Modeling House Prices Using Realtor Data

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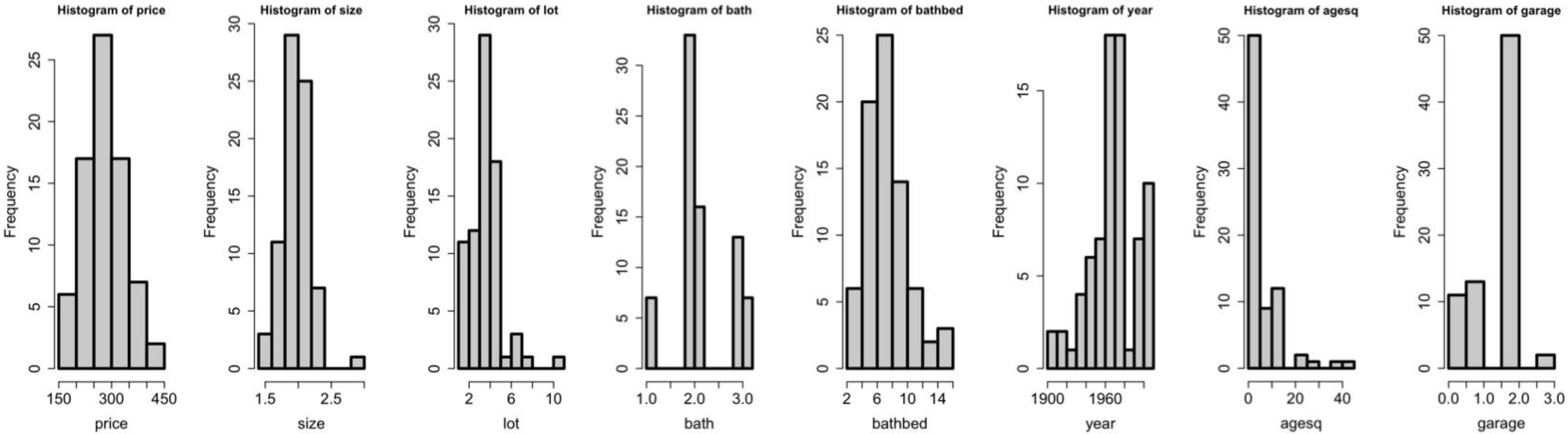
A Little Background Information

- Single-family homes in Eugene, Oregon
- Collected in 2005
- Mix of quantitative and qualitative variables
- 76 data points in total
- 18 variables in total (1 response and 17 predictors)

A Closer Look at the Variables

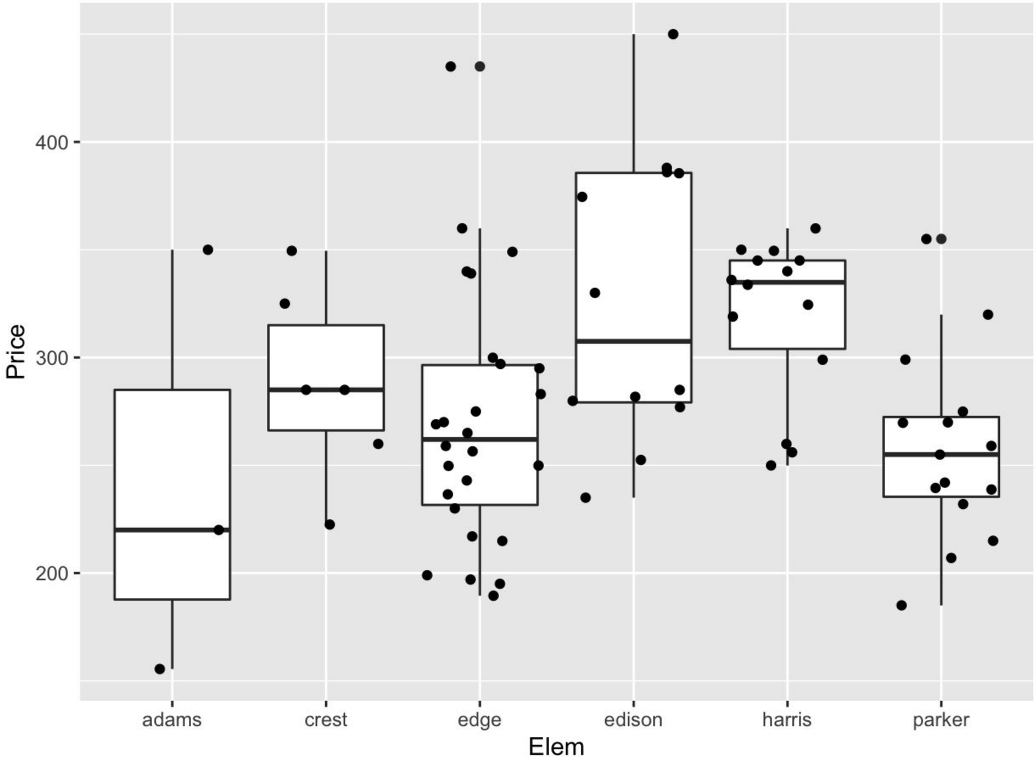
Price	**sale price (thousands of dollars)**
Size	floor size (thousands of square feet)
Lot	lot size category (from 1 to 11)
Bath	number of bathrooms (with half-bathrooms counting as 0.1)
Bed	number of bedrooms (between 2 and 6)
BathBed	interaction of Bath times Bed
Year	year built
Age	age (standardized: (Year-1970)/10)
Agesq	Age squared
Garage	garage size (0, 1, 2, or 3 cars)
Status	act (active listing), pen (pending sale), or sld (sold)
Active	indicator for active listing (reference: pending or sold)
Elem	nearest elementary school (edgewood, edison, harris, adams, crest, or parker)
Edison	indicator for Edison Elementary (reference: Edgewood Elementary)
Harris	indicator for Harris Elementary (reference: Edgewood Elementary)
Adams	indicator for Adams Elementary (reference: Edgewood Elementary)
Crest	indicator for Crest Elementary (reference: Edgewood Elementary)
Parker	indicator for Parker Elementary (reference: Edgewood Elementary)

The Quantitative Variables



They all seem approximately normal..

The Schools


400
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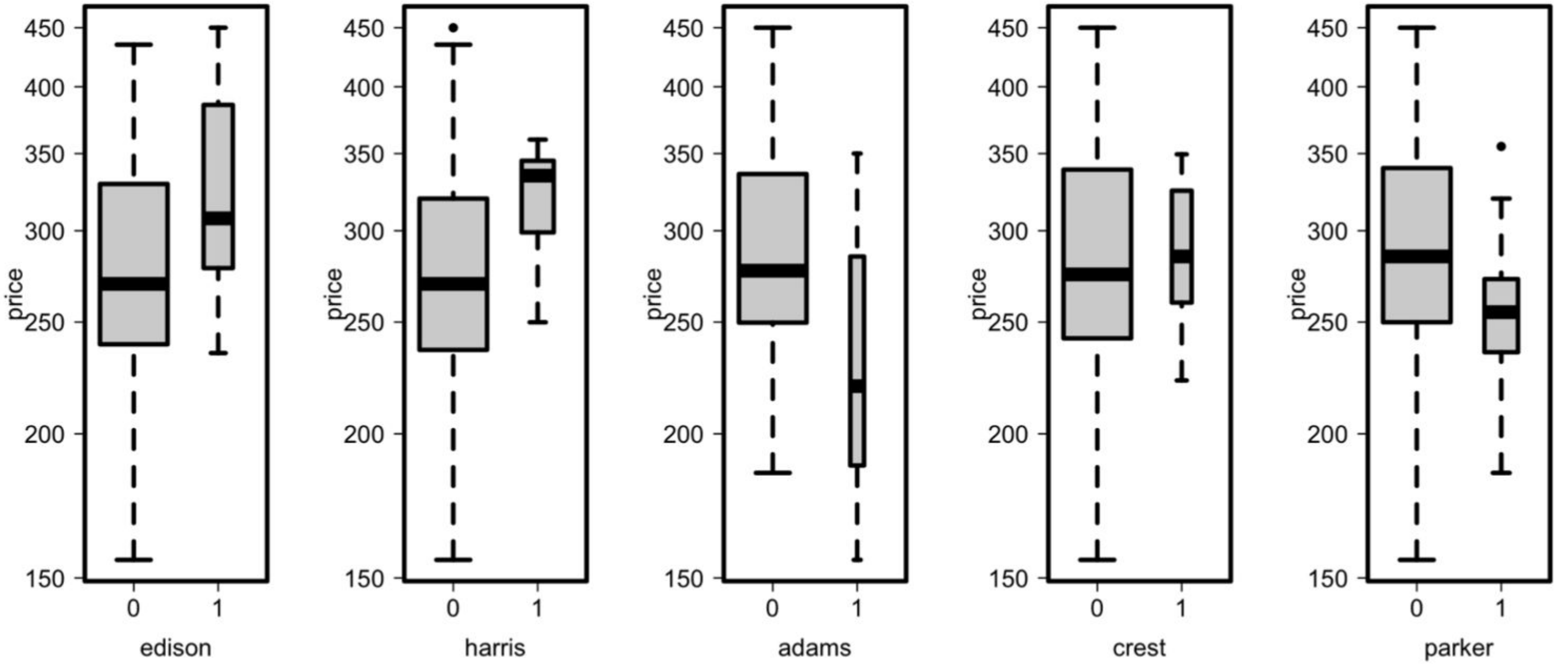
200
Price
adams
crest
edge
edison
harris
parker
Elem

The Schools


price
450
400
350
300
250
200
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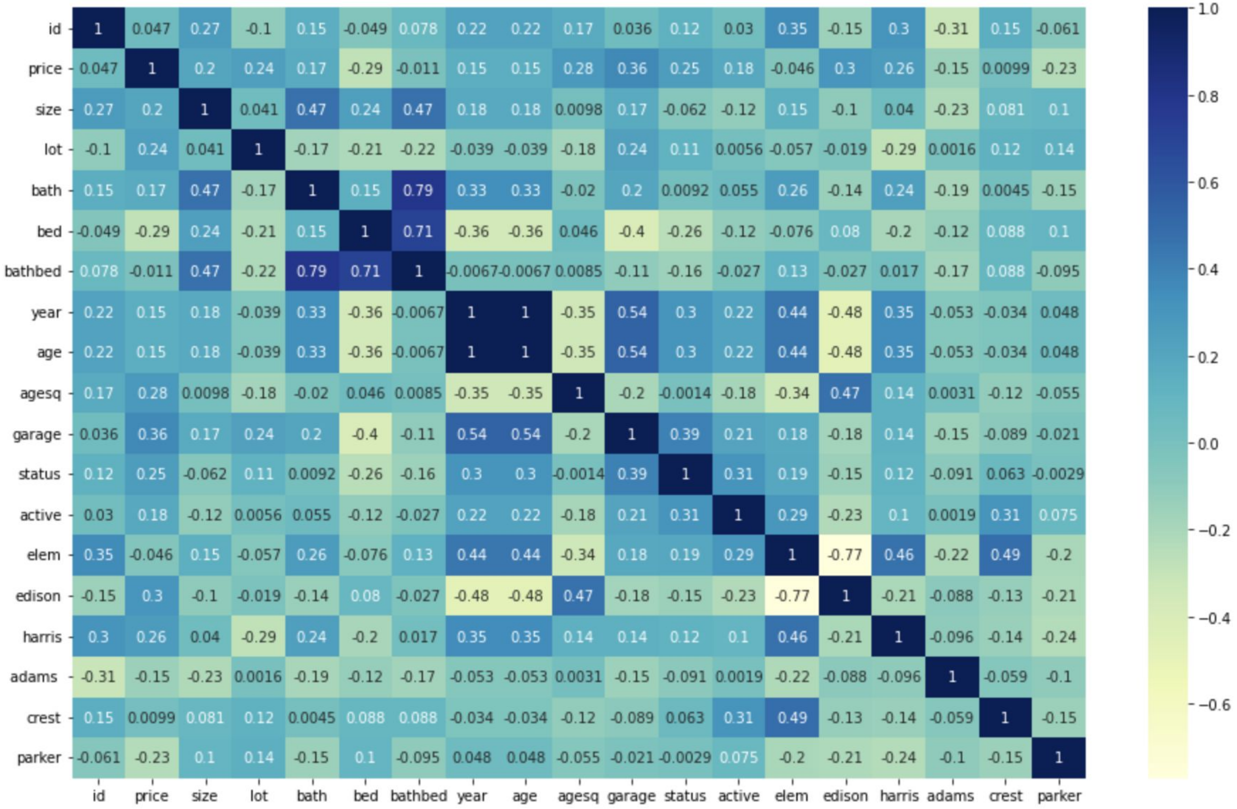
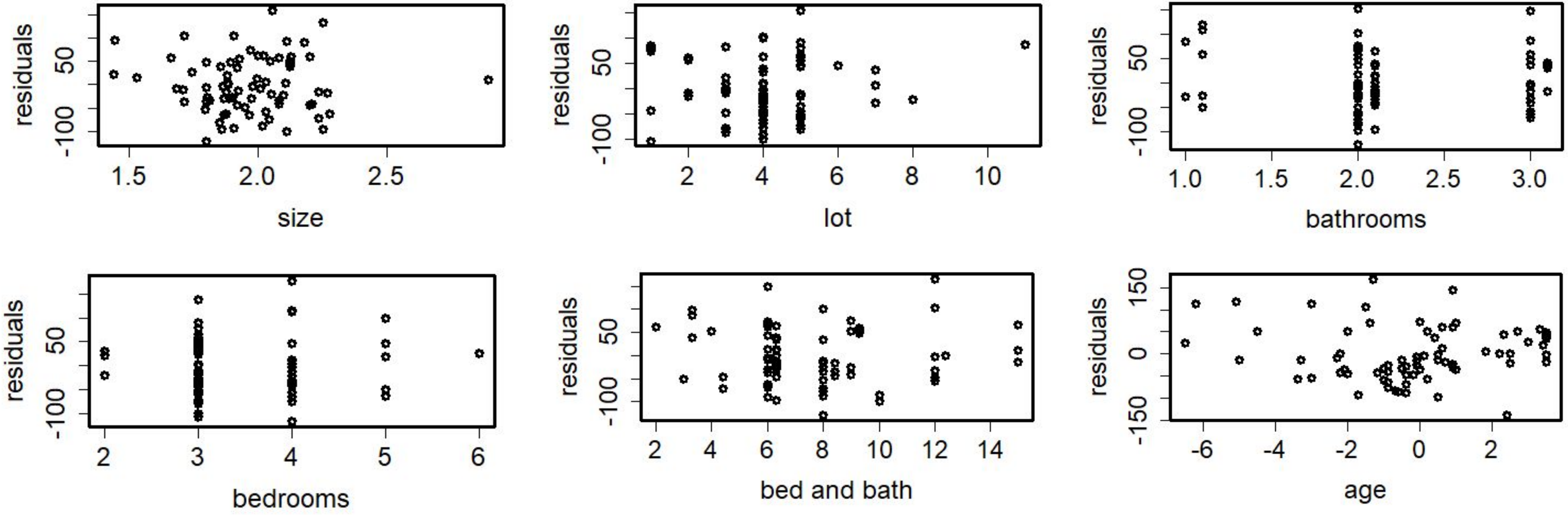
0
1
edison
harris
adams
crest
parker

Correlation Matrix

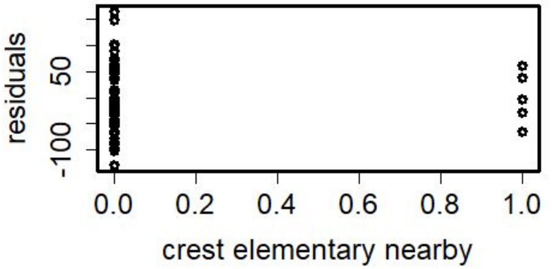


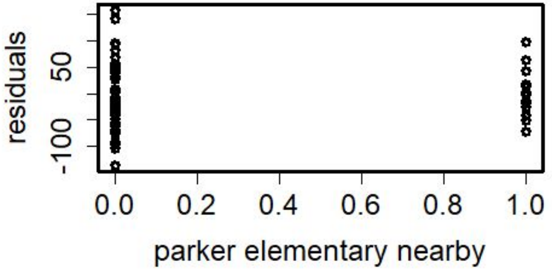
	id	price	size	lot	bath	bed	bathbed	year	age	agesq	garage	status	active	elem	edison	harris	adams	crest	parker
id	1	0.047	0.27	-0.1	0.15	-0.049	0.078	0.22	0.22	0.17	0.036	0.12	0.03	0.35	-0.15	0.3	-0.31	0.15	-0.061
price	0.047	1	0.2	0.24	0.17	-0.29	-0.011	0.15	0.15	0.28	0.36	0.25	0.18	-0.046	0.3	0.26	-0.15	0.0099	-0.23
size	0.27	0.2	1	0.041	0.47	0.24	0.47	0.18	0.18	0.0098	0.17	-0.062	-0.12	0.15	-0.1	0.04	-0.23	0.081	0.1
lot	-0.1	0.24	0.041	1	-0.17	-0.21	-0.22	-0.039	-0.039	-0.18	0.24	0.11	0.0056	-0.057	-0.019	-0.29	0.0016	0.12	0.14
bath	0.15	0.17	0.47	-0.17	1	0.15	0.79	0.33	0.33	-0.02	0.2	0.0092	0.055	0.26	-0.14	0.24	-0.19	0.0045	-0.15
bed	-0.049	-0.29	0.24	-0.21	0.15	1	0.71	-0.36	-0.36	0.046	-0.4	-0.26	-0.12	-0.076	0.08	-0.2	-0.12	0.088	0.1
bathbed	0.078	-0.011	0.47	-0.22	0.79	0.71	1	-0.0067	-0.0067	0.0085	-0.11	-0.16	-0.027	0.13	-0.027	0.017	-0.17	0.088	-0.095
year	0.22	0.15	0.18	-0.039	0.33	-0.36	-0.0067	1	1	-0.35	0.54	0.3	0.22	0.44	-0.48	0.35	-0.053	-0.034	0.048
age	0.22	0.15	0.18	-0.039	0.33	-0.36	-0.0067	1	1	-0.35	0.54	0.3	0.22	0.44	-0.48	0.35	-0.053	-0.034	0.048
agesq	0.17	0.28	0.0098	-0.18	-0.02	0.046	0.0085	-0.35	-0.35	1	-0.2	-0.0014	-0.18	-0.34	0.47	0.14	0.0031	-0.12	-0.055
garage	0.036	0.36	0.17	0.24	0.2	-0.4	-0.11	0.54	0.54	-0.2	1	0.39	0.21	0.18	-0.18	0.14	-0.15	-0.089	-0.021
status	0.12	0.25	-0.062	0.11	0.0092	-0.26	-0.16	0.3	0.3	-0.0014	0.39	1	0.31	0.19	-0.15	0.12	-0.091	0.063	-0.0029
active	0.03	0.18	-0.12	0.0056	0.055	-0.12	-0.027	0.22	0.22	-0.18	0.21	0.31	1	0.29	-0.23	0.1	0.0019	0.31	0.075
elem	0.35	-0.046	0.15	-0.057	0.26	-0.076	0.13	0.44	0.44	-0.34	0.18	0.19	0.29	1	-0.77	0.46	-0.22	0.49	-0.2
edison	-0.15	0.3	-0.1	-0.019	-0.14	0.08	-0.027	-0.48	-0.48	0.47	-0.18	-0.15	-0.23	-0.77	1	-0.21	-0.088	-0.13	-0.21
harris	0.3	0.26	0.04	-0.29	0.24	-0.2	0.017	0.35	0.35	0.14	0.14	0.12	0.1	0.46	-0.21	1	-0.096	-0.14	-0.24
adams	-0.31	-0.15	-0.23	0.0016	-0.19	-0.12	-0.17	-0.053	-0.053	0.0031	-0.15	-0.091	0.0019	-0.22	-0.088	-0.096	1	-0.059	-0.1
crest	0.15	0.0099	0.081	0.12	0.0045	0.088	0.088	-0.034	-0.034	-0.12	-0.089	0.063	0.31	0.49	-0.13	-0.14	-0.059	1	-0.15
parker	-0.061	-0.23	0.1	0.14	-0.15	0.1	-0.095	0.048	0.048	-0.055	-0.021	-0.0029	0.075	-0.2	-0.21	-0.24	-0.1	-0.15	1

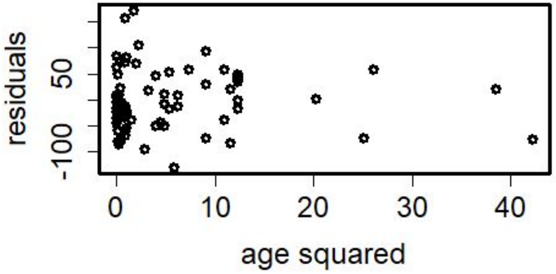
Residual Plots

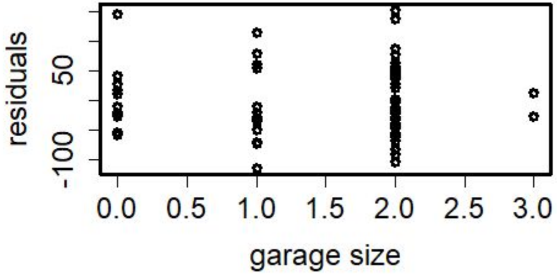


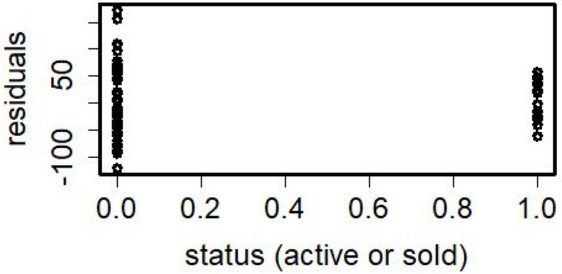
Residual Plots

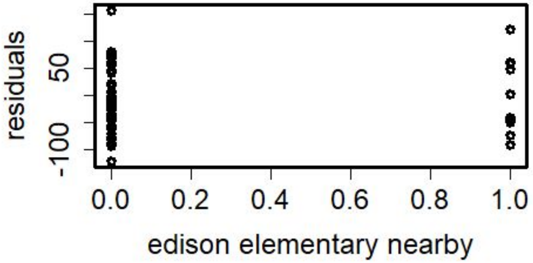


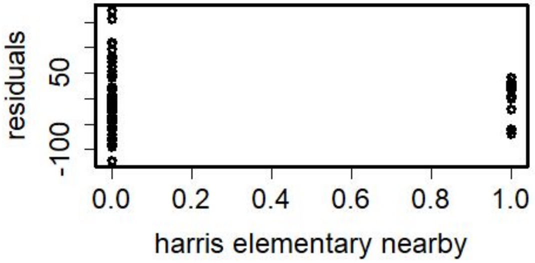


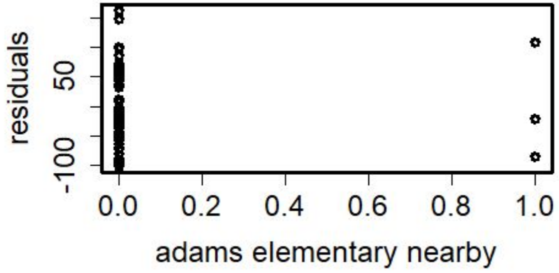




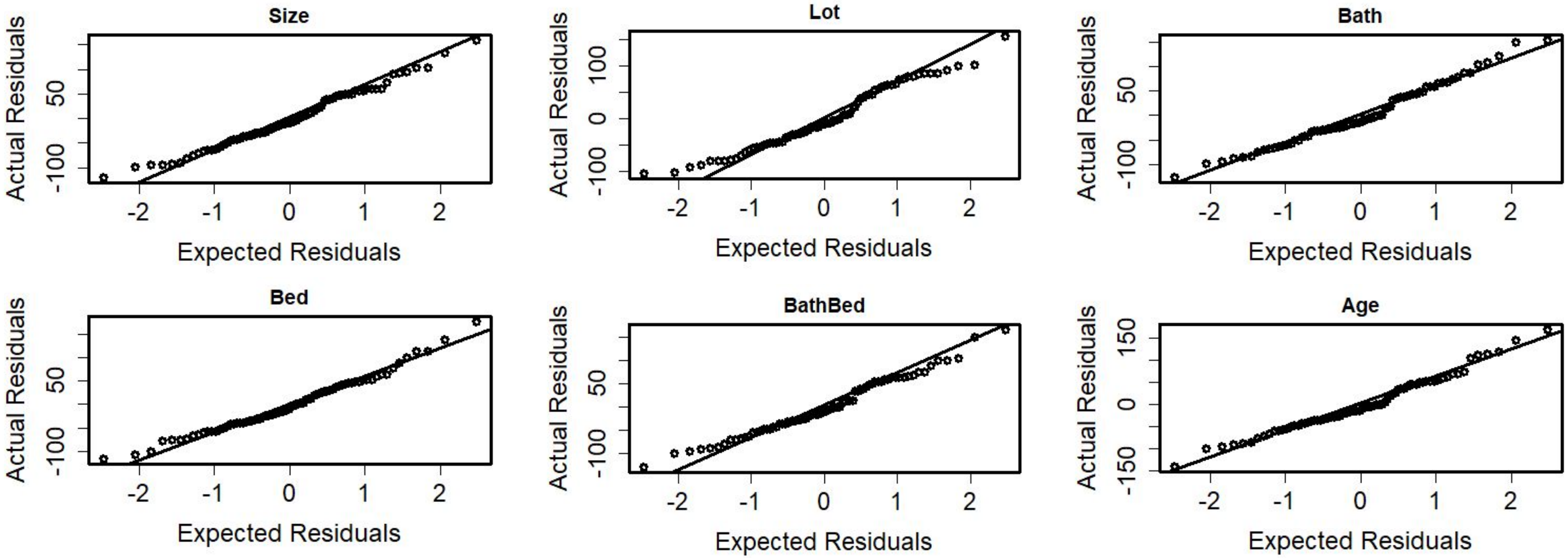




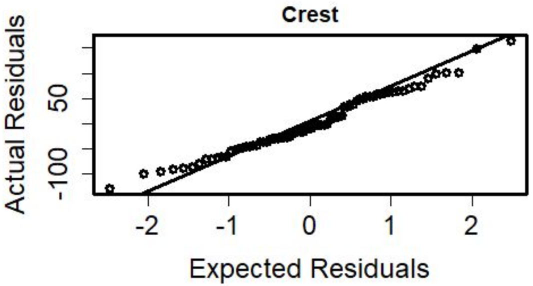


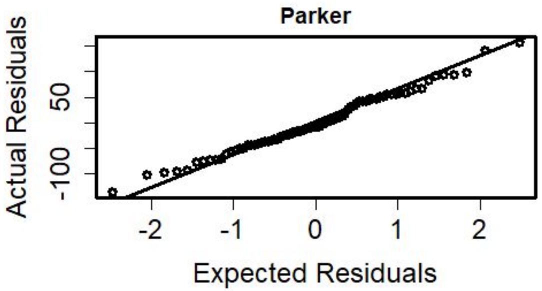


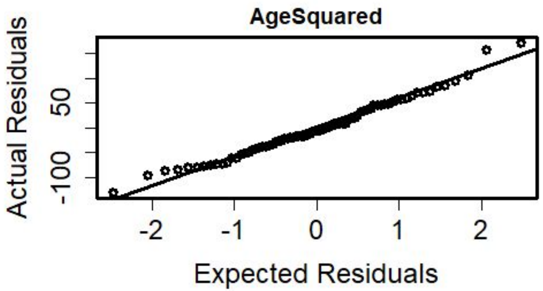
Normal Plots

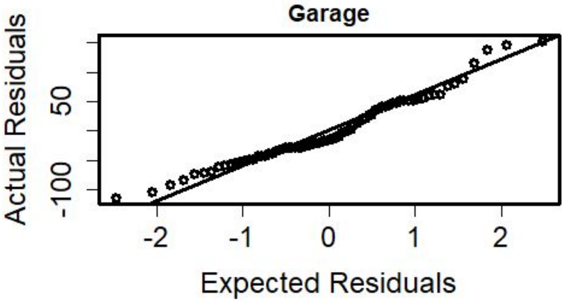


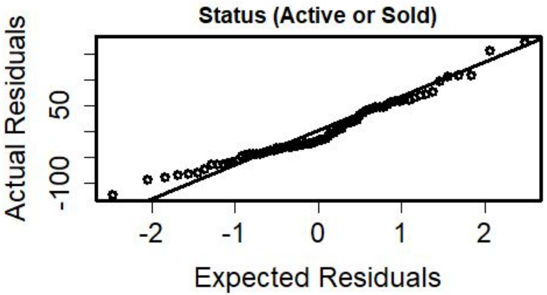
Normal Plots

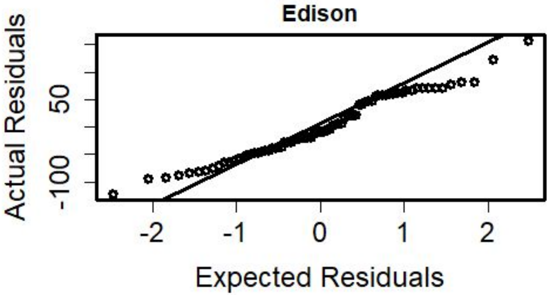


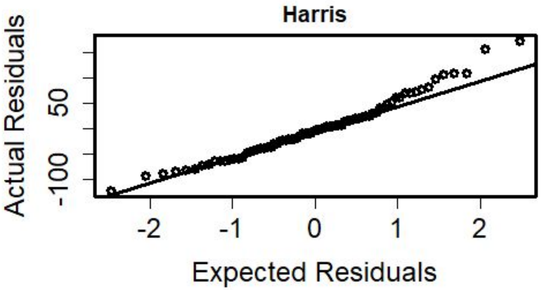


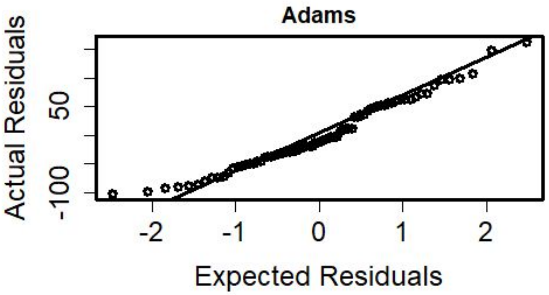






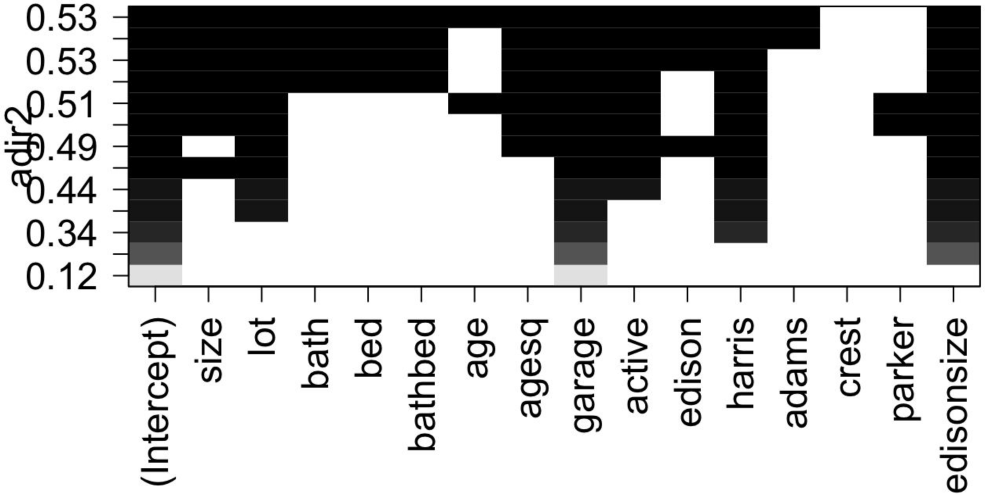






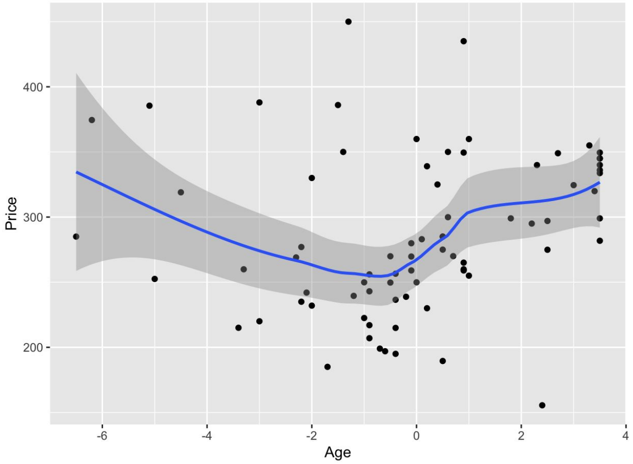
Interaction Terms

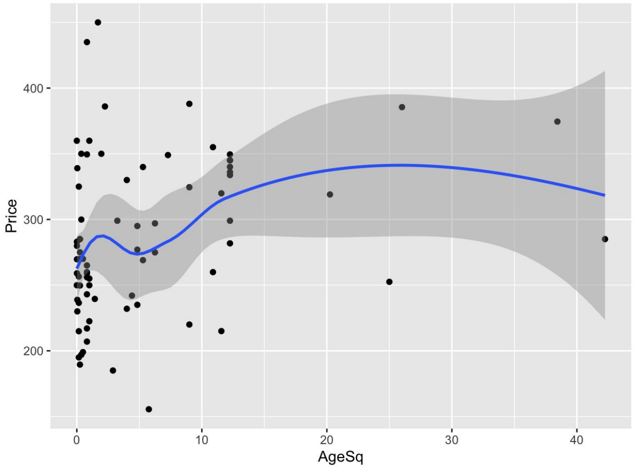
- We included two additional interaction terms
    - bed*bath
    - edison*size



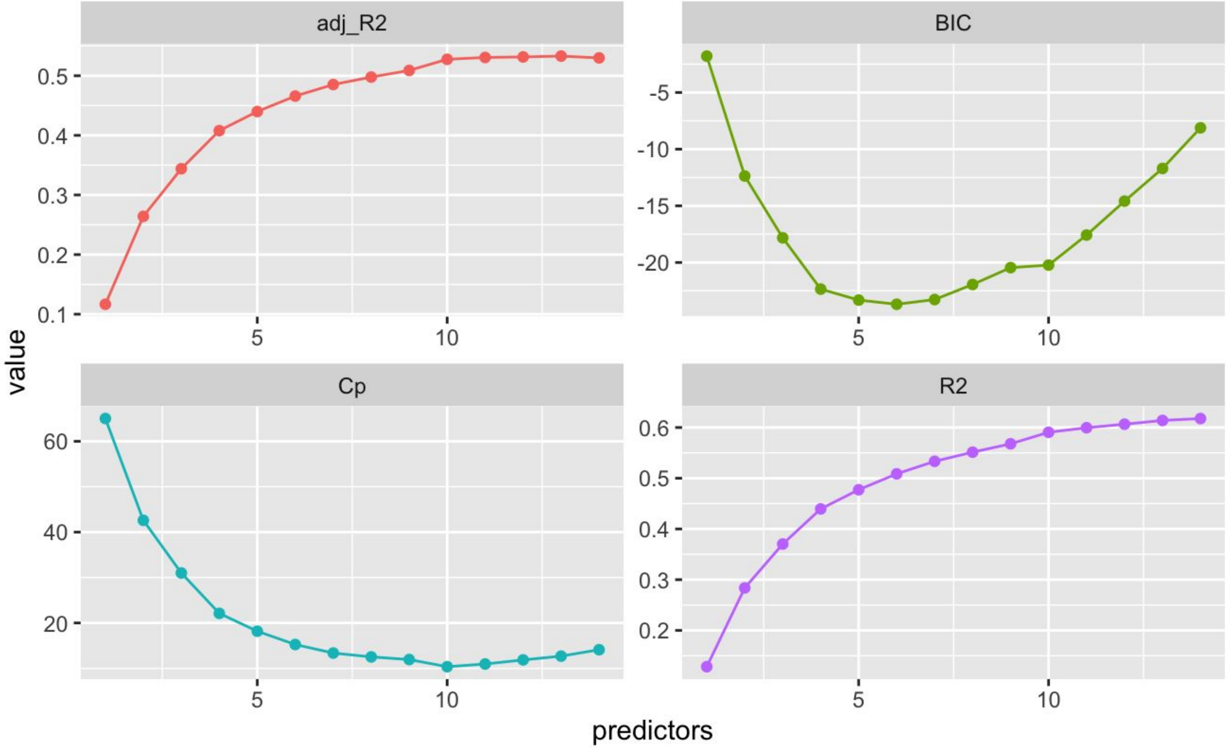
Transformations

- We included a single transform, age^2





Model Selection



The Model

```
price = b0 + b1*size + b2*lot + b3*bath + b4*bed +
        b5*bathbed + b6*agesq + b7*garage +
  b8*active + b9*edison + b10*harris + b11*edisonsize

price = 355.151 + 43.773*size + 8.630*lot - 96.426*bath -
        78.393*bed + 29.347*bathbed + 1.409*agesq +
      20.203*garage + 29.040*active - 149.353*edison +
            50.222*harris + 110.178*edisonsize
```

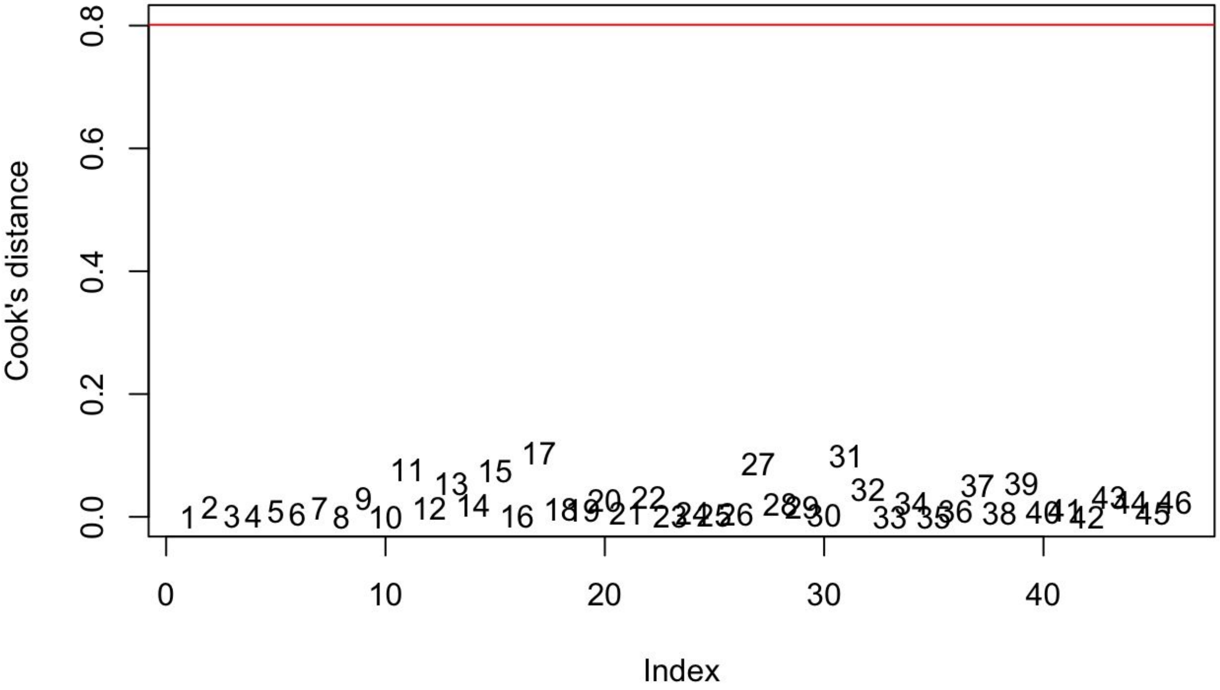
Model Fit

```
Residuals:
    Min      1Q  Median      3Q     Max 
-106.97  -20.91    0.87   23.73   96.69 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  355.151    106.441   3.337 0.001416 ** 
size          43.773     28.981   1.510 0.135861    
lot            8.630      3.364   2.565 0.012656 *  
bath         -96.426     41.831  -2.305 0.024412 *  
bed          -78.393     27.372  -2.864 0.005651 ** 
bathbed       29.347     11.688   2.511 0.014575 *  
agesq          1.409      0.702   2.008 0.048909 *  
garage        20.203      7.973   2.534 0.013741 *  
active        29.040     10.860   2.674 0.009499 ** 
edison      -149.353    124.900  -1.196 0.236192    
harris        50.222     14.418   3.483 0.000898 ***
edisonsize   110.178     64.593   1.706 0.092907 .  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 41.33 on 64 degrees of freedom
Multiple R-squared:  0.5995,Adjusted R-squared:  0.5307 
F-statistic:  8.71 on 11 and 64 DF,  p-value: 3.445e-09
```

Cross Validation

- 70/30 train/validation split
- MSPR: 1611.11
- MSE: 1438.56
- → *MSE* for the selected regression model is not seriously biased
- Achieved minimum MSE from all tested models

No Outliers!


Cook's distance
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Limitations

- We have too little data, there are only 76 data points
- There are only 53 points to fit to with a 70% training split
- Data only representative of Eugene, Oregon
- Data seems to have been pre-processed