THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

STOR 320 Exploratory Data Analysis

Lecture 8

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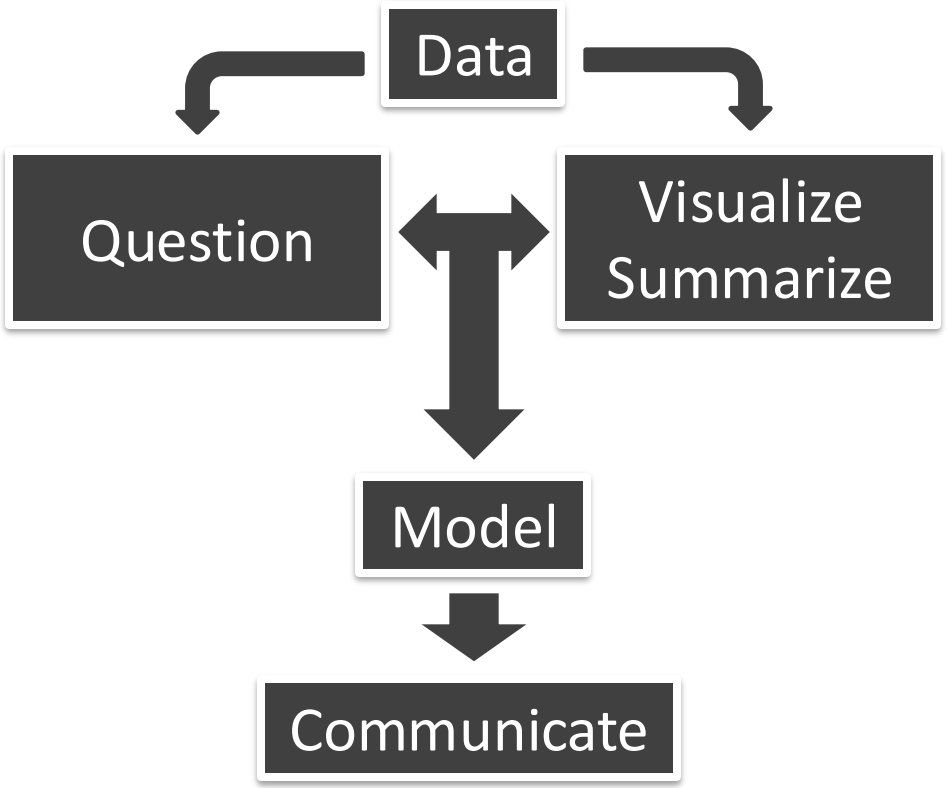
EDA Definition

- Read Chapter 7
- Know the Process
- Respect the Process



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Question

- Think Creatively
- Quantity and Quality
- General:
  - What type of variation occurs **within** my variables?
  - What type of covariation occurs **between** my variables?

Data

- Example: Wages1
  - "Ecdat" R Package
  - Sample from 1976-1982
    - 3,294 Workers
    - 4 variables
  - Variables
    - Experience (Yrs.)
    - Gender (M or F)
    - School (Yrs.)
    - Wage (Hourly in $)

```r
Wage=as.tibble(Wages1) %>%
  rename(experience=exper) %>%
  arrange(school)
head(wage,10)
```

experience <int>	gender <fctr>	school <int>	wage <dbl>
18	male	3	5.51682632
15	male	4	3.56497766
18	male	4	9.09918107
10	female	5	0.60316541
11	male	5	3.80264284
14	male	5	7.50044646
16	male	5	4.30366672
14	male	5	4.88629309
15	female	6	4.30366672
9	female	6	2.21160651

Verbeek, Marno (2004) A Guide to Modern Econometrics, John Wiley and Sons.

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Question

- Variation
  - Variable = Quantity, Quality, or Property You Can Measure
  - Reason: Values Tend to “Vary”
  - Example: Random
    - Categorical:
      - Gender
    - Numerical:
      - Wage
      - Experience
      - School

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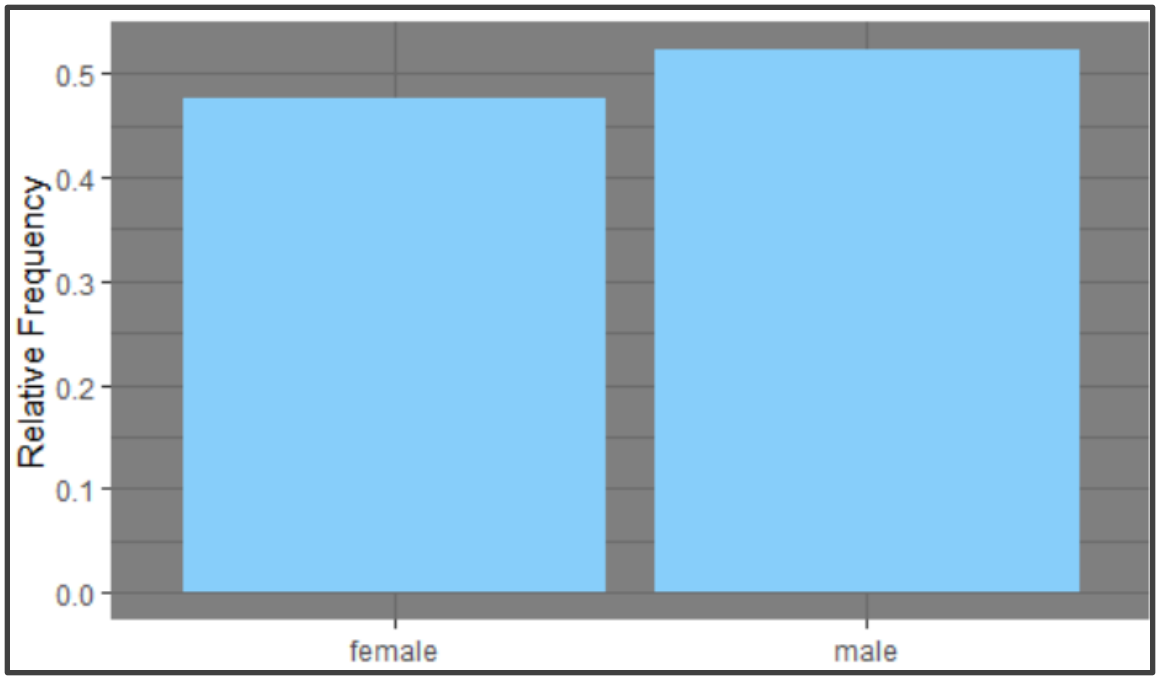
Question

- Initial Questions
  - Example:
    - What did the Workforce Look Like in Terms of Sex?
    - How Spread Out Were Wages?
    - Where is the Middle 50% of the Sample in Regards to Years of Schooling?

Visualize Summarize

- Variation Visualized
  - Example: Wages
    - Categorical: Gender

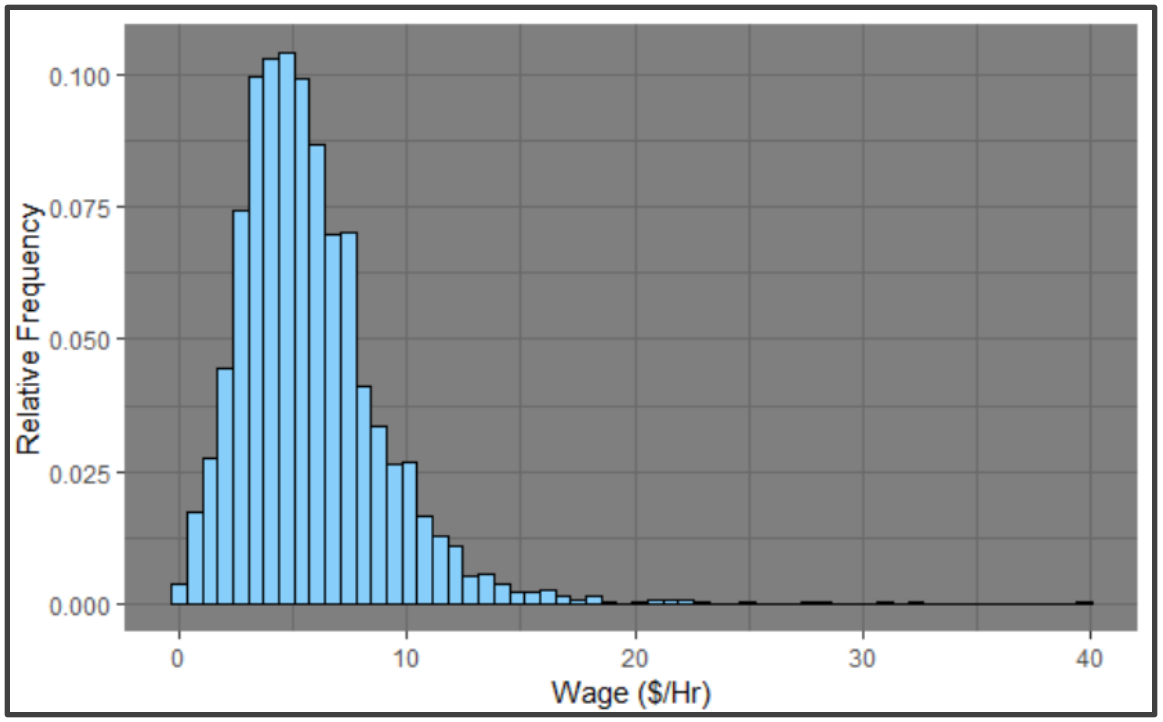
gender <fctr>	n <int>
female	1569
male	1725



Visualize Summarize

- Variation Visualized
  - Example: Wages
    - Numerical: Hourly Wage

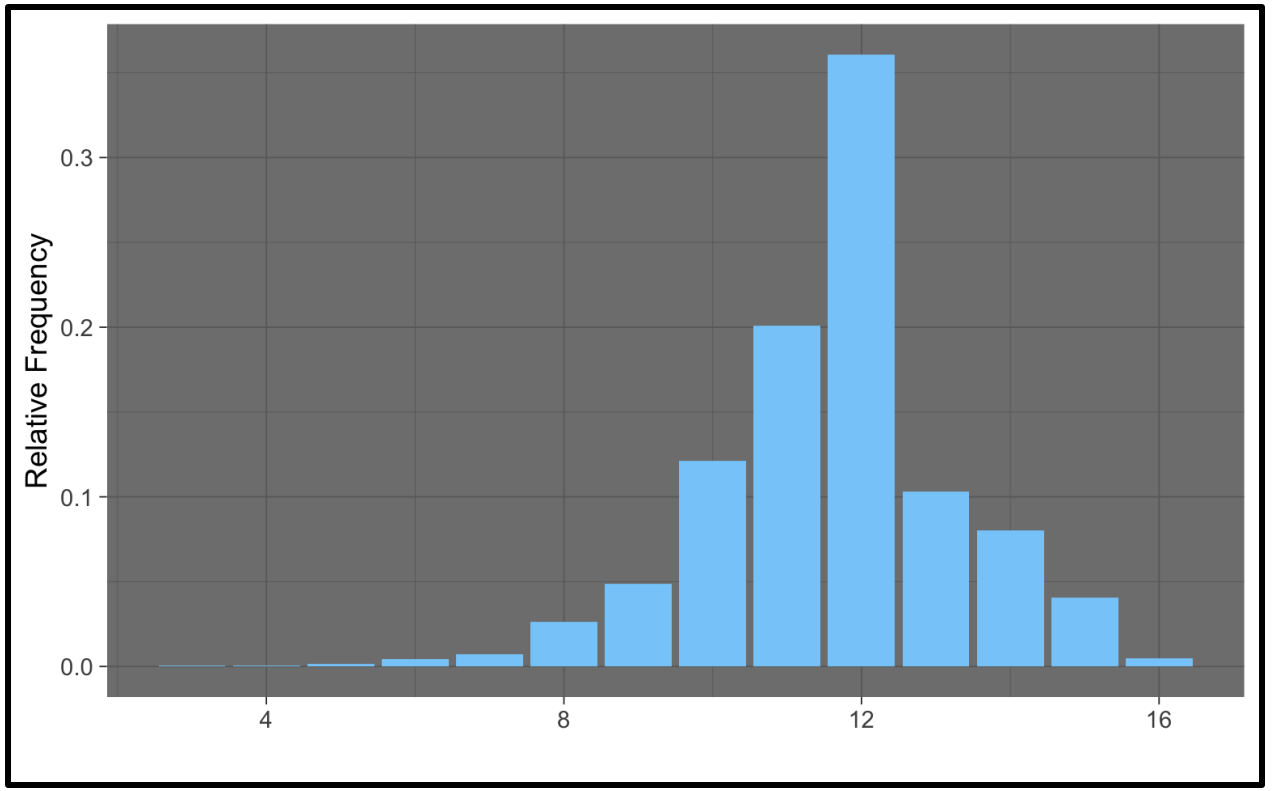
n <int>	avg <dbl>	sd <dbl>	median <dbl>	iqr <dbl>
3294	5.757585	3.269186	5.205781	3.682936



Visualize Summarize

- Variation Visualized
  - Example: Wages
    - Numerical: School

n <int>	avg <dbl>	sd <dbl>	median <dbl>	q1 <dbl>	q3 <dbl>	iqr <dbl>
3294	11.63054	1.657545	12	11	12	1



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Unusual Values

- Outliers = Observations Outside the Pattern of the Data
- Due to Error ➡ Remove
- Don’t Drop or Change Without Justification
- Sensitivity Analysis
- Handling:
  - Drop Entire Row
  - Replace Instance with NA

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Unusual Values

- Example: Wages
  - Few People Above 30 $/Hr
  - Drop Entire Row

```r
Wage2=Wage %>%
        filter(between(wage,0,30))
```

Observations: 3294 ➡ 3291

  - Replace Instance with NA

```r
Wage3=Wage %>%
      mutate(wage=ifelse(wage>30,NA,wage))
```

Observations: 3294 ➡ 3294

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Question

- Covariation
  - Goal: Explain Covariation
  - Describes the Behavior Between Variables
  - We Often Attempt to Explain Variation **Within** by Looking at Covariation **Between**
  - Identify the **Signal** despite the **Noise**

Data

- Example: diamonds
  - "ggplot2" R Package
  - Sample from 1976-1982
    - 53, 940 diamonds
    - 10 variables

- Variables
  - carat
  - cut
  - color
  - clarity
  - depth
  - table
  - price
  - x, y, z

carat <dbl>	cut <ord>	color <ord>	clarity <ord>	depth <dbl>	table <dbl>	price <int>	x <dbl>	y <dbl>	z <dbl>
0.23	Ideal	E	SI2	61.5	55.0	326	3.95	3.98	2.43
0.21	Premium	E	SI1	59.8	61.0	326	3.89	3.84	2.31
0.23	Good	E	VS1	56.9	65.0	327	4.05	4.07	2.31
0.29	Premium	I	VS2	62.4	58.0	334	4.20	4.23	2.63
0.31	Good	J	SI2	63.3	58.0	335	4.34	4.35	2.75
0.24	Very Good	J	VVS2	62.8	57.0	336	3.94	3.96	2.48
0.24	Very Good	I	VVS1	62.3	57.0	336	3.95	3.98	2.47
0.26	Very Good	H	SI1	61.9	55.0	337	4.07	4.11	2.53
0.22	Fair	E	VS2	65.1	61.0	337	3.87	3.78	2.49
0.23	Very Good	H	VS1	59.4	61.0	338	4.00	4.05	2.39

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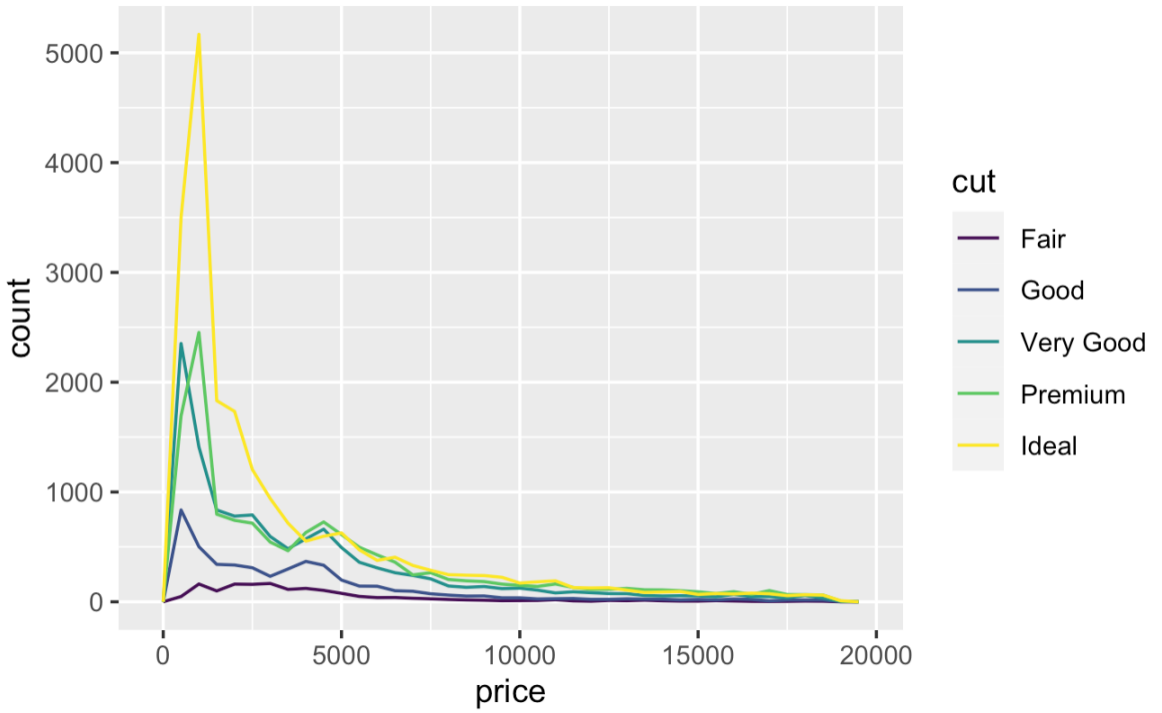
Question

- Covariation Questions
  - Example: Wages
    - Does Quality of a diamond affect Price?
    - Does Color Affect Quality?
    - What is the Relationship Between Weight and Price?

Visualize Summarize

- Categorical and Continuous

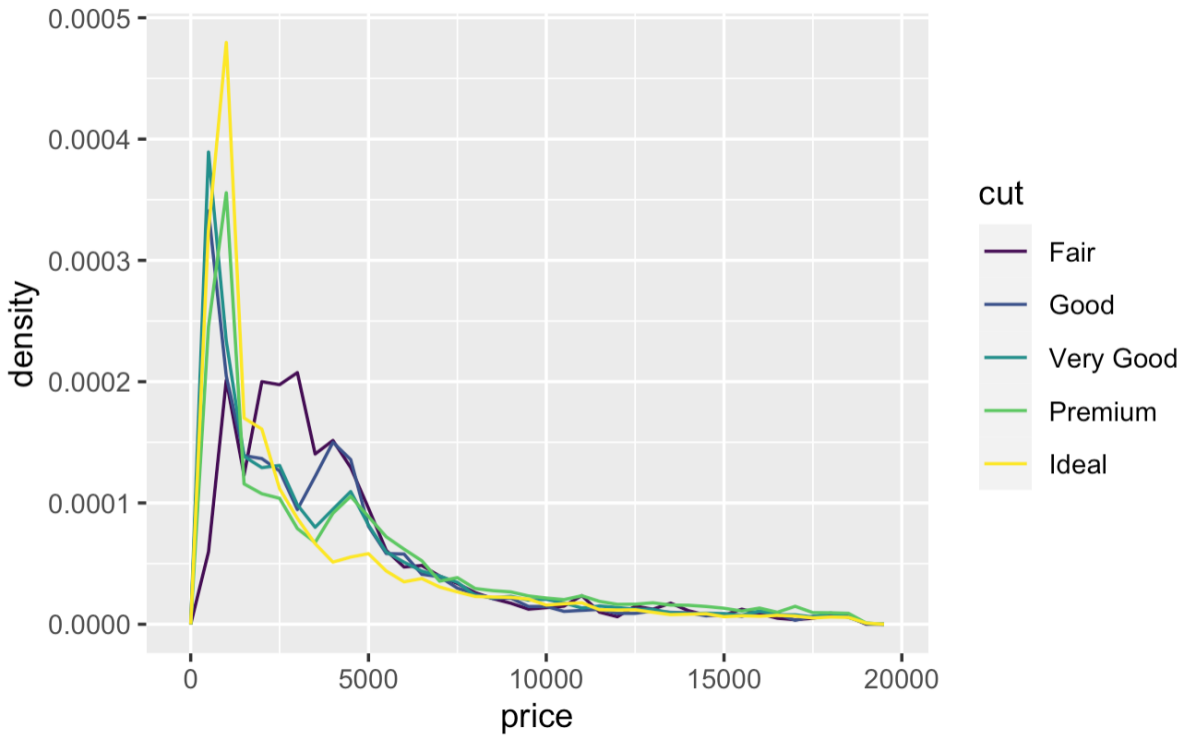
```r
ggplot(data = diamonds, mapping = aes(x = price)) +
  geom_freqpoly(mapping = aes(colour = cut), binwidth = 500)
```



Visualize Summarize

- Categorical and Continuous: density

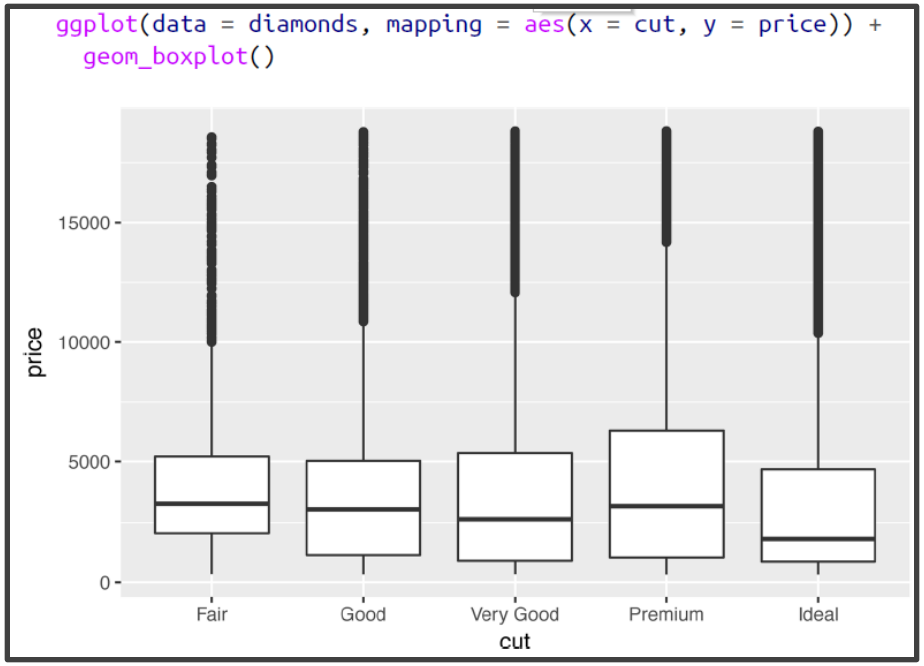
```r
ggplot(data = diamonds, mapping = aes(x = price, y = ..density..)) +
  geom_freqpoly(mapping = aes(colour = cut), binwidth = 500)
```

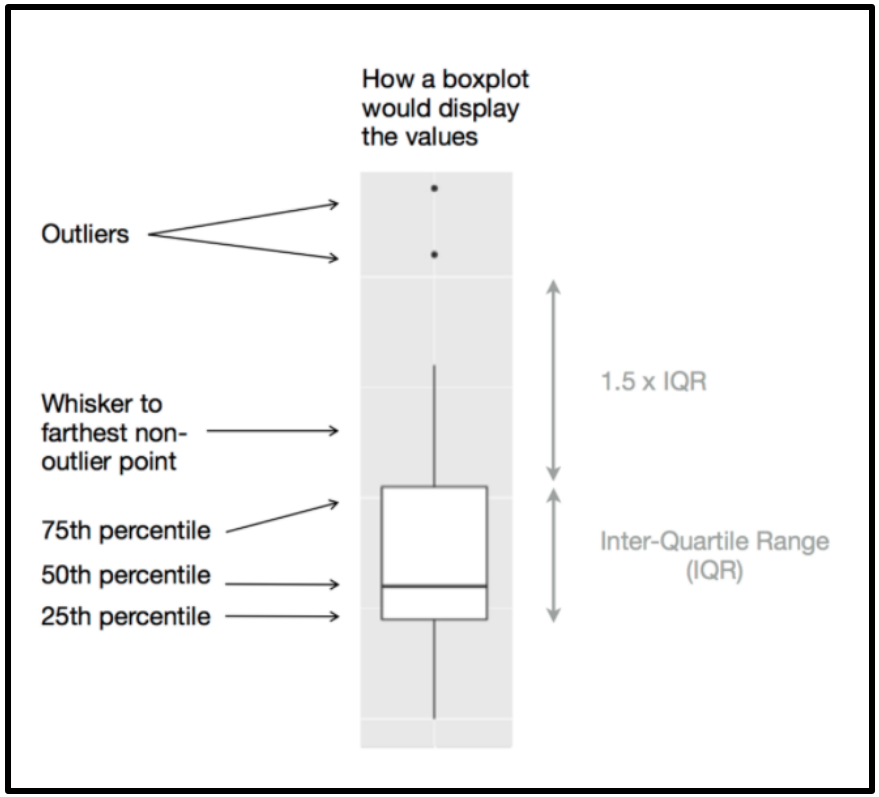


Visualize Summarize

- Categorical and Continuous

```
ggplot(data = diamonds, mapping = aes(x = cut, y = price)) +
  geom_boxplot()
```

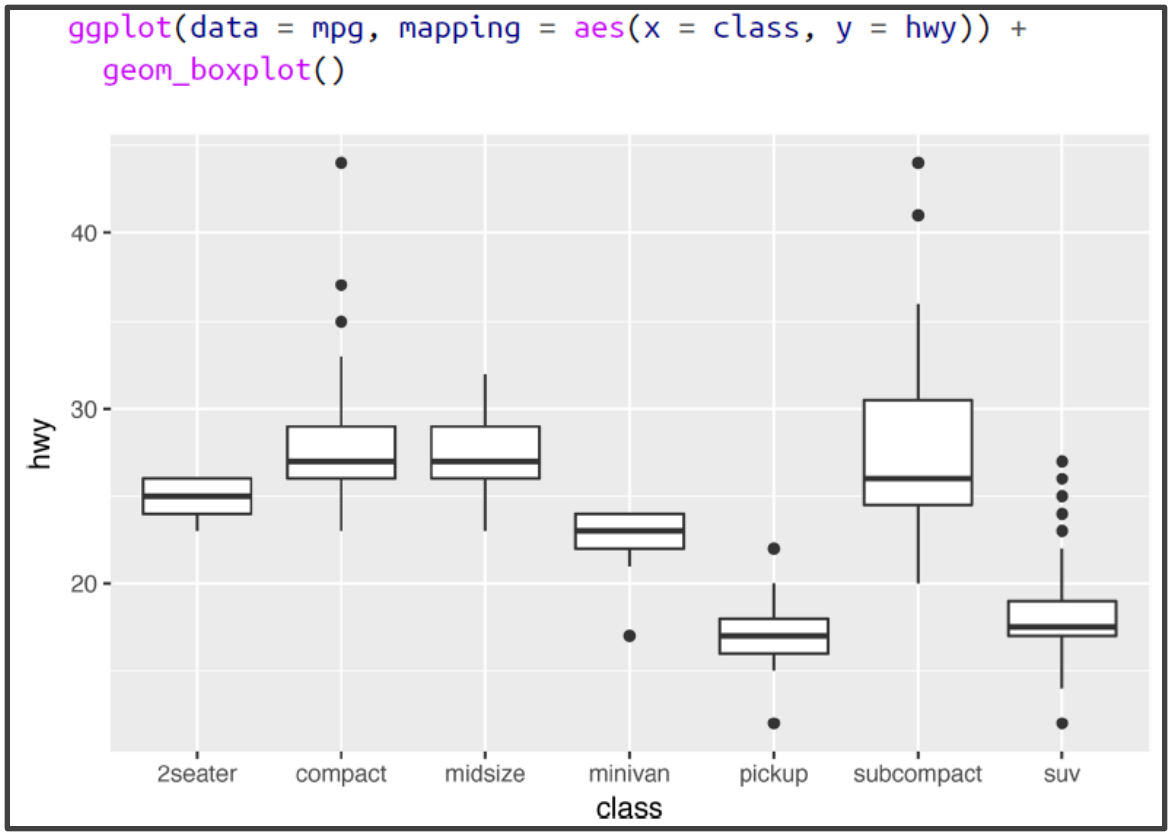




Visualize Summarize

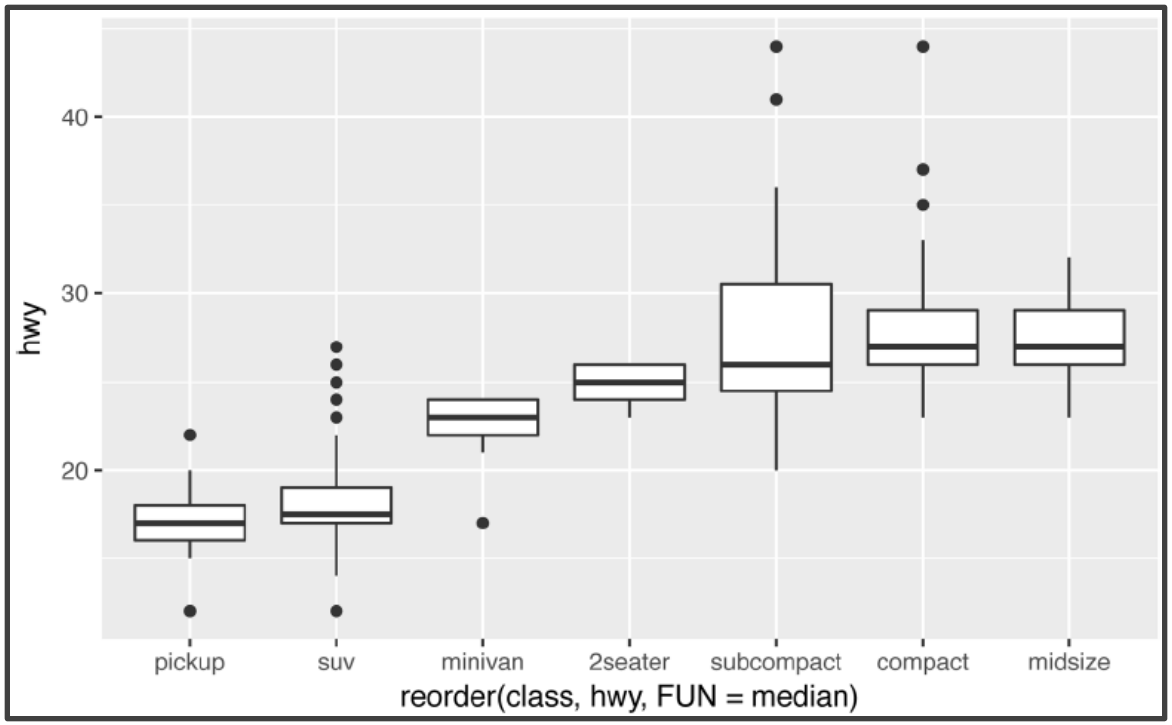
- Categorical and Continuous

```
ggplot(data = mpg, mapping = aes(x = class, y = hwy)) +
  geom_boxplot()
```



- Categorical and Continuous

```
ggplot(data = mpg) +
  geom_boxplot(
    mapping = aes(
      x = reorder(class, hwy, FUN = median),
      y = hwy
    )
  )
```



Visualize Summarize

- Categorical and Categorical

```r
ggplot(data=diamonds) +
  geom_count(mapping=aes(x=cut,y=color))
```

Visualize Summarize

- Categorical and Categorical

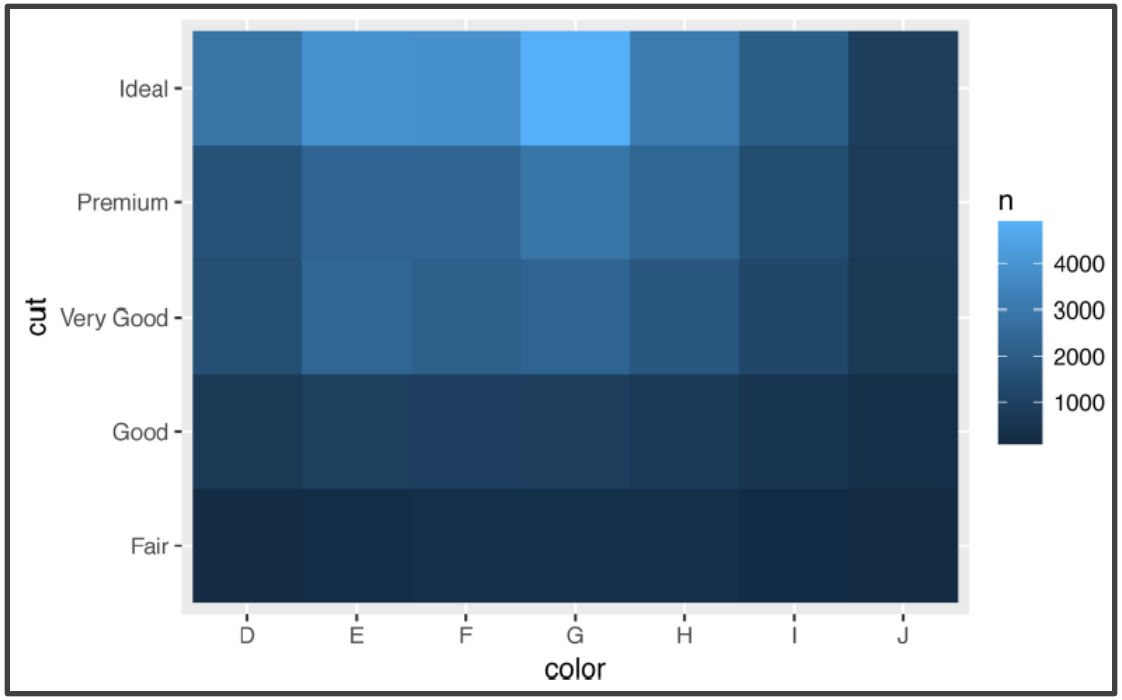
```
```{r}
diamonds %>%
  group_by(cut, color) %>%
  summarize(n=n()) %>%
  spread(cut, n)
```
```

color <ord>	Fair <int>	Good <int>	Very Good <int>	Premium <int>	Ideal <int>
D	163	662	1513	1603	2834
E	224	933	2400	2337	3903
F	312	909	2164	2331	3826
G	314	871	2299	2924	4884
H	303	702	1824	2360	3115
I	175	522	1204	1428	2093
J	119	307	678	808	896

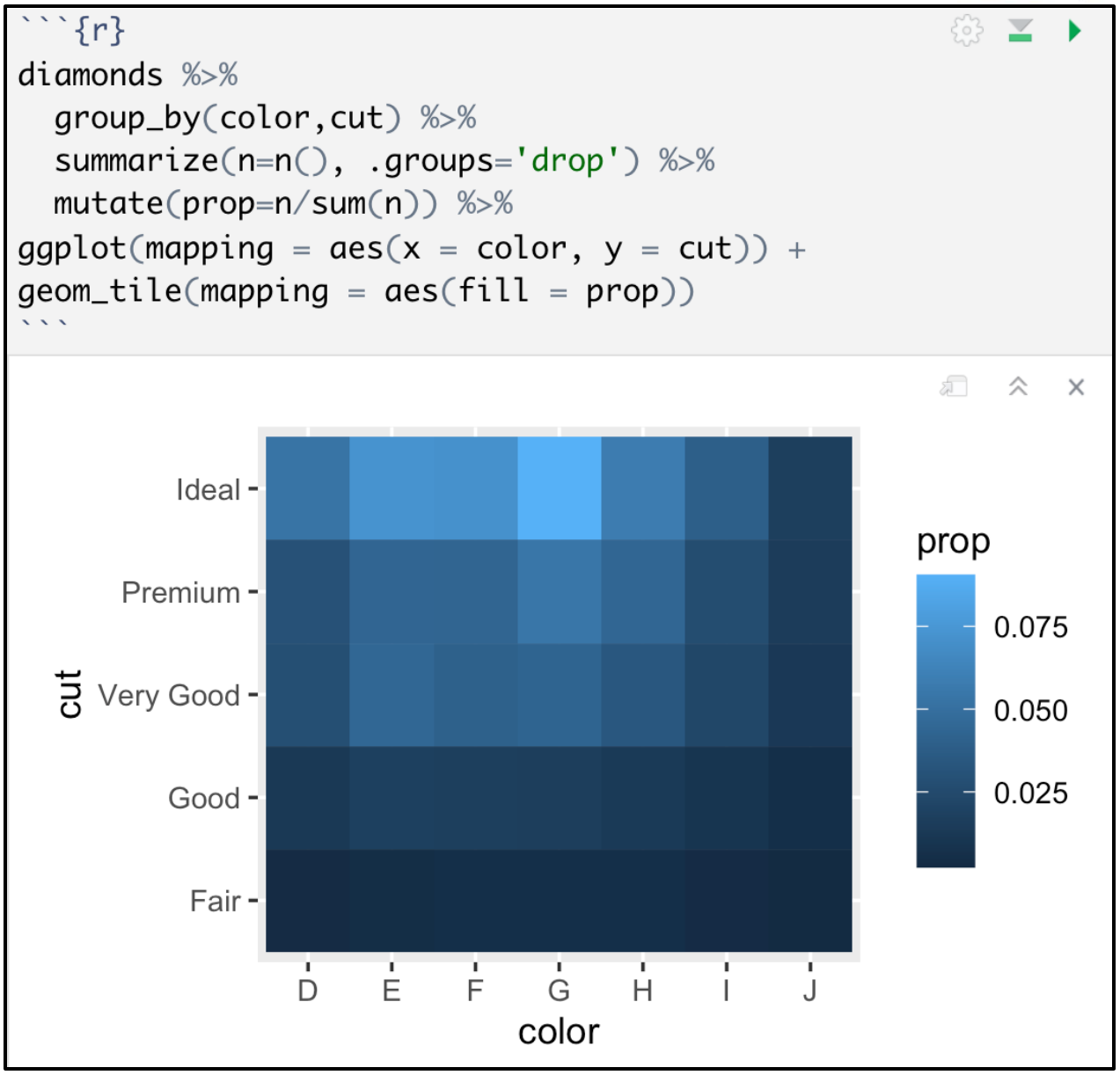
Visualize Summarize

- Categorical and Categorical

```
diamonds %>%
  count(color, cut) %>%
  ggplot(mapping = aes(x = color, y = cut)) +
    geom_tile(mapping = aes(fill = n))
```



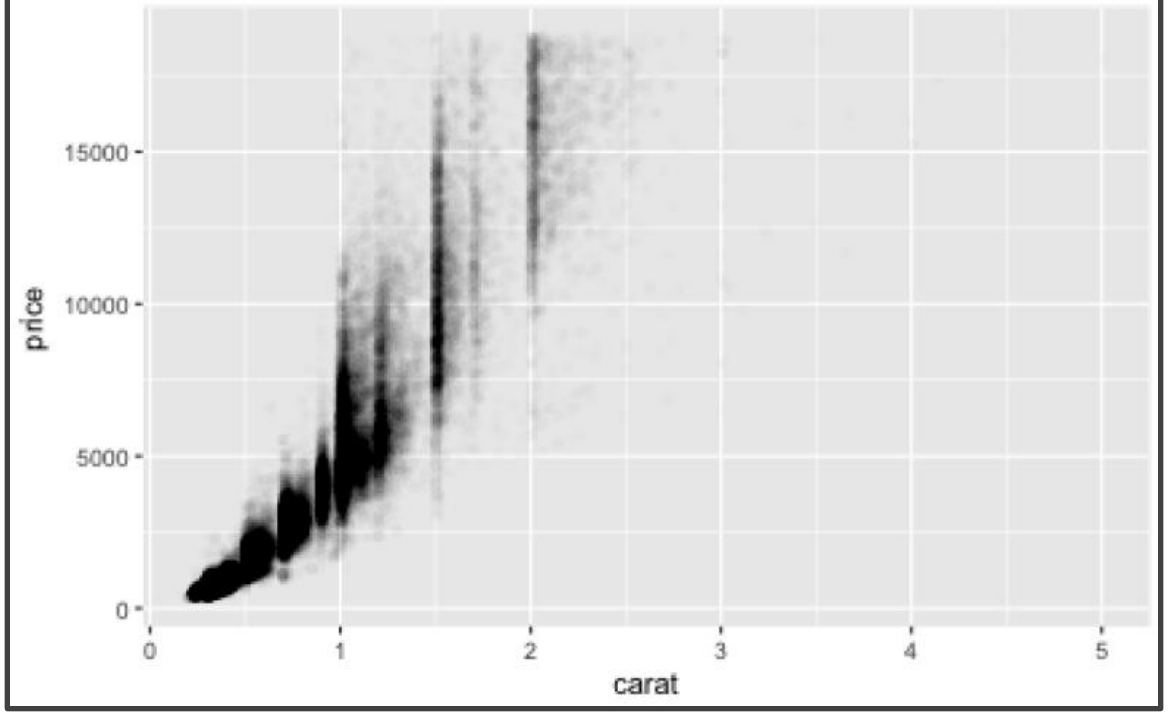
- Categorical and Categorical



Visualize Summarize

- Continuous and Continuous

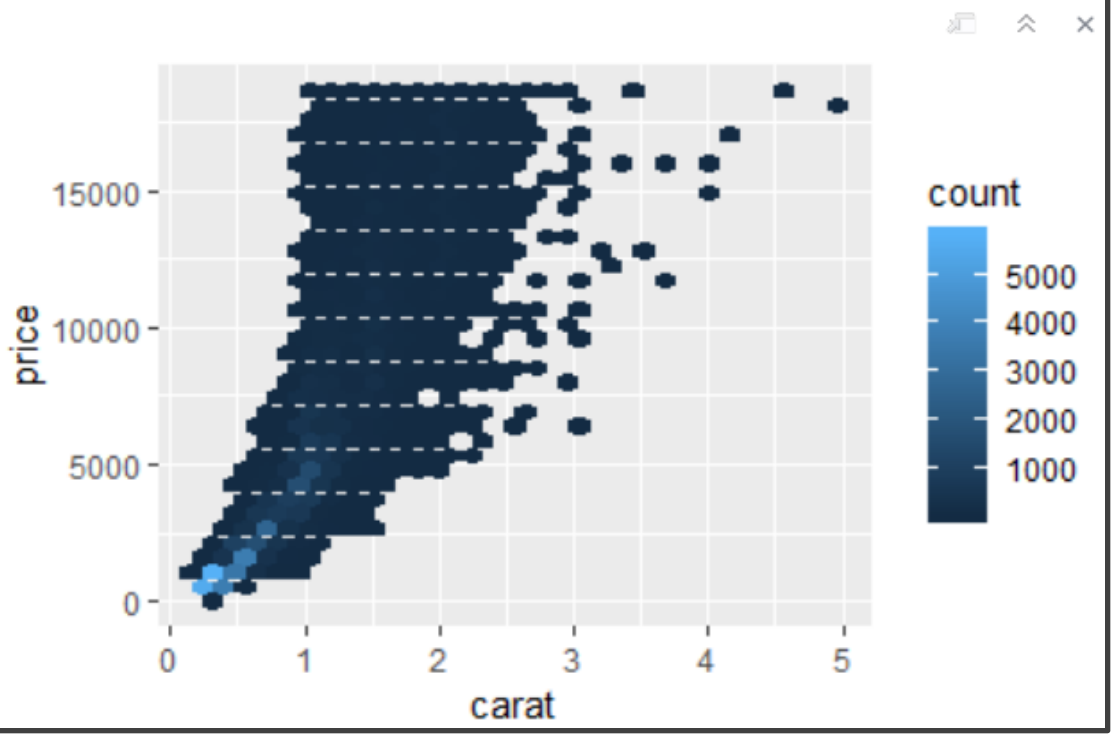
```
ggplot(data = diamonds) +
  geom_point(
    mapping = aes(x = carat, y = price),
    alpha = 1 / 100
  )
```



Visualize Summarize

- Continuous and Continuous

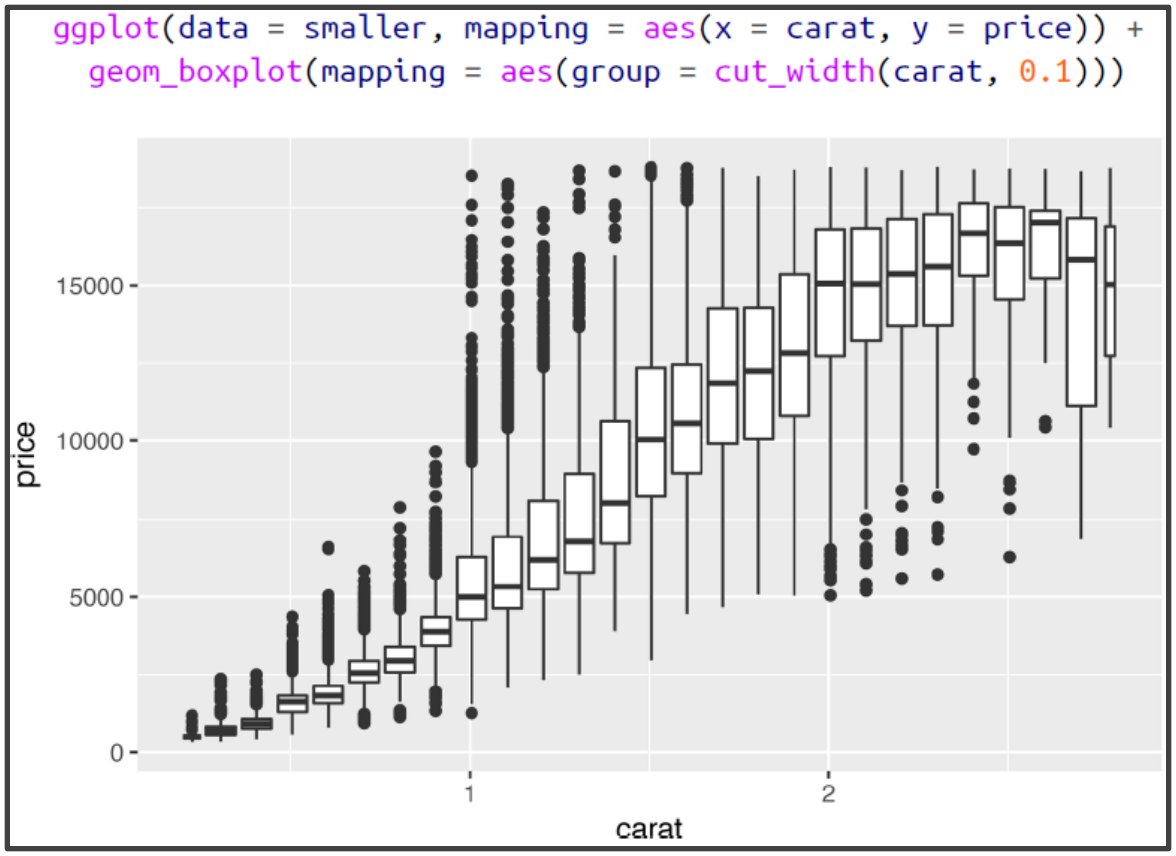
```r
```{r}
library(hexbin)
ggplot(data = diamonds) +
geom_hex(mapping = aes(x = carat, y = price))
```
```



Visualize Summarize

- Continuous and Continuous

```
ggplot(data = smaller, mapping = aes(x = carat, y = price)) +
  geom_boxplot(mapping = aes(group = cut_width(carat, 0.1)))
```



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Visualize Summarize

- Continuous and Continuous

```
ggplot(data = smaller, mapping = aes(x = carat, y = price)) +
  geom_boxplot(mapping = aes(group = cut_number(carat, 20)))
```

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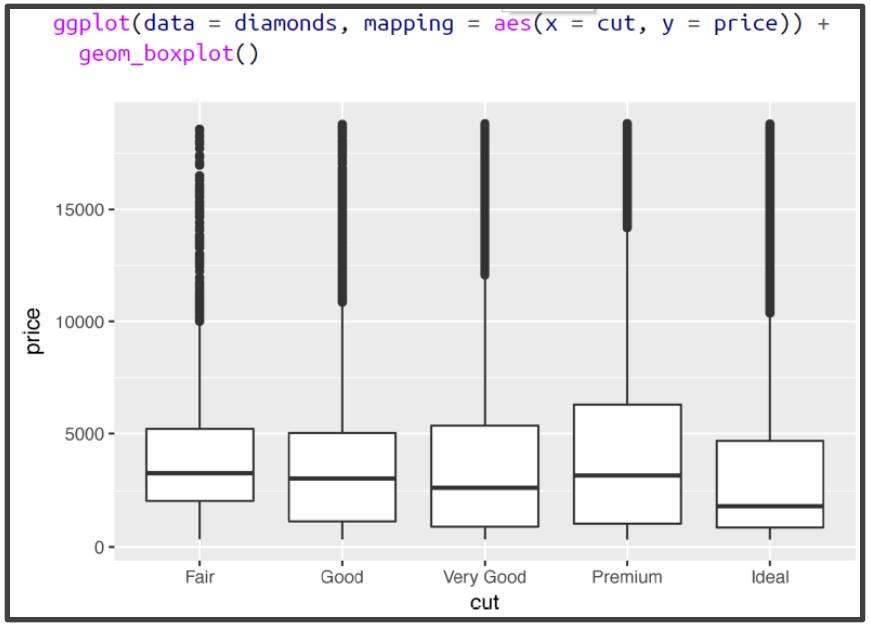
EDA Purpose

- Purpose of Asking Questions and Exploring Those Questions Using Visualizations and Summaries is to Spot Patterns

- Ask Yourself:
  - Is it Coincidence?
  - How Strong is the Relationship?
  - What Variables May Be Confounding?
  - Do Subgroups Cause the Relationship to Change?
  - How Can You Model the Pattern?

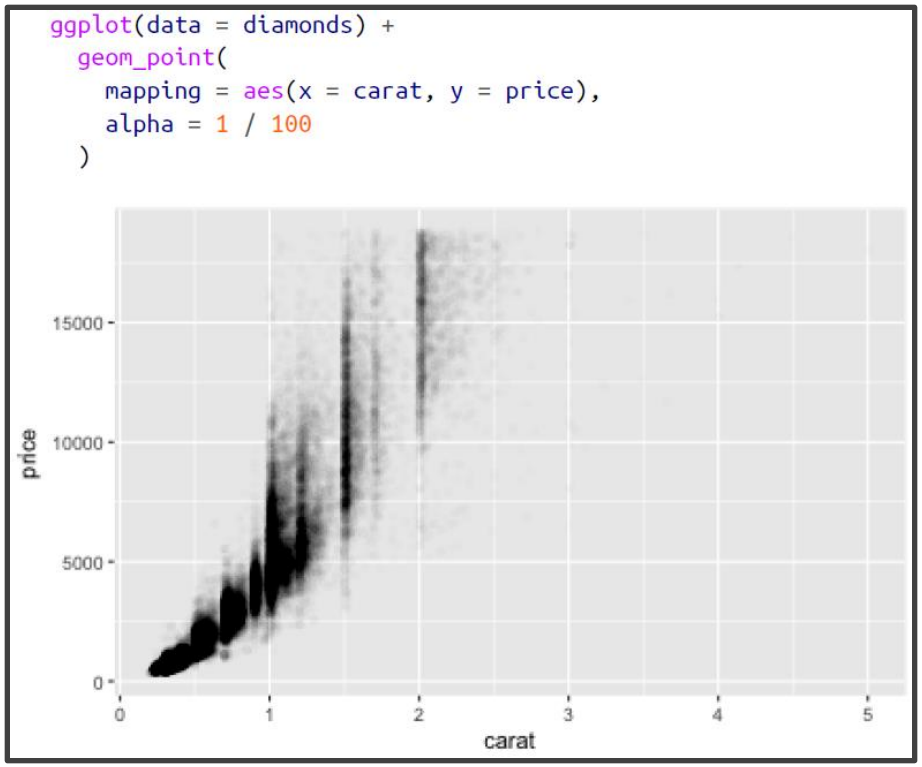
Findings

```
ggplot(data = diamonds, mapping = aes(x = cut, y = price)) +
  geom_boxplot()
```



- Negative relationship between cut and price

```
ggplot(data = diamonds) +
  geom_point(
    mapping = aes(x = carat, y = price),
    alpha = 1 / 100
  )
```



- Positive relationship between size and price

Question

What is the relationship between

the size of the 

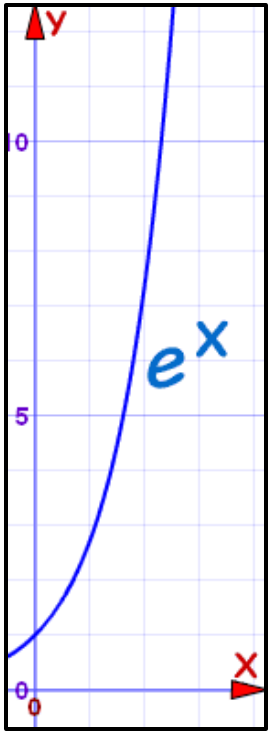
and

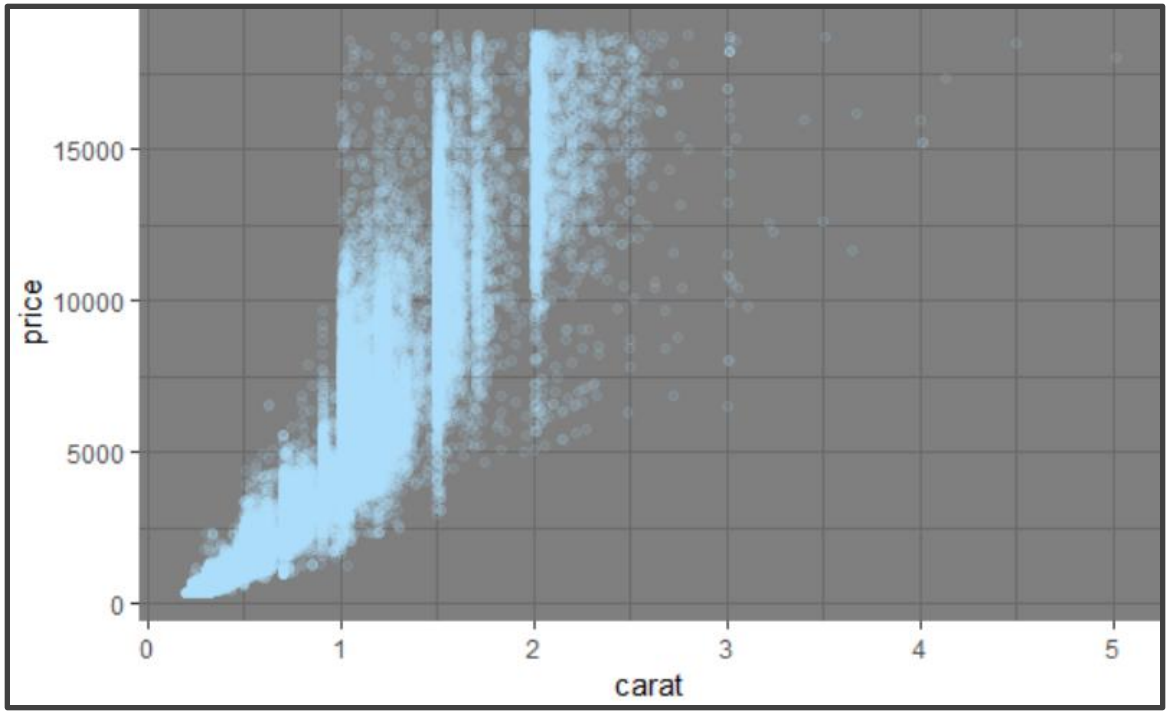
the price of the  ?

Visualize Summarize

```r
diamonds %>%
  summarize(n=n(),avgprice=mean(price),sdprice=sd(price),
            avgcarat=mean(carat),sdcarat=sd(carat),
            correlation=cor(price,carat))
```

n <int>	avgprice <dbl>	sdprice <dbl>	avgcarat <dbl>	sdcarat <dbl>	correlation <dbl>
53940	3932.8	3989.44	0.7979397	0.4740112	0.9215913





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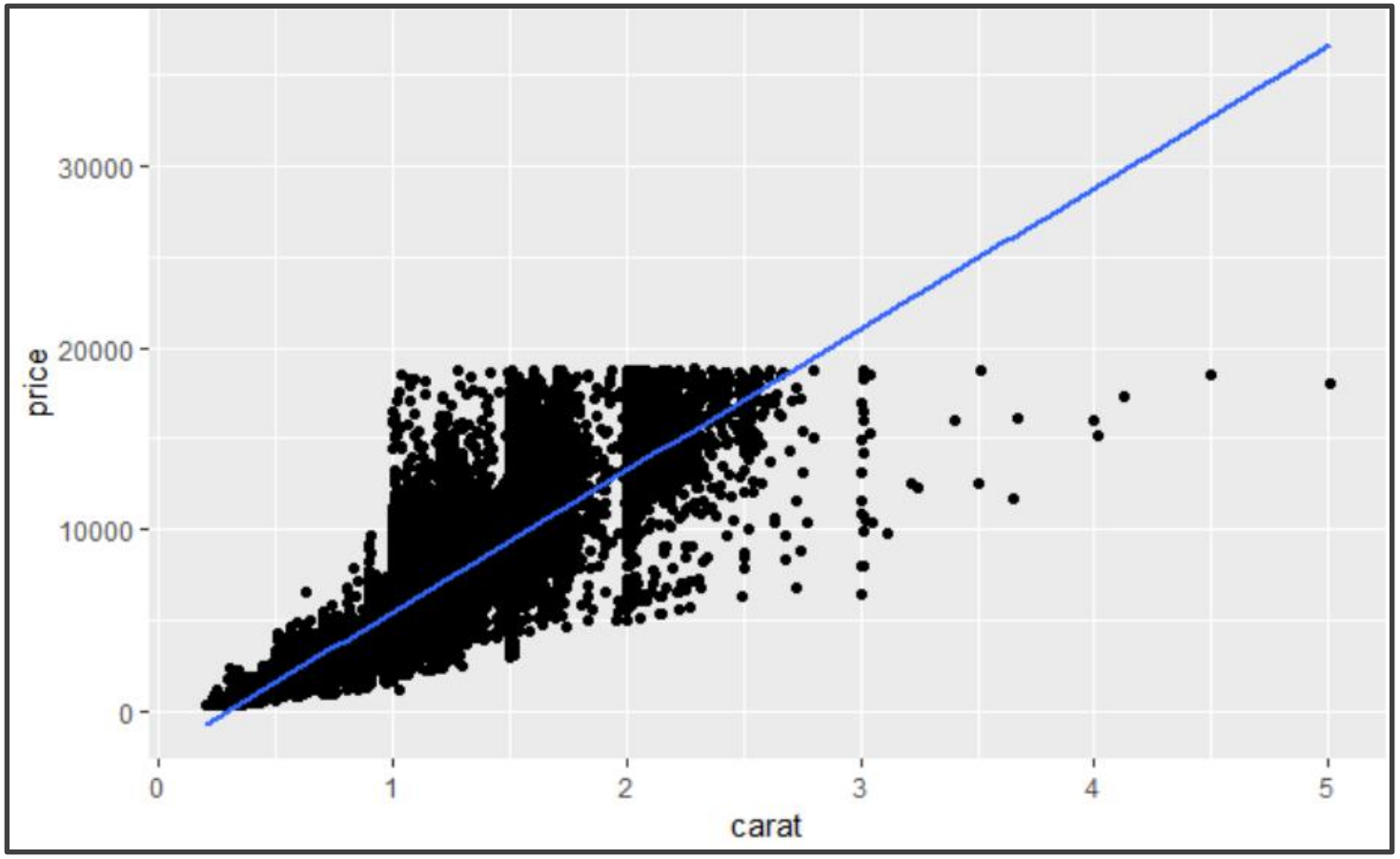
Question

- Refined Questions
  - Is the Observed Relationship Spurious?
  - Can I Represent the Relationship Using a Linear Model?
  - Should I Use an Exponential Model to Represent the Relationship?
  - Does Another Variable Exist to Explain the Drastic Change in Spread?

Model

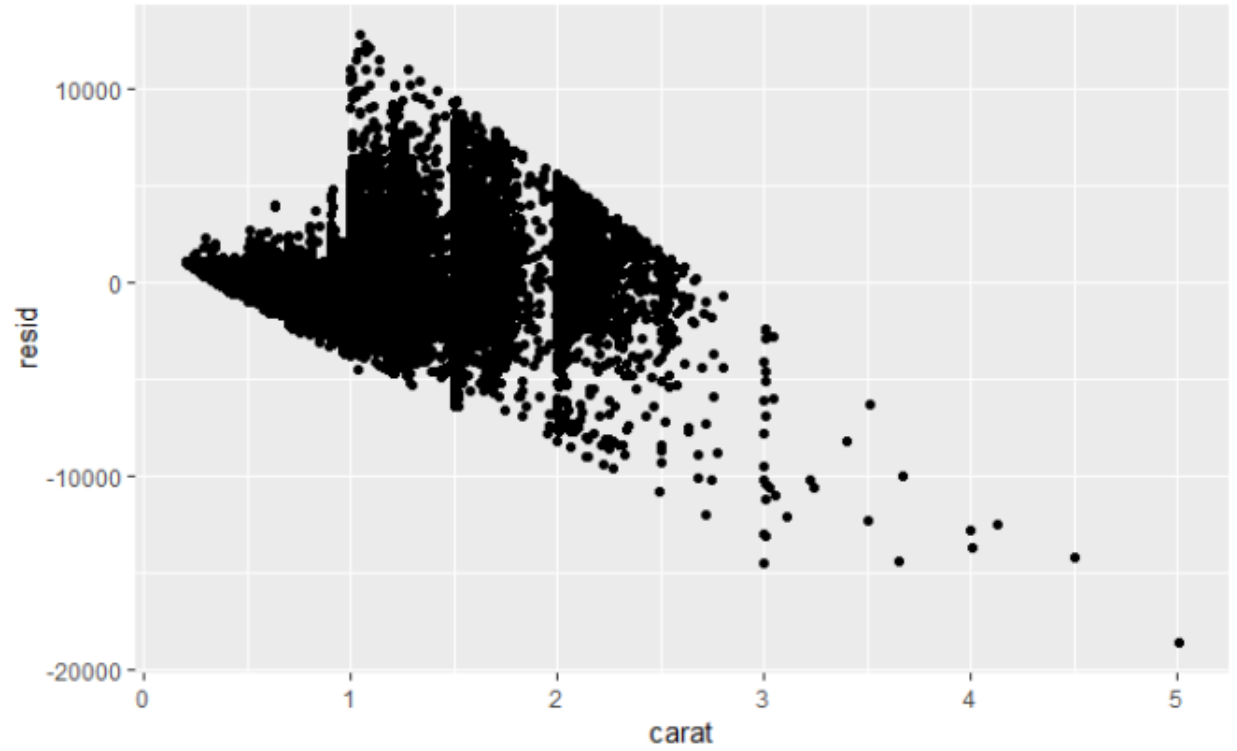
- Linear Model



Model

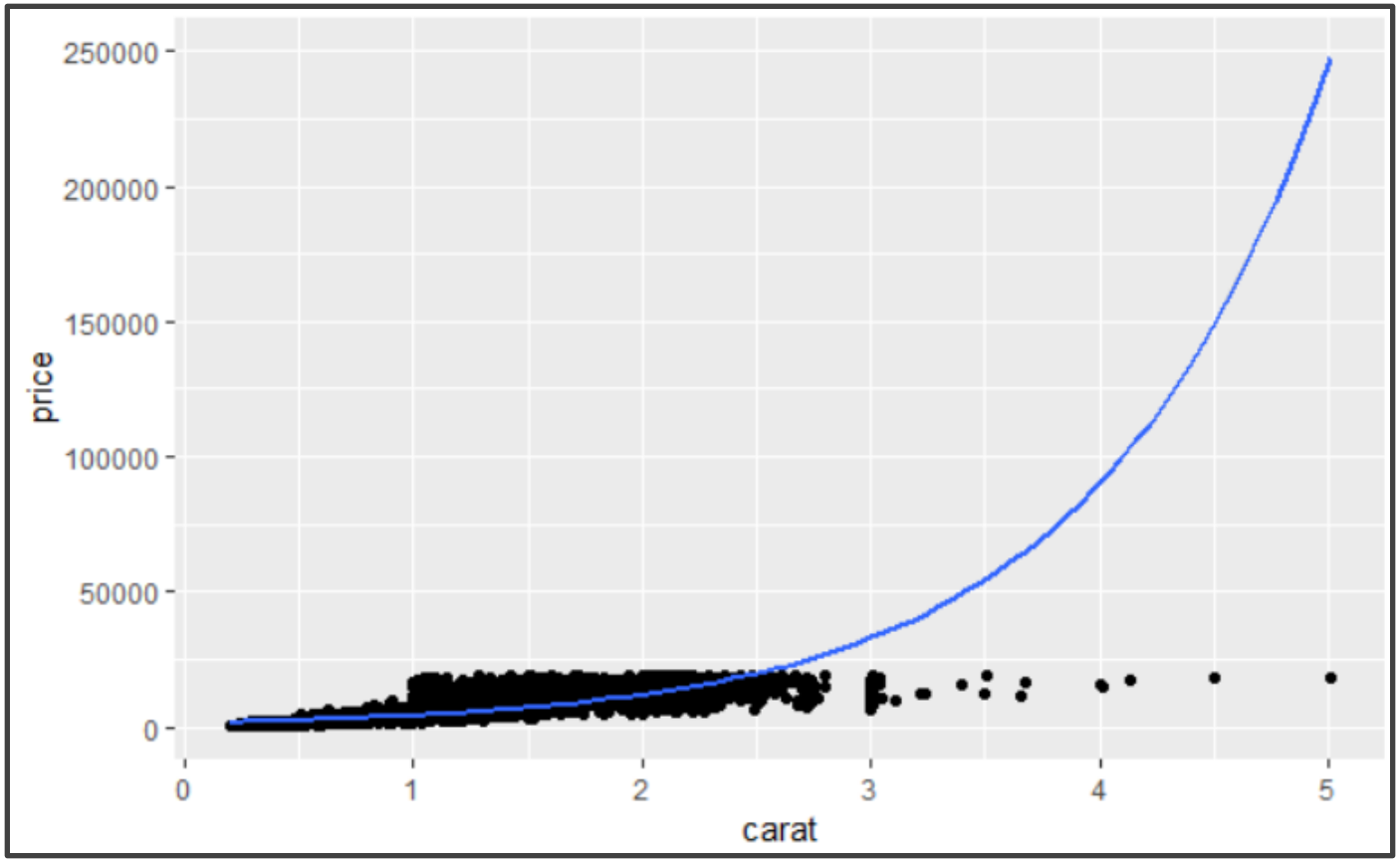
- Linear Model

```r
library(modelr)
lin.mod=lm(price~carat,data=diamonds)
diamonds.lin.resid = diamonds %>%
  add_residuals(mod=lin.mod)
ggplot(data=diamonds.lin.resid) +
  geom_point(aes(x=carat,y=resid))
```



Model

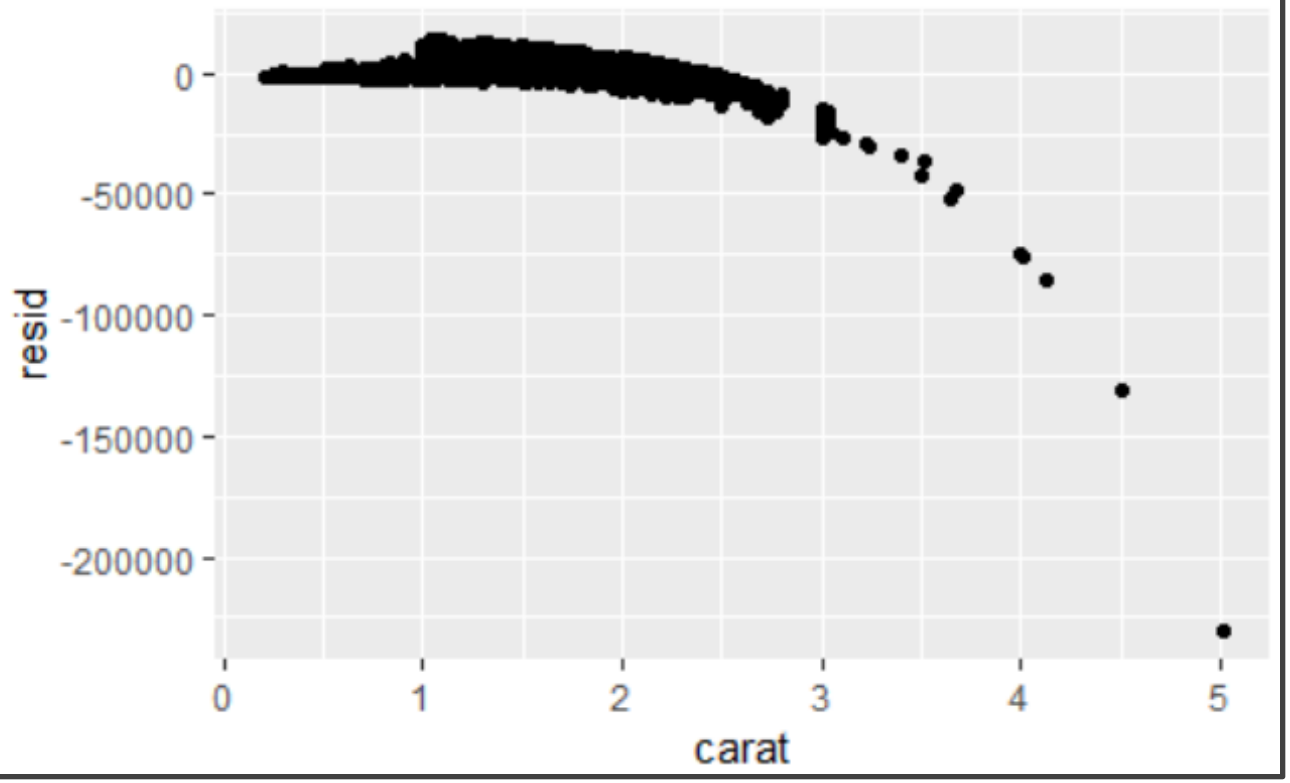
- Exponential Model



Model

- Exponential Model

```r
exp.mod=lm(price~exp(carat),data=diamonds)
diamonds.exp.resid = diamonds %>%
  add_residuals(mod=exp.mod)
ggplot(data=diamonds.exp.resid) +
  geom_point(aes(x=carat,y=resid))
```



Model

- Exponential Model

```r
exp.mod=lm(price~exp(carat),data=diamonds)
diamonds.exp.resid = diamonds %>%
  add_residuals(mod=exp.mod)
ggplot(data=diamonds.exp.resid) +
  geom_point(aes(x=carat,y=resid)) +
  coord_cartesian(xlim=c(0,2.5),
                  ylim=c(-25000,25000))
```