**Insights in Ames, Iowa: Real Estate**

MSDS 6371

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***Made up a dumb title and needs more work but here’s something to start with!!***

1. **Overview**

The selling prices of homes drive the real estate business. However, many factors influence a client’s purchasing decision and additionally the selling price. Aligning the client’s preferences with home attributes that also maximize selling price leads to satisfied buyers and optimal profitability. We will investigate what home characteristics are associated with selling price, so that Century 21 Ames can best position themselves in the market.

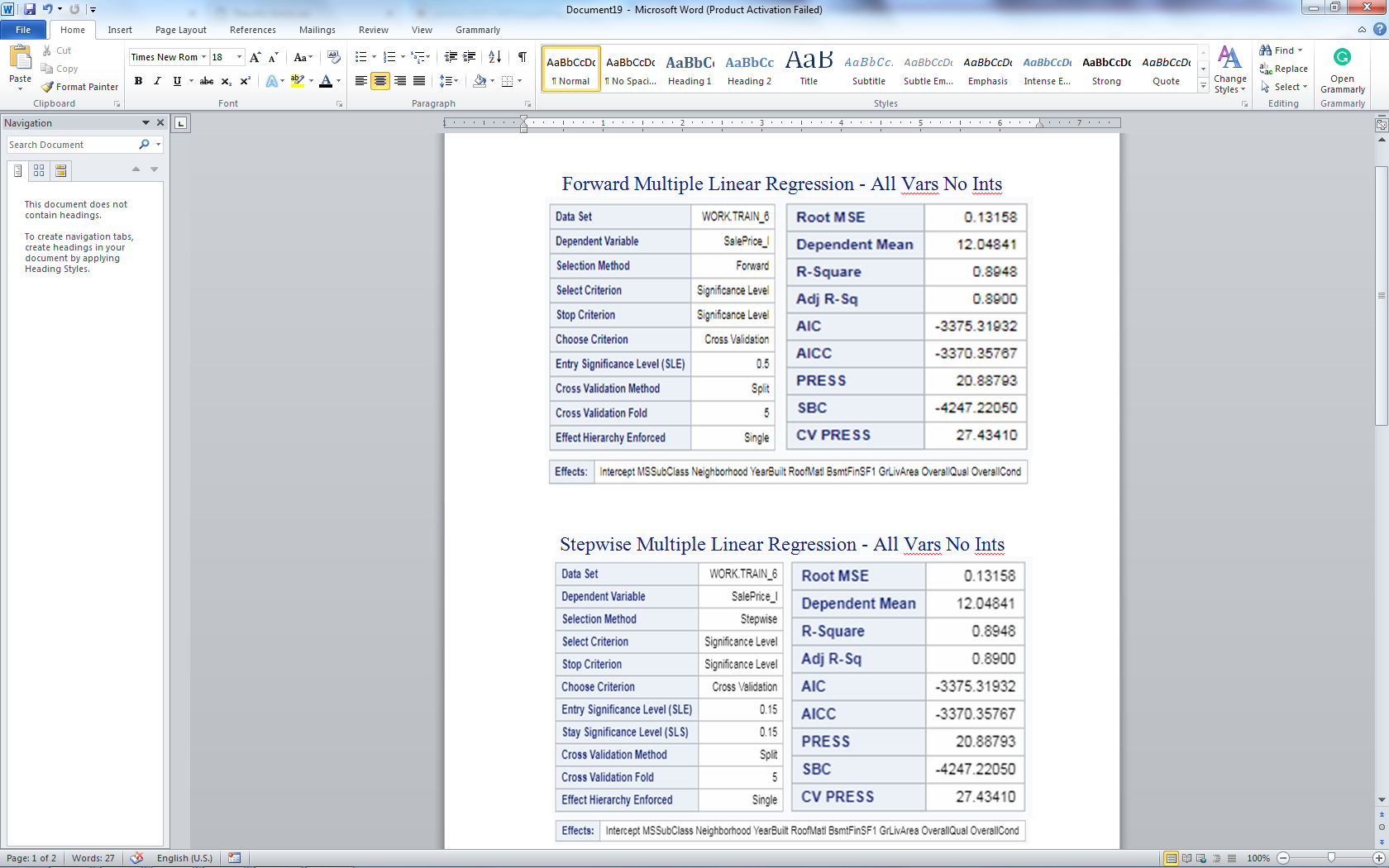
The Ames Housing Dataset compiled by Dean De Cock includes 79 explanatory variables to determine the corresponding selling price. There are 1,460 observations in the training data set and 1,459 in the testing data set. A full description of each variable can be found in the “data\_description” text file on Kaggle.com. *Insert all the important variables.*

1. **Century 21 Analysis**
2. **Predicting Selling Prices**

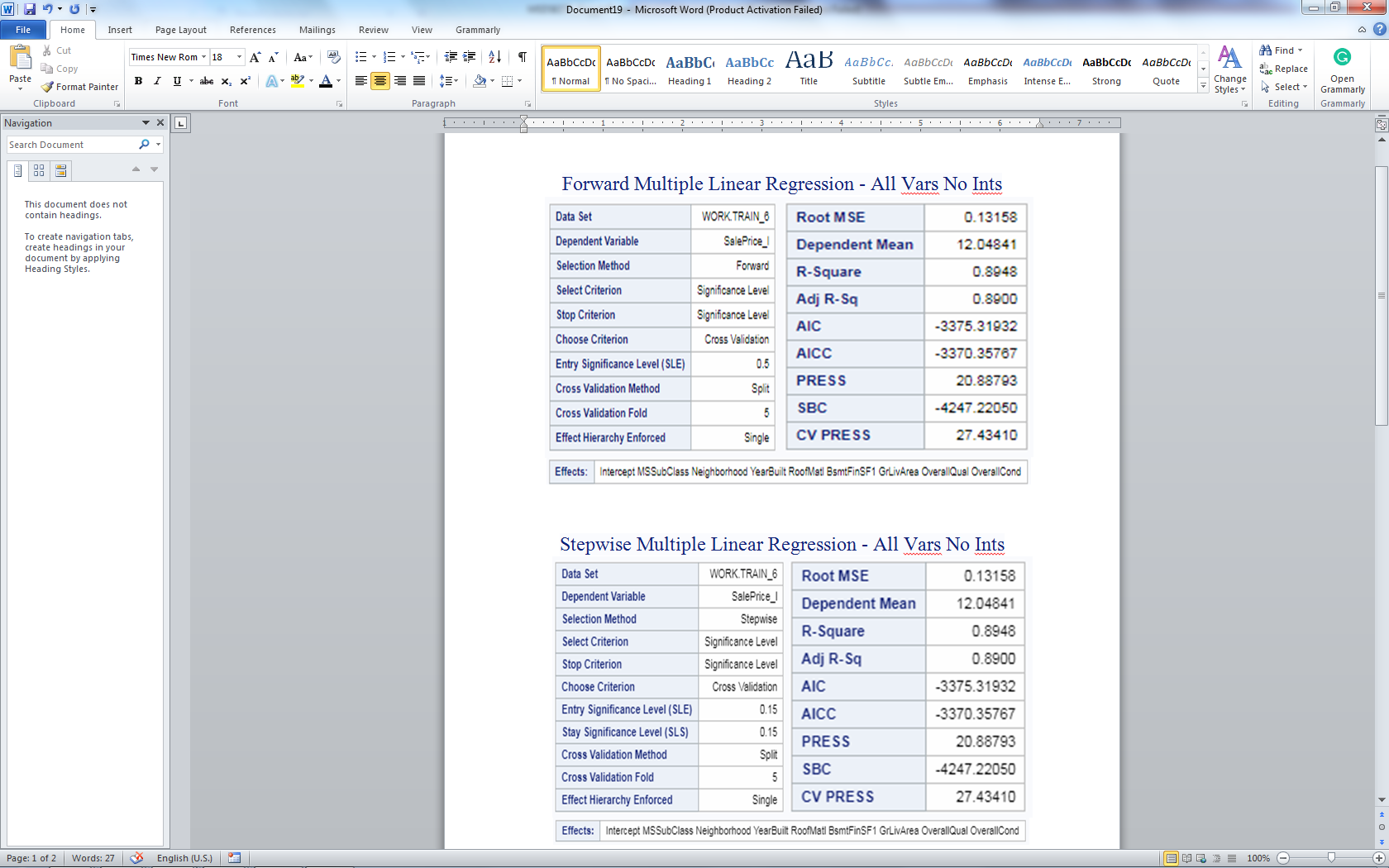
Determining the correlation between the predictive variables and the final selling price of a home allows us to go further into the analysis process and begin modeling. By creating statistical models and using regression techniques, we are able to create custom models that allow us to estimate the predicted selling price of a home based on readily available listing information. Being able to accurately predict the sales price of a home will allow Century 21 to better evaluate listing prices, estimate commissions, and allocate agent resources.

**Model Selection**

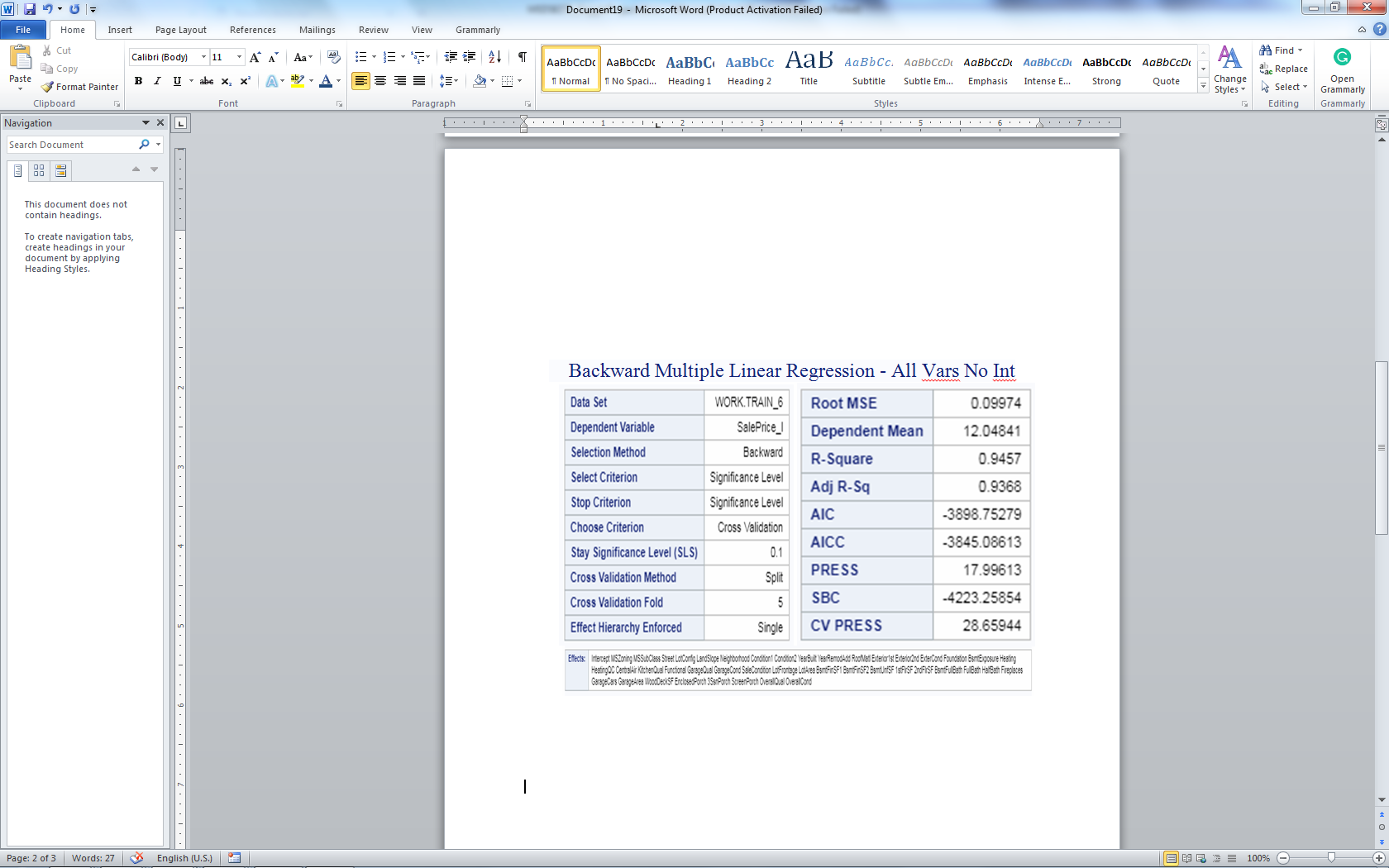
Based on the results of the exploratory data analysis, new variables were created for the log of the sales price and the log of the living area. For each model, the log of the sales price (SalePrice\_l) was used as the dependent variable. The first model selection process used was stepwise multiple linear regression using all explanatory variables and no interaction variables. Selection criterion were based on a significance level of .15 for both entry and stay significance. The step selection process resulted in a reduced model with 8 effect variables and a RMSE of .1316.



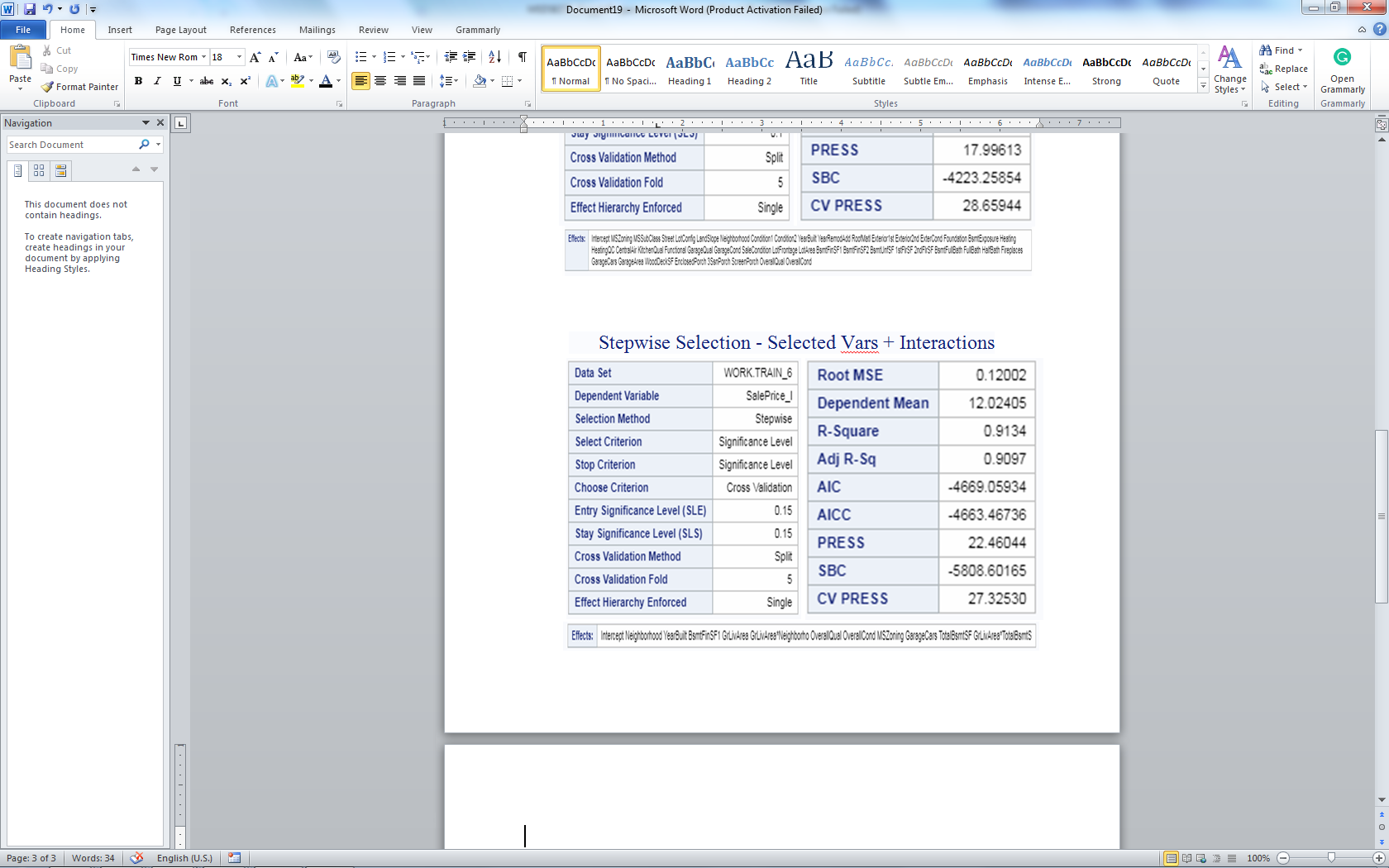
The next model was built using a forward multiple regression process checking all explanatory variables and no interaction variables. As with the stepwise regression, significance level was used as the selection criterion but the entry significance level was set to .5 and resulted in the same 8 variables and as a result, the same RMSE of .1316.



The third model was built using a backward selection process starting with all explanatory variables and no interaction variables. The stay significance for this model was .10 and expectedly the higher significance score led to a model with more included variables. The backward selection model had 33 variables and a RMSE of .0997.



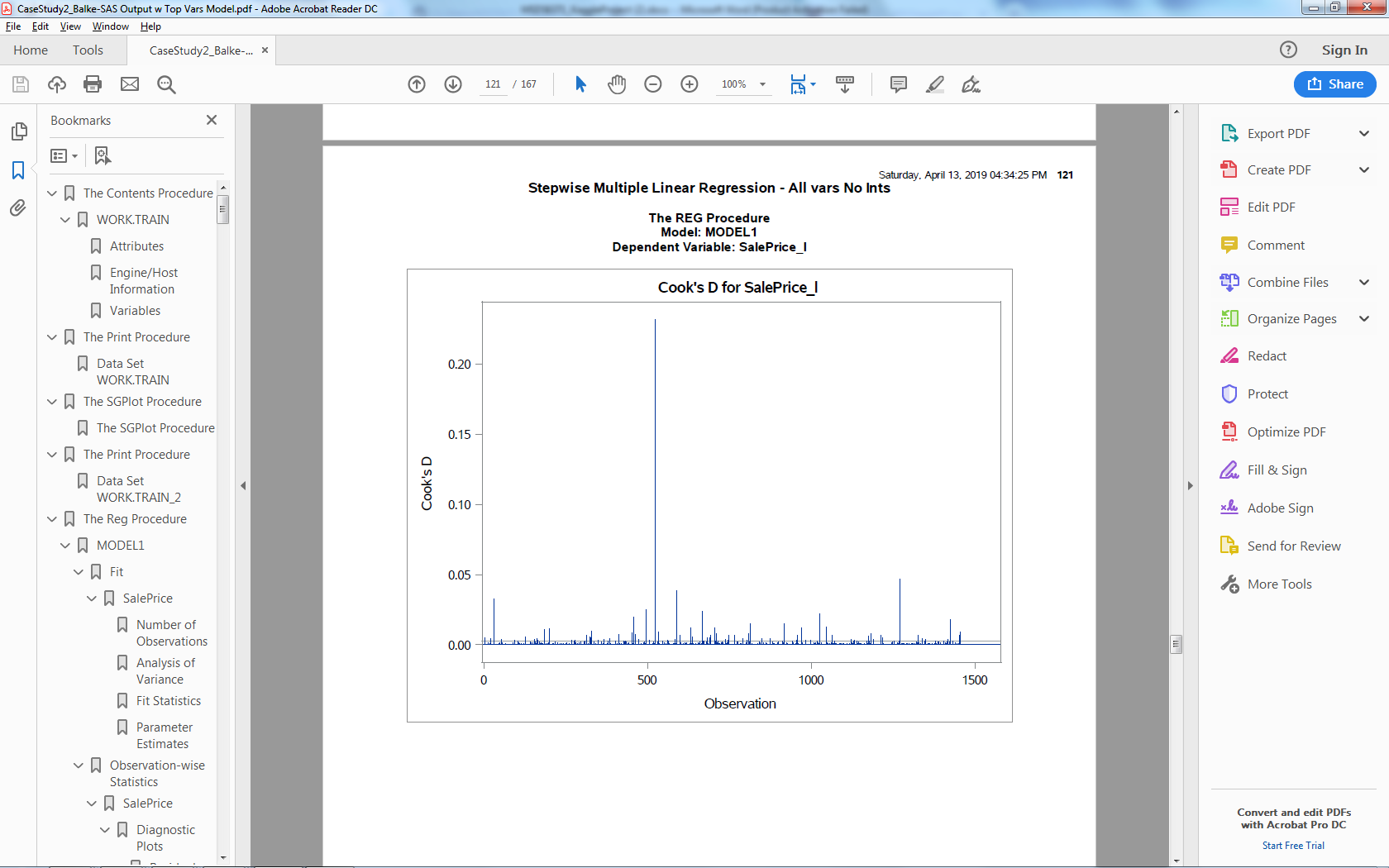
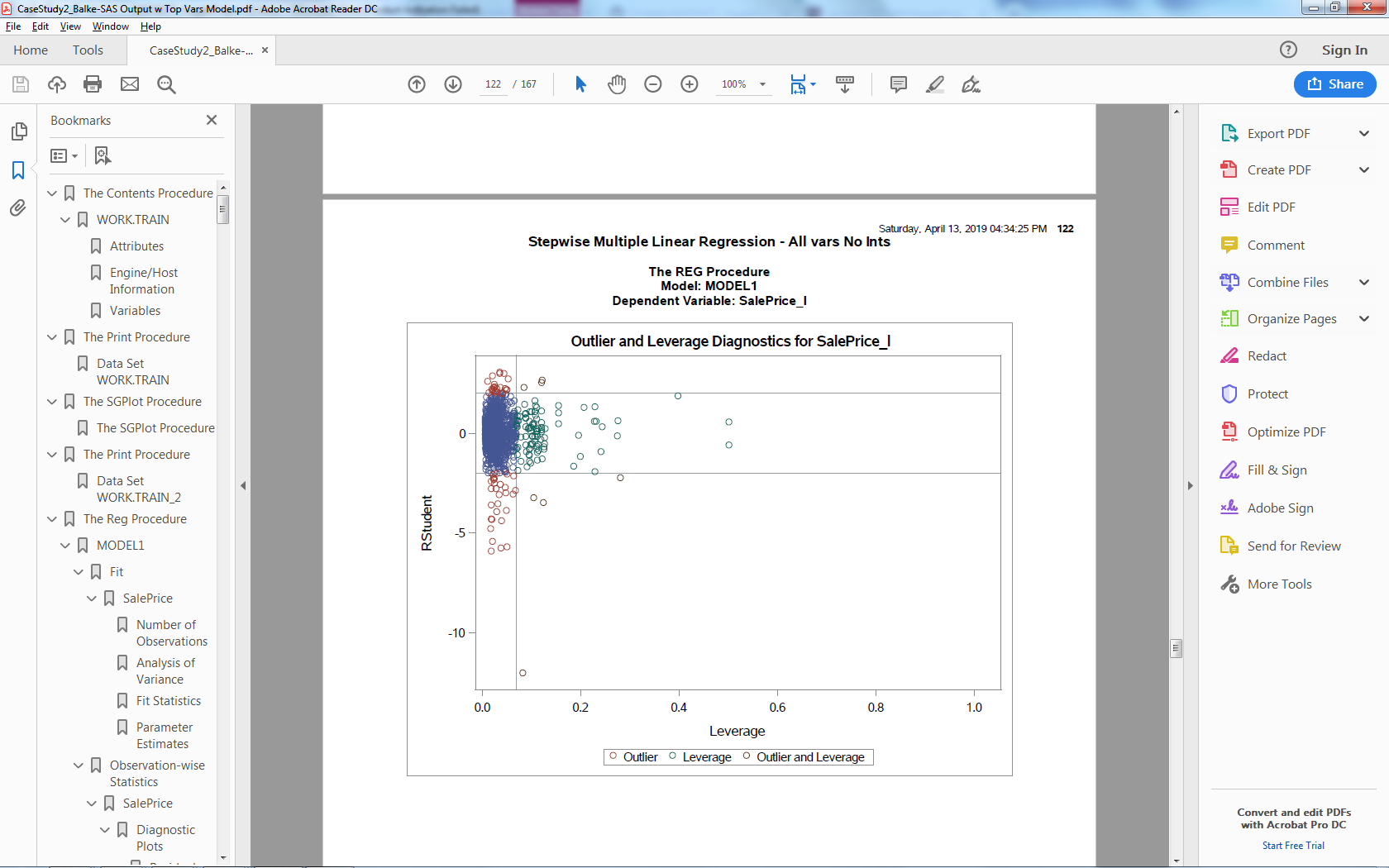
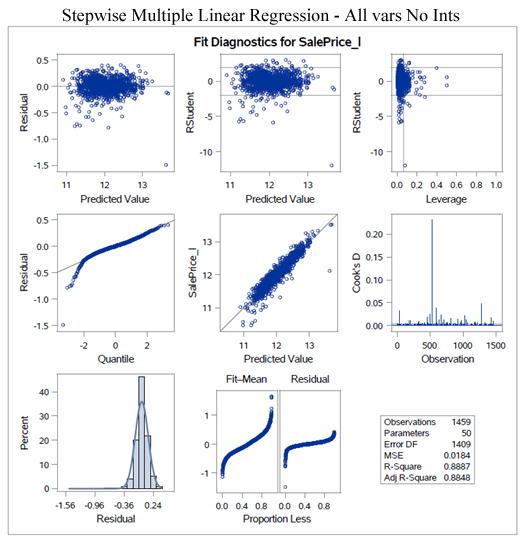
Finally a custom model was created using the stepwise process but allowing for interactions. Like the previous stepwise model, a .15 level of significance was used for both entry and stay. The resulting model had a total of 11 variables, 9 explanatory 2 interaction, and a RMSE of .1200.

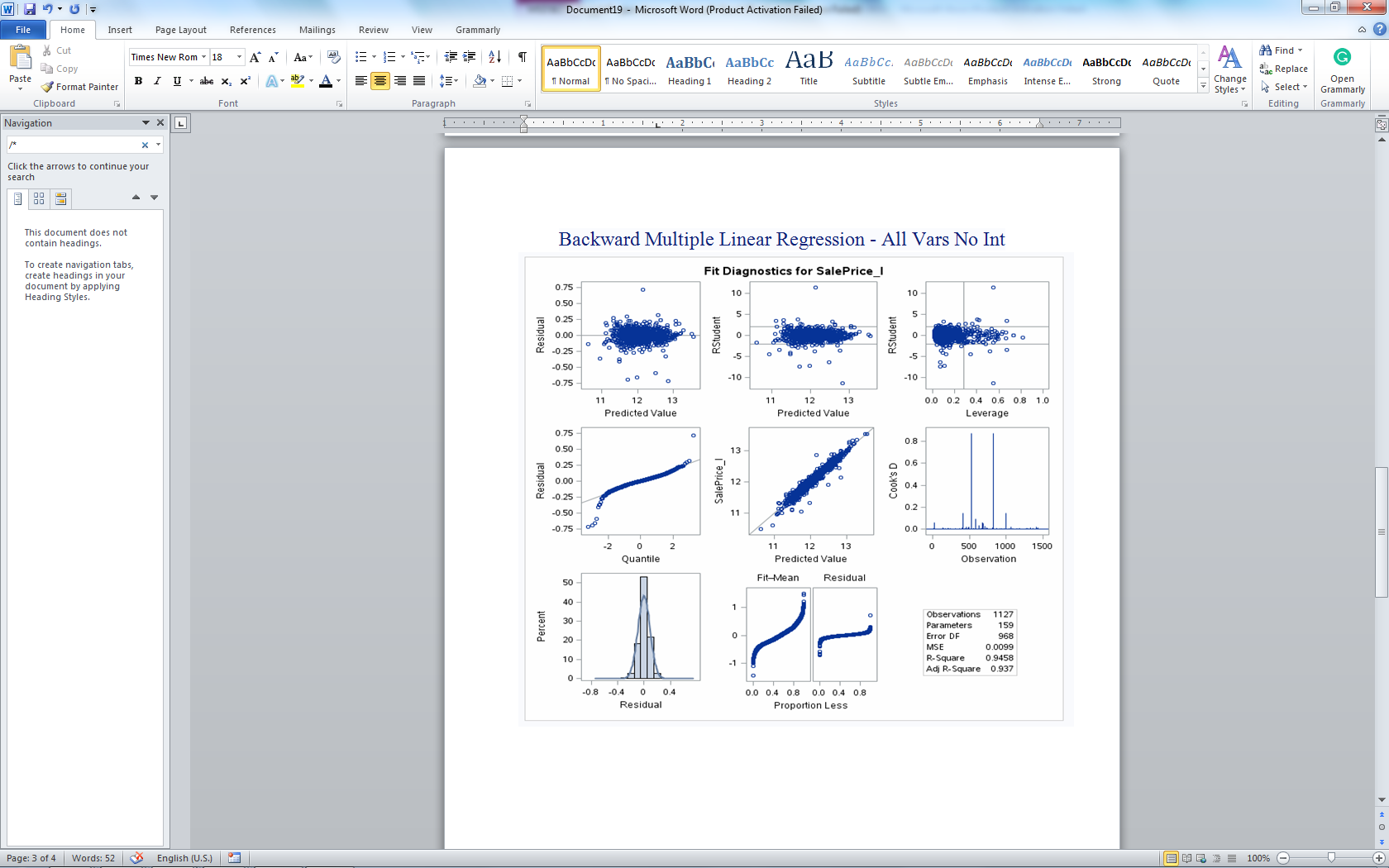


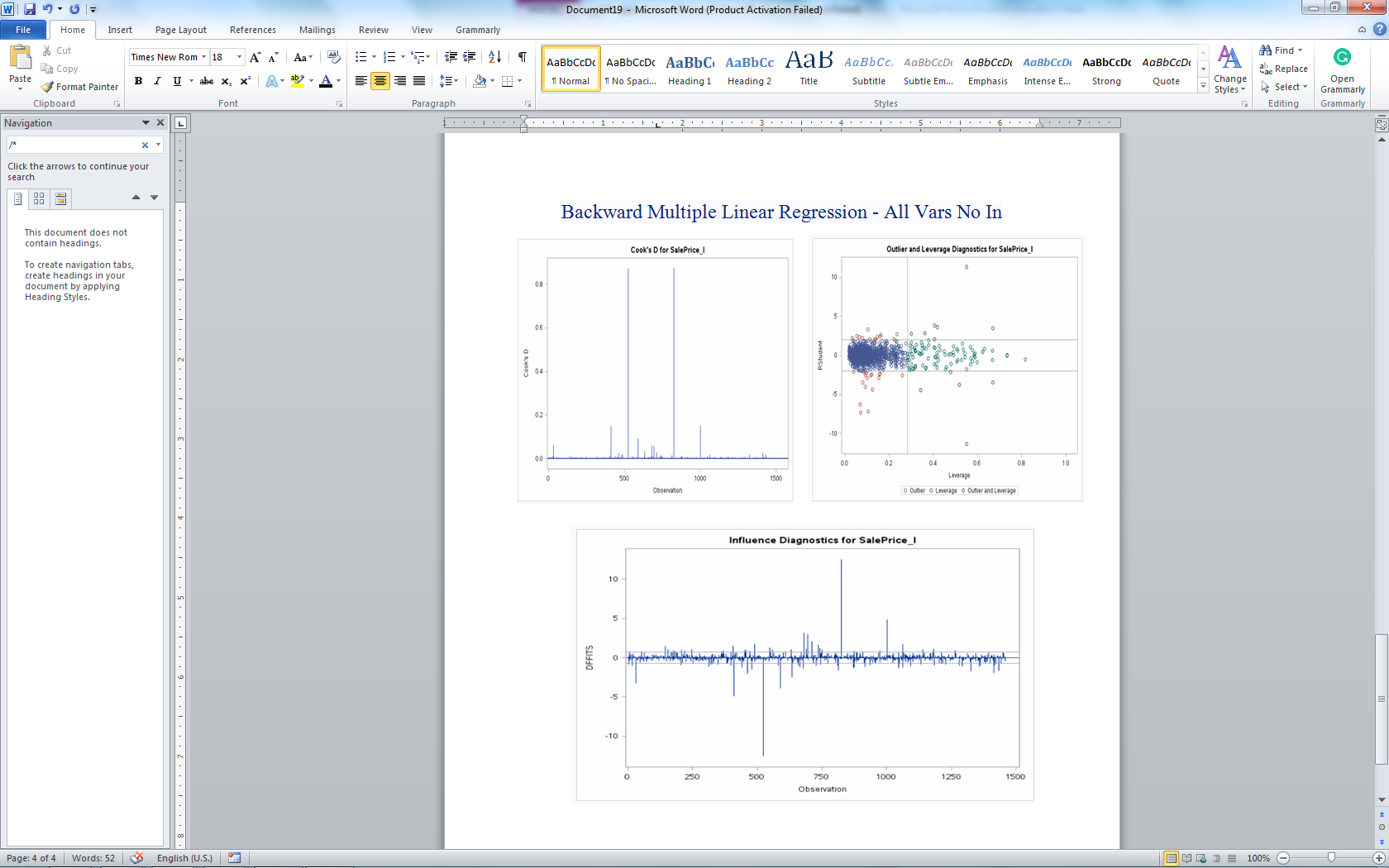
**Checking Assumptions**

Multilinear regression requires that certain assumptions be made about the data being used and that those assumptions be tested as part of the process. These assumptions are that there is a linear relationship (linearity) between the response variable and the explanatory variables, that there is a normal distribution of residuals (normality), and that independent variables are not highly correlated with each other (no multicollinearity). Linearity was checked by reviewing scatterplots of the residuals. Normality was verified by reviewing residual scatterplots and by analyzing the impact of outlier data points. Multicollinearity was checked through Variance Inflation Factor (VIF) values and using model selection processes that reduced the effects of collinearity.

Regression plot data for simple stepwise and forward selection were the same as they both yielded the same models. Residual scatterplots indicated no reason to suggest that the data was not normally distributes and indicated strong linearity between the response and explanatory variables. Cook’s D and Outlier Leverage Diagnostics indicated the presence of outliers but the low Cook’s score of the outlier point and the general distribution of outlying points within the minimal leverage zone suggests that their effect on the regression is negligible. It should be noted that the fit tests do not result in a straight line because the dependent variable was logged.

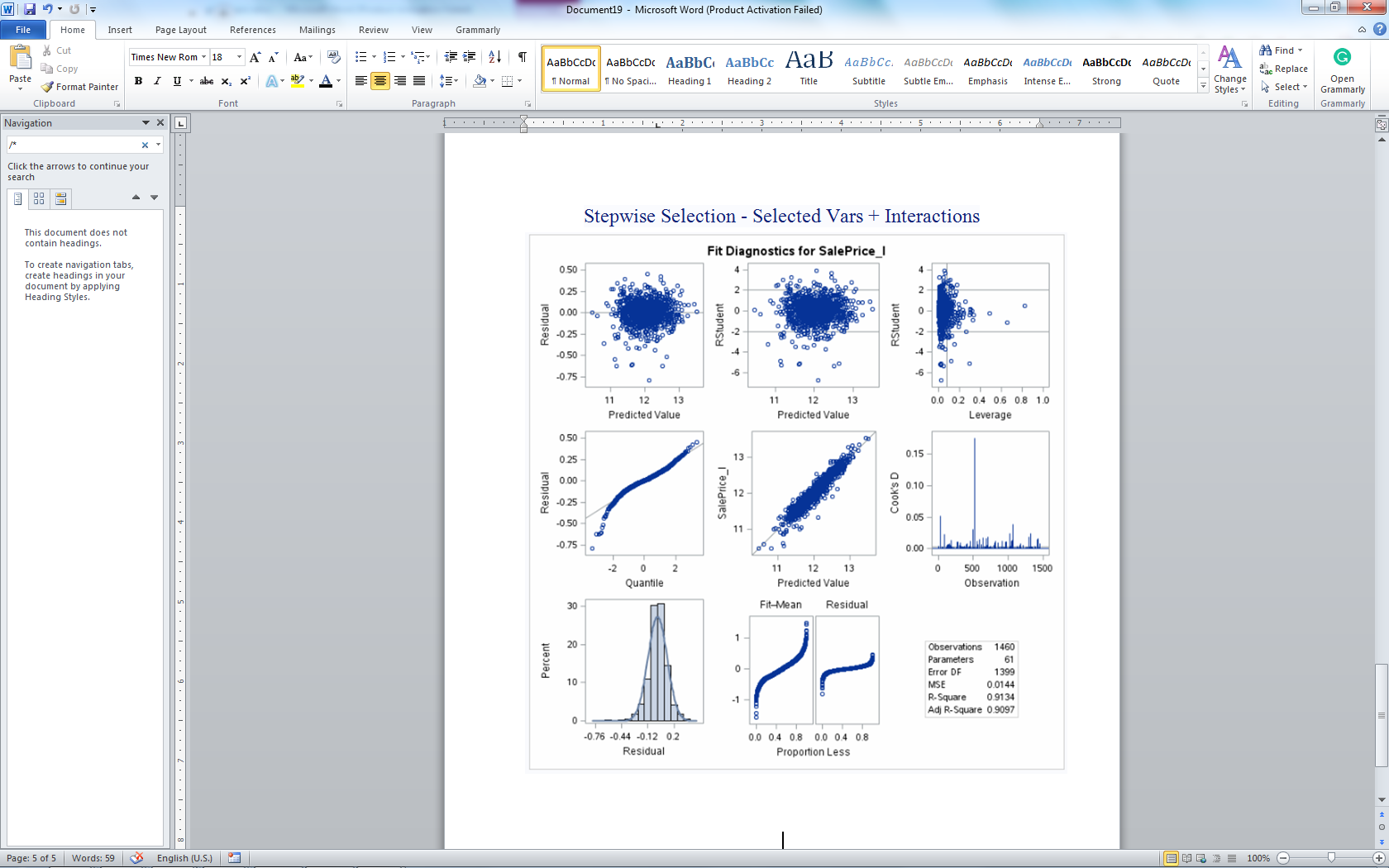
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As with the stepwise and forward selection, residual scatterplots for the backward selection model indicated linearity and normality, however the addition of more variables also resulted in the introduction of more outliers.



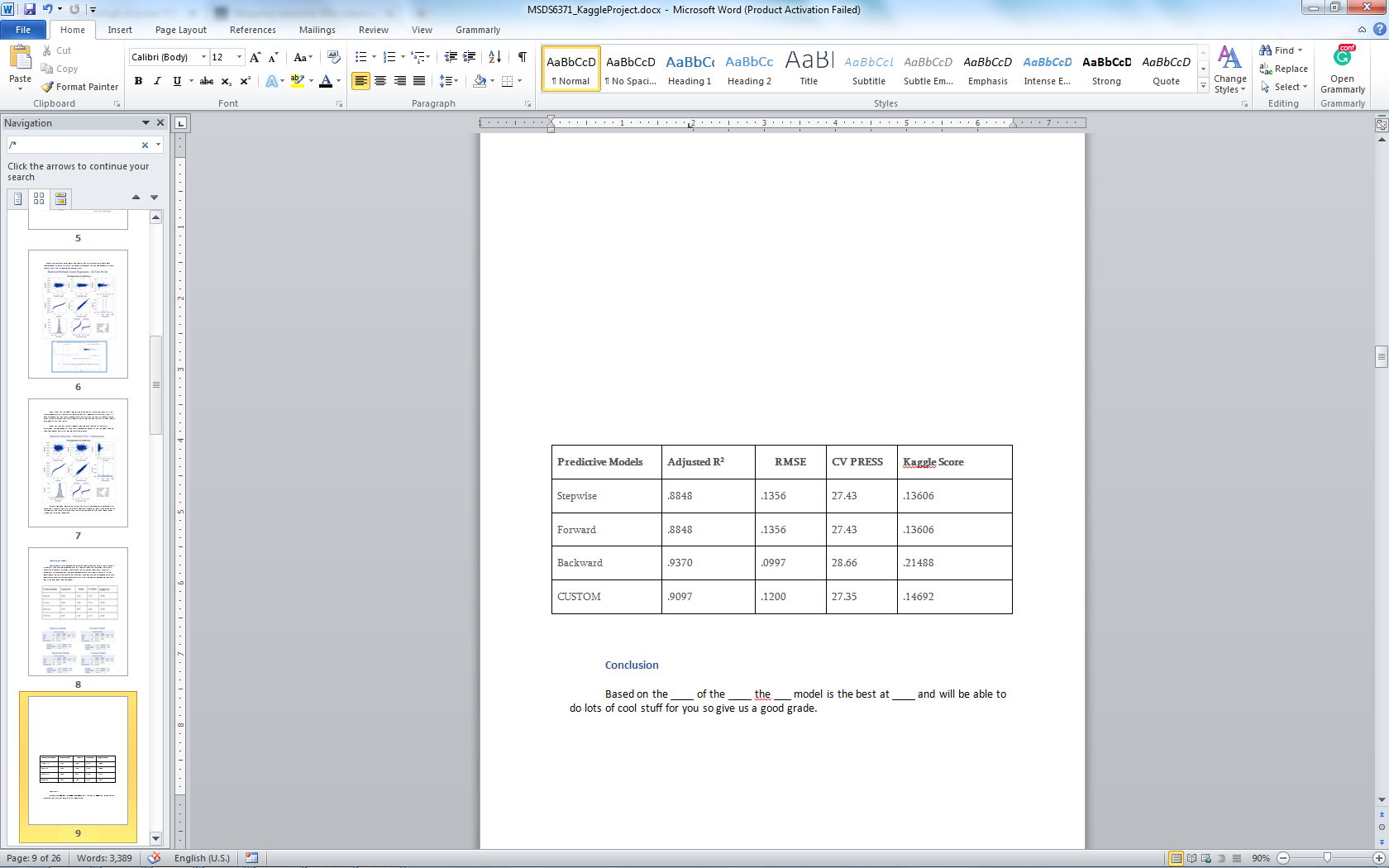
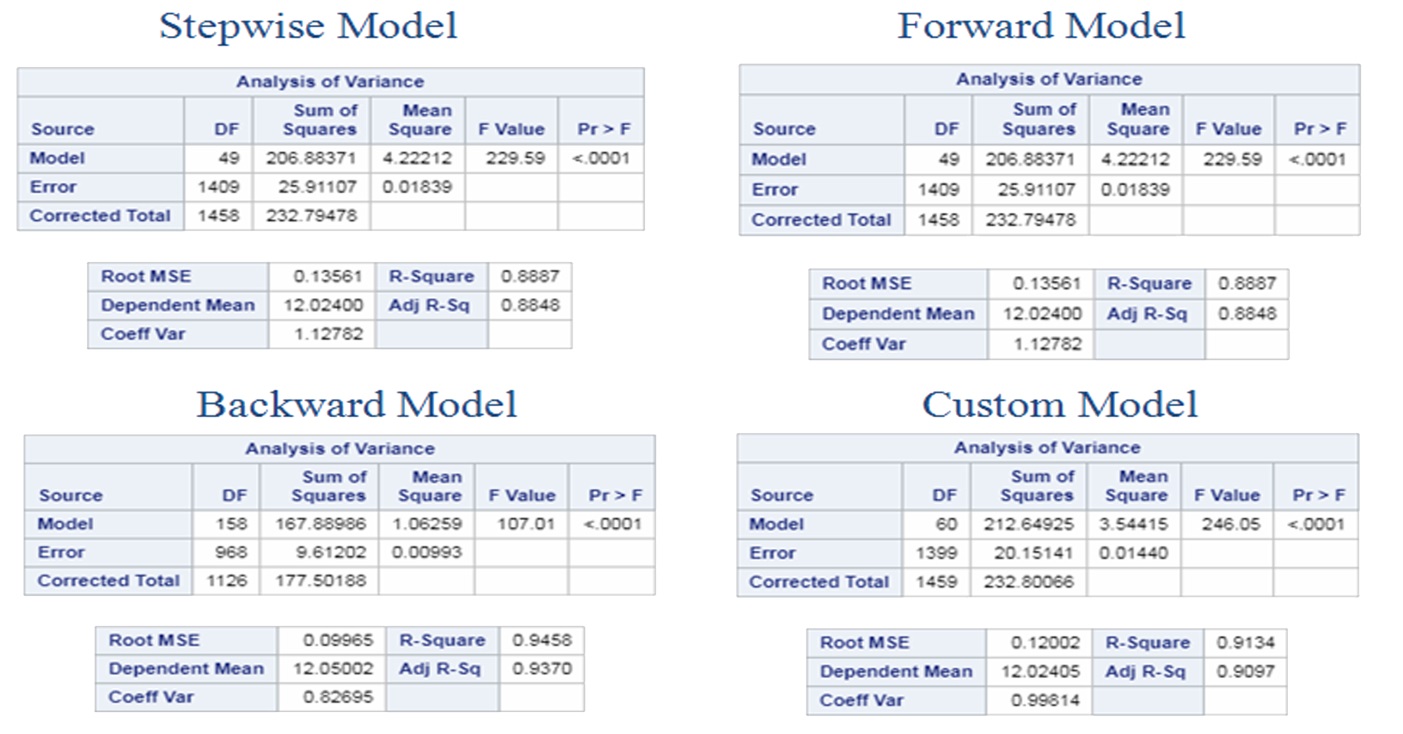
Visual analysis of the Cook’s D graph indicated outliers with values close to 1 and therefore warranted a closer evaluation of the outliers. However, after further analysis it was determined that due to the symmetry of the outliers and their overall impact and the lack of reason to believe they values where errors, it was decided that the variables remain in the model as valid variables.

Analysis of residuals for the stepwise selection with selected variables and interactions (custom) model satisfied the assumption of normality and the Cook’s D value and disbursement of outliers was well within tolerances.



As such all models were tested for their accuracy in determining an unknown sales price given all other required variables for the model. Each model was trained based on the available data and in the case of missing sales prices the median sales price was used for training and testing of the models.

**Comparison of Models**

The stepwise and forward models were the simplest models each using the same 8 variables as such they performed equally in all metrics. They had the lowest adjusted R2 value, highest RMSE, and lowest Kaggle score, indicating they were more accurate at predicting the actual sale price than the other models. The backward model had the highest adjusted R2 value, lowest RMSE, highest CV PRESS, and had the worst Kaggle Score. The custom model had the lowest CV PRESS value and performed worse than the stepwise/forward model, but better than the backward selection model.

**Conclusion**

Based on our analysis the best model to utilize is the stepwise selectin model as it is not only the simplest model but also scored better than the other models when it came to predicting the sales price of a home.

**Appendix**

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/\* Century 21 Analysis \*/  
/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

options mlogic symbolgen;  
  
data train;  
 %let \_EFIERR\_ = 0;  
  
 /\* set the ERROR detection macro variable \*/  
 infile '/home/ spencer.fogelman/CaseStudy2/train.csv' delimiter=','

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 lrecl=32767 firstobs=2;   
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 informat MSSubClass $3.;  
 informat MSZoning $2.;  
 informat LotFrontage best32.;  
 informat LotArea best32.;  
 informat Street $4.;  
 informat Alley $2.;  
 informat LotShape $3.;  
 informat LandContour $3.;  
 informat Utilities $6.;  
 informat LotConfig $7.;  
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 informat Neighborhood $7.;  
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 informat Condition2 $6.;  
 informat BldgType $6.;  
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 informat OverallCond best32.;  
 informat YearBuilt best32.;  
 informat YearRemodAdd best32.;  
 informat RoofStyle $5.;  
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 CentralAir $  
 Electrical $  
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KitchenAbvGr   
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 WoodDeckSF OpenPorchSF EnclosedPorch "3SsnPorch"N   
 ScreenPorch PoolArea PoolQC $  
 Fence $  
 MiscFeature $  
 MiscVal MoSold YrSold SaleType $  
 SaleCondition $  
 SalePrice;  
  
 if \_ERROR\_ then  
 call symputx('\_EFIERR\_', 1);  
  
 /\* set ERROR detection macro variable \*/  
run;  
  
proc contents data=train;  
run;  
  
proc print data=train (obs=10);  
run;  
  
data train\_1;  
 set train;  
 where Neighborhood in ("NAmes", "Edwards", "BrkSide");  
run;  
  
data train\_2;  
 set train\_1;  
 N\_Dummy=0;  
 E\_Dummy=0;  
  
 if Neighborhood="NAmes" then  
 N\_Dummy=1;  
 else if Neighborhood="Edwards" then  
 E\_Dummy=1;  
 int\_e=E\_Dummy \* GrLIvArea;  
 int\_n=N\_Dummy \* GrLIvArea;  
run;  
  
title "Scatterplot of original data";  
  
proc sgplot data=train\_2;  
 scatter x=GrLIvArea y=SalePrice / datalabel=Id   
 markerattrs=(symbol=CircleFilled) group=Neighborhood;  
run;  
  
title;  
  
proc print data=train\_2 (obs=10);  
run;  
  
ods graphics on;  
title   
 "Linear-Linear MLR with Dummy and Interactions with Influential Point 1299";  
  
proc reg data=train\_2 plots=all;  
 model SalePrice=GrLIvArea E\_Dummy N\_Dummy int\_e int\_n;  
 ID id;  
 run;  
quit;  
  
title;  
ods graphics off;  
  
data train\_3;  
 set train\_2;  
 where Id ne 1299;  
run;  
  
ods graphics on;  
title   
 "Linear-Linear MLR with Dummy and Interactions w/o Influential Point 1299";  
  
proc reg data=train\_3 plots=all;  
 model SalePrice=GrLIvArea E\_Dummy N\_Dummy int\_e int\_n;  
 ID id;  
 run;  
quit;  
  
title;  
ods graphics off;  
  
data train\_4;  
 set train\_2;  
 SalePrice\_l=log(SalePrice);  
 GrLIvArea\_l=log(GrLIvArea);  
 int\_e\_l=E\_Dummy \* GrLIvArea\_l;  
 int\_n\_l=N\_Dummy \* GrLIvArea\_l;  
run;  
  
ods graphics on;  
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 run;  
quit;  
  
title;  
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proc means data=train\_4;  
 var GrLIvArea\_l E\_Dummy N\_Dummy;  
run;  
  
data train\_5;  
 set train\_4;  
 centE=(GrLIvArea\_l - 7.1193132)\*(E\_Dummy - 0.2610966);  
 centN=(GrLIvArea\_l - 7.1193132)\*(N\_Dummy - 0.5874674);  
run;  
  
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 ID id;  
 run;  
quit;  
  
title;  
ods graphics off;  
  
/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/  
/\* Predicting Selling Prices \*/  
/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

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 informat OpenPorchSF best32.;  
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 informat ScreenPorch best32.;  
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 format PoolQC $2.;  
 format Fence $5.;  
 format MiscFeature $4.;  
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 format SaleType $3.;  
 format SaleCondition $7.;  
 input Id MSSubClass $  
 MSZoning $  
 LotFrontage LotArea Street $  
 Alley $  
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 BsmtFinType1 $  
 BsmtFinSF1 BsmtFinType2 $  
 BsmtFinSF2 BsmtUnfSF TotalBsmtSF Heating $  
 HeatingQC $  
 CentralAir $  
 Electrical $  
 "1stFlrSF"N "2ndFlrSF"N 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"N   
 ScreenPorch PoolArea PoolQC $  
 Fence $  
 MiscFeature $  
 MiscVal MoSold YrSold SaleType $  
 SaleCondition $;  
  
 if \_ERROR\_ then  
 call symputx('\_EFIERR\_', 1);  
  
 /\* set ERROR detection macro variable \*/  
run;  
  
/\* Stack the test and train datasets so the GLMSELECTS can learn the coefficients \*/  
/\* with the train data and predict the value of the log of the sale price with the test data \*/  
proc append data=test base=train force;  
run;  
  
proc contents data=train;  
run;  
  
proc print data=train (obs=10);  
run;  
  
data train\_6;  
 set train;  
 SalePrice\_l=log(SalePrice);  
 GrLIvArea\_l=log(GrLIvArea);  
run;  
  
ods graphics on;  
title "Stepwise Multiple Linear Regression - All vars No Ints";  
  
proc glmselect data=train\_6 plots(stepAxis=number)=(criterionPanel ASEPlot)   
 outdesign (addinputvars)=step\_allvars\_sel;  
 class MSZoning MSSubClass Street Alley LotShape LandContour Utilities   
 LotConfig LandSlope Neighborhood Condition1 Condition2 BldgType HouseStyle   
 RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType ExterQual ExterCond   
 Foundation BsmtQual BsmtCond BsmtExposure BsmtFinType1 BsmtFinType2 Heating   
 HeatingQC CentralAir Electrical KitchenQual Functional FireplaceQu GarageType   
 GarageFinish GarageQual GarageCond PavedDrive PoolQC Fence MiscFeature   
 SaleType SaleCondition / param=ref;  
 model SalePrice\_l=MSZoning MSSubClass Street Alley LotShape LandContour   
 Utilities LotConfig LandSlope Neighborhood Condition1 Condition2 BldgType   
 HouseStyle YearBuilt YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd   
 MasVnrType ExterQual ExterCond Foundation BsmtQual BsmtCond BsmtExposure   
 BsmtFinType1 BsmtFinType2 Heating HeatingQC CentralAir Electrical KitchenQual   
 Functional FireplaceQu GarageType GarageYrBlt GarageFinish GarageQual   
 GarageCond PavedDrive PoolQC Fence MiscFeature YrSold SaleType SaleCondition   
 LotFrontage LotArea MasVnrArea BsmtFinSF1 BsmtFinSF2 BsmtUnfSF TotalBsmtSF   
 "1stFlrSF"n "2ndFlrSF"n LowQualFinSF GrLivArea BsmtFullBath BsmtHalfBath   
 FullBath HalfBath BedroomAbvGr KitchenAbvGr TotRmsAbvGrd Fireplaces   
 GarageCars GarageArea WoodDeckSF OpenPorchSF EnclosedPorch "3SsnPorch"n   
 ScreenPorch PoolArea MiscVal MoSold OverallQual OverallCond /   
 selection=stepwise(choose=cv select=sl) stats=press cvMethod=split(5)   
 cvDetails=all hierarchy=single;  
 output out=outData\_step\_allvars predicted=pred\_step\_allvars\_l;  
run;  
  
proc contents data=step\_allvars\_sel;  
run;  
  
proc reg data=step\_allvars\_sel plots=all;  
 model SalePrice\_l=&\_GLSMOD.;  
 ID id;  
 run;  
 title;  
 ods graphics off;  
 ods graphics on;  
 title "Forward Multiple Linear Regression - All Vars No Ints";  
  
proc glmselect data=train\_6 plots(stepAxis=number)=(criterionPanel ASEPlot)   
 outdesign (addinputvars)=forw\_allvars\_sel;  
 class MSZoning MSSubClass Street Alley LotShape LandContour Utilities   
 LotConfig LandSlope Neighborhood Condition1 Condition2 BldgType HouseStyle   
 RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType ExterQual ExterCond   
 Foundation BsmtQual BsmtCond BsmtExposure BsmtFinType1 BsmtFinType2 Heating   
 HeatingQC CentralAir Electrical KitchenQual Functional FireplaceQu GarageType   
 GarageFinish GarageQual GarageCond PavedDrive PoolQC Fence MiscFeature   
 SaleType SaleCondition / param=ref;  
 model SalePrice\_l=MSZoning MSSubClass Street Alley LotShape LandContour   
 Utilities LotConfig LandSlope Neighborhood Condition1 Condition2 BldgType   
 HouseStyle YearBuilt YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd   
 MasVnrType ExterQual ExterCond Foundation BsmtQual BsmtCond BsmtExposure   
 BsmtFinType1 BsmtFinType2 Heating HeatingQC CentralAir Electrical KitchenQual   
 Functional FireplaceQu GarageType GarageYrBlt GarageFinish GarageQual   
 GarageCond PavedDrive PoolQC Fence MiscFeature YrSold SaleType SaleCondition   
 LotFrontage LotArea MasVnrArea BsmtFinSF1 BsmtFinSF2 BsmtUnfSF TotalBsmtSF   
 "1stFlrSF"n "2ndFlrSF"n LowQualFinSF GrLivArea BsmtFullBath BsmtHalfBath   
 FullBath HalfBath BedroomAbvGr KitchenAbvGr TotRmsAbvGrd Fireplaces   
 GarageCars GarageArea WoodDeckSF OpenPorchSF EnclosedPorch "3SsnPorch"n   
 ScreenPorch PoolArea MiscVal MoSold OverallQual OverallCond /   
 selection=forward(choose=cv select=sl) stats=press cvMethod=split(5)   
 cvDetails=all hierarchy=single;  
 output out=outData\_forw\_allvars predicted=pred\_forw\_allvars\_l;  
run;  
  
proc reg data=forw\_allvars\_sel plots=all;  
 model SalePrice\_l=&\_GLSMOD.;  
 ID id;  
 run;  
 title;  
 ods graphics off;  
 ods graphics on;  
 title "Backward Selection Multiple Linear Regression - All Vars No Ints";  
  
proc glmselect data=train\_6 plots(stepAxis=number)=(criterionPanel ASEPlot)   
 outdesign (addinputvars)=back\_allvars\_sel;  
 class MSZoning MSSubClass Street Alley LotShape LandContour Utilities   
 LotConfig LandSlope Neighborhood Condition1 Condition2 BldgType HouseStyle   
 RoofStyle RoofMatl Exterior1st Exterior2nd MasVnrType ExterQual ExterCond   
 Foundation BsmtQual BsmtCond BsmtExposure BsmtFinType1 BsmtFinType2 Heating   
 HeatingQC CentralAir Electrical KitchenQual Functional FireplaceQu GarageType   
 GarageFinish GarageQual GarageCond PavedDrive PoolQC Fence MiscFeature   
 SaleType SaleCondition / param=ref;  
 model SalePrice\_l=MSZoning MSSubClass Street Alley LotShape LandContour   
 Utilities LotConfig LandSlope Neighborhood Condition1 Condition2 BldgType   
 HouseStyle YearBuilt YearRemodAdd RoofStyle RoofMatl Exterior1st Exterior2nd   
 MasVnrType ExterQual ExterCond Foundation BsmtQual BsmtCond BsmtExposure   
 BsmtFinType1 BsmtFinType2 Heating HeatingQC CentralAir Electrical KitchenQual   
 Functional FireplaceQu GarageType GarageYrBlt GarageFinish GarageQual   
 GarageCond PavedDrive PoolQC Fence MiscFeature YrSold SaleType SaleCondition   
 LotFrontage LotArea MasVnrArea BsmtFinSF1 BsmtFinSF2 BsmtUnfSF TotalBsmtSF   
 "1stFlrSF"n "2ndFlrSF"n LowQualFinSF GrLivArea BsmtFullBath BsmtHalfBath   
 FullBath HalfBath BedroomAbvGr KitchenAbvGr TotRmsAbvGrd Fireplaces   
 GarageCars GarageArea WoodDeckSF OpenPorchSF EnclosedPorch "3SsnPorch"n   
 ScreenPorch PoolArea MiscVal MoSold OverallQual OverallCond /   
 selection=backward (choose=cv select=sl) stats=press cvMethod=split(5)   
 cvDetails=all hierarchy=single;  
 output out=outData\_back\_allvars predicted=pred\_back\_allvars\_l;  
run;  
  
proc reg data=back\_allvars\_sel plots=all;  
 model SalePrice\_l=&\_GLSMOD.;  
 ID id;  
 run;  
 title;  
 ods graphics off;  
 ods graphics on;  
 title "Stepwise Selection Multiple Linear Regression - Most Promising Previously Selected Vars + Interactions";  
  
proc glmselect data=train\_6 plots(stepAxis=number)=(criterionPanel ASEPlot)   
 outdesign (addinputvars)=step\_topvarsints\_sel;  
 class MSSubClass Neighborhood RoofMatl Condition2 MSZoning SaleCondition   
 CentralAir KitchenQual/ param=ref;  
 model SalePrice\_l=MSSubClass|Neighborhood|YearBuilt|RoofMatl|BsmtFinSF1|GrLivArea|OverallQual|OverallCond|Condition2|MSZoning|GarageCars|TotalBsmtSF|SaleCondition|LotArea|CentralAir|KitchenQual|ScreenPorch  
 @2 / selection=stepwise (choose=cv select=sl) stats=press cvMethod=split(5)   
 cvDetails=all hierarchy=single;  
 output out=outData\_step\_topvarsints predicted=pred\_step\_topvarsints\_l;  
run;  
  
proc reg data=step\_topvarsints\_sel plots=all;  
 model SalePrice\_l=&\_GLSMOD.;  
 ID id;  
 run;  
 title;  
 ods graphics off;  
  
 /\* Macro to loop through creating each of the the three submission files \*/  
 %macro create\_submissions (method);  
 data &method.\_test\_stage1;  
 set outData\_&method.;  
  
 if Id ge 1461;  
 SalePrice=exp(pred\_&method.\_l);  
 run;  
  
 data &method.\_test\_stage2 (keep=Id SalePrice);  
 set &method.\_test\_stage1;  
 run;  
  
 /\* Routine to impute median value when predicted value is missing \*/  
 proc means data=&method.\_test\_stage2 median;  
 var SalePrice;  
 output out=tmp\_median\_SalePrice median=tmp\_median\_SalePrice;  
 run;  
  
 data \_null\_;  
 set tmp\_median\_SalePrice;  
 call symputx('tmp\_median\_SalePrice', tmp\_median\_SalePrice);  
 run;  
  
 %put &tmp\_median\_SalePrice.;  
  
 data &method.\_submission;  
 set &method.\_test\_stage2;  
  
 if SalePrice=. then  
 do;  
 SalePrice=input(&tmp\_median\_SalePrice., 11.2);  
 end;  
 run;  
  
 proc export data=&method.\_submission   
 outfile="/home/sarellano0/dataSets/&method.\_submission.csv"

dbms=csv replace;  
 run;  
  
%mend create\_submissions;  
  
%create\_submissions(method=step\_allvars);  
%create\_submissions(method=forw\_allvars);  
%create\_submissions(method=back\_allvars);  
%create\_submissions(method=step\_topvarsints);