ISOM 670 Stuk **Student ID Number 2369715**

Final Quiz, August 2018

HONOR CODE

The Goizueta Business School Honor Code is the standard of professional behavior on this exam. When you have completed your exam, please read the following pledge and add your signature if you have complied with the Honor Code.

I pledge that I have neither given nor received any unauthorized assistance on this exam, and that any violations of the Honor Code by others that I have observed or otherwise become aware of will be reported by me to the Honor Council.

Type Name to Confirm Philipp Scherbel

INSTRUCTIONS — READ CAREFULLY

During the Decision Analysis exam **all** discussion related to the exam with anyone (other than the professor) is prohibited. Even after you have turned in your own work, you still may not discuss any particulars of the exam until we have indicated that the entire class has submitted their work. Please take great care not to carelessly or inadvertently cause an Honor Code violation.)

Exam Mechanics:

Use only your own notes and exam prep materials. Sharing materials with other students during the exam period is not permitted. You may use anything posted in our course conference, whether you downloaded it before the exam or not.

Computers are permitted throughout and are necessary for some parts. You are not required to use computers if there is another way to get to an answer.

We have not provided space in the exam booklet itself for you to show your work. Please adjust the spacing accordingly when you create the printed version that you will be turning in.

Transfer your answers to the front Answer Sheet when indicated. Failure to do this may cost you some points. Of course, your work pages will contain any long answers & required explanations that might accompany the short answers. They will also show your assumptions and how you got your answers. (Note: we recommend that you support all answers by showing your work.)

Don't forget to read and respond to the Honor Code instructions before you turn in your exam!

Post your completed exam to Canvas by 9PM on Friday 24 August.

Final Quiz, August 2018

Suggestions for taking the exam:

These questions are "fresh baked" for this year's class, so there is the very real possibility that parts of them are half-baked. Contact the professor or TAs (via First Class) if something doesn't seem right. If we do make changes and/or clarifications, we will post them in our course conference in a timely manner. PLEASE — IT IS YOUR RESPONSIBILITY TO CHECK Canvas REGULARLY!

Your best opportunity for clarification of the questions is during the exam, not afterwards. The exam questions are not intended to be ambiguous. If there are words or phrases that you do not fully understand, please ask us about them; this is not a test about American English vocabulary. You can ask any questions you like; we just may not be able to answer some questions that are too close to actual exam content.

Read carefully, and spend some time thinking before you try to answer the questions. The questions range greatly in difficulty; we suggest reading through the entire exam before you start working, so you can gauge the difficulty of the sections and budget your time.

When making assumptions about the problems, try to use the simplest set of assumptions that is consistent with all the information in the problem. Of course, more elaborate complications arise in real life, but here you'll benefit from keeping things simple.

Partial credit IS important for some questions, so make sure your work pages clearly show your line of thinking and the specific steps of any analysis you performed. (State your assumptions! Draw your pictures!)

Good Luck.

Remember: Working this exam requires using an Excel file, which are available on Canvas.

Exams are due to Canvas by 9PM on Thursday 24 August

ANSWER SHEET

PART A *(40 pts)*

1. Simple Statistics & explanation — see exam pages 5-9
2. Comment on Statistics — see exam pages 9
3. Histogram & explanation — see exam pages 10
4. Comment on Histogram — see exam pages 10-11
5. Regression model equation — see exam pages 12-20

```
lm(formula= logs_p ~ltsznew +hssz + f_place + factor(bdrms) +factor(bath) + age5 + dr + ra
tio+ inv)

logs_p(predicted) = 2.812e+04 + ltsznew*3.871e-01 + hssz*1.397e+01 + f_place*9.122e+03 +
factor(bdrms)2*2.601e+03 + factor(bdrms)3*1.008e+04 + factor(bdrms)4*1.950e+04 +
factor(bdrms)5*2.009e+04 + factor(bdrms)6*2.632e+04 + factor(bath)1.5*1.811e+03 +
factor(bath)2*5.393e+03 + factor(bath)2.5*2.176e+04 + factor(bath)3*1.369e+04+
factor(bath)3.5*5.886e+04 + factor(bath)4*4.286e+04 + age5*1.352e+04 + dr*6.636e+03 +
ratio*-2.187e+04
```

6. **Best Answer for Price of House of interest** — see exam pages 21

s_p $ 86795.44
logs_p $ 78742.1 (with log, better r-squared)

7. Prediction interval for your estimate of Price above

	fit	lwr	upr	
s_p	$ 86795.44	$ 81659.16	$ 91931.71	
logs_p	$ 78742.1	$ 74532.55	$ 83189.4	(with log, better r-squared)

With log the prediction looks more "conservative" and lower, whereas without log the skewed distribution to the right is i ncorporated more – and predictions higher.

TOTAL: = 40 pts.

Part A 40 points

The Excel spreadsheet **housedata.xls** contains data on the sales of 950 single-family homes in Springfield, MA. We wish to explain and predict the price of a single-family home (Y, in thousands of dollars) using the following predictor variables:

Data Description

Variable Name	Description	**House of interest**
s_p	Sale price in dollars	**?**
inv	Sale date inventory of homes on market	**100**
bath	Number of bathrooms	**2**
ltsz	Lot size in acres	**.25 = 10890 sq feet**
hssz	Sq. ft. of living area	**1200**
bsemt	1 if basement, 0 otherwise	**0**
a_c	1 if central a/c, 0 otherwise	**1**
f_place	1 if fireplace, 0 otherwise	**0**
garsz_a	1 if garage, 0 otherwise	**1**
dinsp	1 if dining space, 0 otherwise	**1**
dw	1 if dishwasher, 0 otherwise	**1**
dr	1 if dining room, 0 otherwise	**0**
fr	1 if family room, 0 otherwise	**0**
age5	1 if age <= 5 yrs, 0 otherwise	**1**
stl10	1 if 1 story house, 0 otherwise	**1**
bdrms	Number of bedrooms	**4**

1) Calculate simple descriptive statistics for "Sales Price"

I tried to make it easy to distinguish between

- My explanations and highlights
- `Copied code from r`

Having a look at the variables without data analysis, I would like to share my assumptions, that I will (hope to) proof right later during the actual analysis. Given demand and supply influences price, inv will influence the sale price. The less houses there are on the market, the price of the remaining ones will increase (negative correlated). In addition, the bigger the house is (given same area, age etc.) the higher the price. My guess it that the size of the living area is actually not as important as the amount of beds and bathrooms as people usually search for specific amounts of these rooms first, i.e. a house with 2 bedrooms and a huge living room most likely will sell at a lower price compared to a house with 3-4 bedrooms and a smaller living room. From the binary variables, I think that the age matters most – and the more expensive the houses are, also a fireplace may be important to the potential buyers of more expensive houses.

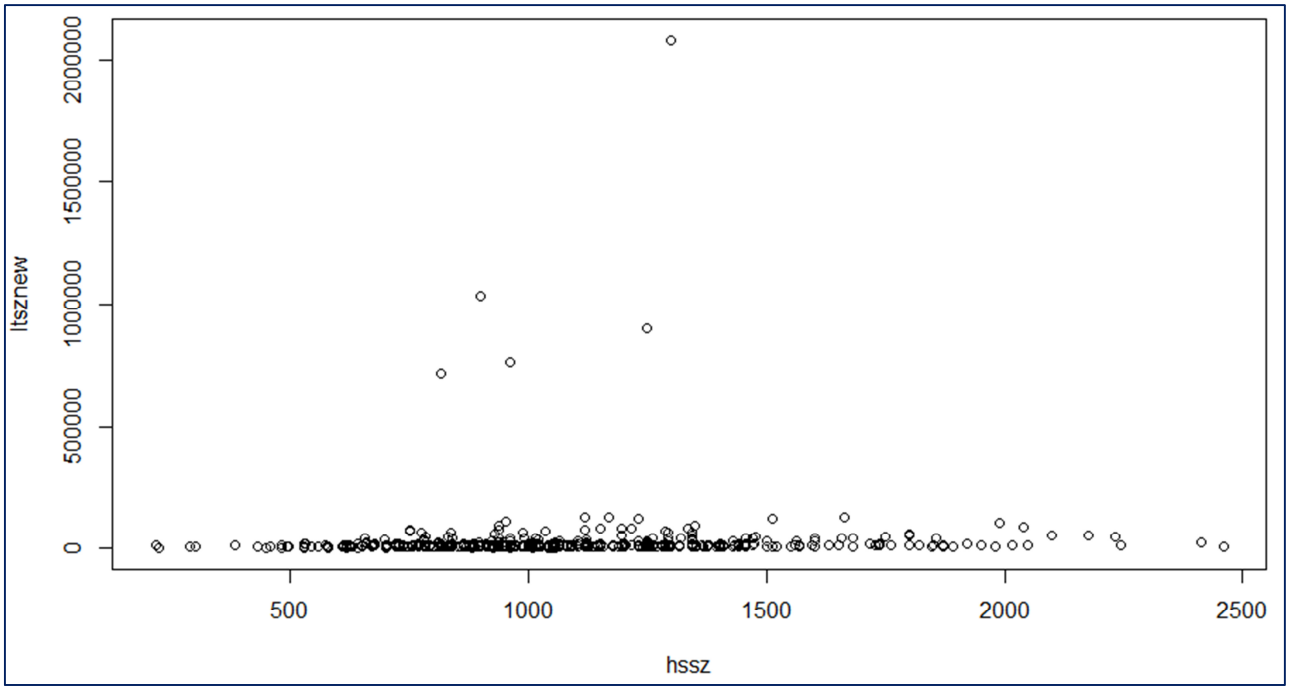
To start off, I will run:

- Describe() and summary()
- Display scatter plots
- Check correlations
- Check outliers/ faulty data

```
> summary(hd)
      s_p              inv              bath             ltsz              hssz             bsemt        
 Min.   : 29864   Min.   : 61.0   Min.   : 1.000   Min.   :0.01561   Min.   : 216   Min.   :0.0000  
 1st Qu.: 59278   1st Qu.:101.0   1st Qu.: 1.500   1st Qu.:0.17880   1st Qu.: 875   1st Qu.:1.0000  
 Median : 70360   Median :135.0   Median : 2.000   Median :0.22495   Median :1014   Median :1.0000  
 Mean   : 79037   Mean   :140.8   Mean   : 1.948   Mean   :0.33333   Mean   :1055   Mean   :0.9368  
 3rd Qu.: 90741   3rd Qu.:154.0   3rd Qu.: 2.500   3rd Qu.:0.27548   3rd Qu.:1199   3rd Qu.:1.0000  
 Max.   :222680   Max.   :322.0   Max.   :20.000   Max.   :4.13223   Max.   :3080   Max.   :1.0000  
      a_c            f_place          garsz_a            dw               dr               fr        
 Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000  
 1st Qu.:1.0000   1st Qu.:0.0000   1st Qu.:1.0000   1st Qu.:1.0000   1st Qu.:1.0000   1st Qu.:1.0000  
 Median :1.0000   Median :1.0000   Median :1.0000   Median :1.0000   Median :1.0000   Median :1.0000  
 Mean   :0.8137   Mean   :0.5968   Mean   :0.9611   Mean   :0.8063   Mean   :0.7589   Mean   :0.7821  
 3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:1.0000  
 Max.   :1.0000   Max.   :1.0000   Max.   :2.0000   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000  
      age5            stl10            bdrms       
 Min.   :0.0000   Min.   :0.0000   Min.   :-4.000  
 1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.: 3.000  
 Median :0.0000   Median :0.0000   Median : 3.000  
 Mean   :0.1537   Mean   :0.4737   Mean   : 3.276  
 3rd Qu.:0.0000   3rd Qu.:1.0000   3rd Qu.: 4.000  
 Max.   :1.0000   Max.   :1.0000   Max.   : 6.000  
```

The summary shows that many variables have a very high max, which implies one specific large house (lot size and house size) or it could be actually false data. As the units are different, I converted also the lot sizes (in acre) to sq feet (ltsznew). Another record shows 20 baths. In addition, a negative amount of bedrooms is not possible, thus we have wrong data here. I will investigate the house and lot size via plotting and replace the data-point with bath = 20 to the median (I assume that way the wrong number will still be in the dataset calculating the median but it should be fine – compared to

using the mean). Also, garage has max of 2 but it is a binary variable with 0 or 1 only, so I will set it to median of that column.



As the graph shows, there are several house/lot combinations far from the "bulk", thus I decided to delete hssz > 2200 and ltsznew > 500000 (acre converted to sqfeet) and to replace each with the column's median.

```
hd$ltsznew <- hd$ltsz*43560
plot(hd$ltsznew, hd$hssz)

#I decided some are outliers or just wrong data and to replace them with median
hd$hssz[hd$hssz > 2200 ] <- median(hd$hssz)
hd$ltsznew[hd$ltsznew > 500000 ] <- median(hd$ltsznew)
hd$garsz_a[hd$garsz_a > 1 ] <- median(hd$garsz_a)
hd$bdrms[hd$bdrms < 0 ] <- median(hd$bdrms)
hd$bath[hd$bath > 10 ] <- median(hd$bath)
plot(hd$ltsznew, hd$hssz)
```

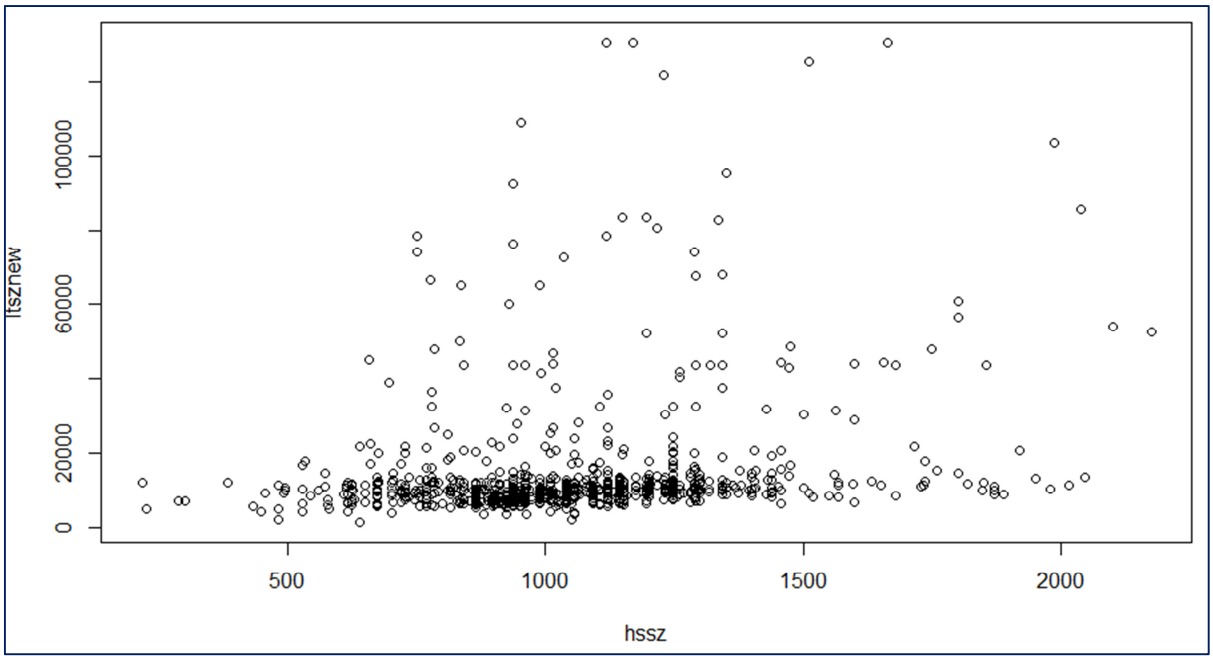
I looked at the ratio from hssz to ltsznew and 5 houses were bigger than the lot. I had two options, deleting them or changi ng. For deleting I used the following formula:

```
hd$ratio <- hd$hssz/hd$ltsznew
summary(hd$ratio)
hd <- hd[hd$ratio<1, ]
#test if it worked
hd$ratio[hd$ratio>1]
shows numeric 0
```

but since the dataset is relatively small, I looked into these 5 ratios and decided to multiply the lotsizes with 10, as this wo uld match with general median and ratios.

```
hd$ratio <- hd$hssz/hd$ltsznew
hd$ltsznew[hd$ratio >1] <- hd$ltsznew[hd$ratio>1]*10
hd$ratio[hd$ratio > 1]
[1] 1.304348 1.142857 1.547619 1.200000 1.273469
hd$ltsznew[hd$ratio>1]
[1] 690 840 840 680 980
hd$hssz[hd$ratio>1]
[1]  900  960 1300  816 1248
mean(hd$hssz)
[1] 1051.398
mean(hd$ltsznew)
[1] 13873.53
median(hd$hssz)
[1] 1014
median(hd$ltsznew)
[1] 9798.5
```

This was the outcome and I decided to not "clean" further.

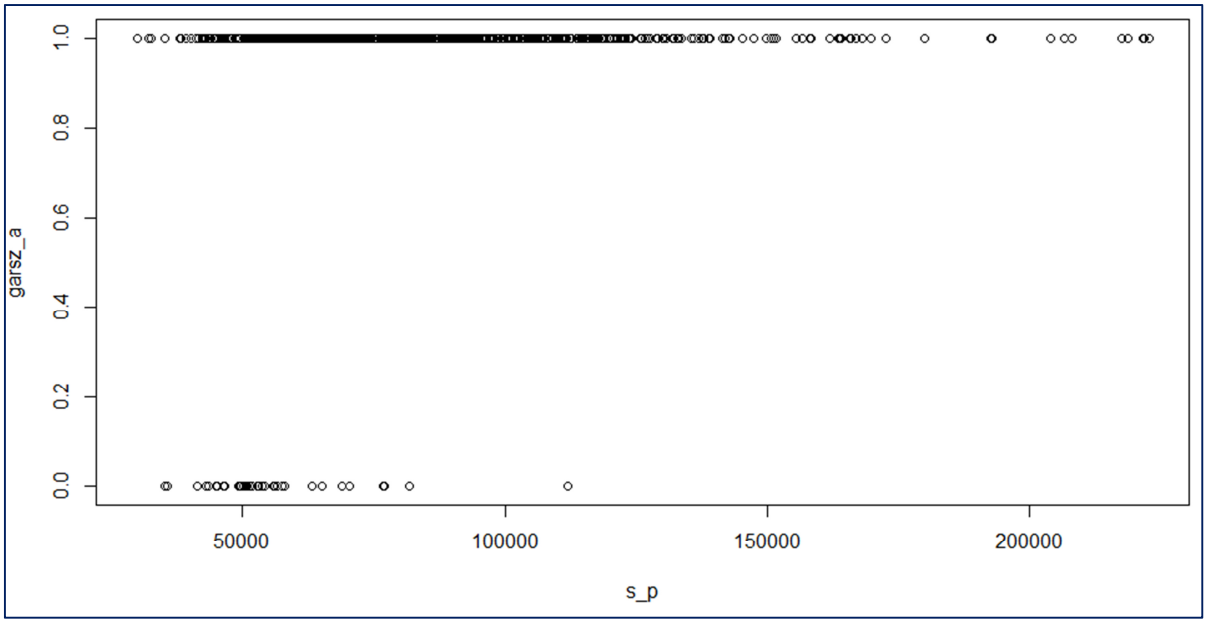


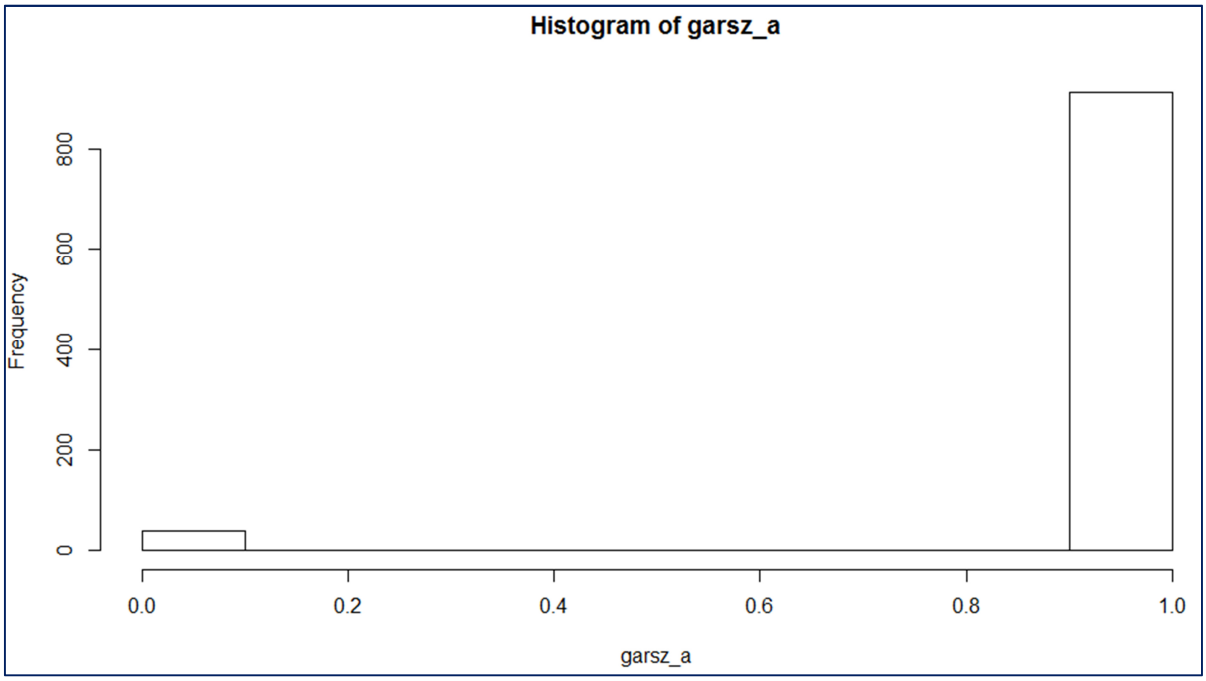
after cleaning, describe() and summary () look as follows:

```
> describe(hd)
         vars   n     mean       sd   median  trimmed      mad      min       max     range  skew kurtosis     se
s_p         1 950 79037.11 29169.78 70360.00 74918.59 20115.92 29864.00 222680.00 192816.00  1.71     4.05 946.39
inv         2 950   140.82    53.28   135.00   133.24    45.96    61.00    322.00    261.00  1.24     1.20   1.73
bath        3 950     1.93     0.65     2.00     1.89     0.74     1.00      4.00      3.00  0.40    -0.18   0.02
ltsz        4 950     0.32     0.36     0.22     0.23     0.07     0.02      3.00      2.98  4.45    23.19   0.01
hssz        5 950  1045.83   270.71  1014.00  1032.09   222.39   216.00   2176.00   1960.00  0.70     1.69   8.78
bsemt       6 950     0.94     0.24     1.00     1.00     0.00     0.00      1.00      1.00 -3.59    10.87   0.01
a_c         7 950     0.81     0.39     1.00     0.89     0.00     0.00      1.00      1.00 -1.61     0.59   0.01
f_place     8 950     0.60     0.49     1.00     0.62     0.00     0.00      1.00      1.00 -0.39    -1.85   0.02
garsz_a     9 950     0.96     0.20     1.00     1.00     0.00     0.00      1.00      1.00 -4.69    19.99   0.01
dw         10 950     0.81     0.40     1.00     0.88     0.00     0.00      1.00      1.00 -1.55     0.40   0.01
dr         11 950     0.76     0.43     1.00     0.82     0.00     0.00      1.00      1.00 -1.21    -0.54   0.01
fr         12 950     0.78     0.41     1.00     0.85     0.00     0.00      1.00      1.00 -1.36    -0.14   0.01
age5       13 950     0.15     0.36     0.00     0.07     0.00     0.00      1.00      1.00  1.92     1.68   0.01
stl10      14 950     0.47     0.50     0.00     0.47     0.00     0.00      1.00      1.00  0.11    -1.99   0.02
bdrms      15 950     3.28     0.68     3.00     3.25     0.00     1.00      6.00      5.00  0.56     1.15   0.02
ltsznew    16 950 13920.87 15793.38  9800.00 10227.50  3261.72  1200.00 130680.00 129480.00  4.47    23.30 512.40
ratio      17 950     0.11     0.05     0.11     0.11     0.04     0.01      0.58      0.57  1.92    17.61   0.00
```

```
> summary(hd)
      s_p              inv              bath            ltsz              hssz            bsemt             a_c             f_place
 Min.   : 29864   Min.   : 61.0   Min.   :1.000   Min.   :0.01561   Min.   : 216   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000
 1st Qu.: 59278   1st Qu.:101.0   1st Qu.:1.500   1st Qu.:0.17881   1st Qu.: 875   1st Qu.:1.0000   1st Qu.:1.0000   1st Qu.:0.0000
 Median : 70360   Median :135.0   Median :2.000   Median :0.22494   Median :1014   Median :1.0000   Median :1.0000   Median :1.0000
 Mean   : 79037   Mean   :140.8   Mean   :1.929   Mean   :0.31849   Mean   :1046   Mean   :0.9368   Mean   :0.8137   Mean   :0.5968
 3rd Qu.: 90741   3rd Qu.:154.0   3rd Qu.:2.500   3rd Qu.:0.27548   3rd Qu.:1196   3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:1.0000
 Max.   :222680   Max.   :322.0   Max.   :4.000   Max.   :3.00000   Max.   :2176   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000
    garsz_a            dw               dr               fr              age5            stl10            bdrms          ltsznew
 Min.   :0.00   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :1.000   Min.   :  1200
 1st Qu.:1.00   1st Qu.:1.0000   1st Qu.:1.0000   1st Qu.:1.0000   1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:3.000   1st Qu.:  7802
 Median :1.00   Median :1.0000   Median :1.0000   Median :1.0000   Median :0.0000   Median :0.0000   Median :3.000   Median :  9800
 Mean   :0.96   Mean   :0.8063   Mean   :0.7589   Mean   :0.7821   Mean   :0.1537   Mean   :0.4737   Mean   :3.283   Mean   : 13921
 3rd Qu.:1.00   3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:1.0000   3rd Qu.:0.0000   3rd Qu.:1.0000   3rd Qu.:4.000   3rd Qu.: 12000
 Max.   :1.00   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000   Max.   :1.0000   Max.   :6.000   Max.   :130680
      ratio
 Min.   :0.008555
 1st Qu.:0.079641
 Median :0.107606
 Mean   :0.105403
 3rd Qu.:0.130909
 Max.   :0.583333
```

Looking at the max, there are still huge lots, but for an amateur real estate agent like me, the data looks fine. There are no negative values or impossible values (2 for binary for example) any more, and mean and median are closer now for each v ariable which means less outliers. Some values are heavily skewed like garage and basement. But this is due to their binar y character.



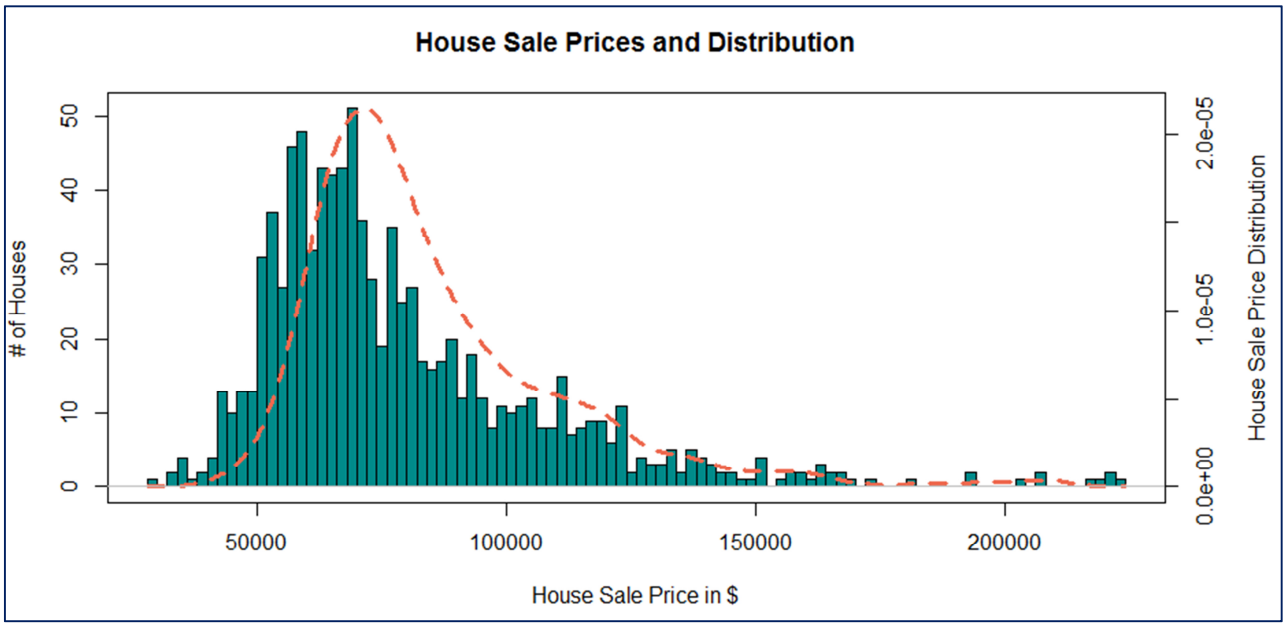


2) and comment.

As I needed to perform cleaning before presenting describe and summary, I commented throughout 1)

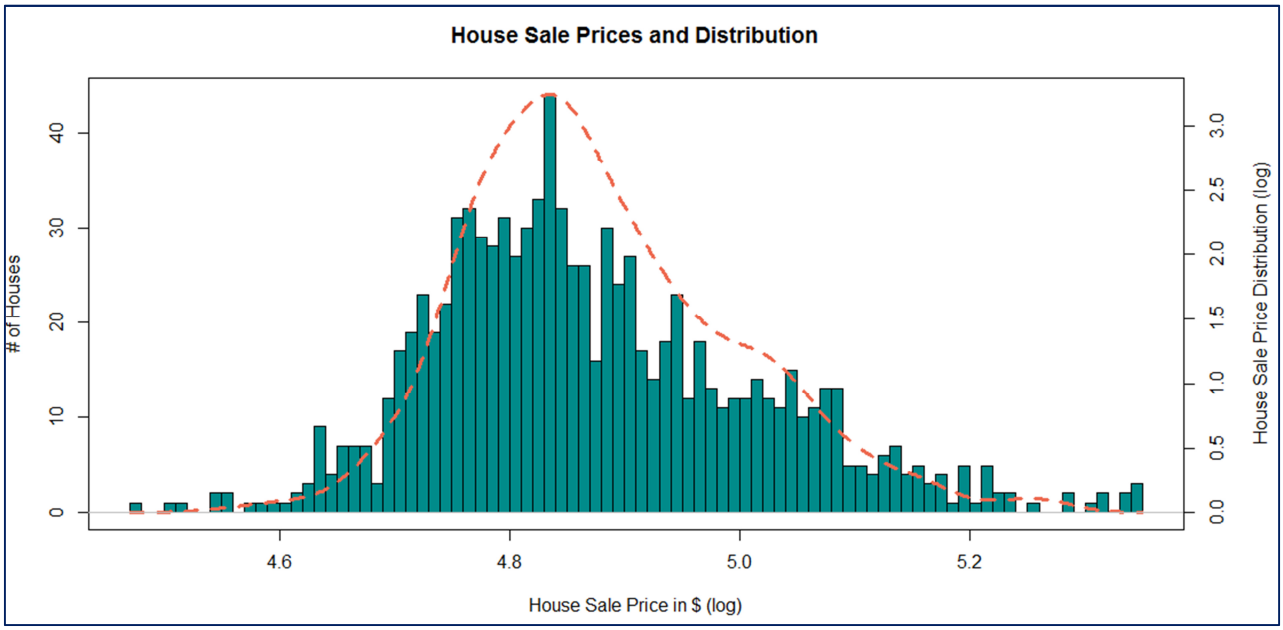
3) Construct a clear well labeled Histogram of "Sales Price"

```
# histogram
hist(s_p)
par(mar = c(5, 4, 4, 5))
hist(hd$s_p, nclass=100, type ="l", ylab = "# of Houses", main = "House Sale Prices and Di
stribution", xlab = "House Sale Price in $", col = "cyan4")
par(new = TRUE)
plot(density(hd$s_p), type = "l", xaxt = "n", yaxt = "n", ylab = "", main="", xlab = "", c
ol = "coral2", lty = 2, lwd = 3)
axis(side = 4)
mtext("House Sale Price Distribution", side = 4, line = 3)
```



4) and **comment** on what you see.

The histogram shows that many houses cost around 50-75 k ("the most frequent house", i.e. median house sold, costs around 70k) and then there are more expensive houses, which are less frequent, the more expensive they are. These houses move the mean to the right, as there are not many houses cheaper than 50 k who would pull it to the left. Overall the curve looks somehow normal from 0 to 100 k but then extends with more expensive houses to the far right on the x axis (skew). This is a reason to use log and I calculated log of s_p to see if the distribution looks more normal.

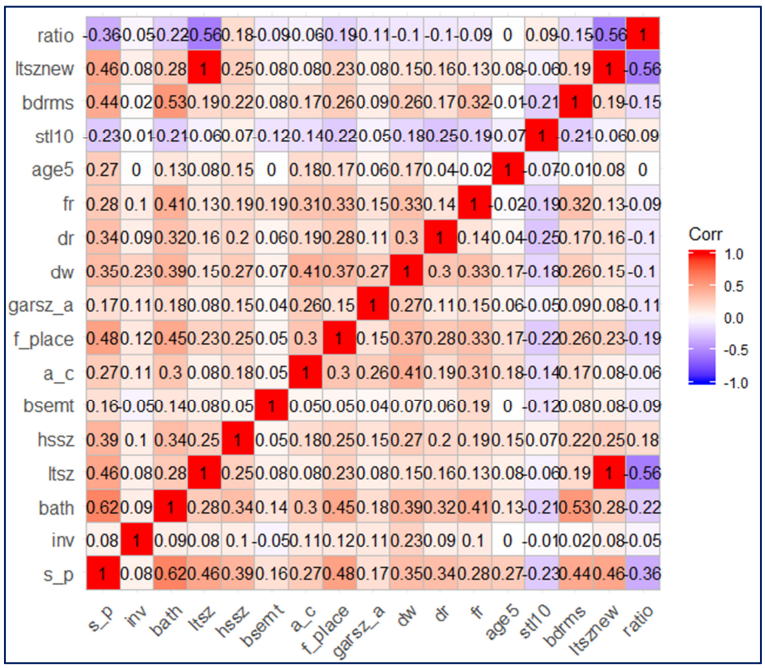


It helps making the distribution look more normal but I don't expect the impact on the model be very high as the distribution still looks very scattered/ random and rather steep left compared to the right side.

5) Build a regression model to predict the selling price for a home. Explain your thinking and your analytical process concisely but clearly, using specific excerpts from your data analysis where appropriate Be sure to discuss any additional steps you would like to perform if you had more time for your analysis (and why those steps would be important.

I created a heatmap and the correlation table first to decide with which variables I want to move forward.

```
ggcorrplot(corr, hc.order = TRUE, type = "lower", lab = TRUE)
```




```
cor(hd)
```

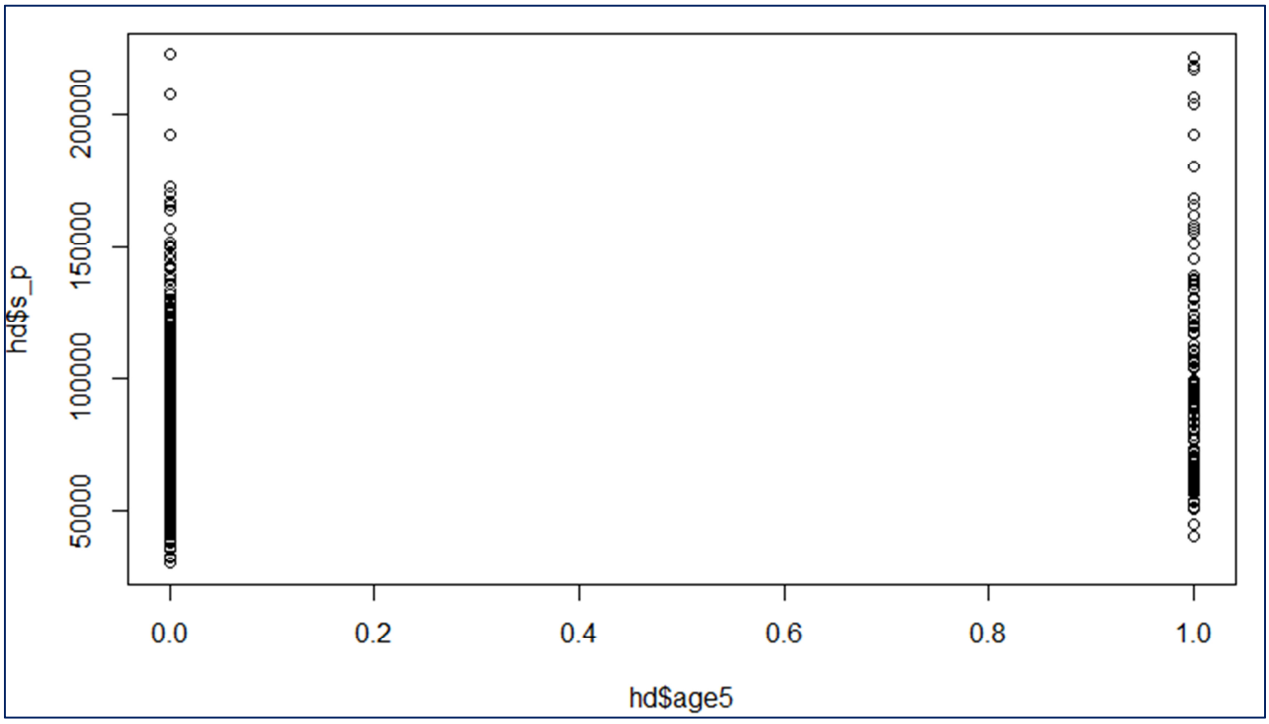
```
> cor(hd)
                s_p
s_p       1.00000000
inv       0.07526516
bath      0.62329758
ltsz      0.46040479
hssz      0.38533399
bsemt     0.16044322
a_c       0.26820048
f_place   0.48467559
garsz_a   0.16688618
dw        0.34707740
dr        0.33738495
fr        0.28017849
age5      0.26594159
stl10    -0.22700986
bdrms     0.44121131
ltsznew   0.45934942
ratio    -0.35573096
```

These variables are highly correlated with s_p:

- Ltsz(new)

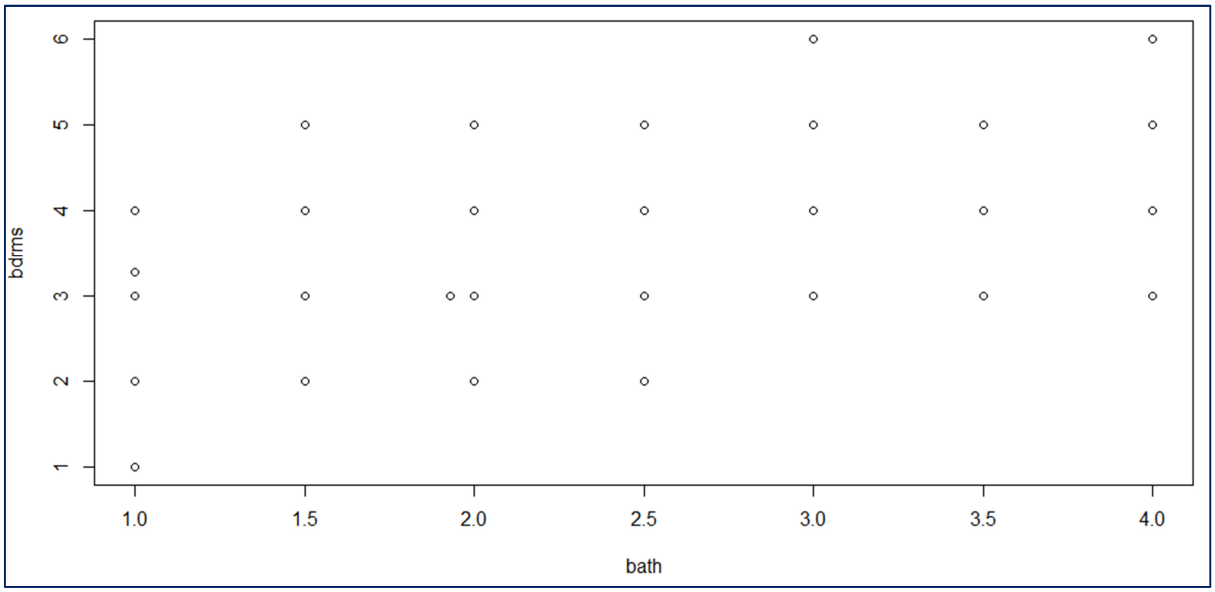
- Hssz
- Bath
- Bdrms
- F_place
- Ratio

In addition, age5 should be very important but it is not highly correlated. Plotting s_p and age5 doesn't show a significant connection.



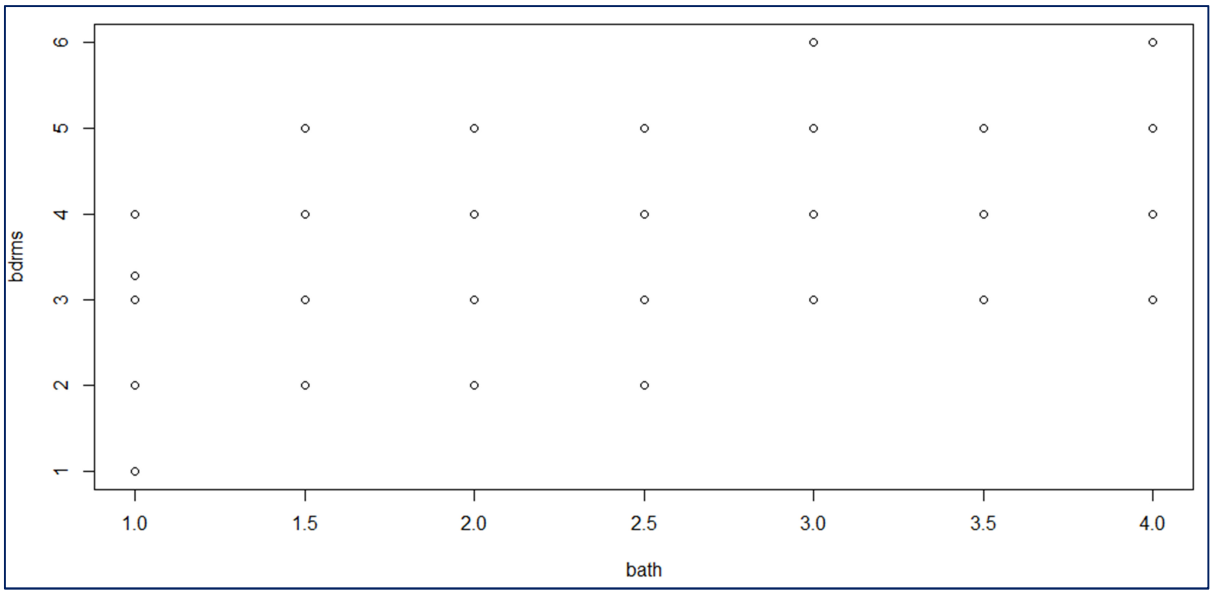
To see if bdrms - bath are related and ltsznew - hssz, I will plot both. As bdrms and bath increase linear with a pretty const ant ratio, I will only include the variable higher correlated with s_p. Ltsznew and hssz, on the other hand, do not seem hig hly correlated. As Bath and Bedroom may be factored variables and "jump" without clear linear connection (there won't b e for example 2,43 baths possible), I will add bath as factor the model instead of linear later. I tried factor(bath) to see wha t these factors are and not all values are ending with .0 or .5 so I set the one outlier (1.93..) to 2.

Before:



After:

```
hd[hd$bath>1.9 & hd$bath <2] <- 2
```



As this was just a single value, I didn't run describe and summary again and also the correlation table shouldn't change m uch. The cleaning helped rather to not get additional factors moving forward:

To start off, I tried both bath and factor(bath) as bath was correlated the strongest with s_p.

My first model:

```
Call:
model1 <- lm(s_p~bath)
hd$resid1 <- resid(model1)
```

```
summary(model1)

Call:
lm(formula = s_p ~ bath)

Residuals:
   Min     1Q Median     3Q
-65290 -13987  -3519   8890
   Max
122462

Coefficients:
            Estimate Std. Error  t value Pr(>|t|)
(Intercept)    24985       2324 10.75   <2e-16***
bath           28014       1141 24.54   <2e-16***

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

Residual standard error: 22820 on 948 degrees of freedom
Multiple R-squared:  0.3885,      Adjusted R-squared:  0.3879
F-statistic: 602.4 on 1 and 948 DF,  p-value: < 2.2e-16
```

	ratio	resid1
s_p	-0.35573096	7.819648e-01
inv	-0.04602600	2.279289e-02
bath	-0.21760957	1.394864e-16
ltsz	-0.56348684	3.679979e-01
hssz	0.17774802	2.200437e-01
bsemt	-0.08925658	9.740185e-02
a_c	-0.06039805	1.037408e-01
f_place	-0.18866124	2.638706e-01
garsz_a	-0.10609056	6.939157e-02
dw	-0.10488131	1.328346e-01
dr	-0.09869742	1.748657e-01
fr	-0.08697653	3.274878e-02
age5	0.00448912	2.332266e-01
stl10	0.09376114	-1.238314e-01
bdrms	-0.14873291	1.431864e-01
ltsznew	-0.56434202	3.667865e-01
ratio	1.00000000	-2.814577e-01
resid1	-0.28145768	1.000000e+00

And with factor (bath):

```
summary(model1)

Call:
lm(formula = s_p ~ factor(bath))

Residuals:
   Min     1Q Median     3Q    Max
-64662 -12735  -3403   8293 121339

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
```

```
(Intercept)        55882       1692  33.031  < 2e-16 ***
factor(bath)1.5    10561       2317   4.558 5.84e-06 ***
factor(bath)2      21401       2077  10.303  < 2e-16 ***
factor(bath)2.5    48040       2508  19.151  < 2e-16 ***
factor(bath)3      44270       2850  15.536  < 2e-16 ***
factor(bath)3.5    95593       5753  16.617  < 2e-16 ***
factor(bath)4      76092       9137   8.328 2.87e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 21990 on 943 degrees of freedom
Multiple R-squared:  0.4351,      Adjusted R-squared:  0.4315
F-statistic: 121.1 on 6 and 943 DF,  p-value: < 2.2e-16
```

The standard error is already lower and I will look at the residuals:

	ratio	resid1
s_p	-0.35573096	7.515900e-01
inv	-0.04602600	5.327148e-03
bath	-0.21760957	-1.983542e-17
ltsz	-0.56348684	3.695315e-01
hssz	0.17774802	2.457172e-01
bsemt	-0.08925658	1.177713e-01
a_c	-0.06039805	1.119000e-01
f_place	-0.18866124	2.602240e-01
garsz_a	-0.10609056	8.073324e-02
dw	-0.10488131	1.484373e-01
dr	-0.09869742	1.800507e-01
fr	-0.08697653	4.555387e-02
age5	0.00448912	2.426059e-01
stl10	0.09376114	-9.863896e-02
bdrms	-0.14873291	1.604887e-01
ltsznew	-0.56434202	3.685419e-01
ratio	1.00000000	-2.711883e-01
resid1	-0.27118829	1.000000e+00

There is no clear “winner” here for the next variable to put in the model. Also the standard error is very high, so testing re siduals and modeling and repeating may not be the best way here. Thus, I chose several variables that are the most correla ted here and added them.

- Ratio
- Ltsznew
- Hssz
- Age5
- F_place

Model2:

```
Call:
lm(formula = s_p ~ ltsznew + hssz + f_place + factor(bath) + age5 + ratio)

Residuals:
   Min     1Q Median     3Q    Max
-62835 -10397  -1545   7705 107509
```

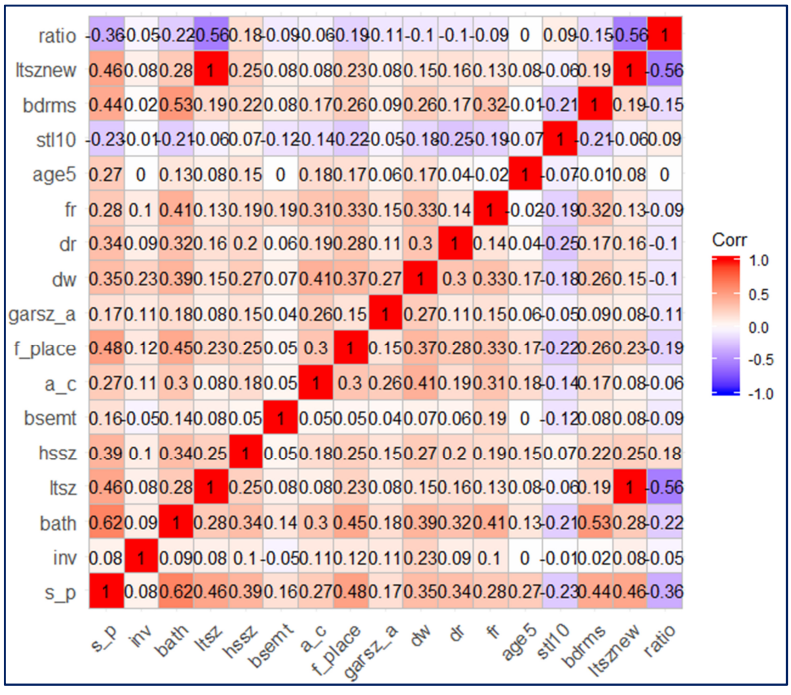
```
Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)      4.476e+04  2.858e+03  15.662  < 2e-16 ***
ltsznew          2.559e-01  5.087e-02   5.031 5.86e-07 ***
hssz             2.189e+01  2.686e+00   8.150 1.16e-15 ***
f_place          1.008e+04  1.405e+03   7.176 1.46e-12 ***
factor(bath)1.5  4.534e+03  1.971e+03   2.301   0.0216 *
factor(bath)2    9.485e+03  1.863e+03   5.090 4.33e-07 ***
factor(bath)2.5  2.783e+04  2.376e+03  11.712  < 2e-16 ***
factor(bath)3    2.306e+04  2.662e+03   8.662  < 2e-16 ***
factor(bath)3.5  7.122e+04  4.982e+03  14.298  < 2e-16 ***
factor(bath)4    5.287e+04  7.719e+03   6.848 1.35e-11 ***
age5             1.215e+04  1.690e+03   7.186 1.36e-12 ***
ratio           -1.158e+05  1.722e+04  -6.728 2.99e-11 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 18330 on 938 degrees of freedom
Multiple R-squared:  0.6099,      Adjusted R-squared:  0.6053
F-statistic: 133.3 on 11 and 938 DF,  p-value: < 2.2e-16
```

After, I tried different models and added binary variables and found this combination:

Model3:

```
Call:
lm(formula = s_p ~ ltsznew + hssz + f_place + factor(bath) + age5 + dr + ratio)
with RSE: 18140
```

As this path with residuals doesn’t seem successful, I checked the original heatmap again and added factor(bdrms).



Model4:

```
Call:
```

```
lm(formula = s_p ~ ltsznew + hssz + f_place + factor(bdrms) + factor(bath) + age5 + dr + r
atio)

Residuals:
   Min     1Q Median     3Q    Max
-63864 -10117  -1076   7656 103120

Coefficients:
                               Estimate Std. Error t value Pr(>|t|)
(Intercept)                   3.984e+04  9.310e+03   4.279 2.07e-05 ***
ltsznew                       2.411e-01  4.944e-02   4.877 1.27e-06 ***
hssz                          1.990e+01  2.629e+00   7.569 9.01e-14 ***
f_place                       8.785e+03  1.381e+03   6.361 3.15e-10 ***
factor(bdrms)2               -2.088e+03  9.226e+03  -0.226    0.821
factor(bdrms)3                4.951e+03  9.049e+03   0.547    0.584
factor(bdrms)3.28345626975764 2.218e+03  1.992e+04   0.111    0.911
factor(bdrms)4                1.414e+04  9.164e+03   1.543    0.123
factor(bdrms)5                1.429e+04  9.501e+03   1.504    0.133
factor(bdrms)6                1.914e+04  1.605e+04   1.193    0.233
factor(bath)1.5               8.675e+02  2.004e+03   0.433    0.665
factor(bath)2                 4.056e+03  1.952e+03   2.078    0.038 *
factor(bath)2.5               1.962e+04  2.512e+03   7.811 1.53e-14 ***
factor(bath)3                 1.330e+04  2.862e+03   4.646 3.86e-06 ***
factor(bath)3.5               6.034e+04  5.001e+03  12.066  < 2e-16 ***
factor(bath)4                 4.082e+04  7.907e+03   5.163 2.97e-07 ***
age5                          1.377e+04  1.657e+03   8.308 3.41e-16 ***
dr                            6.794e+03  1.473e+03   4.613 4.52e-06 ***
ratio                        -1.124e+05  1.676e+04  -6.704 3.51e-11 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 17730 on 931 degrees of freedom
Multiple R-squared:  0.6376,      Adjusted R-squared:  0.6305
F-statistic: 90.98 on 18 and 931 DF,  p-value: < 2.2e-16
```

Bedrooms also has values that don’t match integers, thus I need to clean the data a little further.

```
Factor(bdrms)
hd$bdrms[8] <- 3
```

As bath 1.5 is not very high correlated, I will try two things and add new columns:

- Round bath 1.5 down to 1.5
- Round bath 1.5 up to 2

The standard error went up to 18550. The model got simpler, but slightly worse, so I will keep the step 1.5 for bath. At thi s point I don’t know if getting rid of additional variables is possible. But f_place is not very helpful in terms of decreasing the error and models should be kept simple – if possible.

From here, I tried to add (or get rid of) binary variables to improve (or at least simplify the model):
Adding inv to the model:

```
lm(formula = s_p ~ ltsznew + hssz + f_place + factor(bdrms) + factor(bath) + age5 + dr + r
atio + inv)
```

```
RSE: 17710 instead of 17730
```

I will keep inv in there.

So my final model looks like this:

```
Call:
lm(formula = s_p ~ ltsznew + hssz + f_place + factor(bdrms) + factor(bath) + age5
+ dr + ratio + inv)

Residuals:
   Min     1Q Median     3Q    Max
-61580 -10007  -1204   7864 109318

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)      3.041e+04  9.166e+03   3.318 0.000943 ***
ltsznew          3.908e-01  3.453e-02  11.317  < 2e-16 ***
hssz             1.421e+01  2.378e+00   5.976 3.25e-09 ***
f_place          9.258e+03  1.380e+03   6.708 3.42e-11 ***
factor(bdrms)2   2.547e+03  9.181e+03   0.277 0.781548
factor(bdrms)3   1.014e+04  8.995e+03   1.128 0.259792
factor(bdrms)4   1.950e+04  9.108e+03   2.141 0.032509 *
factor(bdrms)5   1.967e+04  9.457e+03   2.080 0.037794 *
factor(bdrms)6   2.544e+04  1.600e+04   1.590 0.112133
factor(bath)1.5  2.356e+03  2.016e+03   1.169 0.242859
factor(bath)2    5.459e+03  1.932e+03   2.826 0.004810 **
factor(bath)2.5  2.211e+04  2.489e+03   8.885  < 2e-16 ***
factor(bath)3    1.396e+04  2.856e+03   4.889 1.19e-06 ***
factor(bath)3.5  5.951e+04  5.013e+03  11.871  < 2e-16 ***
factor(bath)4    4.301e+04  7.887e+03   5.453 6.36e-08 ***
age5             1.348e+04  1.649e+03   8.172 9.83e-16 ***
dr               6.718e+03  1.471e+03   4.566 5.63e-06 ***
ratio           -2.200e+04  6.230e+03  -3.531 0.000434 ***
inv             -2.104e+01  1.118e+01  -1.881 0.060276 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 17710 on 931 degrees of freedom
Multiple R-squared:  0.6384,   Adjusted R-squared:  0.6314
F-statistic:  91.3 on 18 and 931 DF,  p-value: < 2.2e-16
```

In addition, going back to the histogram and log, I used logs_p and the result was:

```
Call:
lm(formula = logs_p ~ ltsznew + hssz + f_place + factor(bdrms) + factor(bath) + a
ge5 + dr + ratio + inv)

Residuals:
     Min       1Q   Median       3Q      Max
-0.36501 -0.05177 -0.00419  0.05274  0.33324

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)      4.555e+00  4.258e-02 106.962  < 2e-16 ***
ltsznew          1.567e-06  1.604e-07   9.766  < 2e-16 ***
hssz             7.184e-05  1.105e-05   6.502 1.29e-10 ***
f_place          5.827e-02  6.411e-03   9.089  < 2e-16 ***
```

```
factor(bdrms)2   6.250e-02  4.265e-02   1.465 0.143196
factor(bdrms)3   1.153e-01  4.179e-02   2.758 0.005928 **
factor(bdrms)4   1.565e-01  4.231e-02   3.698 0.000230 ***
factor(bdrms)5   1.663e-01  4.393e-02   3.786 0.000163 ***
factor(bdrms)6   2.216e-01  7.433e-02   2.981 0.002947 **
factor(bath)1.5  2.567e-02  9.366e-03   2.741 0.006244 **
factor(bath)2    4.960e-02  8.973e-03   5.527 4.22e-08 ***
factor(bath)2.5  1.205e-01  1.156e-02  10.419  < 2e-16 ***
factor(bath)3    8.829e-02  1.327e-02   6.655 4.84e-11 ***
factor(bath)3.5  2.457e-01  2.329e-02  10.550  < 2e-16 ***
factor(bath)4    1.835e-01  3.664e-02   5.009 6.55e-07 ***
age5             5.354e-02  7.662e-03   6.988 5.30e-12 ***
dr               4.231e-02  6.835e-03   6.190 9.00e-10 ***
ratio           -1.088e-01  2.894e-02  -3.758 0.000182 ***
inv             -1.496e-04  5.196e-05  -2.880 0.004070 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.08228 on 931 degrees of freedom
Multiple R-squared:  0.6668,   Adjusted R-squared:  0.6604
F-statistic: 103.5 on 18 and 931 DF,  p-value: < 2.2e-16
```

As the r-squared is higher in this model, I will use this model as final!

6) What is your BEST -MOST COMPLETE **answer to what the house of interest listed above will cost?**

Final model:

lm(formula= s_p ~ltsznew+hssz+f_place + factor(bdrms)+factor(bath)+age5+dr+ratio+inv)

Recalling house of interest:

s_p	Sale price in dollars	**?**
inv	Sale date inventory of homes on market	**100**
bath	Number of bathrooms	**2**
ltsz	Lot size in acres	**.25 = 10890 sq feet**
hssz	Sq. ft. of living area	**1200**
bsemt	1 if basement, 0 otherwise	**0**
a_c	1 if central a/c, 0 otherwise	**1**
f_place	1 if fireplace, 0 otherwise	**0**
garsz_a	1 if garage, 0 otherwise	**1**
dinsp	1 if dining space, 0 otherwise	**1**
dw	1 if dishwasher, 0 otherwise	**1**
dr	1 if dining room, 0 otherwise	**0**
fr	1 if family room, 0 otherwise	**0**
age5	1 if age <= 5 yrs, 0 otherwise	**1**
stl10	1 if 1 story house, 0 otherwise	**1**
bdrms	Number of bedrooms	**4**

additional variable:

ratio: 1200/20890 = 0.05744375

Calculating:

Without log:

```
predict.lm(model5, newdata=data.frame(inv=100,bath=2,ltsznew=10890,f_place= 0, hs
sz=1200, age5=1, ratio= 0.05744375, bdrms=4, dr =0),  interval="confidence", leve
l=0.95)

       fit      lwr      upr
1 86795.44 81659.16 91931.71
```

With log (better r-squared)

```
predict.lm(model7, newdata=data.frame(inv=100,bath=2,ltsznew=10890,f_place= 0, hs
sz=1200, age5=1, ratio= 0.05744375, bdrms=4, dr =0),  interval="confidence", leve
l=0.95)
       fit      lwr      upr
1 4.896207 4.872346 4.920068
There were 50 or more warnings (use warnings() to see the first 50)
fit <- 10**4.896207
fit
[1] 78742.1
lwr <- 10**4.872346
lwr
[1] 74532.55
upr <- 10**4.920068
upr
[1] 83189.
```

END OF EXAM