Predicting AirBnB Rental Prices

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Motivation

- You are looking for some additional income and decide renting on AirBnB is the best option
- How much should you rent your extra space for?

Data

- In general, AirBnB data is very open and be easily accessed
- The original dataset is from a past Kaggle competition
  - Contained over 74,000 individual listings between 2011-2018
- For sake of time and processing power, we took a random sample of 17,500 from those 74,000 listings
- They also provided a testing file
- Since the competition is over, we will compile our final predictions on that file using our best model

Data

- Original data consists of 30 variables
- Variables are about the property, property location, the host and host reviews
- After cleaning and eliminating variables, our data consisted of 22 variables
- Property:
  - property_type, room_type, accommodates, bedrooms, beds, bed_type, bathrooms
- Location:
  - latitude, longitude, city
- Host:
  - cancellation_policy, cleaning_fee, host_has_profile_pic, host_identify_verified, etc

Baseline Regression

```r
linear = lm(price ~ ., data = training)
```

```
## [1] "MSE of Testing Set:  0.165"
```

Regression Splines/Generalized Additive Models

- 20 Fold Cross-Validation was performed for different degrees of freedom ranging usually between 3 and 6
- Cross-Validation MSE used to pick degrees of freedom for splines

Splines

- Splines fit to variables Accommodates, review_scores_rating, bathrooms, and bedrooms
- Best performing spline based on Cross-Validation MSE was the spline on review_scores_rating with degrees of freedom = 4
- Use these splines with their optimal degrees of freedom in my general additive model

GAM Model

- Performed the GAM on the training data set using all of the predictors plus splines on Accommodates, review_scores_rating, bathrooms, and bedrooms with their optimal degrees of freedom
- Not a great fitting model, $R^2 = 0.6388$
- Decent MSE when fit on the test data set

```
## [1] "Test MSE of GAM:  0.1612"
```

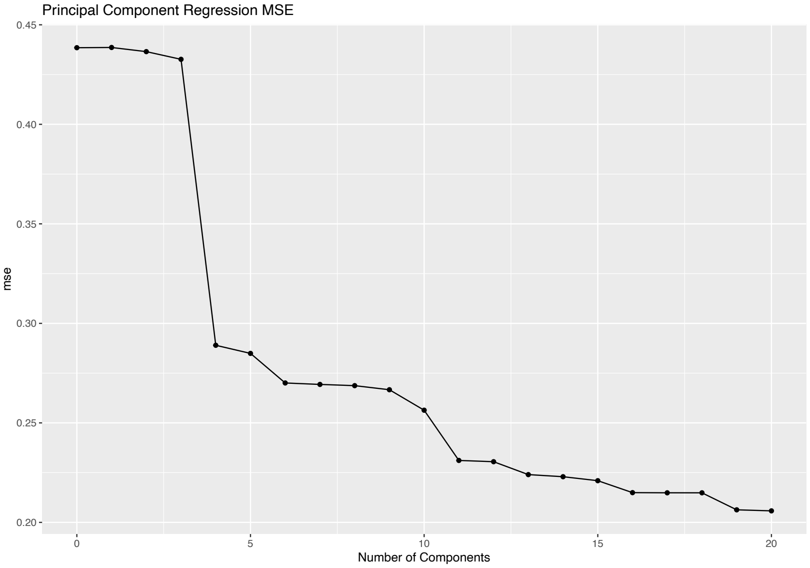
Future Modeling with Splines

- Received errors when using degrees of freedom larger than 6 or so
- Want to look into these errors and figure out if I could try larger degrees of freedom in my splines to get a better model.

PCR and PLS

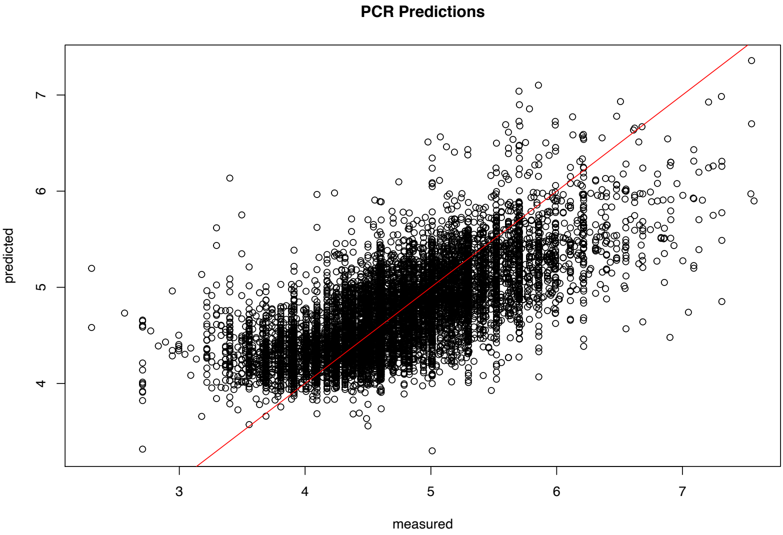
- 10 Fold Cross-Validation was performed for number of components ranging from 1 to 20.
- The Cross-Validation MSE was used to pick optimal number of components for both models.

PCR

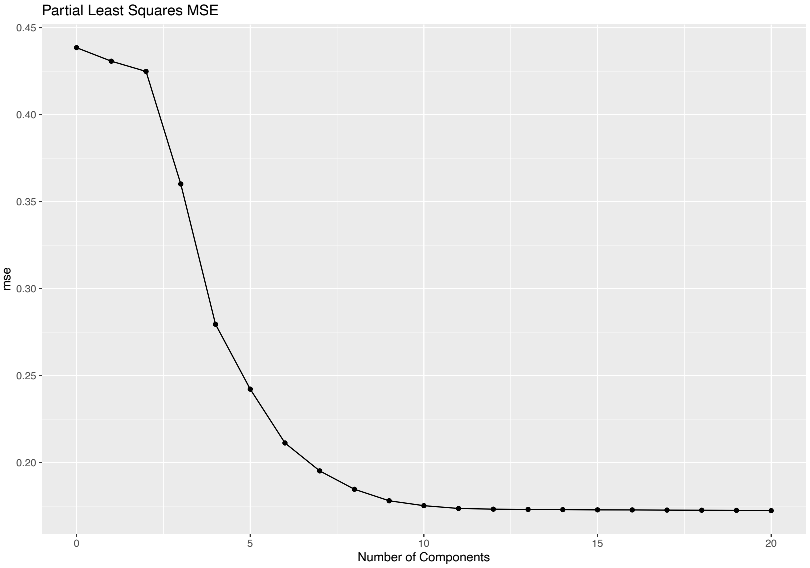


Principal Component Regression MSE
0.45
0.40
0.35
0.30
0.25
0.20
mse
0
5
10
15
20
Number of Components

PCR Predictions

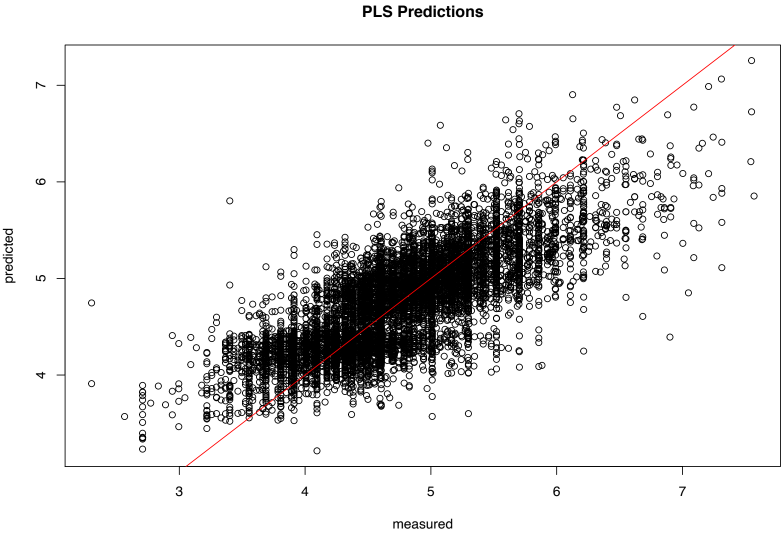


PLS



Partial Least Squares MSE
0.45
0.40
0.35
0.30
0.25
0.20
mse
0
5
10
15
20
Number of Components

PLS Predictions



PCR and PLS Summary

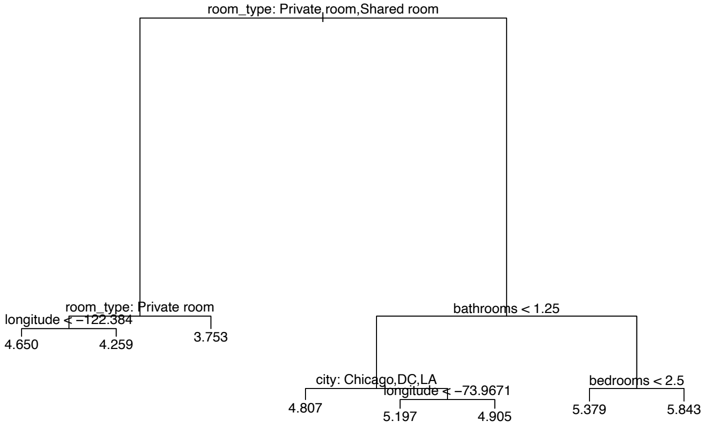
```
##                             PCR     PLS
## Components              15.0000 10.0000
## Test MSE                 0.1765  0.2192
## % Variance Explained    99.7000 99.9000
```

Regression Trees

```
##
## Regression tree:
## tree(formula = price ~ ., data = training)
## Variables actually used in tree construction:
## [1] "room_type" "longitude" "bathrooms" "city"       "bed
## Number of terminal nodes:  8
## Residual mean deviance:  0.1885 = 1695 / 8992
## Distribution of residuals:
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -2.5050 -0.2999 -0.0196  0.0000  0.2558  2.8310

## [1] "Test MSE of Initial Tree:  0.1926"
```

Regression Trees

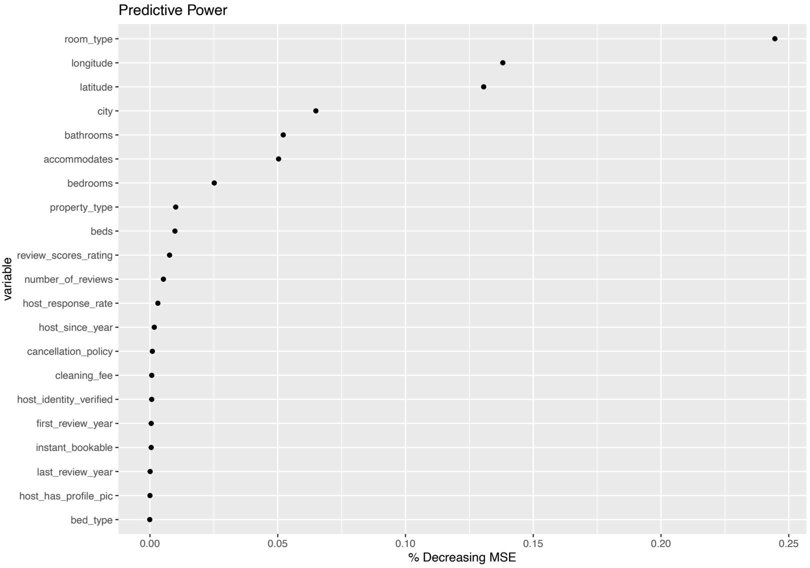


Bagging

```
bag_fit <- randomForest(price ~ ., data = training, mtry =
bag_predict = predict(bag_fit, testing, type = "response")
bag_MSE = round(mean((testing$price - bag_predict)^2), 4)
print(paste("Test MSE of Bagging: ", bag_MSE))
```

```
## [1] "Test MSE of Bagging:  0.1292"
```

Bagging

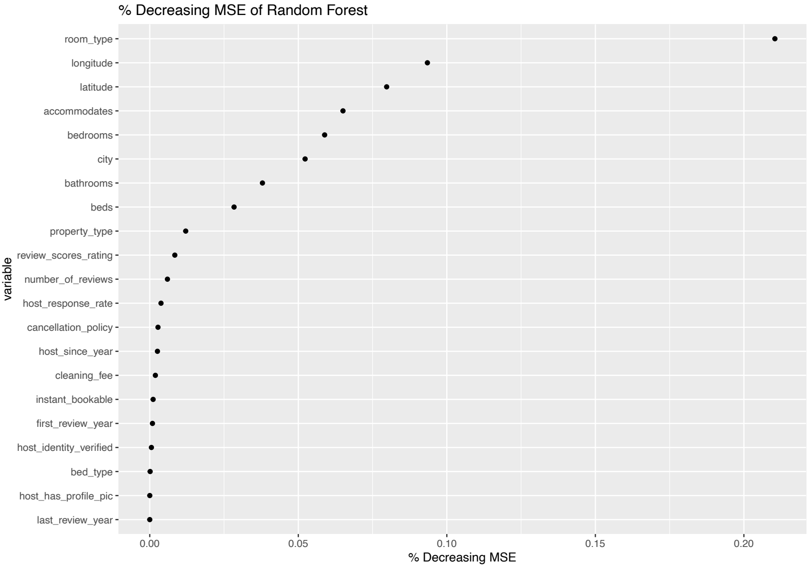

Predictive Power
room_type
longitude
latitude
city
bathrooms
accommodates
bedrooms
property_type
beds
review_scores_rating
number_of_reviews
host_response_rate
host_since_year
cancellation_policy
cleaning_fee
host_identity_verified
first_review_year
instant_bookable
last_review_year
host_has_profile_pic
bed_type
variable
0.00
0.05
0.10
0.15
0.20
0.25
% Decreasing MSE

Random Forests

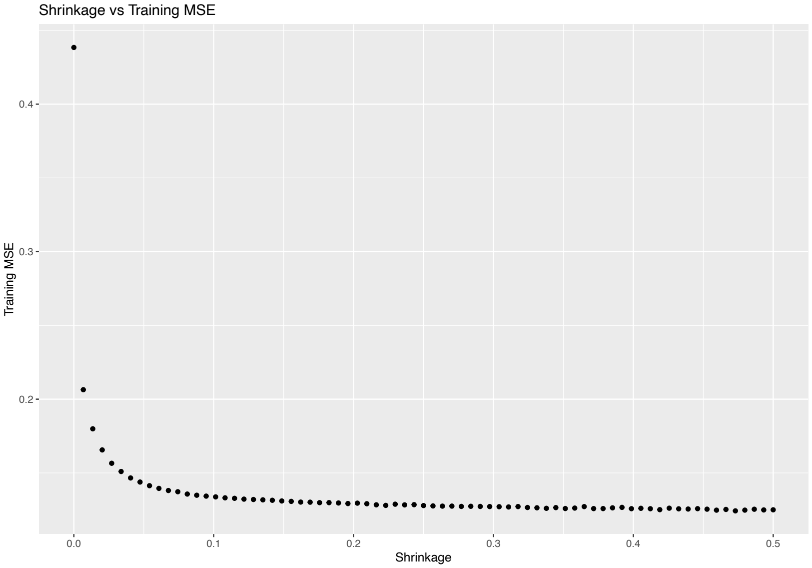
```
rf_fit <- randomForest(price ~ ., data = training, mtry = s
```

```
## [1] "Test MSE of Random Forest:  0.1299"
```

Random Forests



Boosting



Shrinkage vs Training MSE
Training MSE
0.4
0.3
0.2
0.0
0.1
0.2
0.3
0.4
0.5
Shrinkage

Boosting

```
## [1] "Testing MSE for Boosted Model: 0.131"

##                                         var      rel.i
## property_type                 property_type 21.843115
## room_type                         room_type 20.491415
## bedrooms                           bedrooms 13.538098
## bathrooms                         bathrooms  9.790662
## longitude                         longitude  8.009570
## accommodates                   accommodates  7.983493
## latitude                           latitude  7.353239
## beds                                   beds  4.190458
## review_scores_rating   review_scores_rating  2.247604
## city                                   city  2.160149
## number_of_reviews         number_of_reviews  0.595203
## host_response_rate       host_response_rate  0.534926
## bed_type                           bed_type  0.347907
## cancellation_policy     cancellation_policy  0.311338
## instant_bookable           instant_bookable  0.158425
```

MSE Table

```
##              Methods    MSE MSE_Dollars
## 1 Linear Regression 0.1652        1.18
## 2               PCR 0.2192        1.25
## 3               PLS 0.1765        1.19
## 4           Splines 0.4423        1.56
## 5               GAM 0.1612        1.17
## 6             Trees 0.1926        1.21
## 7           Bagging 0.1292        1.14
## 8     Random Forest 0.1299        1.14
## 9          Boosting 0.1310        1.14
```

Going Forward

- Our data has listings from multiple cities across the country
- Can we apply this to a certain city and see similar results?
- Is this accurate enough to help AirBnB hosts in selected cities?
    - Using current data, can this model help hosts correctly adjust their rates?

Questions?