7.731e-02 -0.960 0.337030
## GarageCondPo       2.708e-02  8.779e-02  0.309 0.757742
## GarageCondTA      -4.153e-02  7.539e-02 -0.551 0.581872
## HalfBath          2.145e-02  8.286e-03  2.588 0.009753 **
## FullBath           1.612e-02  9.349e-03  1.725 0.084813 .
## BsmtFinSF1        3.491e-05  1.953e-05  1.788 0.074073 .
## TotRmsAbvGrd      6.244e-03  3.677e-03  1.698 0.089716 .
## `3SsnPorch`       1.582e-04  9.861e-05  1.604 0.108984
## LandContourHLS     3.537e-02  2.222e-02  1.592 0.111598
## LandContourLow    -1.354e-02  2.691e-02 -0.503 0.614883
## LandContourLvl     2.458e-02  1.580e-02  1.555 0.120089
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1032 on 1310 degrees of freedom
## Multiple R-squared:  0.9401, Adjusted R-squared:  0.9333
## F-statistic: 138 on 149 and 1310 DF, p-value: < 2.2e-16
## Stepwise Model Path

```

```

## Analysis of Deviance Table
##
## Initial Model:
## log(SalePrice) ~ 1
##
## Final Model:
## log(SalePrice) ~ OverallQual + Neighborhood + GrLivArea + GarageCars +
## OverallCond + RoofMatl + TotalBsmtSF + YearBuilt + LotArea +
## Condition2 + MSZoning + BsmtUnfSF + SaleCondition + Functional +
## CentralAir + Condition1 + KitchenQual + Fireplaces + Exterior1st +
## Heating + ScreenPorch + YearRemodAdd + BsmtQual + PoolQC +
## Foundation + KitchenAbvGr + SaleType + GarageArea + HeatingQC +
## BsmtExposure + EnclosedPorch + WoodDeckSF + LotConfig + Street +
## BsmtFullBath + PoolArea + LandSlope + GarageCond + HalfBath +
## FullBath + BsmtFinSF1 + TotRmsAbvGrd + `3SsnPorch` + LandContour
##
##
##           Step Df      Deviance Resid. Df Resid. Dev      AIC
## 1
## 2   + OverallQual  1 155.46203888      1458    77.33862 -4285.477
## 3   + Neighborhood 24  20.64653490      1434    56.69209 -4690.893
## 4     + GrLivArea  1  14.83069906      1433    41.86139 -5131.669
## 5   + BsmtFinType1  6   4.03327119      1427    37.82811 -5267.583
## 6     + GarageCars  1   3.26135246      1426    34.56676 -5397.217
## 7   + OverallCond  1   2.68083808      1425    31.88592 -5513.079
## 8     + RoofMatl   7   2.27800530      1418    29.60792 -5607.299
## 9   + TotalBsmtSF  1   2.90424457      1417    26.70367 -5756.030
## 10    + YearBuilt  1   1.54304245      1416    25.16063 -5840.930
## 11     + LotArea   1   1.79077988      1415    23.36985 -5946.728
## 12    + Condition2  7   1.46488205      1408    21.90497 -6027.238
## 13     + MSZoning  4   0.95147479      1404    20.95350 -6084.074
## 14     + BsmtUnfSF  1   0.67072280      1403    20.28277 -6129.573
## 15 + SaleCondition  5   0.84137276      1398    19.44140 -6181.429
## 16     + Functional  6   0.73550628      1392    18.70589 -6225.735
## 17     + CentralAir  1   0.46022681      1391    18.24567 -6260.106
## 18     + Condition1  8   0.53482973      1383    17.71084 -6287.542
## 19    + KitchenQual  3   0.37132218      1380    17.33951 -6312.477
## 20     + Fireplaces  1   0.26880260      1379    17.07071 -6333.288
## 21    + Exterior1st 14   0.54350008      1365    16.52721 -6352.528
## 22       + Heating  5   0.27522498      1360    16.25199 -6367.046
## 23    + ScreenPorch  1   0.15569020      1359    16.09630 -6379.100
## 24   + YearRemodAdd  1   0.15411911      1358    15.94218 -6391.146
## 25     + BsmtQual   3   0.18403447      1355    15.75814 -6402.098

```

## 26	+ PoolQC	3	0.15215182	1352	15.60599	-6410.264
## 27	+ Foundation	5	0.18551221	1347	15.42048	-6417.723
## 28	+ KitchenAbvGr	1	0.10252599	1346	15.31795	-6425.463
## 29	+ SaleType	8	0.24240360	1338	15.07555	-6432.752
## 30	+ GarageArea	1	0.09371674	1337	14.98183	-6439.856
## 31	+ HeatingQC	4	0.15007917	1333	14.83175	-6446.555
## 32	+ BsmtExposure	4	0.13705578	1329	14.69470	-6452.109
## 33	+ EnclosedPorch	1	0.06780557	1328	14.62689	-6456.862
## 34	+ WoodDeckSF	1	0.06736739	1327	14.55953	-6461.602
## 35	+ LotConfig	4	0.11722845	1323	14.44230	-6465.405
## 36	+ Street	1	0.05761598	1322	14.38468	-6469.241
## 37	+ BsmtFullBath	1	0.05359166	1321	14.33109	-6472.690
## 38	+ PoolArea	1	0.04846687	1320	14.28262	-6475.636
## 39	+ LandSlope	2	0.06762462	1318	14.21500	-6478.565
## 40	+ GarageCond	5	0.12893599	1313	14.08606	-6481.869
## 41	+ HalfBath	1	0.04484913	1312	14.04121	-6484.525
## 42	+ FullBath	1	0.04414227	1311	13.99707	-6487.122
## 43	- BsmtFinType1	5	0.08686145	1316	14.08393	-6488.089
## 44	+ BsmtFinSF1	1	0.03205070	1315	14.05188	-6489.416
## 45	+ TotRmsAbvGrd	1	0.02637498	1314	14.02551	-6490.159
## 46	+ `3SsnPorch`	1	0.02698569	1313	13.99852	-6490.971
## 47	+ LandContour	3	0.05866738	1310	13.93985	-6491.102

Custom Variable Selection

To develop the custom model, we employed a combination of a correlation matrix for quantitative data, analysis of the summarization of the suggested model from stepwise selection, and through direct analysis of the pairs plots. As previously mentioned, our final model included 11 linear terms and three interaction terms. We removed all variables suggested to be removed by the stepwise regression and backward elimination tests, then reprocessed the updated models until forward selection, backward elimination, and stepwise regression were in agreeance with respect to the linear terms. Once this trial-and-error process was completed, we added interaction terms based on domain knowledge and re-applied the forward selection, backward elimination, and stepwise regression methods until only significant terms - both linear and interactive - remained. We then used graphical analysis to visually confirm interaction between the interactive terms remaining.

##	row	column	cor	p
## 378	GarageCars	GarageArea	0.8824754143	0.000000e+00
## 270	GrLivArea	TotRmsAbvGrd	0.8254893743	0.000000e+00
## 91	TotalBsmtSF	X1stFlrSF	0.8195299750	0.000000e+00
## 307	YearBuilt	GarageYrBltd	0.7946235492	0.000000e+00
## 671	OverallQual	SalePrice	0.7909816006	0.000000e+00
## 683	GrLivArea	SalePrice	0.7086244776	0.000000e+00
## 135	X2ndFlrSF	GrLivArea	0.6875010642	0.000000e+00
## 275	BedroomAbvGr	TotRmsAbvGrd	0.6766199357	0.000000e+00
## 146	BsmtFinSF1	BsmtFullBath	0.6492117536	0.000000e+00

## 693	GarageCars	SalePrice	0.6404091973	0.000000e+00
## 188	GrLivArea	FullBath	0.6300116463	0.000000e+00
## 308	YearRemodAdd	GarageYrBltd	0.6245045510	0.000000e+00
## 694	GarageArea	SalePrice	0.6234314389	0.000000e+00
## 268	X2ndFlrSF	TotRmsAbvGrd	0.6164226355	0.000000e+00
## 679	TotalBsmtSF	SalePrice	0.6135805516	0.000000e+00
## 205	X2ndFlrSF	HalfBath	0.6097073003	0.000000e+00
## 680	X1stFlrSF	SalePrice	0.6058521847	0.000000e+00
## 330	OverallQual	GarageCars	0.6006707166	0.000000e+00
## 125	OverallQual	GrLivArea	0.5930074300	0.000000e+00
## 28	YearBuilt	YearRemodAdd	0.5928549763	0.000000e+00
## 20	OverallQual	YearBuilt	0.5723227690	0.000000e+00
## 134	X1stFlrSF	GrLivArea	0.5660239689	0.000000e+00
## 356	OverallQual	GarageArea	0.5620217566	0.000000e+00
## 686	FullBath	SalePrice	0.5606637627	0.000000e+00
## 273	FullBath	TotRmsAbvGrd	0.5547842535	0.000000e+00
## 26	OverallQual	YearRemodAdd	0.5506839242	0.000000e+00
## 176	OverallQual	FullBath	0.5505997094	0.000000e+00
## 332	YearBuilt	GarageCars	0.5378500917	0.000000e+00
## 71	OverallQual	TotalBsmtSF	0.5378084986	0.000000e+00
## 305	OverallQual	GarageYrBltd	0.5348401548	0.000000e+00
## 690	TotRmsAbvGrd	SalePrice	0.5337231556	0.000000e+00
## 673	YearBuilt	SalePrice	0.5228973329	0.000000e+00
## 76	BsmtFinSF1	TotalBsmtSF	0.5223960520	0.000000e+00
## 227	GrLivArea	BedroomAbvGr	0.5212695109	0.000000e+00
## 351	GarageYrBltd	GarageCars	0.5208950873	0.000000e+00
## 377	GarageYrBltd	GarageArea	0.5123267593	0.000000e+00
## 674	YearRemodAdd	SalePrice	0.5071009671	0.000000e+00
## 225	X2ndFlrSF	BedroomAbvGr	0.5029006133	0.000000e+00
## 365	X1stFlrSF	GarageArea	0.4897816541	0.000000e+00
## 364	TotalBsmtSF	GarageArea	0.4866654638	0.000000e+00
## 692	GarageYrBltd	SalePrice	0.4853808733	0.000000e+00
## 358	YearBuilt	GarageArea	0.4789538199	0.000000e+00
## 83	OverallQual	X1stFlrSF	0.4762238291	0.000000e+00
## 320	FullBath	GarageYrBltd	0.4751286638	0.000000e+00
## 675	MasVnrArea	SalePrice	0.4726144990	0.000000e+00
## 345	FullBath	GarageCars	0.4696720433	0.000000e+00
## 368	GrLivArea	GarageArea	0.4689974773	0.000000e+00
## 178	YearBuilt	FullBath	0.4682707872	0.000000e+00
## 342	GrLivArea	GarageCars	0.4672474188	0.000000e+00
## 691	Fireplaces	SalePrice	0.4669288368	0.000000e+00
## 293	GrLivArea	Fireplaces	0.4616791338	0.000000e+00
## 133	TotalBsmtSF	GrLivArea	0.4548682025	0.000000e+00

## 88	BsmtFinSF1	X1stFlrSF	0.4458626561	0.000000e+00
## 82	LotArea	X1stFlrSF	0.4438691242	0.000000e+00
## 339	X1stFlrSF	GarageCars	0.4393168080	0.000000e+00
## 179	YearRemodAdd	FullBath	0.4390464839	0.000000e+00
## 338	TotalBsmtSF	GarageCars	0.4345848343	0.000000e+00
## 258	OverallQual	TotRmsAbvGrd	0.4274523433	0.000000e+00
## 186	X2ndFlrSF	FullBath	0.4213779829	0.000000e+00
## 333	YearRemodAdd	GarageCars	0.4206221549	0.000000e+00
## 207	GrLivArea	HalfBath	0.4157716361	0.000000e+00
## 78	BsmtUnfSF	TotalBsmtSF	0.4153596052	0.000000e+00
## 290	X1stFlrSF	Fireplaces	0.4105310847	0.000000e+00
## 267	X1stFlrSF	TotRmsAbvGrd	0.4095159789	0.000000e+00
## 33	OverallQual	MasVnrArea	0.4072521235	0.000000e+00
## 371	FullBath	GarageArea	0.4056562085	0.000000e+00
## 281	OverallQual	Fireplaces	0.3967650380	0.000000e+00
## 124	LotArea	GrLivArea	0.3945774471	0.000000e+00
## 73	YearBuilt	TotalBsmtSF	0.3914520021	0.000000e+00
## 670	LotArea	SalePrice	0.3885202679	0.000000e+00
## 129	MasVnrArea	GrLivArea	0.3880520522	0.000000e+00
## 676	BsmtFinSF1	SalePrice	0.3864198062	0.000000e+00
## 185	X1stFlrSF	FullBath	0.3806374950	0.000000e+00
## 359	YearRemodAdd	GarageArea	0.3715998095	0.000000e+00
## 360	MasVnrArea	GarageArea	0.3708841528	0.000000e+00
## 230	FullBath	BedroomAbvGr	0.3632519830	0.000000e+00
## 349	TotRmsAbvGrd	GarageCars	0.3622885708	0.000000e+00
## 334	MasVnrArea	GarageCars	0.3619445662	0.000000e+00
## 257	LotArea	TotRmsAbvGrd	0.3601291441	0.000000e+00
## 75	MasVnrArea	TotalBsmtSF	0.3600673681	0.000000e+00
## 70	LotArea	TotalBsmtSF	0.3518380024	0.000000e+00
## 274	HalfBath	TotRmsAbvGrd	0.3434148575	0.000000e+00
## 87	MasVnrArea	X1stFlrSF	0.3398504137	0.000000e+00
## 289	TotalBsmtSF	Fireplaces	0.3395193239	0.000000e+00
## 375	TotRmsAbvGrd	GarageArea	0.3378221206	0.000000e+00
## 423	GrLivArea	OpenPorchSF	0.3302239617	0.000000e+00
## 280	LotArea	Fireplaces	0.3277536789	0.000000e+00
## 300	TotRmsAbvGrd	Fireplaces	0.3261144802	0.000000e+00
## 695	WoodDeckSF	SalePrice	0.3244134446	0.000000e+00
## 184	TotalBsmtSF	FullBath	0.3237224136	0.000000e+00
## 355	LotArea	GarageArea	0.3220454756	0.000000e+00
## 313	TotalBsmtSF	GarageYrBltd	0.3219920228	0.000000e+00
## 681	X2ndFlrSF	SalePrice	0.3193338028	0.000000e+00
## 90	BsmtUnfSF	X1stFlrSF	0.3179874384	0.000000e+00
## 696	OpenPorchSF	SalePrice	0.3158562271	0.000000e+00

## 35	YearBuilt	MasVnrArea	0.3116001068	0.000000e+00
## 411	OverallQual	OpenPorchSF	0.3088188234	0.000000e+00
## 60	OverallQual	BsmtUnfSF	0.3081589269	0.000000e+00
## 93	MSSubClass	X2ndFlrSF	0.3078857208	0.000000e+00
## 149	TotalBsmtSF	BsmtFullBath	0.3073505537	0.000000e+00
## 350	Fireplaces	GarageCars	0.3007887663	0.000000e+00
## 361	BsmtFinSF1	GarageArea	0.2969703853	0.000000e+00
## 96	OverallQual	X2ndFlrSF	0.2954928792	0.000000e+00
## 74	YearRemodAdd	TotalBsmtSF	0.2910655826	0.000000e+00
## 183	BsmtUnfSF	FullBath	0.2888860555	0.000000e+00
## 128	YearRemodAdd	GrLivArea	0.2873885197	0.000000e+00
## 266	TotalBsmtSF	TotRmsAbvGrd	0.2855725637	0.000000e+00
## 687	HalfBath	SalePrice	0.2841076756	0.000000e+00
## 85	YearBuilt	X1stFlrSF	0.2819858587	0.000000e+00
## 233	MSSubClass	KitchenAbvGr	0.2817210403	0.000000e+00
## 262	MasVnrArea	TotRmsAbvGrd	0.2795678875	0.000000e+00
## 214	LotArea	BedroomAbvGr	0.2791763555	0.000000e+00
## 195	OverallQual	HalfBath	0.2734580986	0.000000e+00
## 180	MasVnrArea	FullBath	0.2729988557	0.000000e+00
## 329	LotArea	GarageCars	0.2720069723	0.000000e+00
## 376	Fireplaces	GarageArea	0.2691412381	0.000000e+00
## 6	LotFrontage	LotArea	0.2620210123	0.000000e+00
## 45	MasVnrArea	BsmtFinSF1	0.2612560549	0.000000e+00
## 286	BsmtFinSF1	Fireplaces	0.2600109202	0.000000e+00
## 426	FullBath	OpenPorchSF	0.2599774255	0.000000e+00
## 276	KitchenAbvGr	TotRmsAbvGrd	0.2560454085	0.000000e+00
## 309	MasVnrArea	GarageYrBlt	0.2538513431	0.000000e+00
## 265	BsmtUnfSF	TotRmsAbvGrd	0.2506470614	0.000000e+00
## 43	YearBuilt	BsmtFinSF1	0.2495031967	0.000000e+00
## 395	GrLivArea	WoodDeckSF	0.2474328205	0.000000e+00
## 419	TotalBsmtSF	OpenPorchSF	0.2472637463	0.000000e+00
## 285	MasVnrArea	Fireplaces	0.2470152774	0.000000e+00
## 81	LotFrontage	X1stFlrSF	0.2451809314	0.000000e+00
## 150	X1stFlrSF	BsmtFullBath	0.2446711042	0.000000e+00
## 296	FullBath	Fireplaces	0.2436705031	0.000000e+00
## 197	YearBuilt	HalfBath	0.2426559102	0.000000e+00
## 434	GarageArea	OpenPorchSF	0.2414346721	0.000000e+00
## 86	YearRemodAdd	X1stFlrSF	0.2403792676	0.000000e+00
## 132	BsmtUnfSF	GrLivArea	0.2402572683	0.000000e+00
## 41	OverallQual	BsmtFinSF1	0.2396659662	0.000000e+00
## 383	OverallQual	WoodDeckSF	0.2389233922	0.000000e+00
## 69	LotFrontage	TotalBsmtSF	0.2382736687	0.000000e+00
## 314	X1stFlrSF	GarageYrBlt	0.2372582793	0.000000e+00

## 392	X1stFlrSF	WoodDeckSF	0.2354586228	0.000000e+00
## 430	TotRmsAbvGrd	OpenPorchSF	0.2341915878	0.000000e+00
## 391	TotalBsmtSF	WoodDeckSF	0.2320186091	0.000000e+00
## 317	GrLivArea	GarageYrBlt	0.2318559767	0.000000e+00
## 40	LotArea	BsmtFinSF1	0.2309689215	0.000000e+00
## 404	GarageYrBlt	WoodDeckSF	0.2273885171	0.000000e+00
## 684	BsmtFullBath	SalePrice	0.2271222331	0.000000e+00
## 231	HalfBath	BedroomAbvGr	0.2266514842	0.000000e+00
## 405	GarageCars	WoodDeckSF	0.2263421385	0.000000e+00
## 414	YearRemodAdd	OpenPorchSF	0.2262976327	0.000000e+00
## 385	YearBuilt	WoodDeckSF	0.2248801423	0.000000e+00
## 406	GarageArea	WoodDeckSF	0.2246663072	0.000000e+00
## 335	BsmtFinSF1	GarageCars	0.2240535224	0.000000e+00
## 256	LotFrontage	TotRmsAbvGrd	0.2213962408	0.000000e+00
## 432	GarageYrBlt	OpenPorchSF	0.2206152551	0.000000e+00
## 123	LotFrontage	GrLivArea	0.2203472317	0.000000e+00
## 346	HalfBath	GarageCars	0.2191781522	0.000000e+00
## 678	BsmtUnfSF	SalePrice	0.2144791055	0.000000e+00
## 337	BsmtUnfSF	GarageCars	0.2141751898	0.000000e+00
## 433	GarageCars	OpenPorchSF	0.2135694456	0.000000e+00
## 420	X1stFlrSF	OpenPorchSF	0.2116712255	4.440892e-16
## 669	LotFrontage	SalePrice	0.2096239448	4.440892e-16
## 130	BsmtFinSF1	GrLivArea	0.2081711301	8.881784e-16
## 421	X2ndFlrSF	OpenPorchSF	0.2080260632	8.881784e-16
## 386	YearRemodAdd	WoodDeckSF	0.2057259205	1.998401e-15
## 388	BsmtFinSF1	WoodDeckSF	0.2043061452	3.108624e-15
## 297	HalfBath	Fireplaces	0.2036485081	3.996803e-15
## 354	LotFrontage	GarageArea	0.2014733532	7.771561e-15
## 403	Fireplaces	WoodDeckSF	0.2000187958	1.221245e-14
## 382	LotArea	WoodDeckSF	0.1998462802	1.287859e-14
## 427	HalfBath	OpenPorchSF	0.1997401475	1.332268e-14
## 199	MasVnrArea	HalfBath	0.1991075194	1.598721e-14
## 127	YearBuilt	GrLivArea	0.1990097137	1.665335e-14
## 253	BedroomAbvGr	KitchenAbvGr	0.1985967577	1.887379e-14
## 321	HalfBath	GarageYrBlt	0.1979949050	2.264855e-14
## 291	X2ndFlrSF	Fireplaces	0.1945608922	6.394885e-14
## 261	YearRemodAdd	TotRmsAbvGrd	0.1917398163	1.483258e-13
## 413	YearBuilt	OpenPorchSF	0.1886858400	3.623768e-13
## 312	BsmtUnfSF	GarageYrBlt	0.1879249397	4.518608e-13
## 398	FullBath	WoodDeckSF	0.1877032138	4.818368e-13
## 143	YearBuilt	BsmtFullBath	0.1875985500	4.964917e-13
## 521	Fireplaces	ScreenPorch	0.1845302695	1.195044e-12
## 340	X2ndFlrSF	GarageCars	0.1839255831	1.417977e-12

## 198	YearRemodAdd	HalfBath	0.1833306117	1.677547e-12
## 363	BsmtUnfSF	GarageArea	0.1833026977	1.690648e-12
## 63	YearRemodAdd	BsmtUnfSF	0.1811330871	3.104628e-12
## 369	BsmtFullBath	GarageArea	0.1791894804	5.316858e-12
## 175	LotArea	FullBath	0.1791873528	5.319967e-12
## 10	LotArea	OverallQual	0.1782154116	6.946888e-12
## 192	MSSubClass	HalfBath	0.1773543886	8.788081e-12
## 9	LotFrontage	OverallQual	0.1765610224	1.090283e-11
## 36	YearRemodAdd	MasVnrArea	0.1765291806	1.099743e-11
## 396	BsmtFullBath	WoodDeckSF	0.1753151901	1.526557e-11
## 100	MasVnrArea	X2ndFlrSF	0.1738000004	2.291234e-11
## 545	GrLivArea	PoolArea	0.1702053360	5.918421e-11
## 431	Fireplaces	OpenPorchSF	0.1694053271	7.290124e-11
## 688	BedroomAbvGr	SalePrice	0.1682131543	9.927481e-11
## 222	BsmtUnfSF	BedroomAbvGr	0.1666433170	1.485800e-10
## 402	TotRmsAbvGrd	WoodDeckSF	0.1659838837	1.758029e-10
## 328	LotFrontage	GarageCars	0.1652286072	2.129863e-10
## 372	HalfBath	GarageArea	0.1635493640	3.252643e-10
## 58	LotFrontage	BsmtUnfSF	0.1608292768	6.398495e-10
## 387	MasVnrArea	WoodDeckSF	0.1599905296	7.864733e-10
## 147	BsmtFinSF2	BsmtFullBath	0.1586780608	1.083814e-09
## 310	BsmtFinSF1	GarageYrBlt	0.1574262445	1.467971e-09
## 62	YearBuilt	BsmtUnfSF	0.1490403920	1.053186e-08
## 283	YearBuilt	Fireplaces	0.1477163994	1.423520e-08
## 410	LotArea	OpenPorchSF	0.1472237238	1.591339e-08
## 324	TotRmsAbvGrd	GarageYrBlt	0.1465408418	1.856019e-08
## 213	LotFrontage	BedroomAbvGr	0.1444936461	2.931307e-08
## 538	BsmtFinSF1	PoolArea	0.1404912863	7.033185e-08
## 99	YearRemodAdd	X2ndFlrSF	0.1400237788	7.777962e-08
## 366	X2ndFlrSF	GarageArea	0.1383469586	1.112964e-07
## 140	LotArea	BsmtFullBath	0.1382726671	1.130664e-07
## 294	BsmtFullBath	Fireplaces	0.1379277084	1.216474e-07
## 210	FullBath	HalfBath	0.1363805887	1.685130e-07
## 136	LowQualFinSF	GrLivArea	0.1346828130	2.399688e-07
## 251	FullBath	KitchenAbvGr	0.1331152142	3.313172e-07
## 343	BsmtFullBath	GarageCars	0.1318812244	4.259908e-07
## 173	MSSubClass	FullBath	0.1316082224	4.502112e-07
## 542	X1stFlrSF	PoolArea	0.1315249756	4.578571e-07
## 269	LowQualFinSF	TotRmsAbvGrd	0.1311847760	4.904240e-07
## 418	BsmtUnfSF	OpenPorchSF	0.1290054146	7.585232e-07
## 44	YearRemodAdd	BsmtFinSF1	0.1284505471	8.466431e-07
## 224	X1stFlrSF	BedroomAbvGr	0.1274007494	1.041034e-06
## 541	TotalBsmtSF	PoolArea	0.1260531321	1.354117e-06

## 318	BsmtFullBath	GarageYrBlt	0.1225899006	2.628877e-06
## 415	MasVnrArea	OpenPorchSF	0.1225283318	2.659639e-06
## 32	LotArea	MasVnrArea	0.1223499891	2.750708e-06
## 174	LotFrontage	FullBath	0.1205478702	3.855272e-06
## 144	YearRemodAdd	BsmtFullBath	0.1194698791	4.707216e-06
## 159	OverallCond	BsmtHalfBath	0.1178209151	6.367488e-06
## 531	LotFrontage	PoolArea	0.1141063586	1.239367e-05
## 64	MasVnrArea	BsmtUnfSF	0.1138621631	1.293922e-05
## 284	YearRemodAdd	Fireplaces	0.1125813184	1.619633e-05
## 416	BsmtFinSF1	OpenPorchSF	0.1117606134	1.867889e-05
## 699	ScreenPorch	SalePrice	0.1114465711	1.972140e-05
## 141	OverallQual	BsmtFullBath	0.1110977861	2.094407e-05
## 399	HalfBath	WoodDeckSF	0.1080803027	3.498385e-05
## 298	BedroomAbvGr	Fireplaces	0.1075696810	3.810704e-05
## 226	LowQualFinSF	BedroomAbvGr	0.1056065685	5.275462e-05
## 31	LotFrontage	MasVnrArea	0.1050098330	5.817285e-05
## 77	BsmtFinSF2	TotalBsmtSF	0.1048095376	6.010660e-05
## 219	MasVnrArea	BedroomAbvGr	0.1027745161	8.352065e-05
## 215	OverallQual	BedroomAbvGr	0.1016763562	9.949911e-05
## 513	GrLivArea	ScreenPorch	0.1015103957	1.021512e-04
## 248	GrLivArea	KitchenAbvGr	0.1000631647	1.282743e-04
## 500	LotArea	ScreenPorch	0.0973810189	1.940828e-04
## 89	BsmtFinSF2	X1stFlrSF	0.0971174485	2.020319e-04
## 260	YearBuilt	TotRmsAbvGrd	0.0955891283	2.544833e-04
## 553	Fireplaces	PoolArea	0.0950735220	2.748854e-04
## 428	BedroomAbvGr	OpenPorchSF	0.0938095716	3.315593e-04
## 700	PoolArea	SalePrice	0.0924035495	4.073490e-04
## 49	LotArea	BsmtFinSF2	0.0922135123	4.187525e-04
## 393	X2ndFlrSF	WoodDeckSF	0.0921654176	4.216854e-04
## 532	LotArea	PoolArea	0.0917909418	4.451854e-04
## 507	BsmtFinSF2	ScreenPorch	0.0888712514	6.748802e-04
## 510	X1stFlrSF	ScreenPorch	0.0887580726	6.856868e-04
## 347	BedroomAbvGr	GarageCars	0.0861064377	9.897559e-04
## 509	TotalBsmtSF	ScreenPorch	0.0844889859	1.232141e-03
## 552	TotRmsAbvGrd	PoolArea	0.0837573495	1.358848e-03
## 145	MasVnrArea	BsmtFullBath	0.0830100478	1.500572e-03
## 543	X2ndFlrSF	PoolArea	0.0814868780	1.832442e-03
## 95	LotArea	X2ndFlrSF	0.0804654708	2.091386e-03
## 24	LotFrontage	YearRemodAdd	0.0786855146	2.624027e-03
## 59	LotArea	BsmtUnfSF	0.0772470168	3.142026e-03
## 39	LotFrontage	BsmtFinSF1	0.0766699970	3.374784e-03
## 122	MSSubClass	GrLivArea	0.0748531797	4.213734e-03
## 526	OpenPorchSF	ScreenPorch	0.0743039439	4.502235e-03

## 302	MSSubClass	GarageYrBlt	0.0741142186	4.605973e-03
## 27	OverallCond	YearRemodAdd	0.0737414981	4.816090e-03
## 557	WoodDeckSF	PoolArea	0.0733782070	5.029191e-03
## 315	X2ndFlrSF	GarageYrBlt	0.0733417224	5.051056e-03
## 517	HalfBath	ScreenPorch	0.0724258452	5.628839e-03
## 625	OpenPorchSF	MoSold	0.0712548848	6.454026e-03
## 164	BsmtFinSF2	BsmtHalfBath	0.0709481337	6.687445e-03
## 600	OverallQual	MoSold	0.0708151718	6.790956e-03
## 550	BedroomAbvGr	PoolArea	0.0707025836	6.879728e-03
## 441	OverallCond	EnclosedPorch	0.0703561845	7.159420e-03
## 409	LotFrontage	OpenPorchSF	0.0696049521	7.801296e-03
## 567	OverallCond	MiscVal	0.0687768061	8.568159e-03
## 245	X1stFlrSF	KitchenAbvGr	0.0681005882	9.243534e-03
## 389	BsmtFinSF2	WoodDeckSF	0.0678983264	9.454564e-03
## 546	BsmtFullBath	PoolArea	0.0676155562	9.756787e-03
## 163	BsmtFinSF1	BsmtHalfBath	0.0674184779	9.972479e-03
## 424	BsmtFullBath	OpenPorchSF	0.0673414614	1.005792e-02
## 648	BsmtFullBath	YrSold	0.0670491377	1.038816e-02
## 373	BedroomAbvGr	GarageArea	0.0652525299	1.263772e-02
## 533	OverallQual	PoolArea	0.0651658436	1.275642e-02
## 501	OverallQual	ScreenPorch	0.0648863605	1.314582e-02
## 120	X2ndFlrSF	LowQualFinSF	0.0633529501	1.547482e-02
## 584	KitchenAbvGr	MiscVal	0.0623407240	1.720427e-02
## 505	MasVnrArea	ScreenPorch	0.0622477112	1.737138e-02
## 544	LowQualFinSF	PoolArea	0.0621573723	1.753504e-02
## 506	BsmtFinSF1	ScreenPorch	0.0620206227	1.778535e-02
## 450	X2ndFlrSF	EnclosedPorch	0.0619886908	1.784425e-02
## 451	LowQualFinSF	EnclosedPorch	0.0610812378	1.959094e-02
## 556	GarageArea	PoolArea	0.0610472717	1.965912e-02
## 558	OpenPorchSF	PoolArea	0.0607621115	2.023972e-02
## 520	TotRmsAbvGrd	ScreenPorch	0.0593825996	2.326437e-02
## 246	X2ndFlrSF	KitchenAbvGr	0.0593057526	2.344382e-02
## 435	WoodDeckSF	OpenPorchSF	0.0586606086	2.499829e-02
## 181	BsmtFinSF1	FullBath	0.0585431369	2.529073e-02
## 325	Fireplaces	GarageYrBlt	0.0581759561	2.622396e-02
## 529	Id	PoolArea	0.0570439048	2.929065e-02
## 479	X1stFlrSF	X3SsnPorch	0.0561043745	3.206515e-02
## 615	FullBath	MoSold	0.0558721290	3.278470e-02
## 469	LotArea	X3SsnPorch	0.0556995619	3.332825e-02
## 502	OverallCond	ScreenPorch	0.0548105288	3.625216e-02
## 559	EnclosedPorch	PoolArea	0.0542025623	3.837511e-02
## 288	BsmtUnfSF	Fireplaces	0.0515748823	4.880435e-02
## 524	GarageArea	ScreenPorch	0.0514117624	4.952348e-02

## 561	ScreenPorch	PoolArea	0.0513073945	4.998823e-02
## 523	GarageCars	ScreenPorch	0.0504937919	5.373793e-02
## 223	TotalBsmtSF	BedroomAbvGr	0.0504499555	5.394645e-02
## 612	GrLivArea	MoSold	0.0502396808	5.495608e-02
## 108	LotFrontage	LowQualFinSF	0.0499814302	5.621755e-02
## 548	FullBath	PoolArea	0.0496038256	5.810530e-02
## 565	LotArea	MiscVal	0.0477906815	6.791680e-02
## 287	BsmtFinSF2	Fireplaces	0.0469207088	7.308663e-02
## 400	BedroomAbvGr	WoodDeckSF	0.0468537731	7.349738e-02
## 617	BedroomAbvGr	MoSold	0.0465438599	7.542378e-02
## 229	BsmtHalfBath	BedroomAbvGr	0.0465188484	7.558103e-02
## 107	MSSubClass	LowQualFinSF	0.0464737559	7.586521e-02
## 702	MoSold	SalePrice	0.0464322452	7.612758e-02
## 620	Fireplaces	MoSold	0.0463571025	7.660441e-02
## 473	YearRemodAdd	X3SsnPorch	0.0452858098	8.367071e-02
## 157	LotArea	BsmtHalfBath	0.0452181062	8.413444e-02
## 698	X3SsnPorch	SalePrice	0.0445836653	8.858170e-02
## 303	LotFrontage	GarageYrBlt	0.0443393840	9.034373e-02
## 263	BsmtFinSF1	TotRmsAbvGrd	0.0443156239	9.051661e-02
## 518	BedroomAbvGr	ScreenPorch	0.0442996911	9.063268e-02
## 279	LotFrontage	Fireplaces	0.0440176416	9.270736e-02
## 636	OverallCond	YrSold	0.0439497457	9.321243e-02
## 94	LotFrontage	X2ndFlrSF	0.0425492441	1.041311e-01
## 539	BsmtFinSF2	PoolArea	0.0417090547	1.111537e-01
## 457	BedroomAbvGr	EnclosedPorch	0.0415704345	1.123474e-01
## 511	X2ndFlrSF	ScreenPorch	0.0406064476	1.209302e-01
## 23	MSSubClass	YearRemodAdd	0.0405810448	1.211631e-01
## 622	GarageCars	MoSold	0.0405217301	1.217084e-01
## 255	MSSubClass	TotRmsAbvGrd	0.0403800648	1.230183e-01
## 51	OverallCond	BsmtFinSF2	0.0402291699	1.244256e-01
## 397	BsmtHalfBath	WoodDeckSF	0.0401612233	1.250634e-01
## 194	LotArea	HalfBath	0.0387168314	1.392324e-01
## 211	Id	BedroomAbvGr	0.0377185542	1.497254e-01
## 478	TotalBsmtSF	X3SsnPorch	0.0373837273	1.533766e-01
## 458	KitchenAbvGr	EnclosedPorch	0.0373123850	1.541632e-01
## 619	TotRmsAbvGrd	MoSold	0.0369070772	1.586904e-01
## 18	LotFrontage	YearBuilt	0.0368534286	1.592971e-01
## 446	BsmtFinSF2	EnclosedPorch	0.0365433394	1.628382e-01
## 492	GarageCars	X3SsnPorch	0.0357652851	1.719841e-01
## 638	YearRemodAdd	YrSold	0.0357432471	1.722487e-01
## 485	FullBath	X3SsnPorch	0.0353530166	1.769833e-01
## 610	X2ndFlrSF	MoSold	0.0351644274	1.793059e-01
## 484	BsmtHalfBath	X3SsnPorch	0.0351136309	1.799353e-01

## 493	GarageArea	X3SsnPorch	0.0350867002	1.802697e-01
## 607	BsmtUnfSF	MoSold	0.0348884430	1.827454e-01
## 153	GrLivArea	BsmtFullBath	0.0348360495	1.834039e-01
## 234	LotFrontage	KitchenAbvGr	0.0344246581	1.886352e-01
## 614	BsmtHalfBath	MoSold	0.0328727052	2.093598e-01
## 8	MSSubClass	OverallQual	0.0326277075	2.127766e-01
## 515	BsmtHalfBath	ScreenPorch	0.0321214072	2.199645e-01
## 594	ScreenPorch	MiscVal	0.0319457608	2.224984e-01
## 641	BsmtFinSF2	YrSold	0.0317056370	2.259960e-01
## 653	KitchenAbvGr	YrSold	0.0316872065	2.262661e-01
## 609	X1stFlrSF	MoSold	0.0313715604	2.309272e-01
## 472	YearBuilt	X3SsnPorch	0.0313545131	2.311809e-01
## 470	OverallQual	X3SsnPorch	0.0303705671	2.461582e-01
## 243	BsmtUnfSF	KitchenAbvGr	0.0300858683	2.506158e-01
## 595	PoolArea	MiscVal	0.0296686509	2.572495e-01
## 627	X3SsnPorch	MoSold	0.0294737952	2.603891e-01
## 295	BsmtHalfBath	Fireplaces	0.0289755866	2.685363e-01
## 97	OverallCond	X2ndFlrSF	0.0289421160	2.690898e-01
## 117	BsmtUnfSF	LowQualFinSF	0.0281666881	2.821334e-01
## 623	GarageArea	MoSold	0.0279737998	2.854434e-01
## 17	MSSubClass	YearBuilt	0.0278501369	2.875793e-01
## 25	LotArea	YearRemodAdd	0.0276698773	2.907119e-01
## 162	MasVnrArea	BsmtHalfBath	0.0274026623	2.953977e-01
## 438	LotFrontage	EnclosedPorch	0.0273661049	2.960426e-01
## 254	Id	TotRmsAbvGrd	0.0272387244	2.982973e-01
## 512	LowQualFinSF	ScreenPorch	0.0267994130	3.061609e-01
## 618	KitchenAbvGr	MoSold	0.0265889072	3.099771e-01
## 475	BsmtFinSF1	X3SsnPorch	0.0264505062	3.125032e-01
## 471	OverallCond	X3SsnPorch	0.0255036600	3.301473e-01
## 111	OverallCond	LowQualFinSF	0.0254943199	3.303245e-01
## 491	GarageYrBlt	X3SsnPorch	0.0254215000	3.317081e-01
## 585	TotRmsAbvGrd	MiscVal	0.0247628842	3.443919e-01
## 30	MSSubClass	MasVnrArea	0.0235729681	3.680801e-01
## 468	LotFrontage	X3SsnPorch	0.0234987244	3.695909e-01
## 628	ScreenPorch	MoSold	0.0232169918	3.753591e-01
## 514	BsmtFullBath	ScreenPorch	0.0231477258	3.767857e-01
## 499	LotFrontage	ScreenPorch	0.0229687320	3.804877e-01
## 549	HalfBath	PoolArea	0.0223814981	3.927890e-01
## 659	WoodDeckSF	YrSold	0.0222704510	3.951420e-01
## 19	LotArea	YearBuilt	0.0219366834	4.022653e-01
## 603	YearRemodAdd	MoSold	0.0214900022	4.119179e-01
## 596	Id	MoSold	0.0211721766	4.188687e-01
## 624	WoodDeckSF	MoSold	0.0210110443	4.224189e-01

## 555	GarageCars	PoolArea	0.0209335310	4.241329e-01
## 477	BsmtUnfSF	X3SsnPorch	0.0207640057	4.278958e-01
## 482	GrLivArea	X3SsnPorch	0.0206431897	4.305893e-01
## 547	BsmtHalfBath	PoolArea	0.0200246298	4.445328e-01
## 474	MasVnrArea	X3SsnPorch	0.0191437843	4.648259e-01
## 598	LotFrontage	MoSold	0.0189419430	4.695474e-01
## 662	X3SsnPorch	YrSold	0.0186449254	4.765432e-01
## 592	EnclosedPorch	MiscVal	0.0183606001	4.832932e-01
## 422	LowQualFinSF	OpenPorchSF	0.0182510391	4.859080e-01
## 352	Id	GarageArea	0.0176337785	5.007813e-01
## 326	Id	GarageCars	0.0165696771	5.269768e-01
## 576	X2ndFlrSF	MiscVal	0.0161968746	5.363168e-01
## 116	BsmtFinSF2	LowQualFinSF	0.0148069979	5.718554e-01
## 640	BsmtFinSF1	YrSold	0.0143589224	5.835463e-01
## 608	TotalBsmtSF	MoSold	0.0131961786	6.143911e-01
## 216	OverallCond	BedroomAbvGr	0.0129800601	6.202024e-01
## 109	LotArea	LowQualFinSF	0.0128104054	6.247810e-01
## 11	Id	OverallCond	0.0126089248	6.302373e-01
## 602	YearBuilt	MoSold	0.0123984706	6.359583e-01
## 537	MasVnrArea	PoolArea	0.0119283940	6.488149e-01
## 490	Fireplaces	X3SsnPorch	0.0112572390	6.673530e-01
## 1	Id	MSSubClass	0.0111564782	6.701541e-01
## 439	LotArea	EnclosedPorch	0.0109514944	6.758666e-01
## 663	ScreenPorch	YrSold	0.0106941060	6.830660e-01
## 599	LotArea	MoSold	0.0105207039	6.879325e-01
## 139	LotFrontage	BsmtFullBath	0.0105143334	6.881116e-01
## 79	Id	X1stFlrSF	0.0104960410	6.886258e-01
## 98	YearBuilt	X2ndFlrSF	0.0103076596	6.939294e-01
## 452	GrLivArea	EnclosedPorch	0.0091132103	7.278971e-01
## 530	MSSubClass	PoolArea	0.0082827076	7.518384e-01
## 121	Id	GrLivArea	0.0082727577	7.521268e-01
## 583	BedroomAbvGr	MiscVal	0.0077669720	7.668285e-01
## 247	LowQualFinSF	KitchenAbvGr	0.0075217443	7.739873e-01
## 191	Id	HalfBath	0.0067838113	7.956429e-01
## 621	GarageYrBlt	MoSold	0.0064638728	8.050822e-01
## 536	YearRemodAdd	PoolArea	0.0058293720	8.238849e-01
## 92	Id	X2ndFlrSF	0.0055898489	8.310099e-01
## 172	Id	FullBath	0.0055874529	8.310812e-01
## 535	YearBuilt	PoolArea	0.0049497276	8.501179e-01
## 572	BsmtFinSF2	MiscVal	0.0049397812	8.504155e-01
## 665	MiscVal	YrSold	0.0049062625	8.514187e-01
## 103	BsmtUnfSF	X2ndFlrSF	0.0044690921	8.645239e-01
## 200	BsmtFinSF1	HalfBath	0.0042624244	8.707324e-01

## 459	TotRmsAbvGrd	EnclosedPorch	0.0041512990	8.740741e-01
## 571	BsmtFinSF1	MiscVal	0.0035714735	8.915451e-01
## 138	MSSubClass	BsmtFullBath	0.0034910258	8.939735e-01
## 417	BsmtFinSF2	OpenPorchSF	0.0030925622	9.060156e-01
## 232	Id	KitchenAbvGr	0.0029512364	9.102920e-01
## 436	Id	EnclosedPorch	0.0028892179	9.121694e-01
## 137	Id	BsmtFullBath	0.0022885556	9.303768e-01
## 167	X1stFlrSF	BsmtHalfBath	0.0019556536	9.404841e-01
## 235	LotArea	KitchenAbvGr	0.0016780030	9.489212e-01
## 586	Fireplaces	MiscVal	0.0014086054	9.571131e-01
## 497	Id	ScreenPorch	0.0013302086	9.594979e-01
## 582	HalfBath	MiscVal	0.0012901448	9.607167e-01
## 301	Id	GarageYrBlt	0.0010008825	9.695195e-01
## 631	Id	YrSold	0.0007117940	9.783207e-01
## 593	X3SsnPorch	MiscVal	0.0003539653	9.892182e-01
## 483	BsmtFullBath	X3SsnPorch	-0.0001060915	9.967684e-01
## 166	TotalBsmtSF	BsmtHalfBath	-0.0003145818	9.904177e-01
## 407	Id	OpenPorchSF	-0.0004769113	9.854736e-01
## 187	LowQualFinSF	FullBath	-0.0007095096	9.783903e-01
## 656	GarageYrBlt	YrSold	-0.0017497095	9.467416e-01
## 534	OverallCond	PoolArea	-0.0019849423	9.395944e-01
## 155	MSSubClass	BsmtHalfBath	-0.0023325346	9.290423e-01
## 578	GrLivArea	MiscVal	-0.0024156396	9.265212e-01
## 447	BsmtUnfSF	EnclosedPorch	-0.0025378546	9.228150e-01
## 384	OverallCond	WoodDeckSF	-0.0033336993	8.987253e-01
## 601	OverallCond	MoSold	-0.0035108386	8.933753e-01
## 577	LowQualFinSF	MiscVal	-0.0037928708	8.848674e-01
## 481	LowQualFinSF	X3SsnPorch	-0.0042956104	8.697349e-01
## 486	HalfBath	X3SsnPorch	-0.0049724884	8.494369e-01
## 37	Id	BsmtFinSF1	-0.0050240490	8.478946e-01
## 390	BsmtUnfSF	WoodDeckSF	-0.0053164243	8.391603e-01
## 169	LowQualFinSF	BsmtHalfBath	-0.0058415048	8.235244e-01
## 495	OpenPorchSF	X3SsnPorch	-0.0058424993	8.234948e-01
## 46	Id	BsmtFinSF2	-0.0059676720	8.197775e-01
## 408	MSSubClass	OpenPorchSF	-0.0061001212	8.158485e-01
## 562	Id	MiscVal	-0.0062424048	8.116329e-01
## 14	LotArea	OverallCond	-0.0063053353	8.097702e-01
## 630	MiscVal	MoSold	-0.0064945502	8.041758e-01
## 489	TotRmsAbvGrd	X3SsnPorch	-0.0066832410	7.986069e-01
## 604	MasVnrArea	MoSold	-0.0067232039	7.974288e-01
## 580	BsmtHalfBath	MiscVal	-0.0073665245	7.785284e-01
## 563	MSSubClass	MiscVal	-0.0076832913	7.692691e-01
## 56	Id	BsmtUnfSF	-0.0079397034	7.617980e-01

## 560	X3SsnPorch	PoolArea	-0.0079915489	7.602900e-01
## 516	FullBath	ScreenPorch	-0.0081060933	7.569616e-01
## 639	MasVnrArea	YrSold	-0.0083166226	7.508559e-01
## 454	BsmtHalfBath	EnclosedPorch	-0.0085553339	7.439517e-01
## 616	HalfBath	MoSold	-0.0090498882	7.297135e-01
## 48	LotFrontage	BsmtFinSF2	-0.0093123095	7.221957e-01
## 590	WoodDeckSF	MiscVal	-0.0095512282	7.153744e-01
## 131	BsmtFinSF2	GrLivArea	-0.0096398916	7.128488e-01
## 661	EnclosedPorch	YrSold	-0.0099159370	7.050056e-01
## 304	LotArea	GarageYrBlt	-0.0099695529	7.034858e-01
## 651	HalfBath	YrSold	-0.0102686689	6.950290e-01
## 569	YearRemodAdd	MiscVal	-0.0102862488	6.945331e-01
## 677	BsmtFinSF2	SalePrice	-0.0113781215	6.639987e-01
## 437	MSSubClass	EnclosedPorch	-0.0120366219	6.458454e-01
## 633	LotFrontage	YrSold	-0.0120939602	6.442745e-01
## 161	YearRemodAdd	BsmtHalfBath	-0.0123370321	6.376325e-01
## 209	BsmtHalfBath	HalfBath	-0.0123399001	6.375543e-01
## 508	BsmtUnfSF	ScreenPorch	-0.0125792734	6.310420e-01
## 380	MSSubClass	WoodDeckSF	-0.0125793582	6.310397e-01
## 16	Id	YearBuilt	-0.0127127154	6.274240e-01
## 193	LotFrontage	HalfBath	-0.0129521028	6.209559e-01
## 554	GarageYrBlt	PoolArea	-0.0133168950	6.111556e-01
## 597	MSSubClass	MoSold	-0.0135846432	6.040063e-01
## 644	X1stFlrSF	YrSold	-0.0136037705	6.034971e-01
## 637	YearBuilt	YrSold	-0.0136176800	6.031268e-01
## 119	X1stFlrSF	LowQualFinSF	-0.0142406727	5.866501e-01
## 581	FullBath	MiscVal	-0.0142898450	5.853585e-01
## 551	KitchenAbvGr	PoolArea	-0.0145251160	5.791972e-01
## 643	TotalBsmtSF	YrSold	-0.0149686480	5.676652e-01
## 606	BsmtFinSF2	MoSold	-0.0152107380	5.614175e-01
## 67	Id	TotalBsmtSF	-0.0154145661	5.561832e-01
## 605	BsmtFinSF1	MoSold	-0.0157269483	5.482075e-01
## 221	BsmtFinSF2	BedroomAbvGr	-0.0157281136	5.481779e-01
## 381	LotFrontage	WoodDeckSF	-0.0167797589	5.217503e-01
## 685	BsmtHalfBath	SalePrice	-0.0168441543	5.201536e-01
## 4	Id	LotArea	-0.0174824669	5.044637e-01
## 362	BsmtFinSF2	GarageArea	-0.0182265919	4.864925e-01
## 574	TotalBsmtSF	MiscVal	-0.0184789224	4.804779e-01
## 591	OpenPorchSF	MiscVal	-0.0185837390	4.779915e-01
## 170	GrLivArea	BsmtHalfBath	-0.0189184832	4.700979e-01
## 650	FullBath	YrSold	-0.0196688407	4.526681e-01
## 2	Id	LotFrontage	-0.0197613200	4.505455e-01
## 277	Id	Fireplaces	-0.0197716324	4.503091e-01

## 154	Id	BsmtHalfBath	-0.0201547452	4.415786e-01
## 344	BsmtHalfBath	GarageCars	-0.0208910590	4.250739e-01
## 575	X1stFlrSF	MiscVal	-0.0210957195	4.205511e-01
## 701	MiscVal	SalePrice	-0.0211895796	4.184863e-01
## 292	LowQualFinSF	Fireplaces	-0.0212721434	4.166751e-01
## 632	MSSubClass	YrSold	-0.0214070378	4.137257e-01
## 667	Id	SalePrice	-0.0219167194	4.026938e-01
## 22	Id	YearRemodAdd	-0.0219976419	4.009586e-01
## 611	LowQualFinSF	MoSold	-0.0221739606	3.971934e-01
## 579	BsmtFullBath	MiscVal	-0.0230470249	3.788657e-01
## 212	MSSubClass	BedroomAbvGr	-0.0234380285	3.708290e-01
## 282	OverallCond	Fireplaces	-0.0238199778	3.630812e-01
## 272	BsmtHalfBath	TotRmsAbvGrd	-0.0238363413	3.627516e-01
## 573	BsmtUnfSF	MiscVal	-0.0238366451	3.627454e-01
## 168	X2ndFlrSF	BsmtHalfBath	-0.0238547839	3.623802e-01
## 655	Fireplaces	YrSold	-0.0240955650	3.575543e-01
## 480	X2ndFlrSF	X3SsnPorch	-0.0243576484	3.523476e-01
## 487	BedroomAbvGr	X3SsnPorch	-0.0244777964	3.499768e-01
## 370	BsmtHalfBath	GarageArea	-0.0245355796	3.488402e-01
## 488	KitchenAbvGr	X3SsnPorch	-0.0246003587	3.475688e-01
## 460	Fireplaces	EnclosedPorch	-0.0248218685	3.432435e-01
## 425	BsmtHalfBath	OpenPorchSF	-0.0253237579	3.335712e-01
## 613	BsmtFullBath	MoSold	-0.0253608943	3.328625e-01
## 394	LowQualFinSF	WoodDeckSF	-0.0254436480	3.312869e-01
## 682	LowQualFinSF	SalePrice	-0.0256061300	3.282073e-01
## 498	MSSubClass	ScreenPorch	-0.0260301767	3.202578e-01
## 206	LowQualFinSF	HalfBath	-0.0270800493	3.011219e-01
## 634	LotArea	YrSold	-0.0271636631	2.996312e-01
## 635	OverallQual	YrSold	-0.0273467083	2.963852e-01
## 658	GarageArea	YrSold	-0.0273779404	2.958337e-01
## 589	GarageArea	MiscVal	-0.0273999144	2.954461e-01
## 156	LotFrontage	BsmtHalfBath	-0.0278556578	2.874837e-01
## 7	Id	OverallQual	-0.0283647539	2.787617e-01
## 645	X2ndFlrSF	YrSold	-0.0286999139	2.731188e-01
## 626	EnclosedPorch	MoSold	-0.0288872657	2.699986e-01
## 646	LowQualFinSF	YrSold	-0.0289208798	2.694414e-01
## 703	YrSold	SalePrice	-0.0289225852	2.694132e-01
## 570	MasVnrArea	MiscVal	-0.0295122487	2.597674e-01
## 379	Id	WoodDeckSF	-0.0296431972	2.576582e-01
## 476	BsmtFinSF2	X3SsnPorch	-0.0299933980	2.520757e-01
## 110	OverallQual	LowQualFinSF	-0.0304292840	2.452458e-01
## 208	BsmtFullBath	HalfBath	-0.0309049591	2.379416e-01
## 566	OverallQual	MiscVal	-0.0314062105	2.304122e-01

## 528	X3SsnPorch	ScreenPorch	-0.0314358470	2.299724e-01
## 587	GarageYrBltd	MiscVal	-0.0321216929	2.199604e-01
## 201	BsmtFinSF2	HalfBath	-0.0321478375	2.195850e-01
## 412	OverallCond	OpenPorchSF	-0.0325888135	2.133227e-01
## 494	WoodDeckSF	X3SsnPorch	-0.0327706336	2.107784e-01
## 118	TotalBsmtSF	LowQualFinSF	-0.0332453873	2.042388e-01
## 629	PoolArea	MoSold	-0.0337366403	1.976284e-01
## 568	YearBuilt	MiscVal	-0.0343831387	1.891692e-01
## 654	TotRmsAbvGrd	YrSold	-0.0345163543	1.874597e-01
## 540	BsmtUnfSF	PoolArea	-0.0350922408	1.802008e-01
## 264	BsmtFinSF2	TotRmsAbvGrd	-0.0352265479	1.785383e-01
## 652	BedroomAbvGr	YrSold	-0.0360138928	1.690210e-01
## 647	GrLivArea	YrSold	-0.0365258196	1.630401e-01
## 496	EnclosedPorch	X3SsnPorch	-0.0373052828	1.542417e-01
## 250	BsmtHalfBath	KitchenAbvGr	-0.0379443502	1.473008e-01
## 160	YearBuilt	BsmtHalfBath	-0.0381618057	1.449943e-01
## 336	BsmtFinSF2	GarageCars	-0.0382635129	1.439250e-01
## 240	MasVnrArea	KitchenAbvGr	-0.0384501121	1.419789e-01
## 504	YearRemodAdd	ScreenPorch	-0.0387400107	1.389957e-01
## 316	LowQualFinSF	GarageYrBltd	-0.0390991542	1.353671e-01
## 657	GarageCars	YrSold	-0.0391169041	1.351896e-01
## 327	MSSubClass	GarageCars	-0.0401097931	1.255479e-01
## 158	OverallQual	BsmtHalfBath	-0.0401501577	1.251676e-01
## 218	YearRemodAdd	BedroomAbvGr	-0.0405809281	1.211642e-01
## 242	BsmtFinSF2	KitchenAbvGr	-0.0407512364	1.196093e-01
## 202	BsmtUnfSF	HalfBath	-0.0411175301	1.163181e-01
## 642	BsmtUnfSF	YrSold	-0.0412581949	1.150733e-01
## 249	BsmtFullBath	KitchenAbvGr	-0.0415025464	1.129357e-01
## 588	GarageCars	MiscVal	-0.0430801281	9.987840e-02
## 467	MSSubClass	X3SsnPorch	-0.0438245492	9.414954e-02
## 106	Id	LowQualFinSF	-0.0442299581	9.114212e-02
## 278	MSSubClass	Fireplaces	-0.0455693403	8.175110e-02
## 42	OverallCond	BsmtFinSF1	-0.0462308559	7.741099e-02
## 649	BsmtHalfBath	YrSold	-0.0465238818	7.554936e-02
## 466	Id	X3SsnPorch	-0.0466347889	7.485435e-02
## 152	LowQualFinSF	BsmtFullBath	-0.0471434219	7.173346e-02
## 203	TotalBsmtSF	HalfBath	-0.0488037386	6.227931e-02
## 52	YearBuilt	BsmtFinSF2	-0.0491068312	6.066983e-02
## 453	BsmtFullBath	EnclosedPorch	-0.0499106491	5.656746e-02
## 55	BsmtFinSF1	BsmtFinSF2	-0.0501174000	5.555041e-02
## 503	YearBuilt	ScreenPorch	-0.0503644345	5.435519e-02
## 348	KitchenAbvGr	GarageCars	-0.0506338924	5.307601e-02
## 29	Id	MasVnrArea	-0.0510714013	5.105260e-02

## 519	KitchenAbvGr	ScreenPorch	-0.0516133661	4.863597e-02
## 271	BsmtFullBath	TotRmsAbvGrd	-0.0532752361	4.181608e-02
## 13	LotFrontage	OverallCond	-0.0534569624	4.112193e-02
## 190	BsmtHalfBath	FullBath	-0.0545358120	3.719872e-02
## 142	OverallCond	BsmtFullBath	-0.0549415154	3.580810e-02
## 259	OverallCond	TotRmsAbvGrd	-0.0575831661	2.779335e-02
## 660	OpenPorchSF	YrSold	-0.0576193601	2.769526e-02
## 50	OverallQual	BsmtFinSF2	-0.0591186927	2.388567e-02
## 12	MSSubClass	OverallCond	-0.0593158171	2.342025e-02
## 564	LotFrontage	MiscVal	-0.0596057301	2.275005e-02
## 664	PoolArea	YrSold	-0.0596889317	2.256081e-02
## 322	BedroomAbvGr	GarageYrBlt	-0.0605729801	2.063300e-02
## 196	OverallCond	HalfBath	-0.0607693268	2.022485e-02
## 113	YearRemodAdd	LowQualFinSF	-0.0624191001	1.706456e-02
## 374	KitchenAbvGr	GarageArea	-0.0644330472	1.379977e-02
## 115	BsmtFinSF1	LowQualFinSF	-0.0645025969	1.369761e-02
## 189	BsmtFullBath	FullBath	-0.0645120486	1.368378e-02
## 449	X1stFlrSF	EnclosedPorch	-0.0652917009	1.258441e-02
## 47	MSSubClass	BsmtFinSF2	-0.0656485792	1.210779e-02
## 367	LowQualFinSF	GarageArea	-0.0676014132	9.772126e-03
## 53	YearRemodAdd	BsmtFinSF2	-0.0677585136	9.602936e-03
## 252	HalfBath	KitchenAbvGr	-0.0682625489	9.077591e-03
## 114	MasVnrArea	LowQualFinSF	-0.0686279799	8.712897e-03
## 244	TotalBsmtSF	KitchenAbvGr	-0.0689006426	8.449365e-03
## 38	MSSubClass	BsmtFinSF1	-0.0698357492	7.598820e-03
## 429	KitchenAbvGr	OpenPorchSF	-0.0700906099	7.380712e-03
## 522	GarageYrBlt	ScreenPorch	-0.0705636275	6.990725e-03
## 217	YearBuilt	BedroomAbvGr	-0.0706512169	6.920573e-03
## 54	MasVnrArea	BsmtFinSF2	-0.0713296276	6.398272e-03
## 319	BsmtHalfBath	GarageYrBlt	-0.0735219994	4.943847e-03
## 525	WoodDeckSF	ScreenPorch	-0.0741813512	4.569021e-03
## 182	BsmtFinSF2	FullBath	-0.0764438620	3.470202e-03
## 672	OverallCond	SalePrice	-0.0778558940	2.912351e-03
## 126	OverallCond	GrLivArea	-0.0796858654	2.311138e-03
## 241	BsmtFinSF1	KitchenAbvGr	-0.0810068508	1.950233e-03
## 527	EnclosedPorch	ScreenPorch	-0.0828642448	1.529762e-03
## 311	BsmtFinSF2	GarageYrBlt	-0.0841809875	1.284090e-03
## 668	MSSubClass	SalePrice	-0.0842841351	1.266472e-03
## 237	OverallCond	KitchenAbvGr	-0.0870008554	8.754658e-04
## 401	KitchenAbvGr	WoodDeckSF	-0.0901302727	5.648741e-04
## 15	OverallQual	OverallCond	-0.0919323426	4.361720e-04
## 465	OpenPorchSF	EnclosedPorch	-0.0930793175	3.691033e-04
## 341	LowQualFinSF	GarageCars	-0.0944795202	3.002847e-04

## 456	HalfBath	EnclosedPorch	-0.0953165257	2.650863e-04
## 448	TotalBsmtSF	EnclosedPorch	-0.0954777367	2.587670e-04
## 165	BsmtUnfSF	BsmtHalfBath	-0.0958042882	2.463966e-04
## 353	MSSubClass	GarageArea	-0.0986715432	1.592242e-04
## 102	BsmtFinSF2	X2ndFlrSF	-0.0992603160	1.453587e-04
## 445	BsmtFinSF1	EnclosedPorch	-0.1023033055	9.005496e-05
## 220	BsmtFinSF1	BedroomAbvGr	-0.1073546768	3.949968e-05
## 444	MasVnrArea	EnclosedPorch	-0.1099067973	2.568539e-05
## 440	OverallQual	EnclosedPorch	-0.1139368586	1.276996e-05
## 455	FullBath	EnclosedPorch	-0.1150929635	1.040475e-05
## 323	KitchenAbvGr	GarageYrBlt	-0.1178342163	6.352091e-06
## 204	X1stFlrSF	HalfBath	-0.1199159088	4.334881e-06
## 463	GarageArea	EnclosedPorch	-0.1217767196	3.064133e-06
## 299	KitchenAbvGr	Fireplaces	-0.1239362353	2.035535e-06
## 34	OverallCond	MasVnrArea	-0.1256936336	1.451849e-06
## 464	WoodDeckSF	EnclosedPorch	-0.1259888880	1.371105e-06
## 697	EnclosedPorch	SalePrice	-0.1285779579	8.255770e-07
## 689	KitchenAbvGr	SalePrice	-0.1359073708	1.860426e-07
## 61	OverallCond	BsmtUnfSF	-0.1368405699	1.530090e-07
## 101	BsmtFinSF1	X2ndFlrSF	-0.1370789861	1.455247e-07
## 57	MSSubClass	BsmtUnfSF	-0.1407594808	6.637589e-08
## 84	OverallCond	X1stFlrSF	-0.1442027840	3.126348e-08
## 666	MoSold	YrSold	-0.1457214127	2.230274e-08
## 171	BsmtFullBath	BsmtHalfBath	-0.1478709605	1.374507e-08
## 239	YearRemodAdd	KitchenAbvGr	-0.1495975210	9.270323e-09
## 228	BsmtFullBath	BedroomAbvGr	-0.1506728092	7.237186e-09
## 462	GarageCars	EnclosedPorch	-0.1514341600	6.067010e-09
## 357	OverallCond	GarageArea	-0.1515213706	5.945338e-09
## 151	X2ndFlrSF	BsmtFullBath	-0.1694939517	7.124079e-11
## 72	OverallCond	TotalBsmtSF	-0.1710975146	4.685274e-11
## 104	TotalBsmtSF	X2ndFlrSF	-0.1745119501	1.894085e-11
## 238	YearBuilt	KitchenAbvGr	-0.1748002456	1.753175e-11
## 112	YearBuilt	LowQualFinSF	-0.1837843444	1.475930e-12
## 236	OverallQual	KitchenAbvGr	-0.1838822345	1.435740e-12
## 331	OverallCond	GarageCars	-0.1857575106	8.424372e-13
## 443	YearRemodAdd	EnclosedPorch	-0.1939191471	7.771561e-14
## 177	OverallCond	FullBath	-0.1941494887	7.238654e-14
## 105	X1stFlrSF	X2ndFlrSF	-0.2026461810	5.329071e-15
## 66	BsmtFinSF2	BsmtUnfSF	-0.2092944924	6.661338e-16
## 3	MSSubClass	LotFrontage	-0.2150228858	0.000000e+00
## 68	MSSubClass	TotalBsmtSF	-0.2385184093	0.000000e+00
## 80	MSSubClass	X1stFlrSF	-0.2517583519	0.000000e+00
## 461	GarageYrBlt	EnclosedPorch	-0.2894607700	0.000000e+00

```

## 306 OverallCond GarageYrBlt -0.3047730489 0.000000e+00
## 21 OverallCond YearBuilt -0.3759831956 0.000000e+00
## 442 YearBuilt EnclosedPorch -0.3872677829 0.000000e+00
## 148 BsmtUnfSF BsmtFullBath -0.4229004774 0.000000e+00
## 5 MSSubClass LotArea -0.4626677157 0.000000e+00
## 65 BsmtFinSF1 BsmtUnfSF -0.4952514693 0.000000e+00

##
## Call:
## lm(formula = log(SalePrice) ~ (BsmtUnfSF) + CentralAir + HalfBath +
## KitchenQual + Neighborhood + OverallCond + OverallQual +
## RoofMatl + `1stFlrSF` + `2ndFlrSF` + YearBuilt + MSZoning:Neighborhood +
## OverallQual:Neighborhood + YearBuilt:Neighborhood, data = train2)
##
## Residuals:
## Min 1Q Median 3Q Max
## -1.10903 -0.05710 0.00340 0.06988 0.54783
##
## Coefficients: (86 not defined because of singularities)
## Estimate Std. Error t value Pr(>|t|)
## (Intercept) 9.113e+01 5.951e+01 1.531 0.125913
## BsmtUnfSF -7.036e-05 9.483e-06 -7.420 2.06e-13 ***
## CentralAirY 1.133e-01 1.747e-02 6.485 1.24e-10 ***
## HalfBath 2.557e-02 1.005e-02 2.543 0.011104 *
## KitchenQualFa -1.283e-01 3.151e-02 -4.071 4.95e-05 ***
## KitchenQualGd -4.918e-02 1.848e-02 -2.661 0.007883 **
## KitchenQualTA -7.753e-02 2.058e-02 -3.767 0.000172 ***
## NeighborhoodBlueste -1.145e+00 7.682e-01 -1.491 0.136311
## NeighborhoodBrDale -1.013e+02 9.325e+01 -1.087 0.277415
## NeighborhoodBrkSide -8.696e+01 5.959e+01 -1.459 0.144700
## NeighborhoodClearCr -8.553e+01 5.956e+01 -1.436 0.151264
## NeighborhoodCollgCr -9.405e+01 5.961e+01 -1.578 0.114875
## NeighborhoodCrawfor -8.480e+01 5.954e+01 -1.424 0.154607
## NeighborhoodEdwards -8.983e+01 5.951e+01 -1.509 0.131447
## NeighborhoodGilbert -8.989e+01 5.961e+01 -1.508 0.131774
## NeighborhoodIDOTRR -8.423e+01 5.959e+01 -1.414 0.157732
## NeighborhoodMeadowV -1.338e+02 6.699e+01 -1.997 0.046046 *
## NeighborhoodMitchel -8.464e+01 5.959e+01 -1.420 0.155747
## NeighborhoodNames -8.952e+01 5.955e+01 -1.503 0.132966
## NeighborhoodNoRidge -1.078e+02 6.166e+01 -1.748 0.080609 .
## NeighborhoodNPkVill -7.003e+01 9.521e+01 -0.736 0.462130
## NeighborhoodNridgHt -1.373e+02 6.200e+01 -2.215 0.026952 *
## NeighborhoodNWAmes -9.219e+01 5.970e+01 -1.544 0.122798
## NeighborhoodOldTown -8.697e+01 5.952e+01 -1.461 0.144172

```


## NeighborhoodSawyer	-8.858e+01	5.954e+01	-1.488	0.137081
## NeighborhoodSawyerW	-8.983e+01	5.964e+01	-1.506	0.132248
## NeighborhoodSomerst	-1.088e+02	6.031e+01	-1.804	0.071379 .
## NeighborhoodStoneBr	-1.169e+02	5.985e+01	-1.953	0.050984 .
## NeighborhoodSWISU	-8.570e+01	5.982e+01	-1.433	0.152192
## NeighborhoodTimber	-8.856e+01	5.963e+01	-1.485	0.137747
## NeighborhoodVeenker	-9.277e+01	6.086e+01	-1.524	0.127669
## OverallCond	4.899e-02	4.049e-03	12.098	< 2e-16 ***
## OverallQual	9.050e-02	9.185e-02	0.985	0.324637
## RoofMatlCompShg	1.820e+00	1.518e-01	11.989	< 2e-16 ***
## RoofMatlMembran	1.908e+00	2.070e-01	9.217	< 2e-16 ***
## RoofMatlMetal	1.959e+00	2.039e-01	9.606	< 2e-16 ***
## RoofMatlRoll	1.799e+00	2.021e-01	8.903	< 2e-16 ***
## RoofMatlTar&Grv	1.817e+00	1.562e-01	11.627	< 2e-16 ***
## RoofMatlWdShake	1.684e+00	1.635e-01	10.296	< 2e-16 ***
## RoofMatlWdShngl	1.978e+00	1.620e-01	12.213	< 2e-16 ***
## `1stFlrSF`	4.397e-04	1.490e-05	29.503	< 2e-16 ***
## `2ndFlrSF`	2.534e-04	1.301e-05	19.479	< 2e-16 ***
## YearBuilt	-4.108e-02	2.957e-02	-1.389	0.164955
## NeighborhoodBlmngtn:MSZoningFV	NA	NA	NA	NA
## NeighborhoodBlueste:MSZoningFV	NA	NA	NA	NA
## NeighborhoodBrDale:MSZoningFV	NA	NA	NA	NA
## NeighborhoodBrkSide:MSZoningFV	NA	NA	NA	NA
## NeighborhoodClearCr:MSZoningFV	NA	NA	NA	NA
## NeighborhoodCollgCr:MSZoningFV	NA	NA	NA	NA
## NeighborhoodCrawfor:MSZoningFV	NA	NA	NA	NA
## NeighborhoodEdwards:MSZoningFV	NA	NA	NA	NA
## NeighborhoodGilbert:MSZoningFV	NA	NA	NA	NA
## NeighborhoodIDOTRR:MSZoningFV	NA	NA	NA	NA
## NeighborhoodMeadowV:MSZoningFV	NA	NA	NA	NA
## NeighborhoodMitchel:MSZoningFV	NA	NA	NA	NA
## NeighborhoodNames:MSZoningFV	NA	NA	NA	NA
## NeighborhoodNoRidge:MSZoningFV	NA	NA	NA	NA
## NeighborhoodNPkVill:MSZoningFV	NA	NA	NA	NA
## NeighborhoodNridgHt:MSZoningFV	NA	NA	NA	NA
## NeighborhoodNWAmes:MSZoningFV	NA	NA	NA	NA
## NeighborhoodOldTown:MSZoningFV	NA	NA	NA	NA
## NeighborhoodSawyer:MSZoningFV	NA	NA	NA	NA
## NeighborhoodSawyerW:MSZoningFV	NA	NA	NA	NA
## NeighborhoodSomerst:MSZoningFV	-4.127e-02	3.617e-02	-1.141	0.254136
## NeighborhoodStoneBr:MSZoningFV	NA	NA	NA	NA
## NeighborhoodSWISU:MSZoningFV	NA	NA	NA	NA
## NeighborhoodTimber:MSZoningFV	NA	NA	NA	NA

## NeighborhoodVeenker:MSZoningFV	NA	NA	NA	NA
## NeighborhoodBlmngtn:MSZoningRH	NA	NA	NA	NA
## NeighborhoodBlueste:MSZoningRH	NA	NA	NA	NA
## NeighborhoodBrDale:MSZoningRH	NA	NA	NA	NA
## NeighborhoodBrkSide:MSZoningRH	NA	NA	NA	NA
## NeighborhoodClearCr:MSZoningRH	NA	NA	NA	NA
## NeighborhoodCollgCr:MSZoningRH	NA	NA	NA	NA
## NeighborhoodCrawfor:MSZoningRH	-2.891e-01	1.471e-01	-1.965	0.049566 *
## NeighborhoodEdwards:MSZoningRH	-1.153e-02	1.124e-01	-0.103	0.918275
## NeighborhoodGilbert:MSZoningRH	NA	NA	NA	NA
## NeighborhoodIDOTRR:MSZoningRH	NA	NA	NA	NA
## NeighborhoodMeadowV:MSZoningRH	NA	NA	NA	NA
## NeighborhoodMitchel:MSZoningRH	NA	NA	NA	NA
## NeighborhoodNames:MSZoningRH	1.311e-02	1.038e-01	0.126	0.899575
## NeighborhoodNoRidge:MSZoningRH	NA	NA	NA	NA
## NeighborhoodNPkVill:MSZoningRH	NA	NA	NA	NA
## NeighborhoodNridgHt:MSZoningRH	NA	NA	NA	NA
## NeighborhoodNWAmes:MSZoningRH	NA	NA	NA	NA
## NeighborhoodOldTown:MSZoningRH	NA	NA	NA	NA
## NeighborhoodSawyer:MSZoningRH	NA	NA	NA	NA
## NeighborhoodSawyerW:MSZoningRH	-3.157e-02	9.308e-02	-0.339	0.734508
## NeighborhoodSomerst:MSZoningRH	NA	NA	NA	NA
## NeighborhoodStoneBr:MSZoningRH	NA	NA	NA	NA
## NeighborhoodSWISU:MSZoningRH	8.997e-02	6.990e-02	1.287	0.198222
## NeighborhoodTimber:MSZoningRH	NA	NA	NA	NA
## NeighborhoodVeenker:MSZoningRH	NA	NA	NA	NA
## NeighborhoodBlmngtn:MSZoningRL	8.619e-02	1.439e-01	0.599	0.549170
## NeighborhoodBlueste:MSZoningRL	NA	NA	NA	NA
## NeighborhoodBrDale:MSZoningRL	NA	NA	NA	NA
## NeighborhoodBrkSide:MSZoningRL	1.002e-01	3.500e-02	2.862	0.004277 **
## NeighborhoodClearCr:MSZoningRL	NA	NA	NA	NA
## NeighborhoodCollgCr:MSZoningRL	8.415e-02	4.763e-02	1.767	0.077493 .
## NeighborhoodCrawfor:MSZoningRL	-1.794e-01	1.163e-01	-1.543	0.123078
## NeighborhoodEdwards:MSZoningRL	9.354e-02	5.700e-02	1.641	0.100993
## NeighborhoodGilbert:MSZoningRL	NA	NA	NA	NA
## NeighborhoodIDOTRR:MSZoningRL	NA	NA	NA	NA
## NeighborhoodMeadowV:MSZoningRL	NA	NA	NA	NA
## NeighborhoodMitchel:MSZoningRL	-3.520e-02	6.755e-02	-0.521	0.602408
## NeighborhoodNames:MSZoningRL	NA	NA	NA	NA
## NeighborhoodNoRidge:MSZoningRL	NA	NA	NA	NA
## NeighborhoodNPkVill:MSZoningRL	NA	NA	NA	NA
## NeighborhoodNridgHt:MSZoningRL	6.540e-03	1.343e-01	0.049	0.961163
## NeighborhoodNWAmes:MSZoningRL	NA	NA	NA	NA

## NeighborhoodOldTown:MSZoningRL	1.310e-01	1.374e-01	0.953	0.340596
## NeighborhoodSawyer:MSZoningRL	3.789e-01	9.603e-02	3.945	8.38e-05 ***
## NeighborhoodSawyerW:MSZoningRL	NA	NA	NA	NA
## NeighborhoodSomerst:MSZoningRL	NA	NA	NA	NA
## NeighborhoodStoneBr:MSZoningRL	NA	NA	NA	NA
## NeighborhoodSWISU:MSZoningRL	NA	NA	NA	NA
## NeighborhoodTimber:MSZoningRL	NA	NA	NA	NA
## NeighborhoodVeenker:MSZoningRL	NA	NA	NA	NA
## NeighborhoodBlmngtn:MSZoningRM	NA	NA	NA	NA
## NeighborhoodBlueste:MSZoningRM	NA	NA	NA	NA
## NeighborhoodBrDale:MSZoningRM	NA	NA	NA	NA
## NeighborhoodBrkSide:MSZoningRM	NA	NA	NA	NA
## NeighborhoodClearCr:MSZoningRM	NA	NA	NA	NA
## NeighborhoodCollgCr:MSZoningRM	NA	NA	NA	NA
## NeighborhoodCrawfor:MSZoningRM	NA	NA	NA	NA
## NeighborhoodEdwards:MSZoningRM	NA	NA	NA	NA
## NeighborhoodGilbert:MSZoningRM	NA	NA	NA	NA
## NeighborhoodIDOTRR:MSZoningRM	3.285e-01	6.078e-02	5.404	7.67e-08 ***
## NeighborhoodMeadowV:MSZoningRM	NA	NA	NA	NA
## NeighborhoodMitchel:MSZoningRM	NA	NA	NA	NA
## NeighborhoodNames:MSZoningRM	NA	NA	NA	NA
## NeighborhoodNoRidge:MSZoningRM	NA	NA	NA	NA
## NeighborhoodNPkVill:MSZoningRM	NA	NA	NA	NA
## NeighborhoodNridgHt:MSZoningRM	NA	NA	NA	NA
## NeighborhoodNWAmes:MSZoningRM	NA	NA	NA	NA
## NeighborhoodOldTown:MSZoningRM	9.159e-02	1.334e-01	0.687	0.492482
## NeighborhoodSawyer:MSZoningRM	NA	NA	NA	NA
## NeighborhoodSawyerW:MSZoningRM	NA	NA	NA	NA
## NeighborhoodSomerst:MSZoningRM	NA	NA	NA	NA
## NeighborhoodStoneBr:MSZoningRM	NA	NA	NA	NA
## NeighborhoodSWISU:MSZoningRM	NA	NA	NA	NA
## NeighborhoodTimber:MSZoningRM	NA	NA	NA	NA
## NeighborhoodVeenker:MSZoningRM	NA	NA	NA	NA
## NeighborhoodBlueste:OverallQual	NA	NA	NA	NA
## NeighborhoodBrDale:OverallQual	-1.765e-01	1.209e-01	-1.460	0.144598
## NeighborhoodBrkSide:OverallQual	5.238e-02	9.339e-02	0.561	0.574959
## NeighborhoodClearCr:OverallQual	2.198e-02	9.624e-02	0.228	0.819374
## NeighborhoodCollgCr:OverallQual	-2.246e-02	9.310e-02	-0.241	0.809390
## NeighborhoodCrawfor:OverallQual	-2.219e-02	9.423e-02	-0.236	0.813823
## NeighborhoodEdwards:OverallQual	-8.933e-02	9.267e-02	-0.964	0.335226
## NeighborhoodGilbert:OverallQual	-5.617e-02	9.435e-02	-0.595	0.551694
## NeighborhoodIDOTRR:OverallQual	-5.006e-02	9.477e-02	-0.528	0.597419
## NeighborhoodMeadowV:OverallQual	-4.351e-02	1.134e-01	-0.384	0.701160

```

## NeighborhoodMitchel:OverallQual  8.362e-03  9.529e-02  0.088 0.930080
## NeighborhoodNames:OverallQual   -3.913e-02  9.257e-02  -0.423 0.672591
## NeighborhoodNoRidge:OverallQual  -3.349e-02  9.536e-02  -0.351 0.725461
## NeighborhoodNPkVill:OverallQual      NA      NA      NA      NA
## NeighborhoodNridgHt:OverallQual   9.661e-03  9.293e-02  0.104 0.917221
## NeighborhoodNWAmes:OverallQual   -7.376e-02  9.485e-02  -0.778 0.436917
## NeighborhoodOldTown:OverallQual  -1.110e-02  9.244e-02  -0.120 0.904433
## NeighborhoodSawyer:OverallQual   -3.677e-02  9.677e-02  -0.380 0.704025
## NeighborhoodSawyerW:OverallQual   2.947e-02  9.448e-02  0.312 0.755118
## NeighborhoodSomerst:OverallQual  -7.485e-03  9.362e-02  -0.080 0.936292
## NeighborhoodStoneBr:OverallQual  -1.822e-02  1.024e-01  -0.178 0.858829
## NeighborhoodSWISU:OverallQual   -4.943e-02  9.543e-02  -0.518 0.604545
## NeighborhoodTimber:OverallQual    3.304e-03  9.541e-02  0.035 0.972377
## NeighborhoodVeenker:OverallQual   1.644e-02  1.012e-01  0.162 0.871007
## NeighborhoodBlueste:YearBuilt      NA      NA      NA      NA
## NeighborhoodBrDale:YearBuilt       5.108e-02  4.699e-02  1.087 0.277191
## NeighborhoodBrkSide:YearBuilt      4.324e-02  2.961e-02  1.460 0.144418
## NeighborhoodClearCr:YearBuilt      4.268e-02  2.960e-02  1.442 0.149531
## NeighborhoodCollgCr:YearBuilt      4.701e-02  2.962e-02  1.587 0.112692
## NeighborhoodCrawfor:YearBuilt      4.251e-02  2.958e-02  1.437 0.150946
## NeighborhoodEdwards:YearBuilt      4.502e-02  2.957e-02  1.523 0.128094
## NeighborhoodGilbert:YearBuilt      4.509e-02  2.962e-02  1.522 0.128202
## NeighborhoodIDOTRR:YearBuilt       4.192e-02  2.961e-02  1.416 0.157054
## NeighborhoodMeadowV:YearBuilt      6.711e-02  3.347e-02  2.005 0.045127 *
## NeighborhoodMitchel:YearBuilt      4.223e-02  2.961e-02  1.426 0.154071
## NeighborhoodNames:YearBuilt       4.481e-02  2.959e-02  1.515 0.130100
## NeighborhoodNoRidge:YearBuilt      5.404e-02  3.066e-02  1.762 0.078224 .
## NeighborhoodNPkVill:YearBuilt      3.482e-02  4.790e-02  0.727 0.467477
## NeighborhoodNridgHt:YearBuilt      6.854e-02  3.082e-02  2.224 0.026319 *
## NeighborhoodNWAmes:YearBuilt       4.627e-02  2.967e-02  1.560 0.119071
## NeighborhoodOldTown:YearBuilt      4.335e-02  2.957e-02  1.466 0.142934
## NeighborhoodSawyer:YearBuilt       4.413e-02  2.958e-02  1.491 0.136067
## NeighborhoodSawyerW:YearBuilt      4.475e-02  2.963e-02  1.510 0.131263
## NeighborhoodSomerst:YearBuilt      5.440e-02  2.997e-02  1.815 0.069724 .
## NeighborhoodStoneBr:YearBuilt      5.855e-02  2.975e-02  1.968 0.049294 *
## NeighborhoodSWISU:YearBuilt       4.288e-02  2.974e-02  1.442 0.149534
## NeighborhoodTimber:YearBuilt      4.425e-02  2.963e-02  1.493 0.135647
## NeighborhoodVeenker:YearBuilt      4.633e-02  3.028e-02  1.530 0.126250
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1315 on 1355 degrees of freedom
## Multiple R-squared:  0.8993, Adjusted R-squared:  0.8916

```

```
## F-statistic: 116.4 on 104 and 1355 DF,  p-value: < 2.2e-16
```

4.3 Model Assumption Assessment

Address each assumption

4.4 Comparing Competing Models

- Adj R^2 The final adjusted R^2 of our model is 0.8916
- CV Press Our cross-validated PRESS statistic output is below.

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Warning in predict.lm(modelFit, newdata): prediction from a rank-deficient
## fit may be misleading
```

```
## Linear Regression
```

```
##
```

```
## 1460 samples
```

```
## 12 predictor
```

```
##
## No pre-processing
## Resampling: Cross-Validated (10 fold)
## Summary of sample sizes: 1313, 1314, 1315, 1314, 1315, 1313, ...
## Resampling results:
##
##      RMSE      Rsquared   MAE
##    0.171943  0.8187467  0.1030658
##
## Tuning parameter 'intercept' was held constant at a value of TRUE
• Kaggle score
```

4.5 Conclusion

A short summary of the analysis

5 Appendix

5.1 Checking for Linearity in SalePrice vs GrLivArea

The scatter plot in Figure 2 shows relationship of **SalePrice** vs **GrLivArea** for all three neighborhoods of interest to Century 21. Based on this plot, it does not appear that this relationship meets the assumptions of linear regression, specifically the constant variance assumption. The response will be transformed to attempt to handle the changing variance.



Figure 2: Scatter Plot of Sale Price vs Living Room Area

The images below show the scatter plots of log sale price vs living room area (Figure 3). In the image on the right, the scatter plot is shown for each neighborhood. In the image on the left the observations for all three neighborhoods are included. In all cases, a linear model appears to be reasonable to model this data.



Figure 3: Scatter Plots of Log of Sale Price vs Living Room Area

5.2 Analysis of Influential points

The two outlying observations with living room areas greater than 4000 sq. ft. appear to be from a different distribution than the main dataset. Since these are partial sales, it is possible that the sale prices do not reflect market value. For this reason, we will limit the analysis to properties with less than 3500 sq. ft. 4

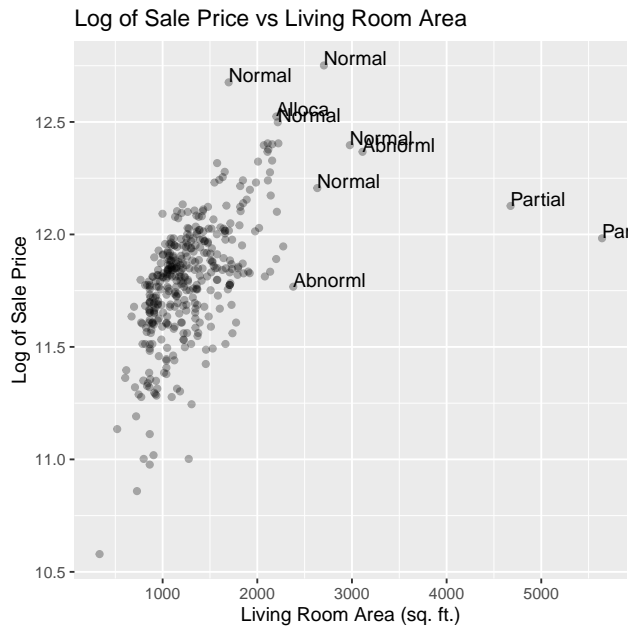


Figure 4: Influential Points

5.3 R Code For Analysis 1

```
### Computational Setup
# libraries
library(knitr)
library(kableExtra)
library(tidyverse)
library(olsrr)
library(gridExtra)
library(caret)
library(multcomp)

# load data
train <- read_csv('./data/train.csv')
test <- read_csv('./data/test.csv')

# set a random seed for reproducibility
set.seed(123)

### Helper Code

#' Print Typical Regression Fit Plots
#'
#' @description
#' Plots QQ plot of residuals, histogram of residuals,
```



```

#' residuals vs predicted values, and studentized
#' residuals vs predicted values. Depends on tidyverse
#' and gridExtra packages being loaded.
#'
#' @param data The true values corresponding to the input.
#' @param model The predicted/fitted values of the model.
basic.fit.plots <- function(data, model) {

  # depends on
  require(tidyverse)
  require(gridExtra)

  # get predicted values
  data$Predicted <- predict(model, data)
  # get residuals
  data$Resid <- model$residuals
  # get studentized residuals
  data$RStudent <- rstudent(model = model)

  # create qqplot of residuals with reference line
  qqplot.resid <- data %>%
    ggplot(aes(sample = Resid)) +
    geom_qq() + geom_qq_line() +
    labs(subtitle = 'QQ Plot of Residuals',
         x = 'Theoretical Quantile',
         y = 'Acutal Quantile')

  # create histogram of residuals
  hist.resid <- data %>%
    ggplot(aes(x = Resid)) +
    geom_histogram(bins = 15) +
    labs(subtitle = 'Histogram of Residuals',
         x = 'Residuals',
         y = 'Count')

  # create scatter plot of residuals vs predicted values
  resid.vs.pred <- data %>%
    ggplot(aes(x = Predicted, y = Resid)) +
    geom_point() +
    geom_abline(slope = 0) +
    labs(subtitle = 'Residuals vs Prediction',
         x = 'Predicted Value',
         y = 'Residual')

```

```

# create scatter plot of studentized
# residuals vs predicted values
rStud.vs.pred <- data %>%
  ggplot(aes(x = Predicted, y = RStudent)) +
  geom_point() +
  geom_abline(slope = 0) +
  geom_abline(slope = 0, intercept = -2) +
  geom_abline(slope = 0, intercept = 2) +
  labs(subtitle = 'RStudent vs Prediction',
       x = 'Predicted Value',
       y = 'RStudent')

# add all four plots to grid as
# qqplot          histogram
# resid vs pred   RStud vs pred
grid.arrange(qqplot.resid,
             hist.resid,
             resid.vs.pred,
             rStud.vs.pred,
             nrow = 2,
             top = 'Fit Assessment Plots')
}

#' Creates dummy variables (columns) for given column
#'
#' @param data A dataframe.
#' @param column A categorical column in data.
#' @param reference A value in the column to use as a reference.
#' @param as.onehot Set to TRUE to use onehot encoding.
#'
get.dummies <- function(data, column, reference, as.onehot = FALSE) {
  # get the levels of the factor in column
  lev <- levels(data[[column]])
  # do not remove reference for onehot encoding
  if (!as.onehot) {
    # remove the reference value
    lev <- lev[lev != reference]
  }
  # add encodings
  for (fct in lev){
    new_col <- paste(column, fct, sep = '_')
    data[new_col] <- as.numeric(data[, column] == fct)
  }
}

```

```

    print(new_col)
  }
  data
}

#' Calculates PRESS from `caret` CV model
#'
#' @param model.cv Calculates press from a model
#' produced by `caret`
#'
PRESS.cv <- function(model.cv) {
  meanN <- 0
  folds <- model.cv$control$index
  for (i in seq(1:length(folds))){
    meanN <- meanN + length(folds[[i]])
  }
  meanN <- meanN / length(folds)
  meanN * ((model.cv$results$RMSE)^2)
}

### plots of log of sale price ~ living room area

# create scatter plot for northwest ames
regplot.names <- train %>% filter(Neighborhood == 'NAmes') %>%
  ggplot(aes(x = (GrLivArea), y = log(SalePrice))) +
  geom_point(alpha = 0.3) +
  ylim(10, 13) +
  xlim(0, 3500) +
  labs(subtitle = 'Northwest Ames',
       y = 'Log of Sale Price', x = 'Living Room Area (sq. ft.)')

# create scatter plot for edwards
regplot.ed <- train %>%
  filter(GrLivArea < 4000) %>%
  filter(Neighborhood == 'Edwards') %>%
  ggplot(aes(x = (GrLivArea), y = log(SalePrice))) +
  geom_point(alpha = 0.3) +
  ylim(10, 13) +
  xlim(0, 3500) +
  labs(subtitle = 'Edwards',
       y = 'Log of Sale Price', x = 'Living Room Area (sq. ft.)')

# create regression plot for brookside

```

```

regplot.brk <- train %>% filter(Neighborhood == 'BrkSide') %>%
  ggplot(aes(x = (GrLivArea), y = log(SalePrice))) +
  geom_point(alpha = 0.3) +
  ylim(10, 13) +
  xlim(0, 3500) +
  labs(subtitle = 'Brook Side',
       y = 'Log of Sale Price', x = 'Living Room Area (sq. ft.)')

# add the scatter plots for the neighborhood into a single plot
grid.arrange(regplot.names, regplot.ed, regplot.brk, nrow = 2,
             top = 'Regression Plots for Neighborhoods')

# scatter plot of observations from all three neighborhoods
train %>%
  filter(GrLivArea < 4000) %>%
  ggplot(aes(x = (GrLivArea), y = log(SalePrice))) +
  geom_point(alpha = 0.3) +
  labs(title = 'Log of Sale Price vs Living Room Area',
       y = 'Log of Sale Price', x = 'Living Room Area (sq. ft.)')

### Filter data for analysis 1

train <- train %>%
  filter(Neighborhood %in% c("Edwards", "BrkSide", "NAMES"))
train$Neighborhood <- as.factor(train$Neighborhood)

# create dummy variables with Neighborhood == 'Edwards' as reference
train <- get.dummies(train, "Neighborhood", reference = 'Edwards')

# remove suspect points from training data
train.mod <- train %>% filter(GrLivArea < 4000)

#### Extra Sum of Squares

# full model formula
model.formula = log(SalePrice) ~ (GrLivArea) +
  Neighborhood_BrkSide +
  Neighborhood_NAMES +
  (GrLivArea) * Neighborhood_BrkSide +
  (GrLivArea) * Neighborhood_NAMES

# reduced model formula
model.reduced.formula = log(SalePrice) ~ (GrLivArea) +
  Neighborhood_BrkSide +

```

Neighborhood_NAmes

```
# fit models
model <- lm(formula = model.formula, data = train.mod)
model.reduced <- lm(formula = model.reduced.formula, data = train.mod)
# ESS test on models
anova(model.reduced, model)

### Assessment plots

# create plots of residuals
basic.fit.plots(train.mod, model)
# create leverage / outlier plot
ols_plot_resid_lev(model)

### cross validation

## cross validate the full model

# Set up repeated k-fold cross-validation
train.control <- trainControl(method = "cv", number = 10)
# Train the model
model.cv <- train(model.formula,
                  data = train.mod,
                  method = 'lm',
                  trControl = train.control)

# print model summary
model.cv

# get the CV results
res <- model.cv$results

# get cross-validated PRESS statistic
PCV <- PRESS.cv(model.cv)

## cross validate the reduced model

# Set up repeated k-fold cross-validation
train.control <- trainControl(method = "cv", number = 10)
# Train the model
model.reduced.cv <- train(model.reduced.formula,
                          data = train.mod,
                          method = 'lm',
```

```

        trControl = train.control)

# print model summary
model.reduced.cv

# get the CV results
res.red <- model.reduced.cv$results

# get cross-validated PRESS statistic
PCV.red <- PRESS.cv(model.reduced.cv)

# print accuracy metrics to md table
kable(data.frame('Model' = c('Full Model', 'Reduced Model'),
                  'RMSE'=c(res$RMSE, res.red$RMSE),
                  'CV Press'=c(PCV, PCV.red),
                  'Adjusted R Squared'=c(res$Rsquared, res.red$Rsquared)),
      "latex", booktabs = T) %>%
  kable_styling(position = "center")

### get the parameters from the CV'ed model

# extract the model estimates from the model summary
sm <- summary(model)
sm.coe <- sm$coefficients
# get the CIs for the coefficients
model.conf <- confint(model)

# print model estimates to md / latex table
# extract the params and put into a dataframe
kable(data.frame('Parameter' = c('Intercept', 'GrLivArea',
                                  'Neighborhood_BrkSide', 'Neighborhood_NAmes',
                                  'GrLivArea:Neighborhood_BrkSide',
                                  'GrLivArea:Neighborhood_NAmes '),
                  'Estimate'=c(sm.coe[[1]], sm.coe[[2]], sm.coe[[3]],
                                sm.coe[[4]], sm.coe[[5]], sm.coe[[6]]),
                  'CI Lower' = c(model.conf[[1]], model.conf[[2]], model.conf[[3]],
                                model.conf[[4]], model.conf[[5]], model.conf[[6]]),
                  'CI Upper' = c(model.conf[[1,2]], model.conf[[1,2]], model.conf[[3,2]],
                                model.conf[[4,2]], model.conf[[5,2]], model.conf[[6,2]])),
      "latex", booktabs = T) %>%
  kable_styling(position = "center")

# summary of model to get overall test
summary(lm(model.formula, data = train.mod))

```

```
## Calculate CIs of slopes not in standard table

# get CI for Northwest Ames
confint(glm(model, lmfct = "GrLivArea + GrLivArea:Neighborhood_NAmes = 1"))

# get CI for Brookside
confint(glm(model, lmfct = "GrLivArea + GrLivArea:Neighborhood_BrkSide = 1"))
```

5.4 R Code For Analysis 2

Include “well commented” code in the appendix!

```
train %>% ggplot(aes(x = (GrLivArea), y = log(SalePrice))) +
  geom_point(alpha = 0.3) +
  labs(title = 'Log of Sale Price vs Living Room Area',
        y = 'Log of Sale Price', x = 'Living Room Area') +
  geom_text(aes(label = ifelse((log(GrLivArea) > 7.75 & log(SalePrice) > 11) |
                              (log(SalePrice) > 12.45),
                              SaleCondition, '')), hjust=0, vjust=0)
```

References

- [1] Cock, D. D. (2011). Ames, iowa: Alternative to the boston housing data as an end of semester regression project. *Journal of Statistics Education*, 19(3).
- [2] Kaggle (2016). Ames housing dataset. Data retrieved from the Kaggle website, <https://www.kaggle.com/c/house-prices-advanced-regression-techniques/data>.
- [3] Ramsey, F. and Schafer, D. (2013). *The Statistical Sleuth: A Course in Methods of Data Analysis*. Brooks/Cole Publishing Company.