CSCI 550 - Project 2

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1 Executive Summary

This project aims to determine the most optimal information to collect on real estate listings in the Chicago area. This was done by scraping data from 2013 to 2019 and collecting variables relating to the area of a listing and physical properties of the listing. When searching for the variables that best explain sale price in the Chicago area, exploratory data analysis found that the size of the listing, number of rooms present, estimated value, and additional quality of life features like a garage or fireplaces are the best predictors. To further determine best predictors, various models were fit and compared. We formally recommend using the estimate of the value of land a listing was built on and the estimate of the building itself as the main factors for determining how much a listing will sell for.

2 Data Preprocessing and Exploration

2.1 Data Cleaning

The data received had a few issues that needed to be dealt with. First of all, the `Description` variable contained pieces of key information that were extracted (number of bathrooms, number of bedrooms, total number of rooms, and sell date). Additionally, Area, Sub-Area, Block, Parcel, and Multicode were parsed from the `PIN` variable.

```
# Extracting important information from descriptions
sell_date = as.numeric(0)
rooms = as.numeric(0)
bedrooms = as.numeric(0)
baths = as.numeric(0)

# Takes a minute to run, not too bad though
for(i in 1:nrow(data)){
    sell_date[i] = str_split(
        str_split(data$Description[i], "sold on ")[[1]][2],
         ", is a")[[1]][1]
    rooms[i] = str_extract_all(
        str_split(data$Description[i], "total of ")[[1]][2],
         "\\d")[[1]][1]
    bedrooms[i] = str_extract_all(
        str_split(data$Description[i], "total of ")[[1]][2],
         "\\d")[[1]][2]
    baths[i] = str_split(
        str_split(data$Description[i], "bedrooms, and ")[[1]][2],
         " of which are bathrooms")[[1]][1]
    Area[i] = substring(data$PIN[i], first = 1, last = 2)
    Sub_Area[i] = substring(data$PIN[i], first = 3, last = 4)
    Block[i] = substring(data$PIN[i], first = 5, last = 6)
    Parcel[i] = substring(data$PIN[i], 7, 8)
    Multicode[i] = substring(data$PIN[i], 9, 12)
}
```

Once these variables were extracted, the `Description` variable was dropped from the data set. We noticed some houses with strange recording like “42 bathrooms and 7 rooms”, so we dropped any listings where the number of bedrooms and number of bathrooms was greater than the total recorded number of rooms.

```
# Adding features of descriptions, removing descriptions
data = data %>%
    mutate(
      Sell_Date = mdy(sell_date),
```

```
      Rooms = as.numeric(rooms),
      Bedrooms = as.numeric(bedrooms),
      Baths = as.numeric(baths)
    ) %>%
    select(-Description)

# Removing rows where num bathrooms/bedrooms exceeds number of rooms
data = data %>%
    filter(Bedrooms < Rooms | Baths < Rooms)
```

Next, we dropped any listings with a missing value in at least one of the variables.

```
# Removing rows with at least 1 missing value
data = data %>%
    drop_na()
```

We also wanted to deal with outliers, so a function was written that would identify a listing as an outlier if it was greater than 3 standard errors away from the mean value and used this to remove outliers for variables where the maximum value was significantly higher than the 3rd quartile.

```
# Filtering extreme observations
is_outlier = function(x){
    result = abs(x - mean(x)) > 3*sd(x)
    return(result)
}

# Removing outliers for variables where max() is greater than q3()
data = data %>%
    filter(!is_outlier(`Sale Price`),
           !is_outlier(`Land Square Feet`),
           !is_outlier(Baths),
           !is_outlier(`Lot Size`),
           !is_outlier(`Town and Neighborhood`),
           !is_outlier(`Age Decade`),
           !is_outlier(`Age`),
           !is_outlier(`Estimate (Land)`),
           !is_outlier(`Estimate (Building)`),
           !is_outlier(`Building Square Feet`),
           !is_outlier(`Other Improvements`))
```

Finally, we removed all spaces from variable names and replaced them with underscores.

```r
# Removing Spaces
data = data %>%
  rename(Property_Class = `Property Class`,
        Neighborhood_Code = `Neighborhood Code`,
        Land_Square_Feet = `Land Square Feet`,
        ...
        Age_Decade = `Age Decade`,
        Neighborhood_Code_Mapping = `Neigborhood Code (mapping)`,
        Town_and_Neighborhood = `Town and Neighborhood`,
        )
```

This cleaned data set was written as `data_cleaned.csv` so it could easily be reloaded for the remainder of the analysis.

```r
# Save cleaned data
write_csv(data, "data_cleaned.csv")
```

2.2 Exploration of Data

Within the data, latitude and longitude coordinates were provided for each listing. A map of the sale price of listings is overlaid on a satellite map of the region (Figure 1). Here, it can be seen that a lot of the higher price listings are on the water, with sale price generally decreasing the more in-land the listing is.

```r
# Spatial Map of Sale Price
ggmap(Map, darken = c(0.1, "white")) +
    geom_polygon(data = cook_map, aes(x = long, y = lat),
        fill = NA, color = "orange") +
    geom_point(data = data,
               aes(x = Longitude,
                   y = Latitude,
                   color = Sale_Price),
               size = 0.02,
               alpha = 0.75) +
    scale_color_gradient(low = "#6fe7f7", high = "#890000") +
    labs(x = "Longitude", y = "Latitude", color = "Sale Price ($)")
```

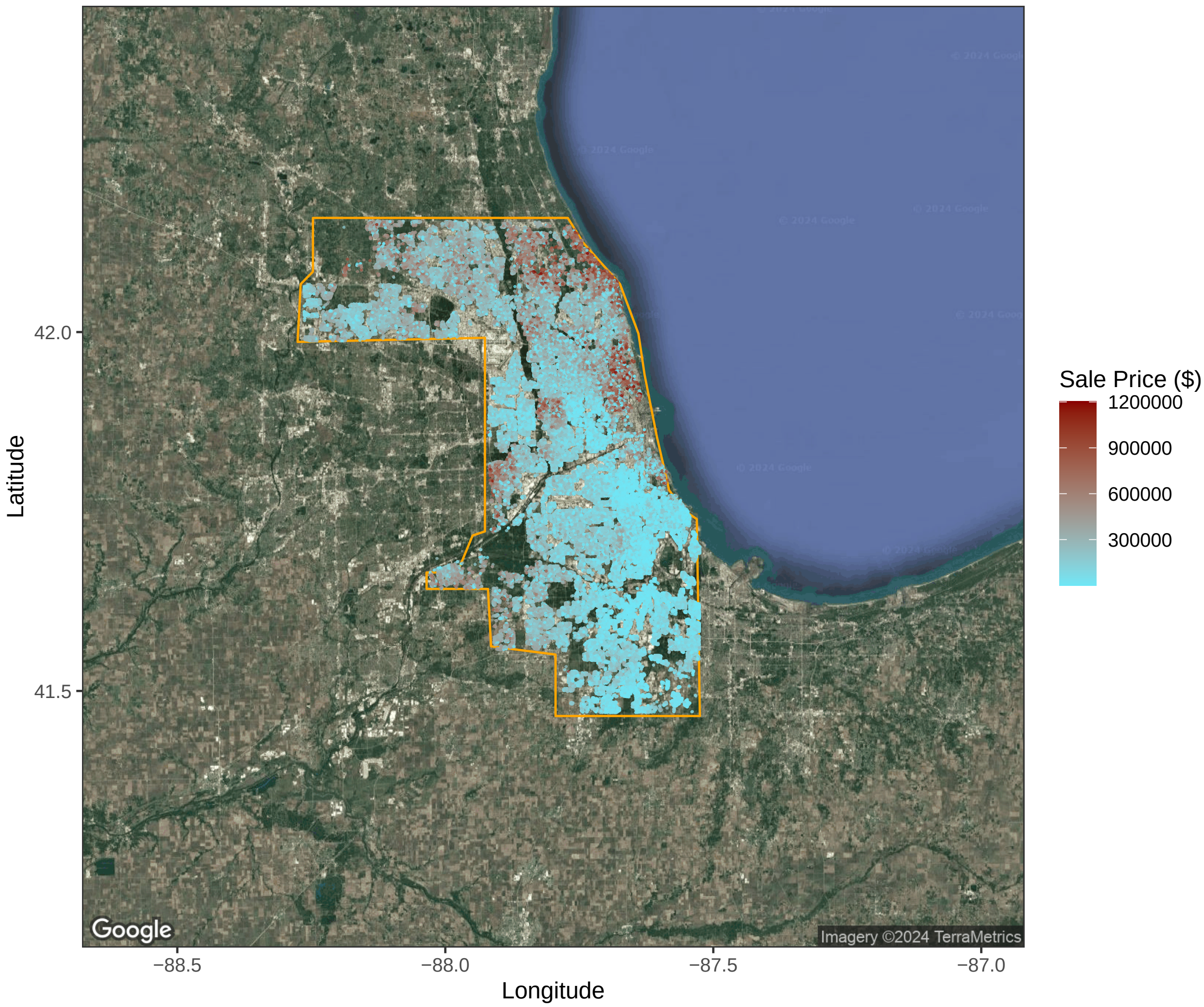

Figure 1: A spatial map of the sale prices over the region.

Multiple boxplots were created for all of the variables pertaining to a garage against the response (Figure 2). As the first garage increases in size, so too does the sale price. Having a garage attached to the building (`Garage_#_Attachement` = 1) is also associated with a higher sale price for both garage 1 and garage 2. Higher quality materials (larger values of `Garage_#_Material`) is associated with higher sale prices too.

```
# Plotting Against Garage Variables
data %>%
    select(Sale_Price,
           Garage_1_Area,
           Garage_1_Size,
           Garage_1_Attachment,
           Garage_1_Material,
           Garage_2_Area,
           Garage_2_Size,
```

```
         Garage_2_Attachment,
         Garage_2_Material) %>%
  pivot_longer(cols = 2:9, names_to = "Variable", values_to = "Value") %>%
  ggplot(aes(x = factor(Value), y = Sale_Price, group = Value)) +
  geom_boxplot() +
  facet_wrap(~Variable, scales = "free_x", nrow = 2) +
  labs(x = " ")
```

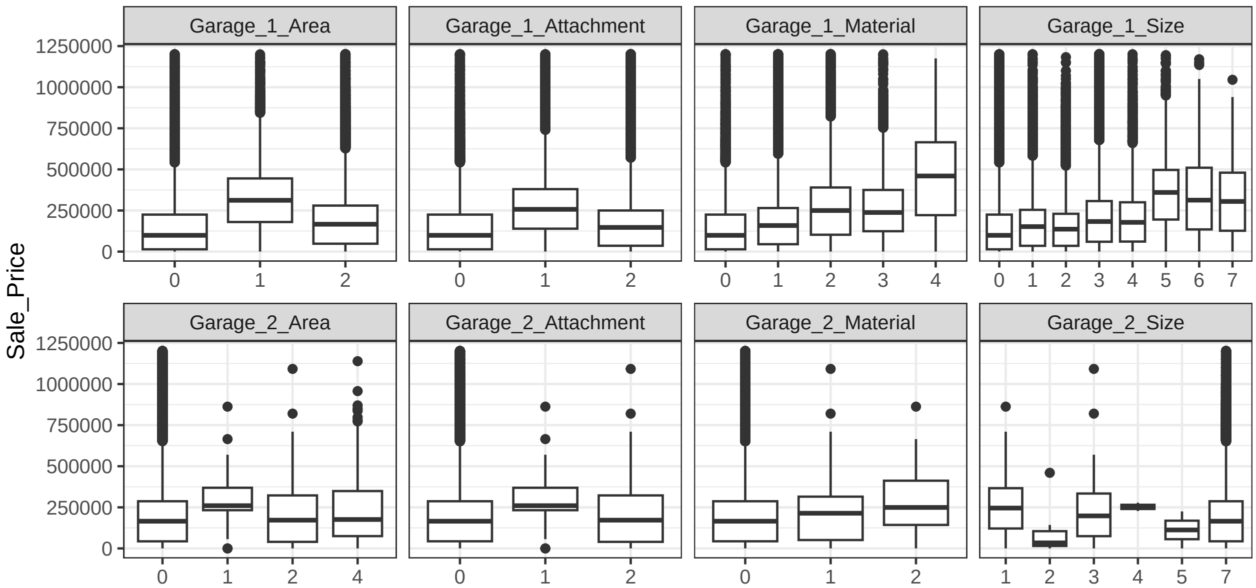

Figure 2: A series of boxplots for all garage variables against sale price.

When comparing sale price to variables related to the physical property, it can be noted that for the `Apartments` variable, there is large varibility in the “0” group, which may be due to non-apartment buildings being more expensive (Figure 3). Sale price is generally the same across attic types, porch groups, and design plans. Sale price appears to increase as the number of fireplaces increases. Additionally, sale price is higher for listings with cathedral ceilings. The `Proprty_Class` variable apperas to have equal variability in sale price for all classes except “209”.

```
data %>%
  select(`Sale_Price`,
         `Property_Class`,
         `Apartments`,
         `Basement`,
         `Attic_Type`,
         `Design_Plan`,
         `Cathedral_Ceiling`,
         Fireplaces,
```

```r
           Porch) %>%
    pivot_longer(cols = 2:9, names_to = "Variable", values_to = "Value") %>%
    ggplot(aes(x = factor(Value), y = Sale_Price, group = Value)) +
    geom_boxplot() +
    facet_wrap(~Variable, scales = "free_x", nrow = 2) +
    labs(x = " ")
```

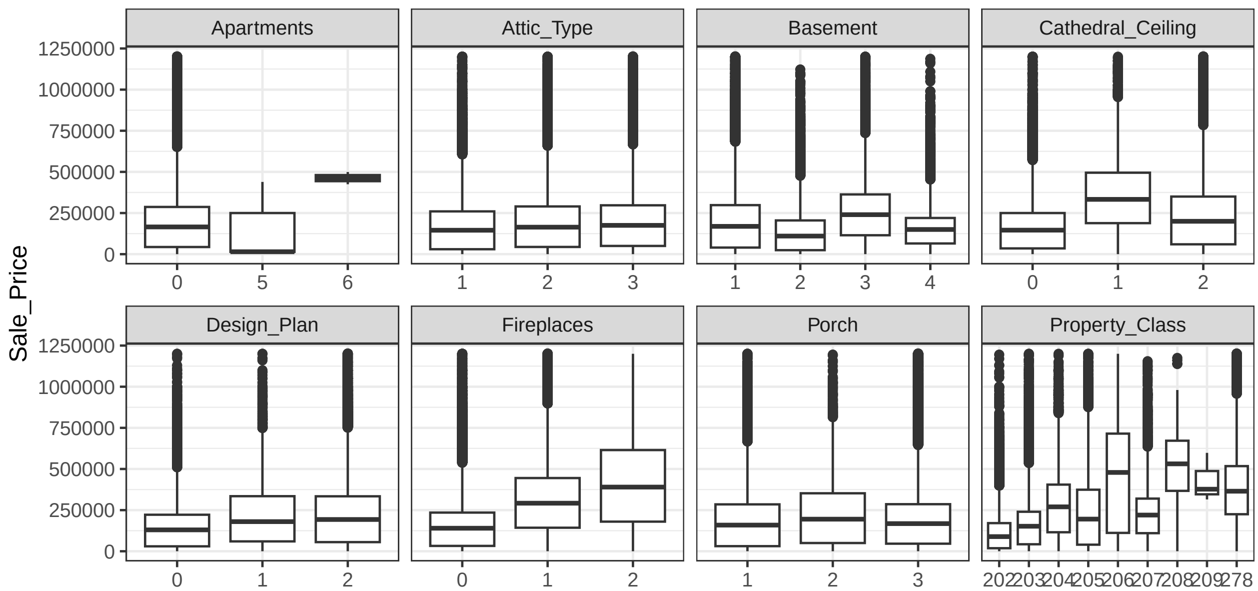

Figure 3: A series of boxplots for variables related to the property itself.

Additional boxplots were created for the number of rooms in each listing (Figure 4). For all room variables, there is generally an increase in sale price as the number of rooms increases. However, the sale price for listings with 1 room is higher, on average, than all other room groups. The same goes for listings with 0 bedrooms.

```r
# Plotting Against Room Variables
data %>%
    select(`Sale_Price`,
           `Bedrooms`,
           `Baths`,
           `Rooms`) %>%
    pivot_longer(cols = 2:4, names_to = "Variable", values_to = "Value") %>%
    ggplot(aes(x = factor(Value), y = Sale_Price, group = Value)) +
    geom_boxplot() +
    facet_wrap(~Variable, scales = "free_x") +
    labs(x = " ")
```

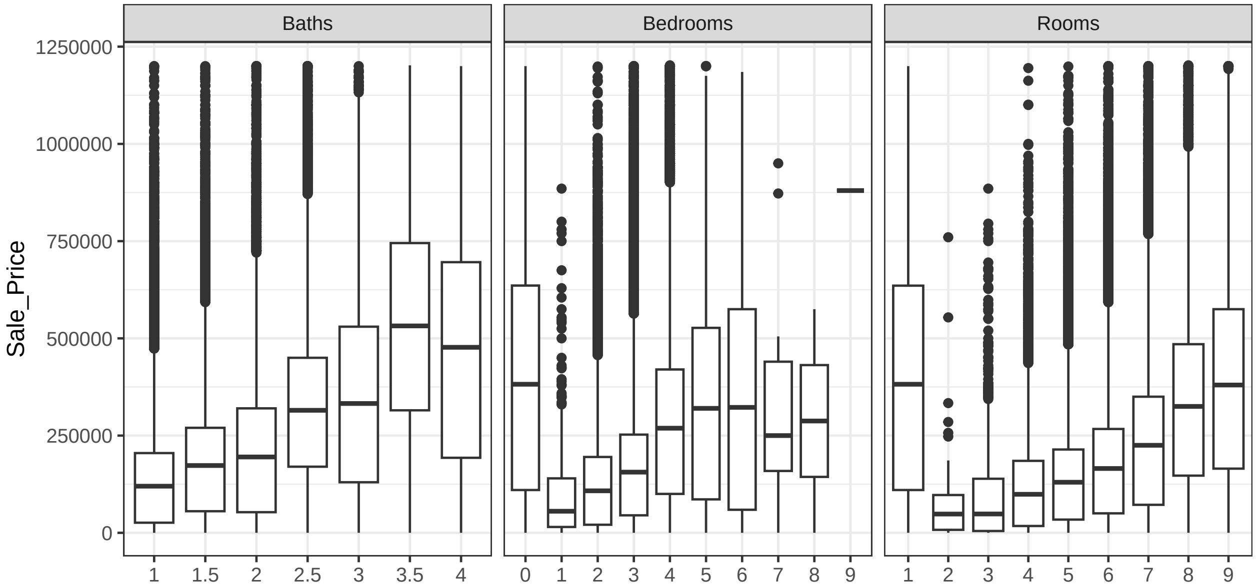

Figure 4: A series of boxplots for the variables relating to number of rooms present.

The final visualization of interest is a scatterplot of sale price against both building square footage and land square footage (Figure 5). Here, it can be seen that for listings with high building square footage, we see higher sale price. The relationship is the same for land square footage, although the highest sale prices occur at high building square footage and average land square footage.

```
data %>%
    ggplot(aes(x = `Building_Square_Feet`,
               y = `Land_Square_Feet`,
               color = `Sale_Price`)) +
    geom_point(size = 2) +
    labs(x = "Building Square Footage",
        y = "Land Square Footage",
        color = "Sale Price ($)")
```

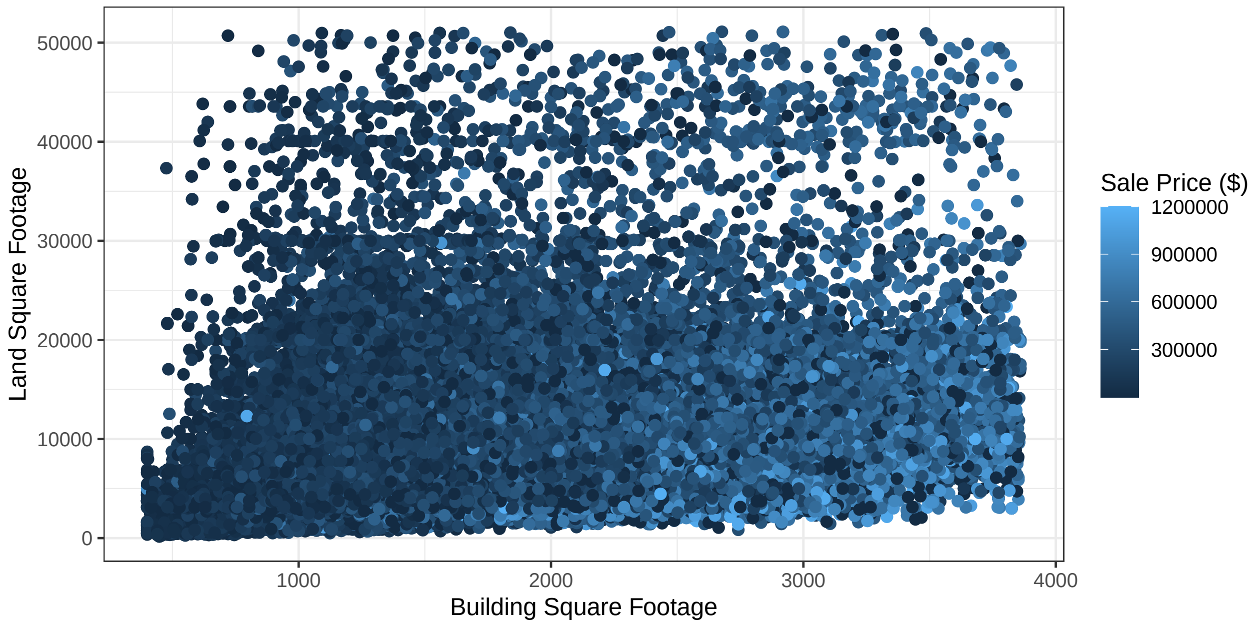

Figure 5: A scatterplot of the relationship between sale price and building/land square footage.

2.3 Hypothesis Development

From the exploration performed above, we hypothesize that building square footage, land square footage, the number of rooms, and location are likely going to have the highest impact on sale price.

3 Model Development and Performance Evaluation

Before starting the modelling process, variables were factored (if categorical) or scaled to have mean of 0 and variance 1 (if quantitative). This ensured that models had the best chance of converging. Additionally, some variables were removed due to having only 1 value or being of no importance.

```
# Scaling numeric variable
Model_Data = data %>%
    select(-c(Modeling_Group,
            Age,
            Use,
            Sale_Half_of_Year,
            `...1`,
            PIN,
            Census_Tract,
            Deed_No,
            Town_and_Neighborhood,
```

```r
            Neighborhood_Code_Mapping)) %>%
    mutate(Land_Square_Feet = scale(Land_Square_Feet),
            Building_Square_Feet = scale(Building_Square_Feet),
            Estimate_Land = scale(Estimate_Land),
            Estimate_Building = scale(Estimate_Building),
            Lot_Size = scale(Lot_Size)) %>%
    filter(Sale_Price > 499)
```

At this point, the data were split into training and testing sets by randomly sampling 80% of the rows for the training set and leaving the remaining rows for the testing set.

```r
# Sampling rows at random
ids_train = sample(1:nrow(Model_Data),
                size = round(0.8*nrow(Model_Data)),
                replace = FALSE)

# Splitting data
train = Model_Data[ids_train,]
test = Model_Data[-ids_train,]
```

To find the best Simple Linear Regression model, all single predictor models were searched and compared on AIC. The top-performing model involved the predictor `Estimate_Building` to predict sale price. A summary of the model fit using K-fold cross-validation is shown below. Note that the R^2 indicates fairly poor model fit, but this is to be expected as it is only a single predictor.

```r
# Define cross-validation method with 5 folds
train_control <- trainControl(method = "cv",
                              number = 5)


# Build model using linear model
slr <- train(Sale_Price~Estimate_Building, data = train,
              trControl = train_control,
              method = "lm")

# Summary of model
print(slr)
```

```
## Linear Regression
##
## 126664 samples
##      1 predictor
##
```

```
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 101332, 101330, 101331, 101331, 101332
## Resampling results:
##
##   RMSE      Rsquared   MAE
##   110616.8  0.6513384  71802.58
##
## Tuning parameter 'intercept' was held constant at a value of TRUE
```

```r
slr_preds = predict(slr, test)
slr_mse = Metrics::mse(slr_preds, test$Sale_Price)
print(paste("MSE from Test Set: ", slr_mse))
```

```
## [1] "MSE from Test Set:  12233023834.1165"
```

To find the best Multiple Linear Regression model, we used all available predictors with no interactions. A summary of the cross-validation process is provided. Then, we predicted to the test data and calculated the mean squared error.

```r
# Train mly model using k-fold cross validation
mlr <- train(Sale_Price~., data = train,
               trControl = train_control,
               method = "lm")

# Print model specifications
print(mlr)
```

```
## Linear Regression
##
## 126664 samples
##     60 predictor
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 101332, 101331, 101332, 101331, 101330
## Resampling results:
##
##   RMSE      Rsquared   MAE
##   85467.95  0.7918842  58622.33
##
## Tuning parameter 'intercept' was held constant at a value of TRUE
```

```r
# Predict to test data
mlr_preds = predict(mlr, test)
mlr_mse = Metrics::mse(mlr_preds, test$Sale_Price)
print(paste("MSE from Test Set: ", mlr_mse))
```

```
## [1] "MSE from Test Set:  7472850774.75837"
```

Starting with the MLR model, subset selection was performed via backwards selection. Each iteration, the term that had the lowest impact on AIC was removed until no other terms needed to be removed. Once the ideal model formula was determined, this model was re-fit using 5-fold cross-validation. The best subset selection process resulted in a model using `Lot_Size`, `Building_Square_Feet`, `Beds`, and `Baths` to predict `Sale_Price`.

```r
# Refit MLR model
mlr = lm(Sale_Price ~ ., data = train)

# Determine best model
best_subset <- MASS::stepAIC(mlr, direction = "backward", scope = ~ 1)
```

```r
# Refit best model
best_subset <- train(Sale_Price ~ Lot_Size + Building_Square_Feet + Bedrooms + Baths,
                     data = train,
                     trControl = train_control,
                     method = 'lm')

# Print model specifications
print(best_subset)
```

```
## Linear Regression
##
## 126664 samples
##      4 predictor
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 101331, 101331, 101332, 101331, 101331
## Resampling results:
##
##   RMSE      Rsquared   MAE
##   148738.4  0.3697105  109168.6
##
## Tuning parameter 'intercept' was held constant at a value of TRUE
```

```r
# Predict to test data
bs_preds = predict(best_subset, test)
bs_mse = Metrics::mse(bs_preds, test$Sale_Price)
print(paste("MSE from Test Set: ", bs_mse))
```

```
## [1] "MSE from Test Set:  22338772109.1458"
```

We fit Ridge and Lasso regression models using am mixutre of the `caret` and `glmnet` packages. `glmnet` was used to find the sequence of λ values to choose from, while `caret` was used to ensure consistency with how we fit our other models. Ridge and Lasso regression can be easily fit using the `glmnet` package alone.

```r
library(glmnet)
data.train.mat <- model.matrix(Sale_Price ~. , data = train)[,-1]
data.test.mat <- model.matrix(Sale_Price ~., data = test)[,-1]


# Fitting ridge regression model
tune.grid.ridge = expand.grid(alpha = 0,
                              lambda = glmnet(data.train.mat,
                                              train$Sale_Price,
                                              alpha = 0)$lambda)
fit.ridge <- train(Sale_Price ~ ., data = train,
  method = 'glmnet',
  trControl = train_control,
  tuneGrid = tune.grid.ridge)

# Tuning Parameters
# print(fit.ridge)

# fitting the model on the test data
ridge_pred <- predict(fit.ridge, test)
ridge_mse = Metrics::mse(ridge_pred, test$Sale_Price)
print(paste("MSE from Test Set: ", ridge_mse))
```

```
## [1] "MSE from Test Set:  7541838873.52322"
```

```r
# model coefficients
coef(fit.ridge$finalModel, s = fit.ridge$bestTune$lambda)
```

```
## 1432 x 1 sparse Matrix of class "dgCMatrix"
##                                       s1
## (Intercept)                -7.660737e+06
## Property_Class203          -4.540570e+03
```

```
## Property_Class204          -3.158354e+03
## Property_Class205           1.468352e+03
## Property_Class206           5.425138e+04
## Property_Class207          -8.768434e+03
## Property_Class208           4.534553e+04
## Property_Class209           4.415182e+04
## Property_Class278           2.090094e+04
## Neighborhood_Code11        -9.654008e+03
## Neighborhood_Code12         1.935911e+03
## Neighborhood_Code13        -1.552868e+04
## Neighborhood_Code14        -3.548789e+04
## Neighborhood_Code15        -5.701944e+03
## Neighborhood_Code18        -6.785824e+04
## Neighborhood_Code19        -5.436405e+04
## Neighborhood_Code20         8.572564e+03
## Neighborhood_Code21         5.750210e+03
## Neighborhood_Code22         1.349560e+04
## Neighborhood_Code23        -2.763531e+03
## Neighborhood_Code24         7.007425e+03
## Neighborhood_Code25        -1.202936e+04
## Neighborhood_Code26        -3.901278e+04
## Neighborhood_Code27        -4.629394e+04
## Neighborhood_Code30         1.546433e+04
## Neighborhood_Code31        -5.335595e+03
## Neighborhood_Code32         1.491133e+04
## Neighborhood_Code33        -3.070348e+03
## Neighborhood_Code34        -2.424544e+04
## Neighborhood_Code35        -2.009593e+04
## Neighborhood_Code36        -4.773934e+03
## Neighborhood_Code37         8.573209e+02
## Neighborhood_Code38        -2.517598e+04
## Neighborhood_Code39         3.330014e+04
## Neighborhood_Code40         7.865437e+02
## Neighborhood_Code41         3.865405e+03
## Neighborhood_Code42        -3.820993e+03
## Neighborhood_Code43         6.669024e+03
## Neighborhood_Code44         4.311804e+03
## Neighborhood_Code45        -1.124588e+04
## Neighborhood_Code46        -2.922473e+04
## Neighborhood_Code47        -3.887874e+04
## Neighborhood_Code48        -7.724144e+04
## Neighborhood_Code50         5.211051e+03
## Neighborhood_Code51        -1.460931e+04
## Neighborhood_Code52        -8.478859e+03
## Neighborhood_Code53        -1.739925e+04
```

```
## Neighborhood_Code54          -3.391718e+04
## Neighborhood_Code55           1.192352e+04
## Neighborhood_Code56          -2.911224e+04
## Neighborhood_Code60           1.414637e+03
## Neighborhood_Code61          -1.040459e+04
## Neighborhood_Code62          -6.384685e+03
## Neighborhood_Code63           1.440435e+04
## Neighborhood_Code64          -6.666801e+03
## Neighborhood_Code65           7.956086e+03
## Neighborhood_Code67           1.063122e+05
## Neighborhood_Code70           1.446044e+04
## Neighborhood_Code71           1.592224e+04
## Neighborhood_Code72           5.537294e+03
## Neighborhood_Code73          -6.361546e+04
## Neighborhood_Code74           7.435734e+04
## Neighborhood_Code75          -2.008954e+03
## Neighborhood_Code80          -6.807277e+03
## Neighborhood_Code81          -1.844548e+03
## Neighborhood_Code82           5.179123e+04
## Neighborhood_Code83          -9.607957e+03
## Neighborhood_Code84          -5.430486e+03
## Neighborhood_Code85           3.685350e+04
## Neighborhood_Code86           9.646113e+03
## Neighborhood_Code87           6.254944e+03
## Neighborhood_Code88          -9.047730e+03
## Neighborhood_Code90           1.099556e+04
## Neighborhood_Code91          -3.898143e+04
## Neighborhood_Code92           1.100677e+04
## Neighborhood_Code93           3.165156e+04
## Neighborhood_Code94           4.129581e+04
## Neighborhood_Code95          -2.662010e+04
## Neighborhood_Code96          -1.603407e+04
## Neighborhood_Code99           .
## Neighborhood_Code100         -5.556564e+03
## Neighborhood_Code101         -1.282794e+04
## Neighborhood_Code102         -3.697404e+04
## Neighborhood_Code103          1.382146e+04
## Neighborhood_Code104          4.970580e+03
## Neighborhood_Code109         -4.168338e+04
## Neighborhood_Code110          2.937623e+04
## Neighborhood_Code111         -5.697066e+03
## Neighborhood_Code112         -9.218953e+03
## Neighborhood_Code113          5.516449e+04
## Neighborhood_Code114         -1.363225e+04
## Neighborhood_Code115         -4.639681e+04
```

```
## Neighborhood_Code116         -2.241201e+04
## Neighborhood_Code117          4.462631e+04
## Neighborhood_Code120          2.760873e+03
## Neighborhood_Code121         -1.604042e+04
## Neighborhood_Code122          5.036487e+03
## Neighborhood_Code130         -2.504502e+03
## Neighborhood_Code131         -2.232622e+04
## Neighborhood_Code132         -7.525834e+03
## Neighborhood_Code133         -3.733366e+04
## Neighborhood_Code134          2.601587e+04
## Neighborhood_Code140         -2.278764e+04
## Neighborhood_Code141          2.006642e+04
## Neighborhood_Code142          1.350931e+04
## Neighborhood_Code143          3.808675e+04
## Neighborhood_Code145         -2.726903e+04
## Neighborhood_Code150          1.355247e+04
## Neighborhood_Code151          1.039413e+04
## Neighborhood_Code152          7.278226e+04
## Neighborhood_Code160          2.838580e+04
## Neighborhood_Code161         -1.516409e+04
## Neighborhood_Code162         -8.025866e+03
## Neighborhood_Code163          1.036023e+04
## Neighborhood_Code164          1.333938e+04
## Neighborhood_Code165         -1.142446e+04
## Neighborhood_Code166          1.027982e+05
## Neighborhood_Code170          1.756244e+04
## Neighborhood_Code171         -1.168168e+04
## Neighborhood_Code174         -3.452239e+04
## Neighborhood_Code175          2.901772e+04
## Neighborhood_Code180         -9.290434e+03
## Neighborhood_Code181          6.718255e+02
## Neighborhood_Code182         -2.214918e+04
## Neighborhood_Code183         -1.349115e+04
## Neighborhood_Code185         -3.851564e+03
## Neighborhood_Code190         -1.794493e+04
## Neighborhood_Code191         -1.508447e+03
## Neighborhood_Code192          1.876502e+04
## Neighborhood_Code193          2.339000e+04
## Neighborhood_Code194          2.680336e+04
## Neighborhood_Code200         -2.655205e+04
## Neighborhood_Code201         -1.566833e+03
## Neighborhood_Code210         -2.046586e+04
## Neighborhood_Code211          1.671189e+04
## Neighborhood_Code212          5.278492e+03
## Neighborhood_Code220         -1.083567e+04
```

```
## Neighborhood_Code221         -6.400261e+03
## Neighborhood_Code222         -1.676631e+04
## Neighborhood_Code223         -1.138323e+04
## Neighborhood_Code224         -1.413580e+04
## Neighborhood_Code226         -3.792505e+03
## Neighborhood_Code227         -1.240249e+05
## Neighborhood_Code230         -1.279052e+04
## Neighborhood_Code232          5.999150e+04
## Neighborhood_Code240         -1.521224e+04
## Neighborhood_Code241          8.472485e+03
## Neighborhood_Code250         -2.929663e+04
## Neighborhood_Code251         -2.615967e+04
## Neighborhood_Code255          2.539496e+04
## Neighborhood_Code257         -1.274841e+04
## Neighborhood_Code260         -1.951501e+04
## Neighborhood_Code262         -8.084279e+04
## Neighborhood_Code270         -6.575796e+04
## Neighborhood_Code271          3.184777e+04
## Neighborhood_Code274          1.284678e+04
## Neighborhood_Code275         -2.082710e+04
## Neighborhood_Code280         -2.872393e+04
## Neighborhood_Code281         -2.067143e+04
## Neighborhood_Code282         -1.647454e+04
## Neighborhood_Code290         -2.126516e+04
## Neighborhood_Code293         -2.457067e+04
## Neighborhood_Code300          1.169827e+04
## Neighborhood_Code310         -1.331358e+04
## Neighborhood_Code312         -7.109521e+03
## Neighborhood_Code314         -1.263351e+04
## Neighborhood_Code315         -3.049212e+04
## Neighborhood_Code316          2.822755e+02
## Neighborhood_Code320         -2.242691e+04
## Neighborhood_Code321         -1.230649e+04
## Neighborhood_Code323         -9.128897e+02
## Neighborhood_Code330         -2.417626e+04
## Neighborhood_Code340         -3.108282e+04
## Neighborhood_Code342         -3.745554e+04
## Neighborhood_Code344         -4.174998e+04
## Neighborhood_Code345         -2.685430e+04
## Neighborhood_Code350          3.292441e+04
## Neighborhood_Code360         -4.642668e+04
## Neighborhood_Code361          1.116291e+04
## Neighborhood_Code362          4.087098e+04
## Neighborhood_Code371         -8.277629e+03
## Neighborhood_Code380          3.992734e+04
```

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## Neighborhood_Code390          2.780524e+03
## Neighborhood_Code400         -3.992746e+04
## Neighborhood_Code402         -1.111988e+04
## Neighborhood_Code410         -9.872697e+03
## Neighborhood_Code420         -2.134100e+04
## Neighborhood_Code422          4.772172e+04
## Neighborhood_Code423          3.094291e+04
## Neighborhood_Code430         -3.501130e+04
## Neighborhood_Code431          2.400526e+04
## Neighborhood_Code432          4.898318e+04
## Neighborhood_Code440          1.493343e+04
## Neighborhood_Code461          6.332476e+04
## Neighborhood_Code463          3.508023e+04
## Neighborhood_Code520         -6.535037e+04
## Neighborhood_Code560          3.890042e+04
## Neighborhood_Code580          1.051638e+05
## Neighborhood_Code600         -1.195424e+05
## Land_Square_Feet             -3.619353e+03
## Town_Code11                   4.416530e+04
## Town_Code12                  -5.392857e+04
## Town_Code13                  -1.164188e+04
## Town_Code14                  -4.526682e+04
## Town_Code15                   4.342602e+03
## Town_Code16                   3.019001e+03
## Town_Code17                   7.763601e+04
## Town_Code18                  -3.452359e+04
## Town_Code19                   2.218303e+04
## Town_Code20                  -3.037796e+04
## Town_Code21                   2.848315e+04
## Town_Code22                   7.355880e+03
## Town_Code23                   5.280354e+04
## Town_Code24                   1.061233e+04
## Town_Code25                   3.252305e+04
## Town_Code26                   6.440271e+03
## Town_Code27                   1.427429e+05
## Town_Code28                  -2.416399e+03
## Town_Code29                  -3.812767e+03
## Town_Code30                   4.911045e+03
## Town_Code31                  -1.018200e+04
## Town_Code32                  -4.041841e+04
## Town_Code33                   1.277827e+05
## Town_Code34                   1.218635e+04
## Town_Code35                  -1.546155e+04
## Town_Code36                  -1.778517e+04
## Town_Code37                  -1.314439e+04
```

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## Town_Code38                  1.546547e+04
## Town_Code39                 -1.430772e+04
## Town_Code70                 -2.988870e+04
## Town_Code71                  4.064887e+03
## Town_Code72                 -1.689708e+04
## Town_Code73                  3.522574e+04
## Town_Code74                  1.048632e+05
## Town_Code75                 -1.356545e+04
## Town_Code76                 -5.630044e+04
## Town_Code77                  5.218465e+04
## Apartments5                 -1.972347e+04
## Apartments6                  1.502689e+04
## Wall_Material2              -3.867455e+03
## Wall_Material3              -8.225468e+03
## Wall_Material4               8.022265e+03
## Roof_Material2               2.984707e+04
## Roof_Material3               2.222898e+04
## Roof_Material4               2.770804e+04
## Roof_Material5               1.459884e+04
## Roof_Material6               2.945930e+04
## Basement2                   -1.137739e+04
## Basement3                   -8.608806e+03
## Basement4                   -2.171264e+04
## Basement_Finish3            -9.819789e+03
## Central_Heating1            -9.245260e+02
## Central_Heating2             2.375732e+03
## Other_Heating5               1.671600e+03
## Central_Air1                 5.483607e+03
## Fireplaces1                  1.231435e+04
## Fireplaces2                  3.496761e+04
## Attic_Type2                  9.822108e+02
## Attic_Type3                  4.112001e+02
## Attic_Finish1               -4.828386e+03
## Attic_Finish3                3.035344e+03
## Design_Plan1                -4.865475e+03
## Design_Plan2                -2.087133e+03
## Cathedral_Ceiling1           1.690484e+04
## Cathedral_Ceiling2           1.439474e+04
## Construction_Quality2       -6.644544e+03
## Construction_Quality3        6.556626e+03
## Site_Desirability2           4.371101e+03
## Site_Desirability3          -2.611580e+04
## Garage_1_Size1               1.872800e+02
## Garage_1_Size2              -3.919518e+03
## Garage_1_Size3               2.730563e+02
```

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## Garage_1_Size4             -1.263212e+03
## Garage_1_Size5              8.368469e+03
## Garage_1_Size6              1.025329e+04
## Garage_1_Size7              1.272070e+04
## Garage_1_Material1         -8.540850e+02
## Garage_1_Material2          4.830645e+02
## Garage_1_Material3          1.950977e+03
## Garage_1_Material4          2.787807e+03
## Garage_1_Attachment1       -3.347001e+03
## Garage_1_Attachment2        2.638874e+03
## Garage_1_Area1             -4.563648e+03
## Garage_1_Area2              1.679690e+03
## Garage_2_Size2              3.776756e+03
## Garage_2_Size3             -5.327998e+03
## Garage_2_Size4              4.510121e+04
## Garage_2_Size5              4.849640e+04
## Garage_2_Size7             -1.227278e+02
## Garage_2_Material1         -4.247371e+03
## Garage_2_Material2          2.781028e+04
## Garage_2_Attachment1       -4.776717e+03
## Garage_2_Attachment2        1.429506e+03
## Garage_2_Area1             -4.965649e+03
## Garage_2_Area2              1.431711e+03
## Garage_2_Area4             -1.572515e+03
## Porch2                      4.278757e+03
## Porch3                      1.290194e+03
## Other_Improvements1        -3.519498e+04
## Other_Improvements2        -3.513386e+03
## Other_Improvements3        -6.809545e+03
## Other_Improvements4        -1.882027e+04
## Other_Improvements5        -3.230280e+04
## Other_Improvements6         4.586440e+03
## Other_Improvements7        -3.287487e+04
## Other_Improvements8        -3.713730e+04
## Other_Improvements9         1.096204e+04
## Other_Improvements10       -7.860114e+03
## Other_Improvements11       -1.681360e+04
## Other_Improvements12       -1.654317e+04
## Other_Improvements13       -8.110200e+03
## Other_Improvements14        5.789763e+04
## Other_Improvements15        4.751812e+03
## Other_Improvements16        1.192931e+04
## Other_Improvements17        2.756650e+04
## Other_Improvements18       -7.855438e+03
## Other_Improvements19        3.440236e+04
```

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## Other_Improvements20        -2.470450e+04
## Other_Improvements21         1.288054e+04
## Other_Improvements22         1.032787e+04
## Other_Improvements23         1.085998e+03
## Other_Improvements24         8.759361e+03
## Other_Improvements25         6.800466e+03
## Other_Improvements26        -2.652926e+04
## Other_Improvements27        -2.811906e+04
## Other_Improvements28         3.299305e+04
## Other_Improvements29         4.948248e+03
## Other_Improvements30        -8.881807e+03
## Other_Improvements31        -3.517312e+02
## Other_Improvements32         2.594710e+04
## Other_Improvements33         1.036052e+04
## Other_Improvements34        -1.854056e+04
## Other_Improvements35        -1.629534e+04
## Other_Improvements36         6.061856e+04
## Other_Improvements37         1.458358e+04
## Other_Improvements38         2.756072e+04
## Other_Improvements39        -5.289614e+04
## Other_Improvements40         4.695571e+02
## Other_Improvements41        -7.331058e+03
## Other_Improvements42         2.554138e+04
## Other_Improvements43         6.858865e+02
## Other_Improvements44        -1.785168e+04
## Other_Improvements45         1.264453e+04
## Other_Improvements46         3.136861e+03
## Other_Improvements47         2.287800e+04
## Other_Improvements48         8.870060e+03
## Other_Improvements49        -9.698474e+03
## Other_Improvements50        -1.868211e+04
## Other_Improvements51         2.835495e+04
## Other_Improvements52        -4.480526e+04
## Other_Improvements53         9.837146e+03
## Other_Improvements54        -3.380447e+04
## Other_Improvements55        -2.625661e+04
## Other_Improvements56         7.815845e+03
## Other_Improvements57        -5.642346e+03
## Other_Improvements58         3.850577e+04
## Other_Improvements59        -3.079563e+04
## Other_Improvements60         2.668870e+04
## Other_Improvements61        -3.633246e+04
## Other_Improvements62        -2.066347e+04
## Other_Improvements63         1.881222e+04
## Other_Improvements64         6.775716e+03
```

```
## Other_Improvements65          5.170130e+04
## Other_Improvements66         -1.000846e+05
## Other_Improvements67         -9.897786e+03
## Other_Improvements68         -3.360299e+04
## Other_Improvements69         -4.062912e+04
## Other_Improvements70         -1.164613e+04
## Other_Improvements71         -3.746423e+03
## Other_Improvements72          2.564855e+03
## Other_Improvements73          2.608123e+04
## Other_Improvements74         -1.434979e+04
## Other_Improvements75         -9.391588e+03
## Other_Improvements76         -9.007651e+03
## Other_Improvements77         -4.761112e+03
## Other_Improvements78         -2.034862e+04
## Other_Improvements79         -5.089692e+04
## Other_Improvements80          2.558803e+04
## Other_Improvements81          2.643399e+03
## Other_Improvements82         -2.785481e+04
## Other_Improvements83         -3.027176e+04
## Other_Improvements84          3.643670e+04
## Other_Improvements85         -1.157186e+04
## Other_Improvements86         -1.088572e+04
## Other_Improvements87          1.884412e+04
## Other_Improvements88          3.639257e+04
## Other_Improvements89         -1.575072e+04
## Other_Improvements90          2.154358e+04
## Other_Improvements91          1.152699e+04
## Other_Improvements92          9.559710e+03
## Other_Improvements93         -1.571515e+04
## Other_Improvements94          1.593630e+04
## Other_Improvements95         -3.656846e+03
## Other_Improvements96         -1.774781e+04
## Other_Improvements97         -2.986535e+03
## Other_Improvements98          9.120613e+04
## Other_Improvements99         -1.285499e+04
## Other_Improvements100        -1.029216e+04
## Other_Improvements101         3.477266e+03
## Other_Improvements102         5.135379e+03
## Other_Improvements103        -3.821731e+04
## Other_Improvements104        -1.604979e+04
## Other_Improvements105         2.839281e+04
## Other_Improvements106        -4.250814e+04
## Other_Improvements107         2.066683e+04
## Other_Improvements108         2.639341e+04
## Other_Improvements109         1.051751e+04
```

```
## Other_Improvements110        -2.874803e+04
## Other_Improvements111        -5.692252e+03
## Other_Improvements112        -7.767050e+03
## Other_Improvements113         9.378317e+03
## Other_Improvements114         1.958526e+03
## Other_Improvements115         9.082374e+03
## Other_Improvements116         5.929816e+03
## Other_Improvements117        -6.664290e+04
## Other_Improvements118         1.345584e+04
## Other_Improvements119         8.475381e+03
## Other_Improvements120         2.565147e+03
## Other_Improvements121        -1.621102e+02
## Other_Improvements122         1.924947e+04
## Other_Improvements123        -6.325480e+04
## Other_Improvements124        -1.084737e+05
## Other_Improvements125        -1.420230e+04
## Other_Improvements126        -2.463567e+04
## Other_Improvements127        -1.584601e+04
## Other_Improvements128        -1.276572e+04
## Other_Improvements129         1.270602e+04
## Other_Improvements130         8.334319e+03
## Other_Improvements131        -8.082089e+03
## Other_Improvements132        -1.692867e+04
## Other_Improvements133         5.693327e+04
## Other_Improvements134         5.296046e+03
## Other_Improvements135         7.610640e+03
## Other_Improvements136         2.354041e+03
## Other_Improvements137        -3.922840e+03
## Other_Improvements138         3.081878e+03
## Other_Improvements139         5.318244e+04
## Other_Improvements140         2.262059e+04
## Other_Improvements141        -2.947026e+04
## Other_Improvements142         2.270237e+04
## Other_Improvements143         1.690120e+04
## Other_Improvements144        -3.138204e+04
## Other_Improvements145        -4.187348e+03
## Other_Improvements146        -2.106674e+04
## Other_Improvements147        -2.411938e+04
## Other_Improvements148         2.046123e+04
## Other_Improvements149        -1.935389e+04
## Other_Improvements150         4.742194e+03
## Other_Improvements151        -6.435438e+04
## Other_Improvements152         1.478142e+04
## Other_Improvements153         8.492942e+03
## Other_Improvements154         2.688302e+04
```

```
## Other_Improvements155       -5.173648e+04
## Other_Improvements156        3.712231e+04
## Other_Improvements157        1.802223e+04
## Other_Improvements158        1.417789e+04
## Other_Improvements159        2.944813e+04
## Other_Improvements160       -2.187023e+04
## Other_Improvements161       -4.230785e+04
## Other_Improvements162       -2.030300e+04
## Other_Improvements163       -1.425593e+03
## Other_Improvements164        1.094877e+04
## Other_Improvements165       -1.107585e+04
## Other_Improvements166       -7.439667e+04
## Other_Improvements167       -2.459563e+04
## Other_Improvements168        6.013007e+03
## Other_Improvements169       -6.021027e+04
## Other_Improvements170       -7.300420e+04
## Other_Improvements171       -2.098766e+04
## Other_Improvements172       -2.418429e+04
## Other_Improvements173       -2.204470e+04
## Other_Improvements174       -4.859670e+04
## Other_Improvements175       -1.651991e+04
## Other_Improvements176        3.288482e+03
## Other_Improvements177       -2.849894e+04
## Other_Improvements178        7.747251e+03
## Other_Improvements179       -1.079893e+04
## Other_Improvements180        2.738591e+04
## Other_Improvements181       -3.030282e+04
## Other_Improvements182       -1.510886e+04
## Other_Improvements183       -3.804673e+04
## Other_Improvements184        2.420103e+03
## Other_Improvements185       -2.179449e+04
## Other_Improvements186       -3.841691e+04
## Other_Improvements187        3.878413e+04
## Other_Improvements188       -1.038740e+04
## Other_Improvements189       -4.817192e+04
## Other_Improvements190        7.033190e+04
## Other_Improvements191        1.213082e+04
## Other_Improvements192       -3.921791e+03
## Other_Improvements193        2.891046e+04
## Other_Improvements194        7.003636e+04
## Other_Improvements195        6.497729e+03
## Other_Improvements196       -1.897337e+04
## Other_Improvements197       -8.762376e+04
## Other_Improvements198        3.763650e+04
## Other_Improvements199        5.478935e+04
```

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## Other_Improvements200        1.059541e+04
## Other_Improvements201       -3.499384e+04
## Other_Improvements202        2.216918e+04
## Other_Improvements203       -1.224739e+05
## Other_Improvements204       -2.125241e+02
## Other_Improvements205        1.012478e+04
## Other_Improvements206       -7.575328e+03
## Other_Improvements207       -1.443574e+04
## Other_Improvements208        1.739808e+04
## Other_Improvements209       -3.891422e+04
## Other_Improvements210       -3.981649e+03
## Other_Improvements211        1.280440e+03
## Other_Improvements212        2.637755e+03
## Other_Improvements213        .
## Other_Improvements214        1.350264e+04
## Other_Improvements215       -4.376379e+04
## Other_Improvements217        1.218982e+04
## Other_Improvements218       -9.072791e+04
## Other_Improvements219       -1.664666e+04
## Other_Improvements220        1.693102e+04
## Other_Improvements221       -6.641133e+03
## Other_Improvements222        4.960096e+03
## Other_Improvements223        .
## Other_Improvements224        4.437561e+04
## Other_Improvements225       -5.063976e+03
## Other_Improvements226       -4.535862e+04
## Other_Improvements227       -1.803639e+03
## Other_Improvements228       -1.093598e+04
## Other_Improvements229        .
## Other_Improvements230        2.569117e+04
## Other_Improvements231        4.897269e+03
## Other_Improvements232        1.563731e+04
## Other_Improvements233        7.364868e+04
## Other_Improvements234        8.608792e+03
## Other_Improvements235       -2.678033e+04
## Other_Improvements236        4.016318e+04
## Other_Improvements237       -5.161836e+04
## Other_Improvements238       -4.548324e+03
## Other_Improvements239        1.154847e+03
## Other_Improvements240        5.488136e+04
## Other_Improvements241       -6.604834e+04
## Other_Improvements242        1.527019e+05
## Other_Improvements243       -8.757849e+02
## Other_Improvements244        2.179631e+04
## Other_Improvements245        3.527491e+04
```

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## Other_Improvements246         1.976899e+03
## Other_Improvements247         2.296630e+04
## Other_Improvements248        -2.340622e+04
## Other_Improvements249         4.291677e+03
## Other_Improvements250         7.349963e+03
## Other_Improvements251         7.097883e+04
## Other_Improvements252        -2.318004e+04
## Other_Improvements253         7.989514e+03
## Other_Improvements254         2.297530e+02
## Other_Improvements255        -1.158494e+04
## Other_Improvements256         6.518530e+03
## Other_Improvements257        -2.499654e+03
## Other_Improvements258         1.639095e+04
## Other_Improvements259        -4.743773e+04
## Other_Improvements260         1.048702e+05
## Other_Improvements261        -9.710573e+04
## Other_Improvements262        -1.983825e+04
## Other_Improvements264        -1.352783e+04
## Other_Improvements265        -7.189998e+04
## Other_Improvements267        -5.913763e+04
## Other_Improvements268         2.023113e+04
## Other_Improvements269        -1.410741e+04
## Other_Improvements270        -3.999411e+04
## Other_Improvements271        -5.469132e+04
## Other_Improvements272        -1.123424e+04
## Other_Improvements273        -4.959785e+04
## Other_Improvements274         4.443999e+04
## Other_Improvements275        -9.904679e+03
## Other_Improvements276        -1.546725e+04
## Other_Improvements277        -5.048458e+04
## Other_Improvements278        -5.741130e+04
## Other_Improvements279        -9.655796e+04
## Other_Improvements280         4.321340e+04
## Other_Improvements281         2.993759e+04
## Other_Improvements283         2.066219e+05
## Other_Improvements285        -3.818997e+04
## Other_Improvements286         4.518925e+04
## Other_Improvements287        -1.408770e+04
## Other_Improvements288        -3.519972e+03
## Other_Improvements289        -2.954474e+04
## Other_Improvements290        -6.659718e+03
## Other_Improvements291         2.216900e+04
## Other_Improvements292        -4.867197e+04
## Other_Improvements293         .
## Other_Improvements294        -4.761280e+04
```

```
## Other_Improvements295         9.433108e+02
## Other_Improvements296         5.187236e+04
## Other_Improvements297        -4.158690e+04
## Other_Improvements298         .
## Other_Improvements299        -9.443092e+04
## Other_Improvements300        -1.526912e+04
## Other_Improvements301        -7.574938e+04
## Other_Improvements302        -1.069538e+05
## Other_Improvements303         1.373943e+05
## Other_Improvements304         2.883854e+04
## Other_Improvements305        -6.506336e+03
## Other_Improvements306        -1.730381e+03
## Other_Improvements307         1.650595e+04
## Other_Improvements308        -1.708377e+05
## Other_Improvements309         3.420078e+04
## Other_Improvements310        -1.140844e+05
## Other_Improvements311        -9.341230e+04
## Other_Improvements312         5.474938e+04
## Other_Improvements313         .
## Other_Improvements314         .
## Other_Improvements315         3.419786e+03
## Other_Improvements316        -4.734353e+03
## Other_Improvements317         1.695902e+04
## Other_Improvements319        -6.979723e+04
## Other_Improvements320        -1.403373e+03
## Other_Improvements321         1.434869e+04
## Other_Improvements322         3.748499e+04
## Other_Improvements323         1.737089e+03
## Other_Improvements324         2.515330e+04
## Other_Improvements325        -2.172804e+04
## Other_Improvements326        -8.321704e+03
## Other_Improvements327        -1.526696e+04
## Other_Improvements328         2.095654e+04
## Other_Improvements330        -1.554689e+04
## Other_Improvements331        -6.255364e+03
## Other_Improvements332         5.574523e+03
## Other_Improvements333         9.534766e+03
## Other_Improvements335         3.275641e+04
## Other_Improvements336        -5.171084e+04
## Other_Improvements337        -2.141321e+04
## Other_Improvements338        -1.224612e+04
## Other_Improvements339        -3.520968e+03
## Other_Improvements340         5.814093e+04
## Other_Improvements341        -1.099195e+05
## Other_Improvements343        -4.594012e+04
```

```
## Other_Improvements344          .
## Other_Improvements345       -1.198845e+04
## Other_Improvements346        9.750003e+03
## Other_Improvements347        8.587616e+03
## Other_Improvements348       -1.065904e+05
## Other_Improvements349        2.078885e+04
## Other_Improvements350       -3.792512e+04
## Other_Improvements351          .
## Other_Improvements352       -3.344464e+04
## Other_Improvements355          .
## Other_Improvements358        2.976646e+04
## Other_Improvements359        2.452258e+04
## Other_Improvements360       -8.950573e+03
## Other_Improvements361          .
## Other_Improvements363       -2.245749e+04
## Other_Improvements364        2.471771e+02
## Other_Improvements365       -1.992905e+04
## Other_Improvements366       -3.989482e+04
## Other_Improvements367        2.748461e+04
## Other_Improvements368       -1.079035e+04
## Other_Improvements369          .
## Other_Improvements370        3.108736e+04
## Other_Improvements372        1.044557e+05
## Other_Improvements373        7.669068e+04
## Other_Improvements374        2.893637e+05
## Other_Improvements375        1.310648e+05
## Other_Improvements377        1.759321e+04
## Other_Improvements378       -2.641871e+04
## Other_Improvements380       -4.684064e+04
## Other_Improvements381       -1.334915e+04
## Other_Improvements382       -4.970649e+04
## Other_Improvements384       -8.198149e+04
## Other_Improvements385       -7.179987e+04
## Other_Improvements388        2.636080e+03
## Other_Improvements389          .
## Other_Improvements390        5.275955e+04
## Other_Improvements391        3.024186e+04
## Other_Improvements392       -1.914611e+04
## Other_Improvements394        9.826954e+04
## Other_Improvements395        1.270998e+05
## Other_Improvements396        1.627877e+04
## Other_Improvements398       -2.844332e+04
## Other_Improvements399       -7.609088e+04
## Other_Improvements400        1.836008e+03
## Other_Improvements401        3.246117e+04
```

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## Other_Improvements402        3.216273e+04
## Other_Improvements403        .
## Other_Improvements404        1.275234e+05
## Other_Improvements405        3.058823e+04
## Other_Improvements406        1.000694e+04
## Other_Improvements408        1.025832e+05
## Other_Improvements409        1.493810e+04
## Other_Improvements410       -5.907793e+04
## Other_Improvements411        2.419489e+04
## Other_Improvements412        3.325878e+02
## Other_Improvements413       -1.666843e+05
## Other_Improvements415        .
## Other_Improvements416        1.940683e+03
## Other_Improvements417        6.534080e+04
## Other_Improvements418        1.744764e+04
## Other_Improvements419        9.299244e+04
## Other_Improvements420       -4.143011e+04
## Other_Improvements421        4.989267e+04
## Other_Improvements422        1.819778e+04
## Other_Improvements424        2.043415e+04
## Other_Improvements425        2.020501e+05
## Other_Improvements426        3.781040e+04
## Other_Improvements427       -3.671581e+04
## Other_Improvements428        4.492046e+04
## Other_Improvements429        4.723628e+04
## Other_Improvements430        4.876142e+04
## Other_Improvements432        1.092300e+05
## Other_Improvements433       -6.749181e+04
## Other_Improvements435       -6.105025e+04
## Other_Improvements436        .
## Other_Improvements438        3.476654e+04
## Other_Improvements439        .
## Other_Improvements440        7.643578e+04
## Other_Improvements441        4.357608e+04
## Other_Improvements442        1.913950e+04
## Other_Improvements445       -5.147328e+04
## Other_Improvements447        4.712651e+04
## Other_Improvements448       -4.195727e+04
## Other_Improvements450       -7.842293e+03
## Other_Improvements451        3.315692e+03
## Other_Improvements453        .
## Other_Improvements454        .
## Other_Improvements457       -2.860966e+04
## Other_Improvements459       -7.799356e+04
## Other_Improvements460        2.604134e+04
```

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## Other_Improvements462         1.423973e+04
## Other_Improvements463        -1.496390e+05
## Other_Improvements464        -6.838645e+04
## Other_Improvements466        -3.849382e+04
## Other_Improvements468        -3.728817e+03
## Other_Improvements471        -1.426866e+05
## Other_Improvements473         .
## Other_Improvements475        -7.348903e+04
## Other_Improvements476        -7.959468e+03
## Other_Improvements477         .
## Other_Improvements478         2.591782e+03
## Other_Improvements480         7.573099e+04
## Other_Improvements481        -1.774940e+05
## Other_Improvements482         .
## Other_Improvements483         9.847354e+03
## Other_Improvements485         4.965010e+03
## Other_Improvements486        -1.563248e+04
## Other_Improvements489        -1.159163e+04
## Other_Improvements490        -3.095872e+04
## Other_Improvements491         .
## Other_Improvements492        -1.323034e+04
## Other_Improvements495        -2.943490e+04
## Other_Improvements496        -1.229781e+04
## Other_Improvements497         1.156937e+04
## Other_Improvements498         6.456180e+04
## Other_Improvements499         1.044302e+05
## Other_Improvements500         2.334871e+04
## Other_Improvements504         4.283626e+04
## Other_Improvements505         1.341361e+04
## Other_Improvements506        -1.333359e+04
## Other_Improvements508         .
## Other_Improvements509         4.902859e+04
## Other_Improvements512        -1.156064e+05
## Other_Improvements514        -5.719053e+04
## Other_Improvements517        -4.689380e+04
## Other_Improvements519         2.008743e+03
## Other_Improvements520        -6.408171e+04
## Other_Improvements523        -1.486874e+05
## Other_Improvements524         .
## Other_Improvements525        -6.854659e+02
## Other_Improvements527        -5.009635e+03
## Other_Improvements528         .
## Other_Improvements529         2.936172e+04
## Other_Improvements530        -1.495630e+04
## Other_Improvements531        -2.374987e+04
```

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## Other_Improvements532       -1.014599e+03
## Other_Improvements534       -6.282761e+04
## Other_Improvements535       -1.358249e+03
## Other_Improvements536       -1.406240e+05
## Other_Improvements537        4.812583e+04
## Other_Improvements538        9.720873e+04
## Other_Improvements539       -1.710885e+04
## Other_Improvements540        .
## Other_Improvements541        2.641136e+04
## Other_Improvements542       -4.998009e+04
## Other_Improvements543       -3.110807e+03
## Other_Improvements544       -5.650395e+04
## Other_Improvements547       -4.384618e+03
## Other_Improvements549       -1.862929e+04
## Other_Improvements550        2.084533e+04
## Other_Improvements551       -9.797660e+04
## Other_Improvements552        .
## Other_Improvements554       -6.777913e+04
## Other_Improvements555        3.137710e+03
## Other_Improvements556        2.141217e+05
## Other_Improvements557       -6.158799e+04
## Other_Improvements559        4.825876e+04
## Other_Improvements560       -2.163961e+04
## Other_Improvements563        1.607173e+05
## Other_Improvements565        4.358214e+04
## Other_Improvements566        1.205337e+04
## Other_Improvements568        6.687021e+03
## Other_Improvements569       -4.693867e+04
## Other_Improvements570        1.364542e+04
## Other_Improvements571        4.617140e+04
## Other_Improvements573        8.777191e+04
## Other_Improvements574       -2.044038e+05
## Other_Improvements575        1.241557e+04
## Other_Improvements576        .
## Other_Improvements577        .
## Other_Improvements579       -4.114531e+04
## Other_Improvements581       -2.363900e+04
## Other_Improvements582        6.395374e+04
## Other_Improvements583        3.194766e+04
## Other_Improvements589        9.449614e+04
## Other_Improvements590       -6.394818e+02
## Other_Improvements592       -1.188356e+04
## Other_Improvements594        .
## Other_Improvements595        3.515110e+03
## Other_Improvements596        4.738633e+04
```

```
## Other_Improvements598        2.879081e+03
## Other_Improvements599        1.168778e+04
## Other_Improvements600        4.589267e+04
## Other_Improvements607        6.889679e+04
## Other_Improvements608       -1.059531e+05
## Other_Improvements612        .
## Other_Improvements615        1.359497e+05
## Other_Improvements616       -4.384110e+04
## Other_Improvements619        .
## Other_Improvements620        2.856815e+03
## Other_Improvements621       -4.559949e+04
## Other_Improvements624       -4.184100e+03
## Other_Improvements625        6.910836e+03
## Other_Improvements627        .
## Other_Improvements638       -5.534102e+04
## Other_Improvements639       -2.740338e+04
## Other_Improvements640       -1.788578e+04
## Other_Improvements646        .
## Other_Improvements649        1.339269e+04
## Other_Improvements650        1.834065e+03
## Other_Improvements651        7.350028e+04
## Other_Improvements652        3.363379e+04
## Other_Improvements655       -5.973672e+04
## Other_Improvements656        2.378176e+04
## Other_Improvements657        .
## Other_Improvements658        .
## Other_Improvements659        .
## Other_Improvements660        .
## Other_Improvements661        1.923402e+05
## Other_Improvements662        1.325501e+05
## Other_Improvements663        6.672924e+04
## Other_Improvements664        1.569739e+04
## Other_Improvements665        2.382610e+04
## Other_Improvements667        1.013617e+05
## Other_Improvements675       -9.921016e+04
## Other_Improvements678        7.801677e+04
## Other_Improvements681        .
## Other_Improvements687       -3.209900e+04
## Other_Improvements688        4.307034e+04
## Other_Improvements690       -3.452266e+04
## Other_Improvements693       -1.894686e+04
## Other_Improvements695        2.738074e+04
## Other_Improvements696       -2.950234e+03
## Other_Improvements700       -2.769939e+04
## Other_Improvements702        3.682943e+03
```

```
## Other_Improvements704        4.097587e+04
## Other_Improvements705        6.916951e+04
## Other_Improvements708        .
## Other_Improvements710       -2.727711e+04
## Other_Improvements712       -7.214792e+03
## Other_Improvements714        .
## Other_Improvements715        1.944894e+04
## Other_Improvements717        .
## Other_Improvements720       -1.901160e+04
## Other_Improvements721       -5.059927e+04
## Other_Improvements723       -3.691567e+04
## Other_Improvements725        6.384668e+04
## Other_Improvements726        9.755124e+03
## Other_Improvements730       -4.921266e+04
## Other_Improvements733       -1.004503e+05
## Other_Improvements740        1.497272e+04
## Other_Improvements741        .
## Other_Improvements742        1.459080e+05
## Other_Improvements748       -1.035919e+05
## Other_Improvements749       -7.827737e+04
## Other_Improvements750        .
## Other_Improvements755       -4.257637e+04
## Other_Improvements756        .
## Other_Improvements757       -3.301797e+04
## Other_Improvements760        2.971804e+04
## Other_Improvements762        .
## Other_Improvements765        5.212141e+04
## Other_Improvements766       -3.171967e+04
## Other_Improvements768        .
## Other_Improvements769       -9.956842e+04
## Other_Improvements770        4.961752e+04
## Other_Improvements772       -8.051630e+03
## Other_Improvements773        .
## Other_Improvements774        .
## Other_Improvements775       -1.222061e+05
## Other_Improvements776        3.099214e+04
## Other_Improvements777       -4.446094e+04
## Other_Improvements778       -5.330469e+04
## Other_Improvements780        1.187555e+04
## Other_Improvements785        .
## Other_Improvements787       -3.898478e+04
## Other_Improvements790       -1.803074e+04
## Other_Improvements792       -4.690594e+03
## Other_Improvements795       -5.362448e+04
## Other_Improvements798       -7.763323e+04
```

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## Other_Improvements800         4.224523e+04
## Other_Improvements801        -3.100850e+04
## Other_Improvements802        -9.692580e+04
## Other_Improvements803         .
## Other_Improvements805         3.171822e+04
## Other_Improvements806        -2.299622e+04
## Other_Improvements808        -9.557774e+04
## Other_Improvements809         .
## Other_Improvements810         1.158749e+05
## Other_Improvements812        -4.466101e+04
## Other_Improvements815        -1.769544e+04
## Other_Improvements816         1.422778e+04
## Other_Improvements819         5.768238e+04
## Other_Improvements821         .
## Other_Improvements823         2.301302e+04
## Other_Improvements824         .
## Other_Improvements825         9.807811e+04
## Other_Improvements831         1.496796e+04
## Other_Improvements832         .
## Other_Improvements833         1.398767e+04
## Other_Improvements835         .
## Other_Improvements836         2.714732e+04
## Other_Improvements841         .
## Other_Improvements842         6.931249e+04
## Other_Improvements843        -7.072605e+04
## Other_Improvements846        -1.695630e+04
## Other_Improvements847         2.109828e+04
## Other_Improvements848         3.582805e+04
## Other_Improvements849         7.523952e+04
## Other_Improvements850         4.733644e+04
## Other_Improvements852        -2.963018e+04
## Other_Improvements853        -1.961156e+05
## Other_Improvements854         5.668744e+04
## Other_Improvements855         1.012754e+05
## Other_Improvements858        -6.158481e+04
## Other_Improvements861         .
## Other_Improvements864        -5.105756e+04
## Other_Improvements865         .
## Other_Improvements866         .
## Other_Improvements869        -1.296224e+05
## Other_Improvements872        -5.591059e+04
## Other_Improvements873         6.508021e+04
## Other_Improvements875        -4.848461e+04
## Other_Improvements876        -1.679109e+04
## Other_Improvements878         .
```

```
## Other_Improvements879        -1.607928e+05
## Other_Improvements880        -3.356858e+03
## Other_Improvements882        -8.552170e+04
## Other_Improvements884         .
## Other_Improvements890        -4.064273e+04
## Other_Improvements892        -3.377684e+04
## Other_Improvements898         .
## Other_Improvements899        -1.348339e+05
## Other_Improvements902         .
## Other_Improvements905         .
## Other_Improvements906         6.245816e+04
## Other_Improvements908         1.399050e+05
## Other_Improvements910         .
## Other_Improvements912         9.388682e+03
## Other_Improvements915         1.191786e+05
## Other_Improvements918        -7.858033e+04
## Other_Improvements934         3.741675e+04
## Other_Improvements935         7.771104e+04
## Other_Improvements940         .
## Other_Improvements943         2.830955e+04
## Other_Improvements950        -4.355237e+04
## Other_Improvements955        -4.398115e+04
## Other_Improvements956        -3.063570e+04
## Other_Improvements960         .
## Other_Improvements961         .
## Other_Improvements965        -1.499531e+05
## Other_Improvements966         4.479986e+04
## Other_Improvements975        -4.095239e+04
## Other_Improvements976         3.389279e+04
## Other_Improvements980         3.975742e+04
## Other_Improvements981         4.438108e+04
## Other_Improvements984        -4.028724e+04
## Other_Improvements985         .
## Other_Improvements994         .
## Other_Improvements995         8.830475e+04
## Other_Improvements997        -1.146378e+04
## Other_Improvements1000       -7.130158e+04
## Other_Improvements1018       -1.254598e+05
## Other_Improvements1020        .
## Other_Improvements1021       -1.146188e+05
## Other_Improvements1023        4.667290e+04
## Other_Improvements1026        2.731379e+05
## Other_Improvements1030       -8.173522e+03
## Other_Improvements1032        1.286217e+05
## Other_Improvements1045        3.107172e+04
```

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## Other_Improvements1047       -9.342509e+04
## Other_Improvements1048        .
## Other_Improvements1050        1.189432e+05
## Other_Improvements1055        6.902078e+05
## Other_Improvements1057        8.248416e+04
## Other_Improvements1058       -4.891133e+04
## Other_Improvements1062       -2.501463e+04
## Other_Improvements1064        8.874663e+04
## Other_Improvements1065        9.842108e+04
## Other_Improvements1067        6.266284e+04
## Other_Improvements1069        .
## Other_Improvements1072        4.051959e+04
## Other_Improvements1076        6.142534e+04
## Other_Improvements1084        7.737292e+03
## Other_Improvements1088       -1.548663e+05
## Other_Improvements1090        .
## Other_Improvements1091        4.925251e+03
## Other_Improvements1093       -2.169631e+04
## Other_Improvements1095       -5.162027e+04
## Other_Improvements1099        .
## Other_Improvements1100        2.060932e+04
## Other_Improvements1102        8.584275e+03
## Other_Improvements1105        .
## Other_Improvements1117       -1.073231e+05
## Other_Improvements1120       -2.564170e+04
## Other_Improvements1124        2.457855e+04
## Other_Improvements1125       -2.370253e+04
## Other_Improvements1126       -9.259264e+04
## Other_Improvements1127        1.958000e+05
## Other_Improvements1128        3.427804e+04
## Other_Improvements1133        1.225620e+04
## Other_Improvements1134        .
## Other_Improvements1140        .
## Other_Improvements1146        3.537014e+04
## Other_Improvements1153        1.287263e+05
## Other_Improvements1163       -5.739142e+04
## Other_Improvements1167        .
## Other_Improvements1173        1.360160e+05
## Other_Improvements1175       -4.648641e+04
## Other_Improvements1183        .
## Other_Improvements1185        4.202464e+04
## Other_Improvements1200        4.539545e+04
## Other_Improvements1201        1.215133e+05
## Other_Improvements1202       -5.363014e+03
## Other_Improvements1203        .
```

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## Other_Improvements1205      -5.366599e+04
## Other_Improvements1216       .
## Other_Improvements1217      -2.003870e+04
## Other_Improvements1226       1.378208e+05
## Other_Improvements1233      -7.017353e+03
## Other_Improvements1237      -1.041563e+05
## Other_Improvements1246       2.221274e+05
## Other_Improvements1250      -7.456511e+04
## Other_Improvements1251       1.289120e+04
## Other_Improvements1267       .
## Other_Improvements1268       .
## Other_Improvements1273       1.374277e+05
## Other_Improvements1278       7.519672e+04
## Other_Improvements1281       1.555213e+05
## Other_Improvements1282       2.787503e+04
## Other_Improvements1283       .
## Other_Improvements1285       1.706423e+04
## Other_Improvements1286      -7.683119e+04
## Other_Improvements1290      -2.288504e+04
## Other_Improvements1293       .
## Other_Improvements1300      -2.426615e+04
## Other_Improvements1308       1.405252e+05
## Other_Improvements1315       1.073631e+04
## Other_Improvements1321       .
## Other_Improvements1345      -1.846047e+04
## Other_Improvements1349       3.033949e+04
## Other_Improvements1358       3.022868e+04
## Other_Improvements1368       6.289934e+03
## Other_Improvements1370       .
## Other_Improvements1371       .
## Other_Improvements1387       .
## Other_Improvements1397       .
## Other_Improvements1400      -3.309575e+04
## Other_Improvements1401      -1.185267e+05
## Other_Improvements1410       1.586513e+04
## Other_Improvements1415       .
## Other_Improvements1430      -1.093917e+04
## Other_Improvements1432       8.252668e+04
## Other_Improvements1439      -1.320958e+04
## Other_Improvements1445      -9.288306e+04
## Other_Improvements1446      -2.305934e+04
## Other_Improvements1453      -8.746478e+04
## Other_Improvements1464       .
## Other_Improvements1476       5.531761e+04
## Other_Improvements1494      -2.293719e+04
```

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## Other_Improvements1502       2.002342e+04
## Building_Square_Feet         2.373864e+04
## Repair_Condition2           -2.323673e+03
## Repair_Condition3           -1.161759e+04
## Multi_Code3                  1.774316e+03
## Multi_Code4                  1.213387e+04
## Multi_Code5                  7.715892e+04
## Number_of_Commercial_Units1 -5.164478e+04
## Number_of_Commercial_Units2 -3.522425e+04
## Number_of_Commercial_Units5 -1.812488e+04
## Estimate_Land                3.197750e+04
## Estimate_Building            4.679760e+04
## Longitude                   -7.169389e+03
## Latitude                     9.205508e+04
## Multi_Property_Indicator1   -1.620687e+05
## OHare_Noise1                 1.714745e+04
## Floodplain1                 -1.663874e+04
## Road_Proximity1             -2.468247e+04
## Sale_Year                    1.597196e+03
## Sale_Quarter                 4.657742e+02
## Sale_Half_Year               8.862768e+02
## Sale_Quarter_of_Year2        8.609698e+03
## Sale_Quarter_of_Year3        8.617617e+03
## Sale_Quarter_of_Year4       -1.809693e+03
## Sale_Month_of_Year           7.859783e+02
## Most_Recent_Sale1            3.918067e+04
## Age_Decade                  -5.726366e+03
## Pure_Market_Filter1          3.134239e+04
## Garage_Indicator1           -9.451181e+02
## Lot_Size                    -3.980475e+03
## Sell_Date                    4.877861e+00
## Rooms                        9.610297e+02
## Bedrooms                    -3.058887e+03
## Baths                        1.653230e+04
## Area2                       -3.024285e+04
## Area3                       -3.844608e+04
## Area5                        1.457379e+05
## Area8                       -6.845424e+04
## Area9                       -6.469099e+04
## Area10                       2.590085e+04
## Area11                       5.705271e+04
## Area12                       7.459296e+03
## Area13                       4.483038e+04
## Area14                       1.659704e+05
## Area15                       1.248743e+03
```

```
## Area16                         -5.491726e+04
## Area17                          8.982950e+04
## Area18                          2.690355e+04
## Area19                         -1.252669e+04
## Area20                         -3.542161e+04
## Area21                         -3.045135e+04
## Area22                          3.030048e+03
## Area23                         -1.737739e+04
## Area24                         -2.107648e+03
## Area25                         -1.732992e+04
## Area26                         -7.516261e+01
## Area27                         -2.871185e+03
## Area28                         -1.133725e+04
## Area29                         -3.646278e+04
## Area30                         -2.556218e+04
## Area31                         -2.705419e+04
## Area32                          5.821226e+01
## Area33                          1.832812e+04
## Area40                          1.609219e+04
## Area41                          2.354120e+04
## Area42                          5.674284e+04
## Area43                          6.892977e+04
## Area50                          1.307436e+04
## Area51                          4.482285e+04
## Area52                          1.039697e+05
## Area53                          6.216077e+04
## Area60                         -3.852622e+04
## Area61                         -4.069795e+04
## Area62                         -2.684363e+04
## Area63                         -4.461638e+04
## Area70                         -1.067061e+04
## Area71                         -2.149942e+04
## Area72                         -5.531315e+03
## Area73                         -3.240738e+04
## Area80                         -2.430528e+04
## Area81                          1.253472e+04
## Area82                         -5.929178e+03
## Area83                          2.263623e+03
## Area90                         -2.613465e+04
## Area91                         -1.781238e+04
## Area92                          1.830517e+04
## Area93                          3.152476e+04
## Sub_Area02                     -8.213140e+03
## Sub_Area03                     -6.577563e+03
## Sub_Area04                     -6.956449e+03
```

```
## Sub_Area05                     2.726251e+03
## Sub_Area06                     2.376146e+04
## Sub_Area07                     2.014122e+04
## Sub_Area08                     3.668188e+02
## Sub_Area09                    -1.385952e+04
## Sub_Area10                    -1.200597e+04
## Sub_Area11                     2.046488e+03
## Sub_Area12                     4.550331e+03
## Sub_Area13                     5.016988e+03
## Sub_Area14                    -2.458666e+03
## Sub_Area15                    -5.501832e+03
## Sub_Area16                    -1.448472e+04
## Sub_Area17                    -8.315389e+03
## Sub_Area18                    -1.927102e+03
## Sub_Area19                    -1.568493e+04
## Sub_Area20                    -1.384667e+04
## Sub_Area21                    -1.096118e+04
## Sub_Area22                    -1.123728e+04
## Sub_Area23                    -6.509925e+03
## Sub_Area24                    -5.664112e+03
## Sub_Area25                     6.345902e+03
## Sub_Area26                     9.995703e+03
## Sub_Area27                    -8.624420e+03
## Sub_Area28                    -1.197304e+04
## Sub_Area29                    -7.779078e+03
## Sub_Area30                    -9.317749e+03
## Sub_Area31                    -6.075991e+01
## Sub_Area32                     4.929293e+02
## Sub_Area33                    -3.360417e+03
## Sub_Area34                    -1.156113e+03
## Sub_Area35                     1.845042e+04
## Sub_Area36                     2.247480e+04
## Sub_Area41                    -6.096307e+03
## Sub_Area42                     9.255945e+03
## Sub_Area43                     5.335318e+03
## Sub_Area44                    -3.291126e+03
## Sub_Area50                     1.044604e+04
## Sub_Area51                     1.262102e+04
## Sub_Area52                     7.467043e+03
## Sub_Area53                     1.170726e+04
## Sub_Area54                     1.218942e+04
## Sub_Area61                     9.341359e+03
## Sub_Area62                     1.170289e+04
## Sub_Area63                     1.302934e+04
## Sub_Area64                     2.363678e+04
```

```
## Sub_Area71                      8.704009e+03
## Sub_Area72                      1.058098e+03
## Sub_Area73                      1.431102e+04
## Sub_Area74                      2.751607e+04
## Sub_Area81                      4.781343e+03
## Sub_Area82                      1.002784e+04
## Sub_Area83                     -4.543383e+02
## Sub_Area84                      7.317495e+03
## Sub_Area90                      1.215335e+04
## Sub_Area91                      2.657986e+03
## Sub_Area92                      7.850613e+03
## Sub_Area93                      1.850577e+04
## Sub_Area94                      1.405757e+04
## Block01                         3.113644e+03
## Block02                        -3.872536e+03
## Block03                        -3.952303e+03
## Block04                        -2.019962e+03
## Block05                         3.095712e+03
## Block06                        -4.963648e+03
## Block07                        -1.894567e+03
## Block08                        -1.276586e+03
## Block09                        -4.414726e+03
## Block10                        -2.076619e+03
## Block11                        -3.209250e+03
## Block12                         3.186419e+03
## Block13                         3.824674e+03
## Block14                        -3.748077e+03
## Block15                        -1.341656e+03
## Block16                         6.849258e+03
## Block17                         1.075009e+03
## Block18                         8.351930e+03
## Block19                         4.424396e+03
## Block20                         1.713469e+03
## Block21                         2.765601e+03
## Block22                         1.716985e+03
## Block23                        -2.279970e+03
## Block24                         1.680502e+04
## Block25                         2.221550e+04
## Block26                         1.753307e+04
## Block27                         5.622925e+01
## Block28                         1.589499e+04
## Block29                        -6.963923e+03
## Block30                         1.673888e+03
## Block31                         3.358990e+02
## Block32                         5.834059e+02
```

```
## Block33                          2.122053e+02
## Block34                         -5.837285e+03
## Block35                          1.075257e+04
## Block36                          7.260703e+03
## Block37                          8.083339e+04
## Block38                          6.415385e+04
## Block39                          1.519249e+04
## Block40                          1.973583e+03
## Block41                          1.138004e+03
## Block42                         -9.987228e+02
## Block43                         -7.379241e+02
## Block44                          1.451690e+04
## Block45                          3.172694e+04
## Block46                          3.065626e+04
## Block62                         -6.926978e+04
## Block63                          4.982519e+04
## Block64                          5.826687e+04
## Block71                         -6.318109e+04
## Block73                         -5.448726e+03
## Block84                          1.251738e+04
## Block91                          2.621281e+04
## Parcel01                         9.936613e+02
## Parcel02                         1.395451e+03
## Parcel03                         1.770779e+03
## Parcel04                        -2.598834e+03
## Parcel05                        -3.020514e+03
## Parcel06                        -3.446287e+03
## Parcel07                        -1.307771e+03
## Parcel08                         1.100357e+04
## Parcel09                        -4.415446e+03
## Parcel10                        -2.262970e+03
## Parcel11                        -6.353928e+03
## Parcel12                         4.513999e+04
## Parcel13                         1.580183e+04
## Parcel14                        -1.803947e+04
## Parcel15                        -2.225270e+04
## Parcel16                         4.602023e+04
## Parcel17                        -6.415152e+04
## Parcel18                        -3.029043e+04
## Parcel19                        -4.873615e+04
## Parcel20                        -2.333376e+03
## Parcel21                        -1.515763e+04
## Parcel22                         2.905202e+03
## Parcel23                        -7.293066e+04
## Parcel24                         1.398125e+04
```

```
## Parcel25                    -1.311208e+04
## Parcel26                     6.032595e+04
## Parcel27                    -9.934244e+04
## Parcel28                    -1.338881e+05
## Parcel30                    -2.174639e+03
## Parcel31                    -1.159819e+04
## Parcel32                    -3.949010e+04
## Parcel40                    -1.718602e+03
## Parcel41                    -2.823646e+03
## Parcel42                    -5.869608e+04
## Parcel50                    -2.284792e+03
## Parcel51                    -1.671783e+04
## Parcel52                    -4.261187e+04
## Parcel60                     8.463397e+01
## Parcel61                    -8.270298e+03
## Parcel62                    -9.503967e+03
## Parcel70                    -1.115094e+03
## Parcel71                    -2.214838e+04
## Parcel72                    -1.315069e+05
## Parcel80                    -4.666496e+02
## Parcel81                     1.973533e+03
## Parcel90                    -2.746620e+03
## Parcel91                    -1.206068e+04
## Multicode0100                6.352658e+02
## Multicode0200               -1.039510e+03
## Multicode0300                1.922878e+03
## Multicode0400                9.369834e+02
## Multicode0500                2.541523e+03
## Multicode0600                1.531165e+03
## Multicode0700                2.922328e+02
## Multicode0800                5.008340e+02
## Multicode0900                4.061055e+02
## Multicode1000                3.691053e+02
## Multicode1100                1.219418e+03
## Multicode1200                2.951205e+03
## Multicode1300                2.167289e+03
## Multicode1400               -7.054602e+02
## Multicode1500               -1.128911e+03
## Multicode1600               -8.982279e+02
## Multicode1700                1.633950e+03
## Multicode1800               -4.722789e+02
## Multicode1900                2.195965e+03
## Multicode1e+1               -1.317369e+04
## Multicode2000                1.237073e+03
## Multicode2100                6.946432e+02
```

```
## Multicode2200              -1.783151e+03
## Multicode2300               2.006827e+01
## Multicode2400               2.235219e+03
## Multicode2500              -1.244406e+00
## Multicode2600               2.042470e+03
## Multicode2700              -3.174247e+02
## Multicode2800              -4.091453e+02
## Multicode2900              -2.978968e+03
## Multicode2e+1               .
## Multicode3000               6.430214e+02
## Multicode3100              -8.074114e+02
## Multicode3200              -4.955477e+02
## Multicode3300              -3.230503e+03
## Multicode3400              -3.135458e+03
## Multicode3500              -4.488930e+03
## Multicode3600              -5.829945e+03
## Multicode3700              -5.419656e+03
## Multicode3800              -3.224377e+03
## Multicode3900              -3.039543e+03
## Multicode4000               3.967846e+01
## Multicode4100              -7.376955e+03
## Multicode4200              -5.125310e+03
## Multicode4300              -2.115126e+03
## Multicode4400              -4.622526e+03
## Multicode4500              -4.442443e+03
## Multicode4600              -8.911740e+03
## Multicode4700              -3.937675e+03
## Multicode4800              -2.739384e+03
## Multicode4900              -1.997799e+03
## Multicode5000               2.379859e+03
## Multicode5100              -3.849490e+03
## Multicode5200              -3.118772e+03
## Multicode5300              -4.202061e+03
## Multicode5400              -1.112752e+03
## Multicode5500              -6.861739e+02
## Multicode5600              -6.176135e+03
## Multicode5700              -6.184655e+03
## Multicode5800              -6.914524e+03
## Multicode5900              -3.904773e+02
## Multicode6000               2.090829e+03
## Multicode6100              -6.930392e+03
## Multicode6200              -7.185240e+03
## Multicode6300              -8.920328e+03
## Multicode6400              -8.467834e+03
## Multicode6500              -4.938982e+03
```

```
## Multicode6600                  4.825216e+03
## Multicode6700                  5.762403e+03
## Multicode6800                 -1.357032e+04
## Multicode6900                 -7.535705e+03
## Multicode7000                  3.605412e+03
## Multicode7100                 -1.278143e+04
## Multicode7200                 -2.015148e+03
## Multicode7300                 -9.084396e+02
## Multicode7400                  3.273140e+03
## Multicode7500                 -1.449253e+04
## Multicode7600                 -4.071294e+03
## Multicode7700                 -5.560624e+03
## Multicode7800                 -2.047662e+04
## Multicode7900                 -1.157143e+04
## Multicode8000                  4.538897e+02
## Multicode8100                  1.463895e+02
## Multicode8200                 -1.753421e+04
## Multicode8300                 -2.546661e+04
## Multicode8400                 -1.228498e+04
## Multicode8500                 -1.837262e+04
## Multicode8600                 -2.417299e+04
## Multicode8700                 -3.657355e+03
## Multicode8800                 -1.314390e+04
## Multicode8900                 -5.787616e+03
## Multicode9000                  1.269774e+03
## Multicode9100                 -8.251444e+03
## Multicode9200                 -1.695448e+04
## Multicode9300                  2.953315e+03
## Multicode9400                 -3.780742e+04
## Multicode9500                 -3.709906e+04
## Multicode9600                 -7.278316e+03
## Multicode9700                 -1.227990e+04
## Multicode9800                 -4.337193e+03
## Multicode9900                 -1.354142e+04
## Multicodee+12                  2.470156e+04
```

```r
# Fitting Lasso regression model
tune.grid.lasso = expand.grid(alpha = 1,
                              lambda = glmnet(data.train.mat,
                                              train$Sale_Price,
                                              alpha = 1)$lambda)
fit.lasso <- train(Sale_Price ~., data = train,
                   method = 'glmnet',
                   trControl = train_control,
                   tuneGrid = tune.grid.lasso)
```

```r
# Tuning Parameters
print(fit.lasso)
```

```
## glmnet
##
## 126664 samples
##     60 predictor
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 101330, 101331, 101332, 101331, 101332
## Resampling results across tuning parameters:
##
##   lambda        RMSE       Rsquared   MAE
##       16.59414   85497.77  0.7918009   58582.70
##       18.21205   85496.76  0.7918056   58579.89
##       19.98770   85495.96  0.7918094   58576.76
##       21.93647   85494.65  0.7918156   58573.35
##       24.07525   85492.57  0.7918254   58568.26
##       26.42256   85490.52  0.7918350   58562.02
##       28.99873   85487.40  0.7918495   58554.87
##       31.82607   85484.10  0.7918651   58546.88
##       34.92907   85480.64  0.7918814   58538.31
##       38.33461   85477.26  0.7918972   58529.27
##       42.07219   85473.60  0.7919145   58519.64
##       46.17417   85469.52  0.7919338   58508.86
##       50.67610   85465.18  0.7919542   58498.29
##       55.61695   85462.62  0.7919660   58486.69
##       61.03954   85459.39  0.7919812   58473.17
##       66.99082   85455.96  0.7919975   58459.66
##       73.52234   85454.23  0.7920054   58445.95
##       80.69068   85453.37  0.7920094   58430.96
##       88.55792   85449.98  0.7920259   58416.64
##       97.19221   85450.82  0.7920217   58399.78
##      106.66833   85449.59  0.7920280   58384.28
##      117.06836   85452.05  0.7920162   58366.35
##      128.48238   85453.16  0.7920116   58349.61
##      141.00925   85457.82  0.7919897   58330.86
##      154.75748   85462.47  0.7919687   58313.06
##      169.84614   85471.83  0.7919249   58296.08
##      186.40593   85484.52  0.7918656   58279.67
##      204.58028   85500.06  0.7917932   58264.74
##      224.52660   85521.70  0.7916915   58252.24
##      246.41767   85548.32  0.7915666   58241.34
```

```
##      270.44309  85579.14 0.7914220  58231.36
##      296.81096  85615.69 0.7912504  58224.51
##      325.74966  85658.05 0.7910518  58221.66
##      357.50985  85705.88 0.7908274  58221.05
##      392.36662  85760.84 0.7905697  58224.39
##      430.62188  85826.67 0.7902608  58234.21
##      472.60698  85904.16 0.7898950  58251.45
##      518.68557  85994.86 0.7894663  58274.96
##      569.25678  86102.69 0.7889547  58307.03
##      624.75861  86224.98 0.7883731  58346.05
##      685.67180  86362.37 0.7877188  58393.19
##      752.52396  86514.46 0.7869934  58443.91
##      825.89412  86687.88 0.7861630  58503.53
##      906.41777  86886.97 0.7852073  58575.95
##      994.79239  87102.52 0.7841697  58657.57
##     1091.78342  87341.38 0.7830151  58753.15
##     1198.23095  87568.38 0.7819236  58835.35
##     1315.05699  87815.47 0.7807345  58925.02
##     1443.27342  88096.53 0.7793738  59033.86
##     1583.99080  88406.82 0.7778676  59159.11
##     1738.42795  88749.68 0.7761931  59300.77
##     1907.92252  89121.31 0.7743724  59460.73
##     2093.94262  89534.15 0.7723353  59644.61
##     2298.09944  89971.11 0.7701711  59847.58
##     2522.16129  90414.29 0.7679715  60047.41
##     2768.06891  90859.57 0.7657665  60257.12
##     3037.95221  91242.22 0.7638989  60426.19
##     3334.14880  91641.70 0.7619571  60613.59
##     3659.22419  92081.09 0.7598076  60823.61
##     4015.99403  92566.14 0.7574253  61068.65
##     4407.54849  93089.00 0.7548424  61334.62
##     4837.27903  93631.26 0.7521683  61623.08
##     5308.90776  94211.24 0.7492963  61951.97
##     5826.51971  94878.65 0.7459415  62356.87
##     6394.59819  95545.12 0.7426040  62773.01
##     7018.06362  96135.17 0.7397399  63166.26
##     7702.31616  96756.42 0.7367252  63587.19
##     8453.28248  97408.72 0.7335899  64035.59
##     9277.46708  98016.81 0.7307656  64480.73
##    10182.00867  98600.27 0.7281812  64920.36
##    11174.74195  99215.93 0.7255211  65414.59
##    12264.26549  99947.85 0.7222550  66002.67
##    13460.01624 100657.67 0.7192879  66557.66
##    14772.35120 101387.27 0.7163553  67141.70
##    16212.63721 102201.62 0.7130999  67798.19
```

```
##    17793.34932  103174.12  0.7090571   68576.70
##    19528.17892  104222.23  0.7047175   69439.41
##    21432.15225  105248.32  0.7008782   70370.70
##    23521.76064  106163.54  0.6982724   71122.20
##    25815.10326  107194.28  0.6954305   71966.98
##    28332.04396  108357.39  0.6923232   72935.46
##    31094.38327  109480.73  0.6904171   73852.65
##    34126.04726  110754.88  0.6884748   74920.63
##    37453.29473  112111.76  0.6873054   76135.16
##    41104.94474  113671.18  0.6862483   77547.04
##    45112.62610  115519.76  0.6848414   79203.83
##    49511.05146  117709.65  0.6829112   81143.98
##    54338.31785  120294.50  0.6802337   83412.13
##    59636.23676  123336.08  0.6764422   86052.34
##    65450.69622  126902.93  0.6709402   89119.54
##    71832.05831  131069.11  0.6627341   92654.88
##    78835.59531  135825.75  0.6515173   96653.77
##    86521.96853  140433.36  0.6514051  100578.72
##    94957.75365  145782.28  0.6514051  105069.48
##   104216.01741  151975.33  0.6514051  110191.47
##   114376.95045  159115.17  0.6514051  116006.35
##   125528.56192  167311.08  0.6514051  122595.47
##   137767.44174  176679.02  0.6514051  130036.41
##   151199.59724  187251.31  0.6499115  138344.07
##
## Tuning parameter 'alpha' was held constant at a value of 1
## RMSE was used to select the optimal model using the smallest value.
## The final values used for the model were alpha = 1 and lambda = 106.6683.
```

```r
# Fitting the model on our test data
lasso_pred <- predict(fit.lasso, test)
lasso_mse = Metrics::mse(lasso_pred, test$Sale_Price)
print(paste("MSE from Test Set: ", lasso_mse))
```

```
## [1] "MSE from Test Set:  7458837515.98409"
```

```r
# model coefficients
# coef(fit.lasso$finalModel, s = fit.lasso$bestTune$lambda)
```

For the model using principle components, we first selected all numeric variables except for the response and calculated the principle components. The cumulative variance is shown below, indicating that only the first two principle components are needed.

```
# Calculating principle components using numeric data
numeric_data = Model_Data %>% select_if(is.numeric) %>% select(-Sale_Price)
PCs = prcomp(numeric_data)

# Determining how many PCs to use
PCs$sdev^2/sum(PCs$sdev^2)
```

```
##  [1] 7.599511e-01 9.662336e-02 7.520483e-02 3.207665e-02 1.571743e-02
##  [6] 1.045565e-02 3.960374e-03 2.199857e-03 1.770254e-03 1.281368e-03
## [11] 3.996414e-04 2.743077e-04 4.706330e-05 3.811454e-05 1.099480e-28
```

Then, a data frame is created using the first two principle components' variable values. The observed response values were then binded to this data frame and the train-test splits were made again using the original training IDs. The model was trained on the training data using the 5-fold cross-validation and predictions were made on the test set.

```
# Obtain first principle component as data
PC_data = data.frame(PCs$x[,1:2])

# Convert into data frame, adding response
PC_data = bind_cols(PC_data, data.frame(Sale_Price = Model_Data$Sale_Price))

# Split into test and train
PC_train = PC_data[ids_train,]
PC_test = PC_data[-ids_train,]

# train model with k-fold cv
pc_slr <- train(Sale_Price~., data = PC_train,
               trControl = train_control,
               method = "lm")

# display model
print(pc_slr)
```

```
## Linear Regression
##
## 126664 samples
##      2 predictor
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 101331, 101331, 101331, 101333, 101330
## Resampling results:
##
```

```
##   RMSE      Rsquared    MAE
##   186406.6  0.01005841  137154.9
##
## Tuning parameter 'intercept' was held constant at a value of TRUE
```

```r
# predict to test data
pc_slr_preds = predict(pc_slr, PC_test)
pc_mse = Metrics::mse(pc_slr_preds, PC_test$Sale_Price)
print(paste("MSE from Test Set: ", pc_mse))
```

```
## [1] "MSE from Test Set:  35259839965.94"
```

```r
# Loadings from first PC
PCs$rotation[,1]
```

```
##     Land_Square_Feet Building_Square_Feet        Estimate_Land
##         0.0008882040         0.0010883960         0.0066974675
##    Estimate_Building            Longitude             Latitude
##         0.0010046124         0.0002311904        -0.0005799016
##            Sale_Year         Sale_Quarter       Sale_Half_Year
##         0.2162570564         0.8730671078         0.4360019681
##   Sale_Month_of_Year           Age_Decade             Lot_Size
##         0.0232759222         0.0171276107         0.0008882040
##                Rooms             Bedrooms                Baths
##         0.0016421643         0.0012608425         0.0007531130
```

A similar process was performed for the non-linear model as for the principle component model. We start by calculating the orthogonal 4^{th} degree polynomial variables from the `Estimate_Building` variable, renaming each term as `Poly_#`. This data set was binded with the original data as to have all polynomial variables and the response in a single data frame. Then, train and test splits were made. The model was trained on the training set and predicted to the testing set, resulting in the MSE provided.

```r
# Adding polynomial terms for later use
poly_predictors = data.frame(poly(Model_Data$Estimate_Building, 4))

Polynomial_Data = poly_predictors %>%
    rename(Poly_1 = X1,
           Poly_2 = X2,
           Poly_3 = X3,
           Poly_4 = X4) %>%
    bind_cols(Model_Data)

# Split polynomial data
```

```r
poly_train = Polynomial_Data[ids_train,]
poly_test = Polynomial_Data[-ids_train,]

# Training 5th degree polynomial
poly_slr = train(Sale_Price ~ Poly_1 + Poly_2 + Poly_3 + Poly_4,
                 data = poly_train,
                 trControl = train_control,
                 method = 'lm')


# Summary of model
print(poly_slr)
```

```
## Linear Regression
##
## 126664 samples
##      4 predictor
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 101332, 101330, 101331, 101332, 101331
## Resampling results:
##
##   RMSE      Rsquared   MAE
##   108246.6  0.6661593  73244.79
##
## Tuning parameter 'intercept' was held constant at a value of TRUE
```

```r
# Predicting and Calculating MSE
poly_slr_preds = predict(poly_slr, poly_test, type = 'raw')
poly_mse = Metrics::mse(poly_slr_preds, poly_test$Sale_Price)
print(paste("MSE from Test Set: ", poly_mse))
```

```
## [1] "MSE from Test Set:  11742883379.0502"
```

Comparing the models on mean squared error when predicting to the test set, we can see which model performed the best when predicting to the test data (Table 1). From this table, the top performing model on test data was the Lasso regularized model, followed closely by the MLR model. This is likely due to overfitting from the MLR model and effective variable selection for the Lasso model.

```r
tibble(Model = c("SLR", "MLR", "Backward Selection",
                 "Ridge", "Lasso", "PCA", "Polynomial"),
    MSE = c(slr_mse, mlr_mse, bs_mse, ridge_mse, lasso_mse, pc_mse, poly_mse)) %>%
```

Table 1: A table of MSE for the models compared when predicting to the test data.

Model	MSE
Lasso	7458837516
MLR	7472850775
Ridge	7541838874
Polynomial	11742883379
SLR	12233023834
Backward Selection	22338772109
PCA	35259839966

```
  arrange(MSE) %>%
  knitr::kable(caption = "A table of MSE for the models compared when predicting to th
```