STOR 320 Exploratory Data Analysis

Lecture 7

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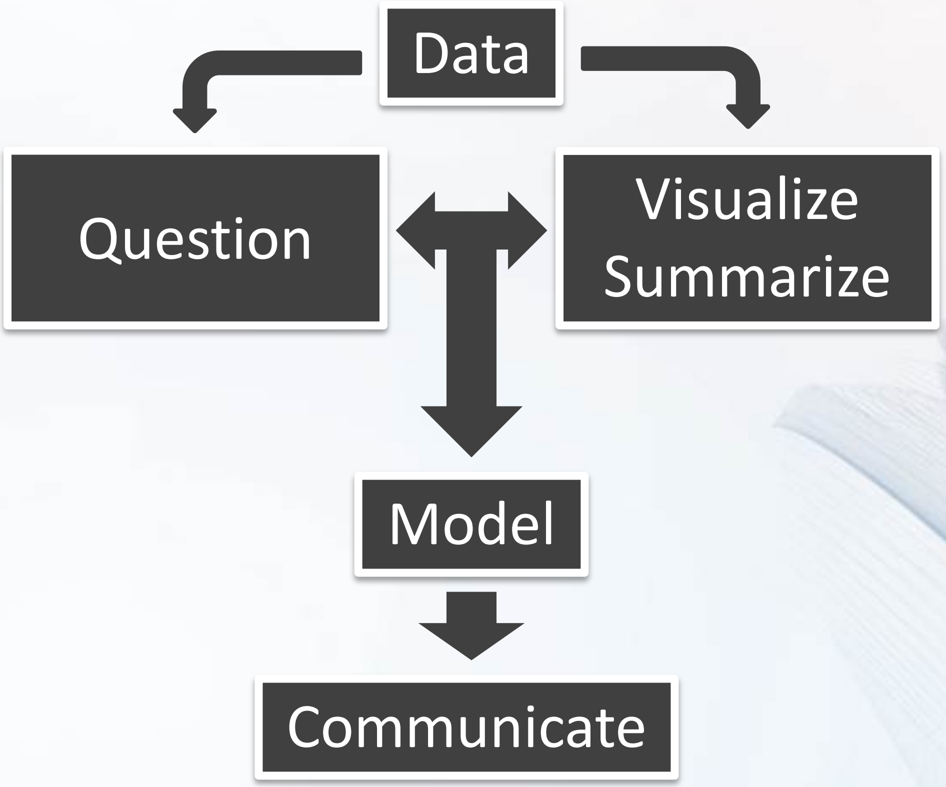
EDA Definition

- Read Chapter 5
- Know the Process
- Respect the Process

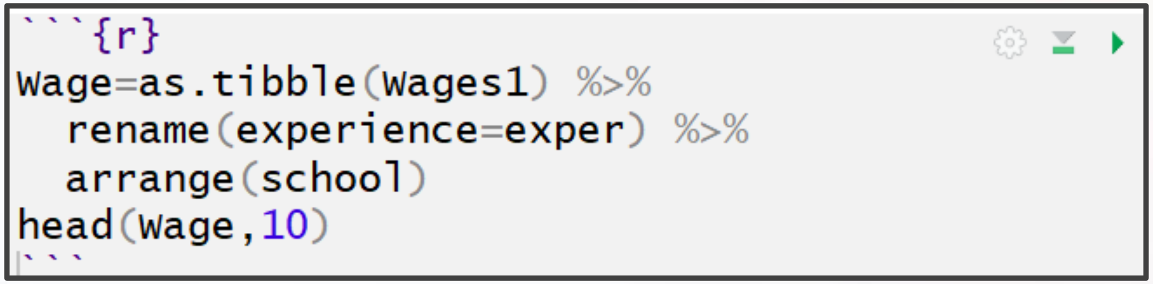


Question

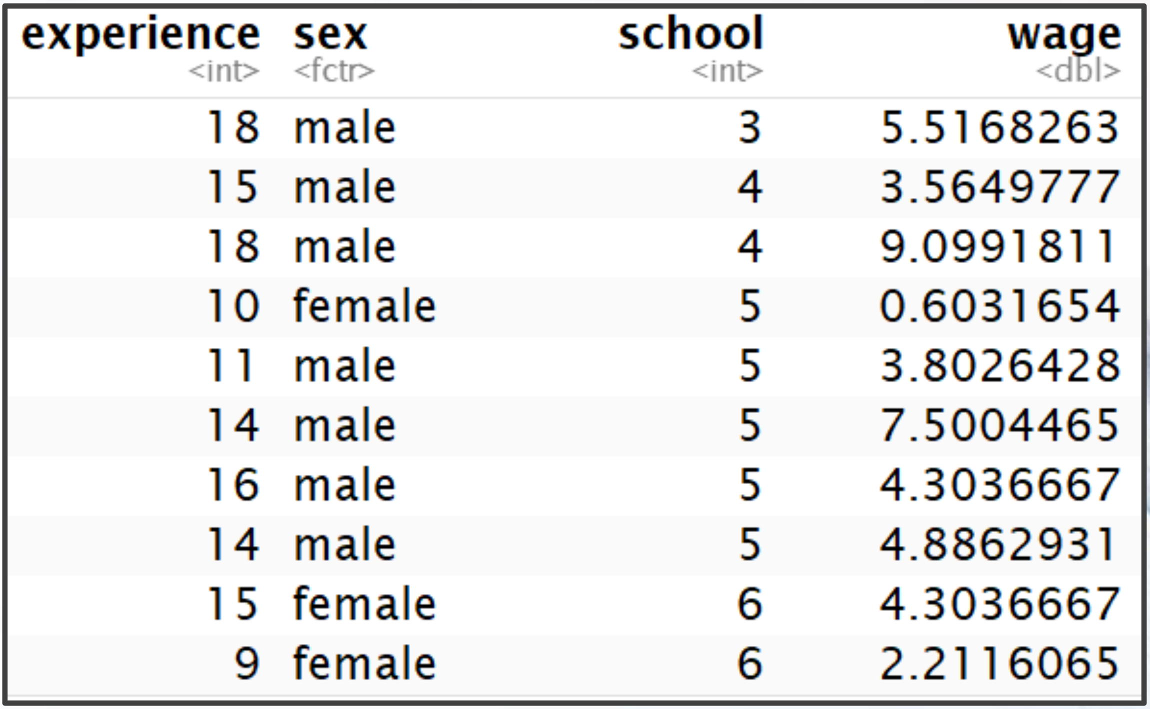
- Think Creatively
- Quantity and Quality
- General:
  - What type of variation occurs **within** my variables?
  - What type of covariation occurs **between** my variables?

Data

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



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



experience <int>	sex <fctr>	school <int>	wage <dbl>
18	male	3	5.5168263
15	male	4	3.5649777
18	male	4	9.0991811
10	female	5	0.6031654
11	male	5	3.8026428
14	male	5	7.5004465
16	male	5	4.3036667
14	male	5	4.8862931
15	female	6	4.3036667
9	female	6	2.2116065

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

Question

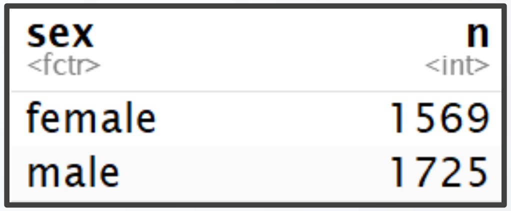
- Variation
  - Variable = Quantity, Quality, or Property You Can Measure
  - Reason: Values Tend to “Vary”
  - Example: Random
    - Categorical:
      - Sex
    - Numerical:
      - Wage
      - Experience
      - School

Question

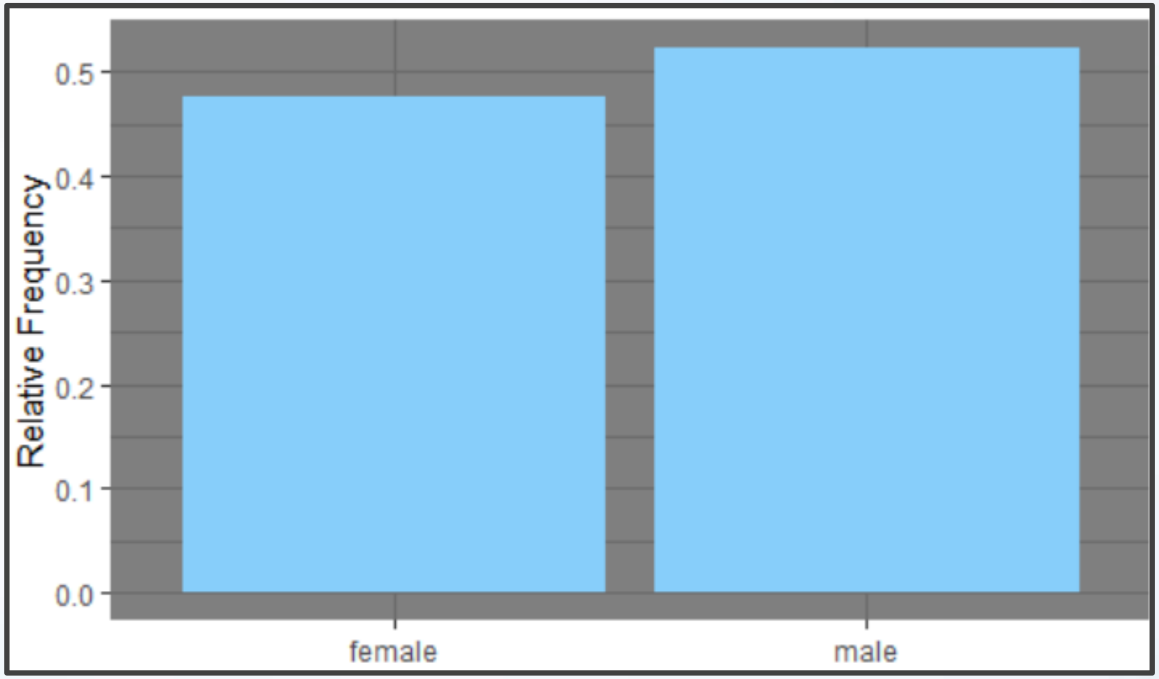
- Initial Questions
  - Example:
    - What did the Workforce Look Like in Terms of Sex?
    - How Spread Out Were Wages?
    - Where is the Middle 50% of the Sample in Regards to Years of Schooling?

Visualize Summarize

- Variation Visualized
  - Example: Wages
    - Categorical: Sex

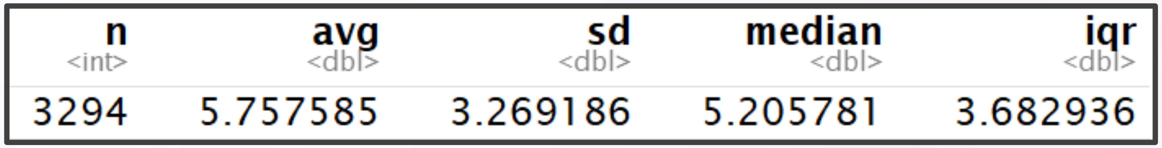


sex	n
<fctr>	<int>
female	1569
male	1725

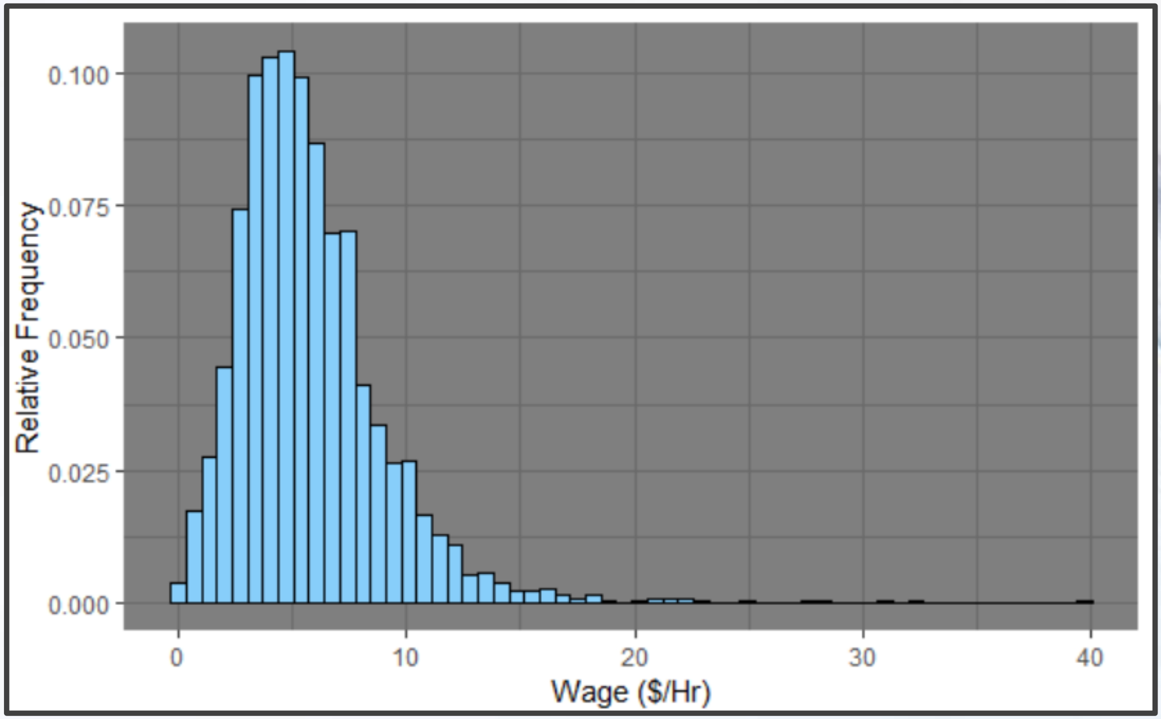


Visualize Summarize

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

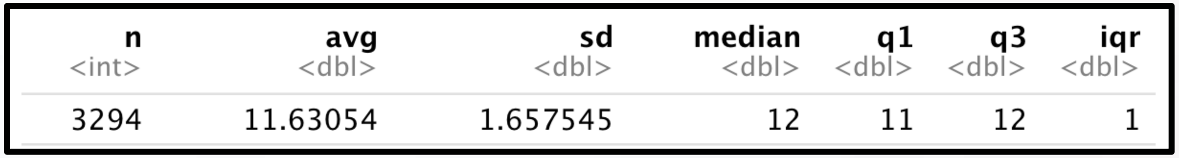


n	avg	sd	median	iqr
<int>	<dbl>	<dbl>	<dbl>	<dbl>
3294	5.757585	3.269186	5.205781	3.682936

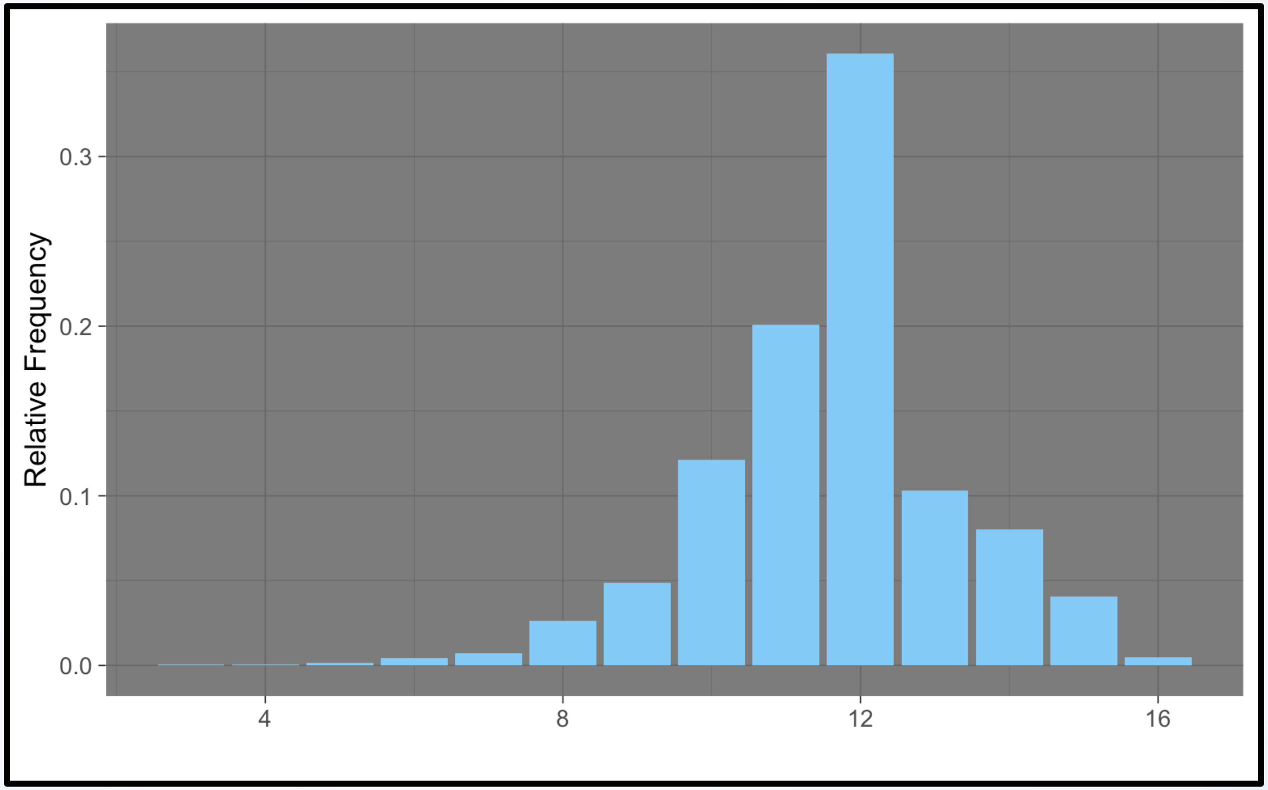


Visualize Summarize

- Variation Visualized
  - Example: Wages
    - Numerical: School



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

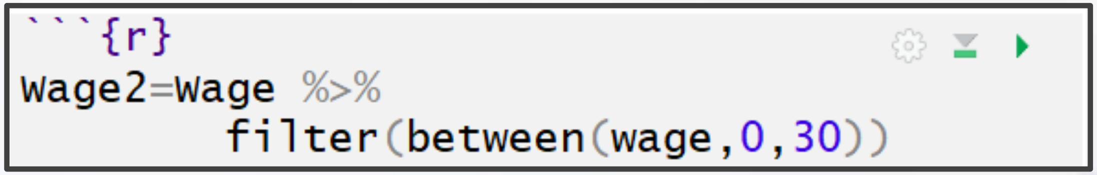


Unusual Values

- 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

Unusual Values

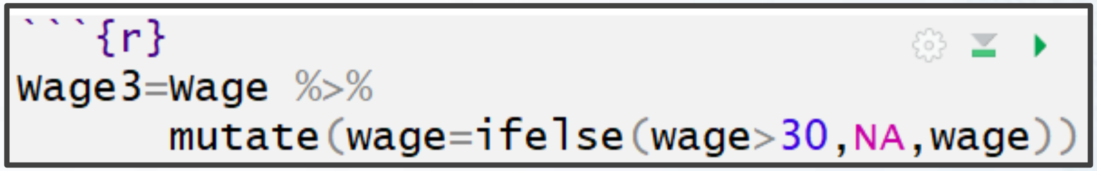
- Example: Wages
  - Few People Above 30 $/Hr
  - Drop Entire Row



~~~
```{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

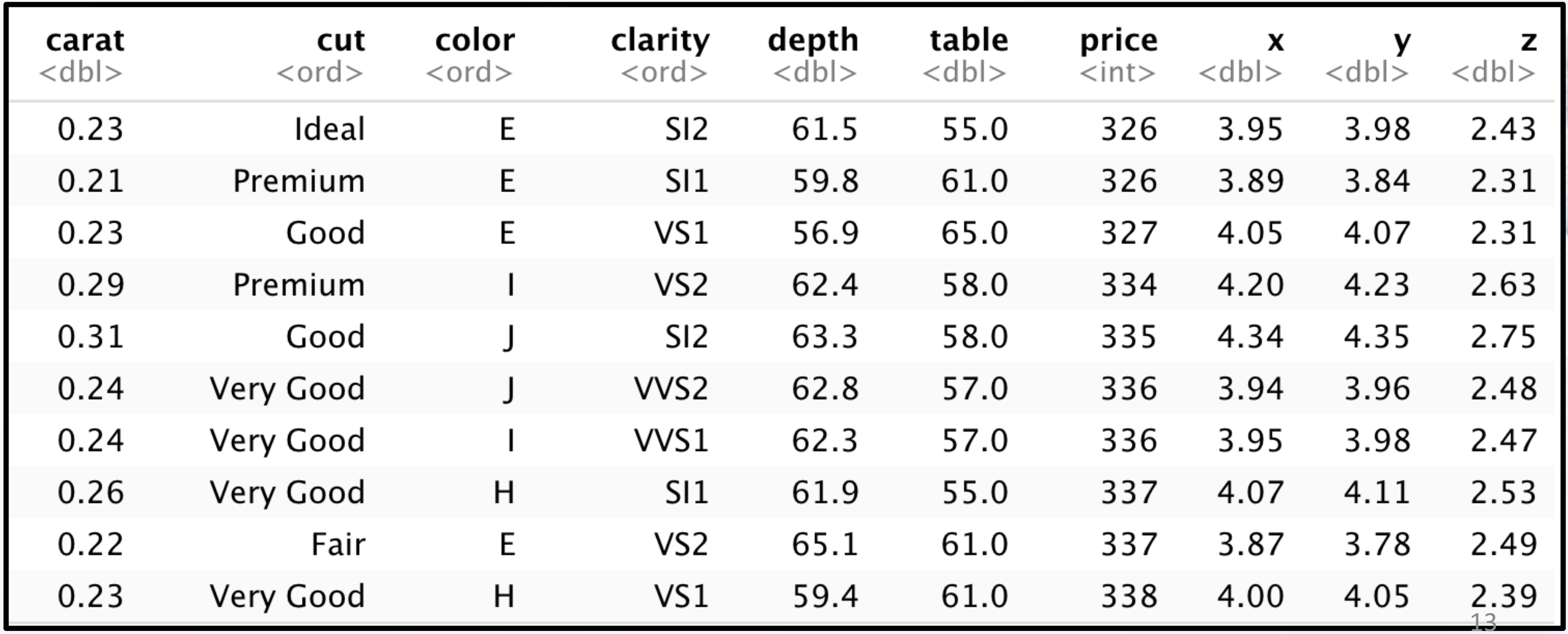
Question

- 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



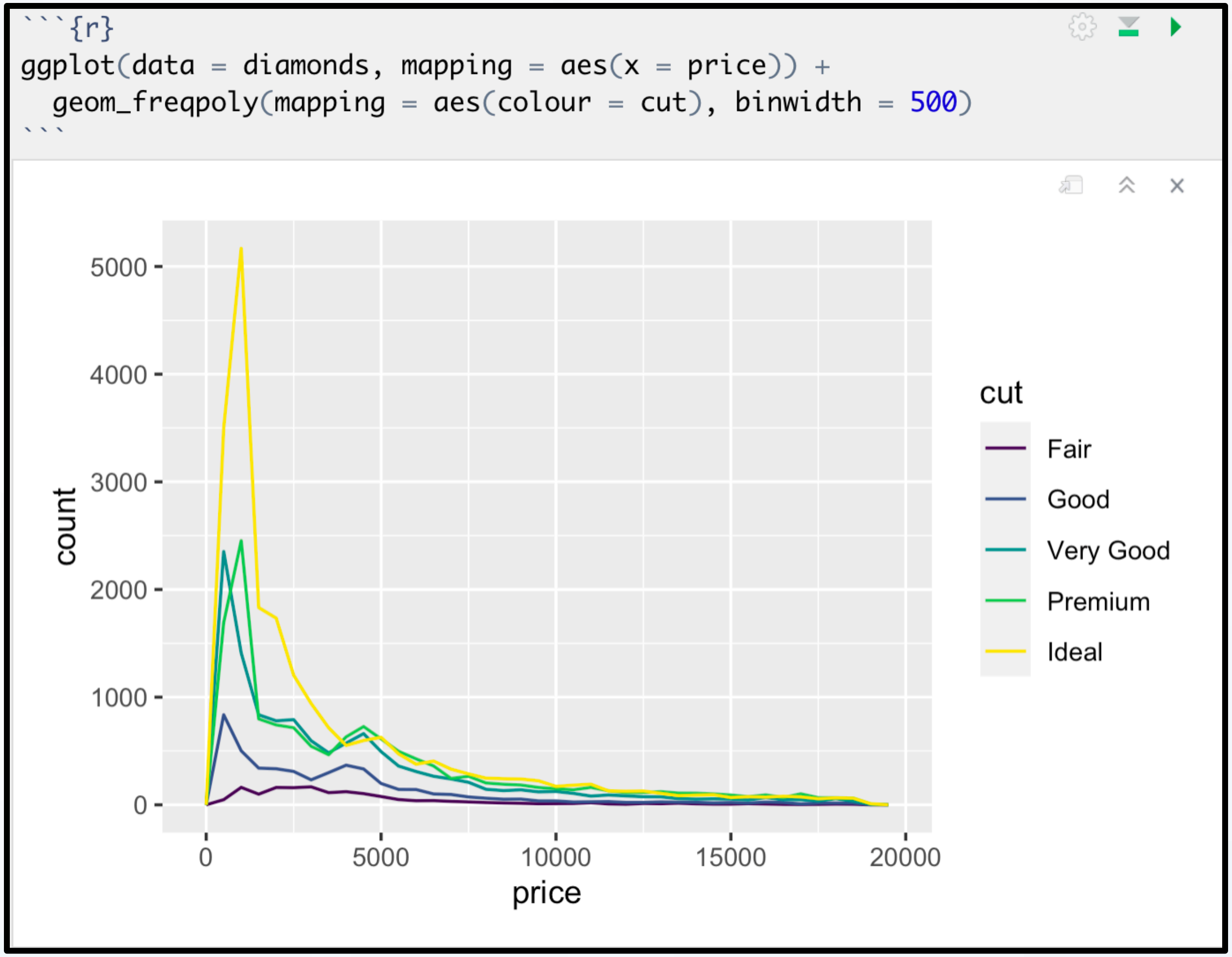
carat	cut	color	clarity	depth	table	price	x	y	z
<dbl>	<ord>	<ord>	<ord>	<dbl>	<dbl>	<int>	<dbl>	<dbl>	<dbl>
0.23	Ideal	E	SI2	61.5	55.0	326	3.95	3.98	2.43
0.21	Premium	E	SI1	59.8	61.0	326	3.89	3.84	2.31
0.23	Good	E	VS1	56.9	65.0	327	4.05	4.07	2.31
0.29	Premium	I	VS2	62.4	58.0	334	4.20	4.23	2.63
0.31	Good	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

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

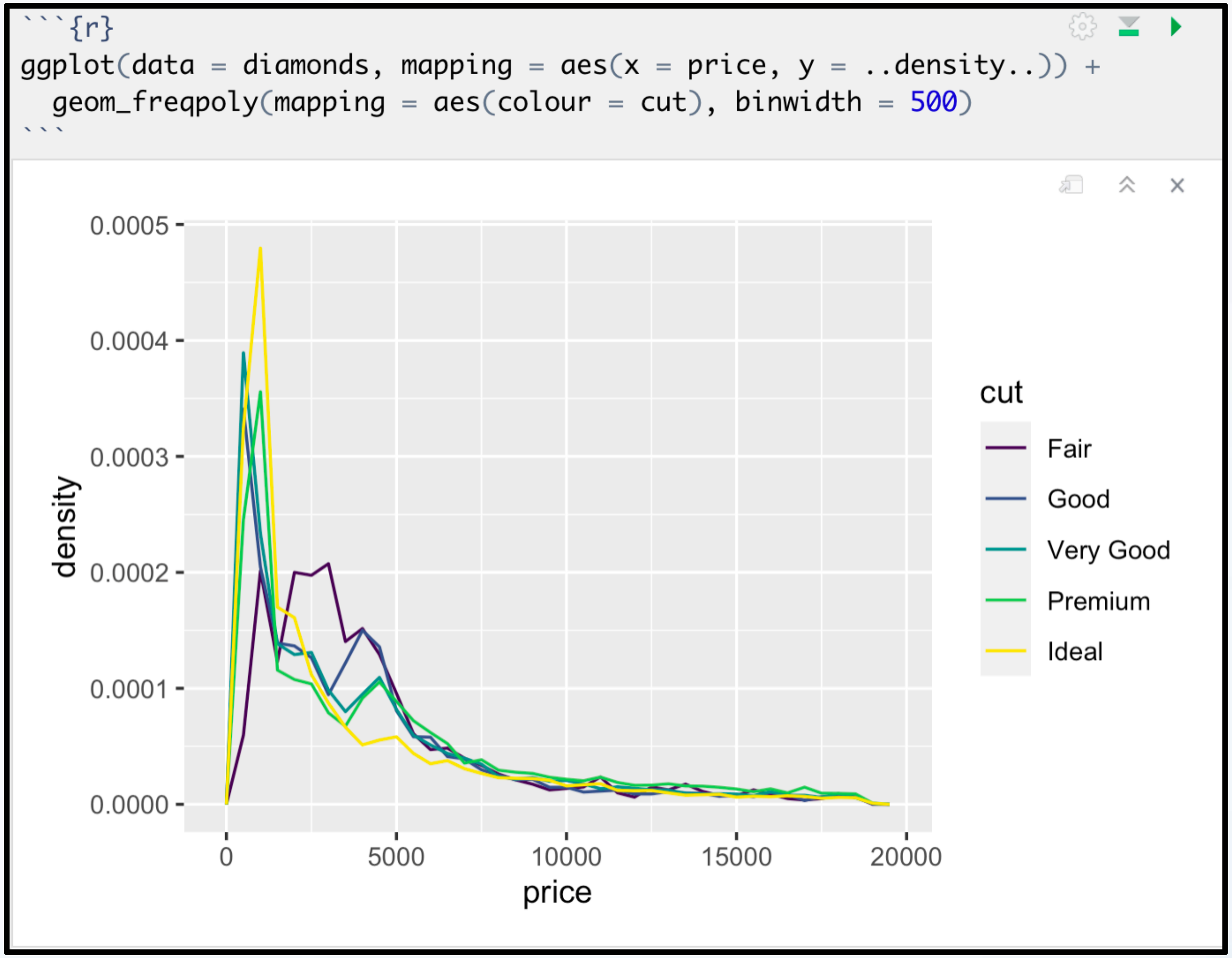
- Categorical and Continuous



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

Visualize Summarize

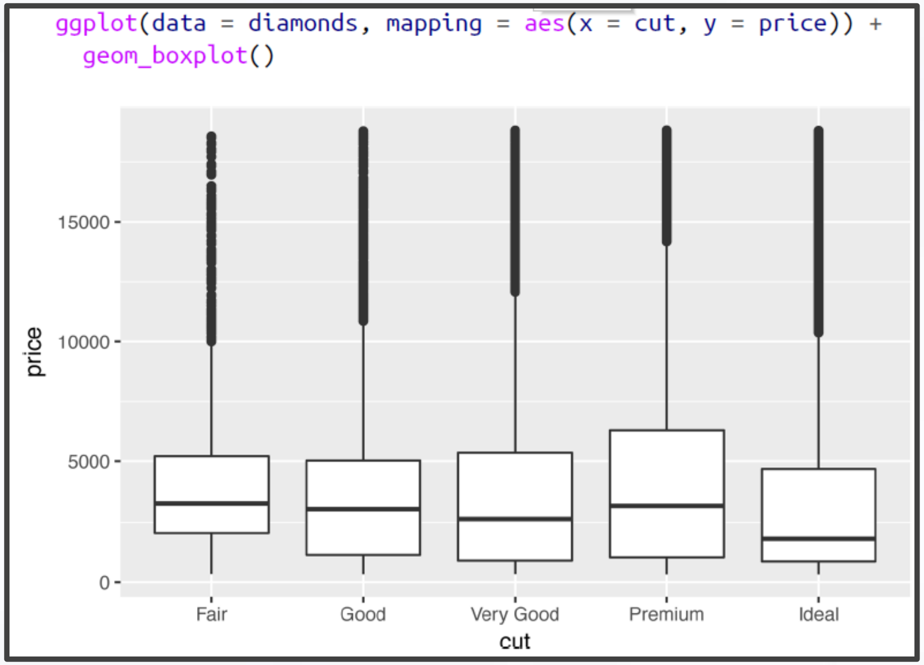
- Categorical and Continuous: density



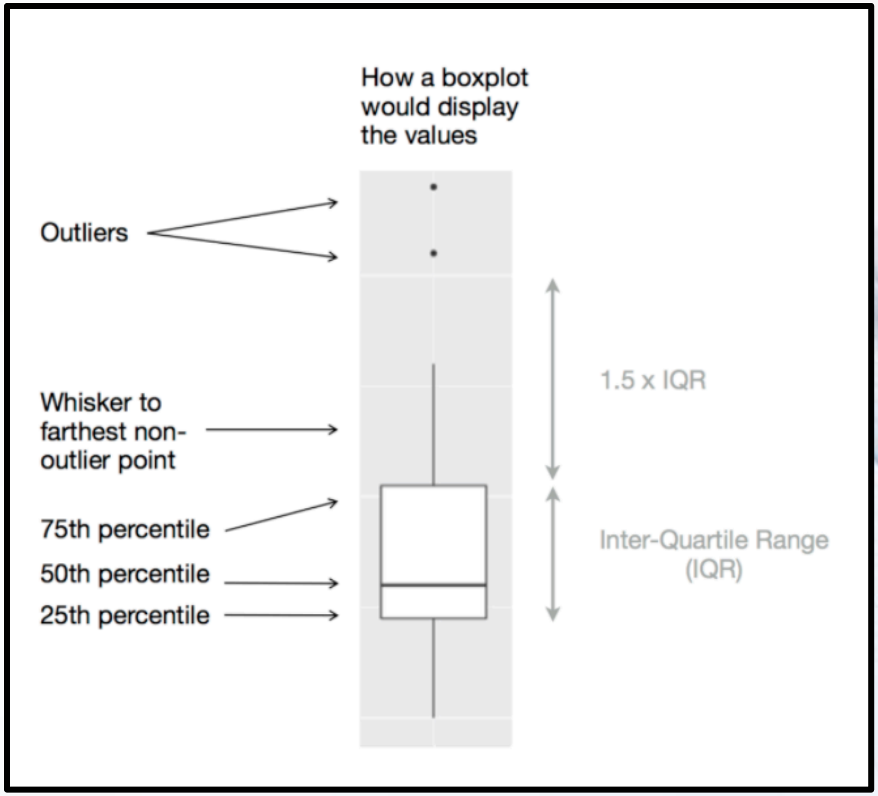
~~~
```{r}
ggplot(data = diamonds, mapping = aes(x = price, y = ..density..)) +
  geom_freqpoly(mapping = aes(colour = cut), binwidth = 500)
```
~~~

Visualize Summarize

- Categorical and Continuous



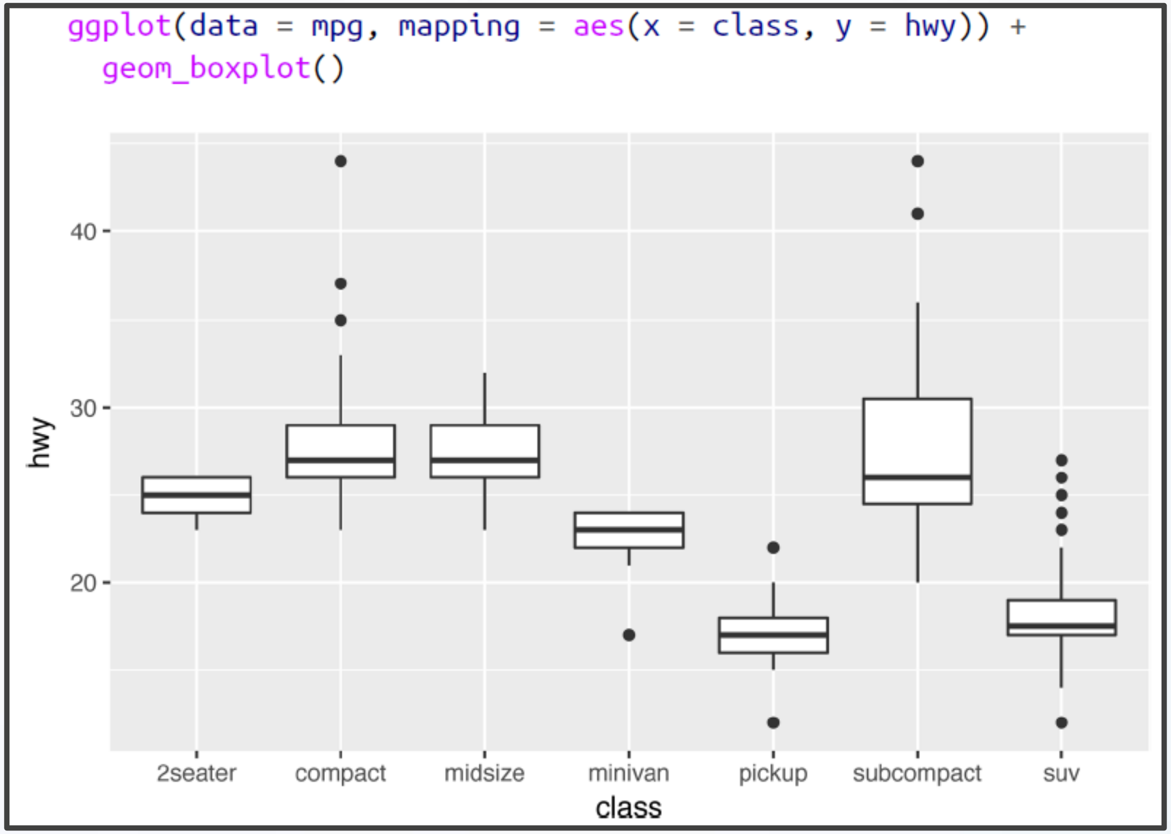
```
ggplot(data = diamonds, mapping = aes(x = cut, y = price)) +
  geom_boxplot()
```



How a boxplot would display the values
Outliers
Whisker to farthest non-outlier point
75th percentile
50th percentile
25th percentile
1.5 x IQR
Inter-Quartile Range (IQR)

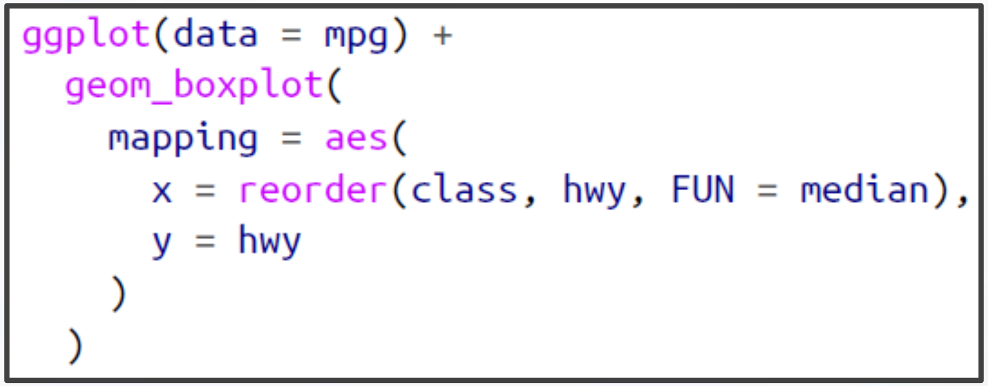
Visualize Summarize

- Categorical and Continuous

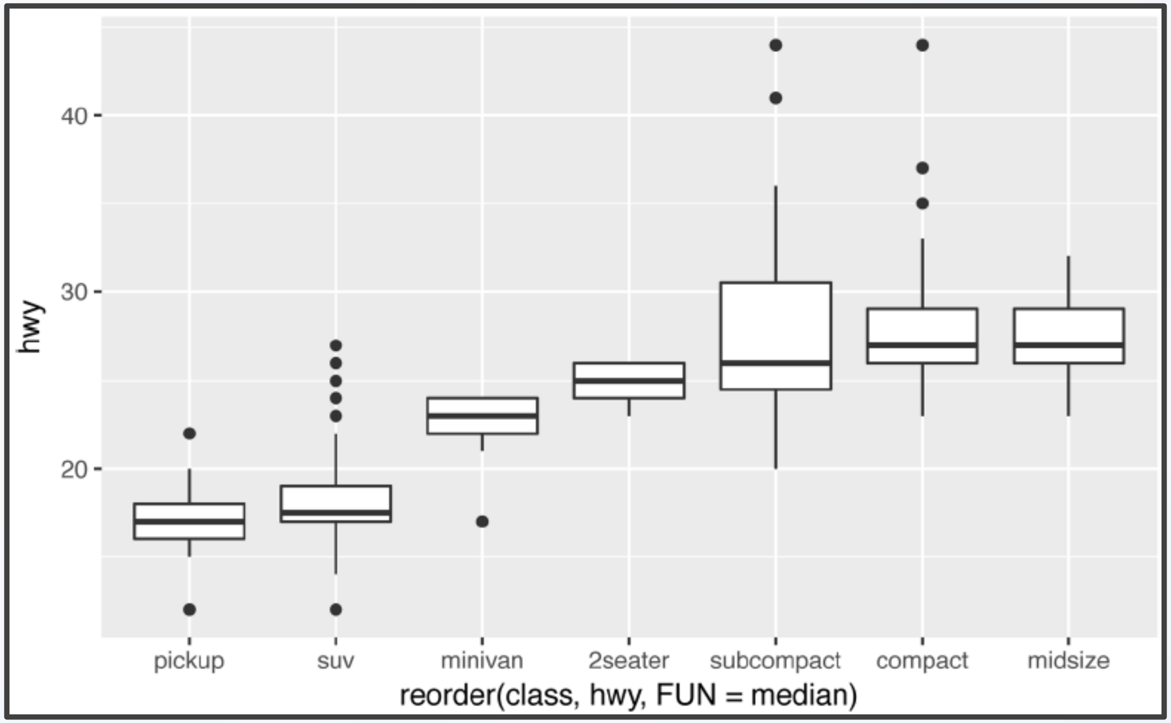


```
ggplot(data = mpg, mapping = aes(x = class, y = hwy)) +
  geom_boxplot()
```

- Categorical and Continuous

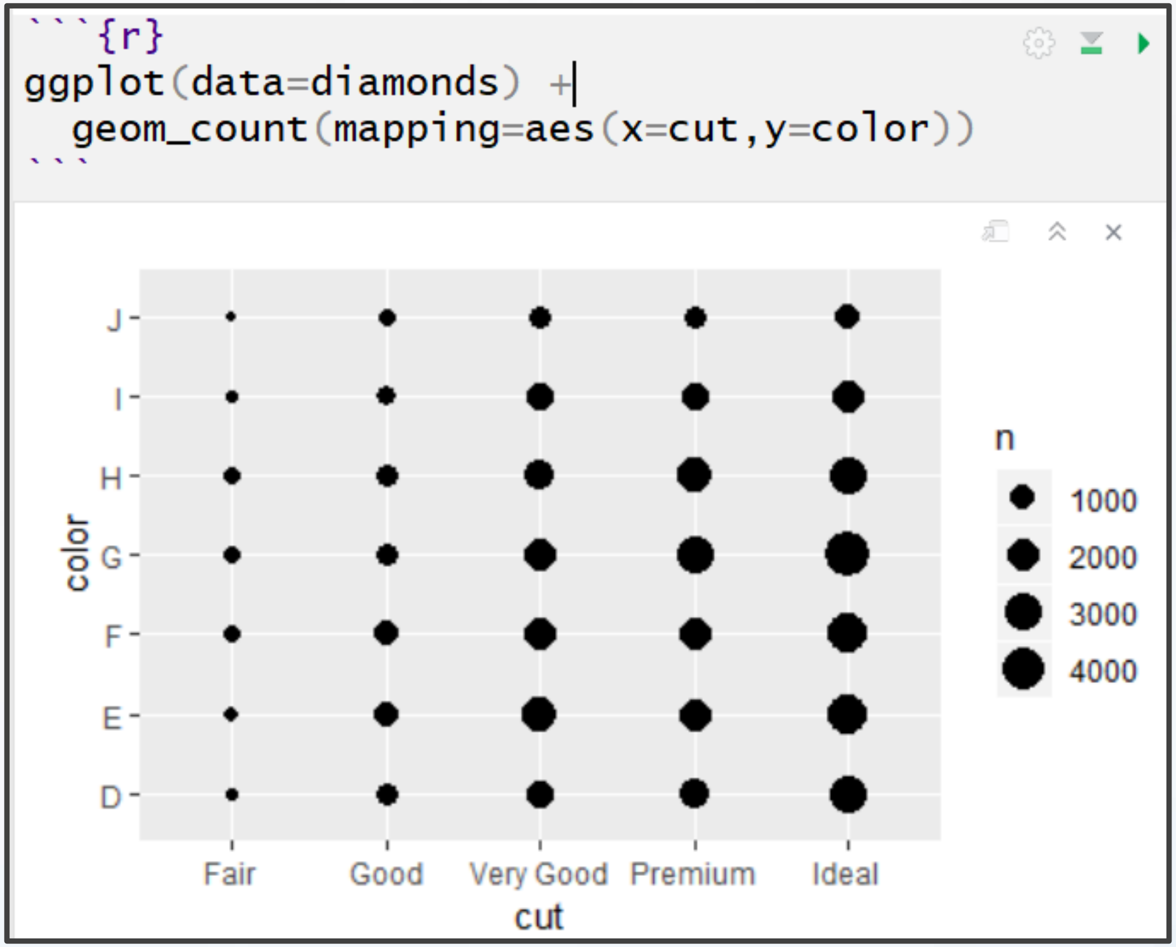


```
ggplot(data = mpg) +
  geom_boxplot(
    mapping = aes(
      x = reorder(class, hwy, FUN = median),
      y = hwy
    )
  )
```



Visualize Summarize

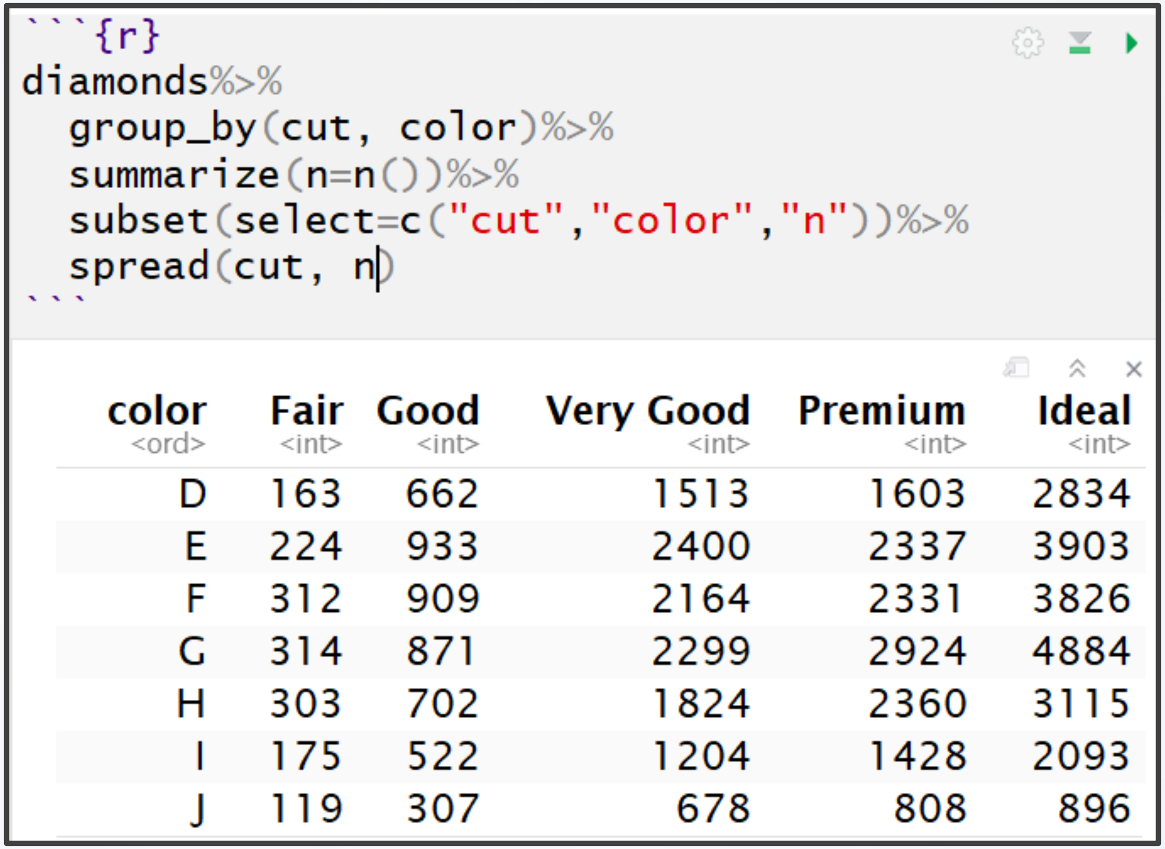
- Categorical and Categorical



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

Visualize Summarize

- Categorical and Categorical

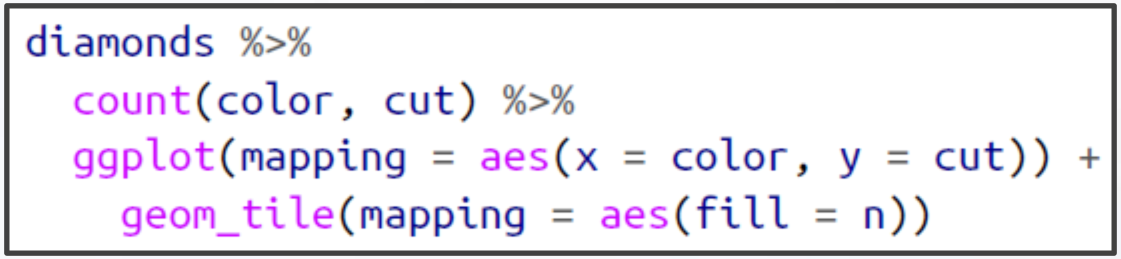


~~~
```{r}
diamonds%>%
  group_by(cut, color)%>%
  summarize(n=n())%>%
  subset(select=c("cut","color","n"))%>%
  spread(cut, n)
```
~~~

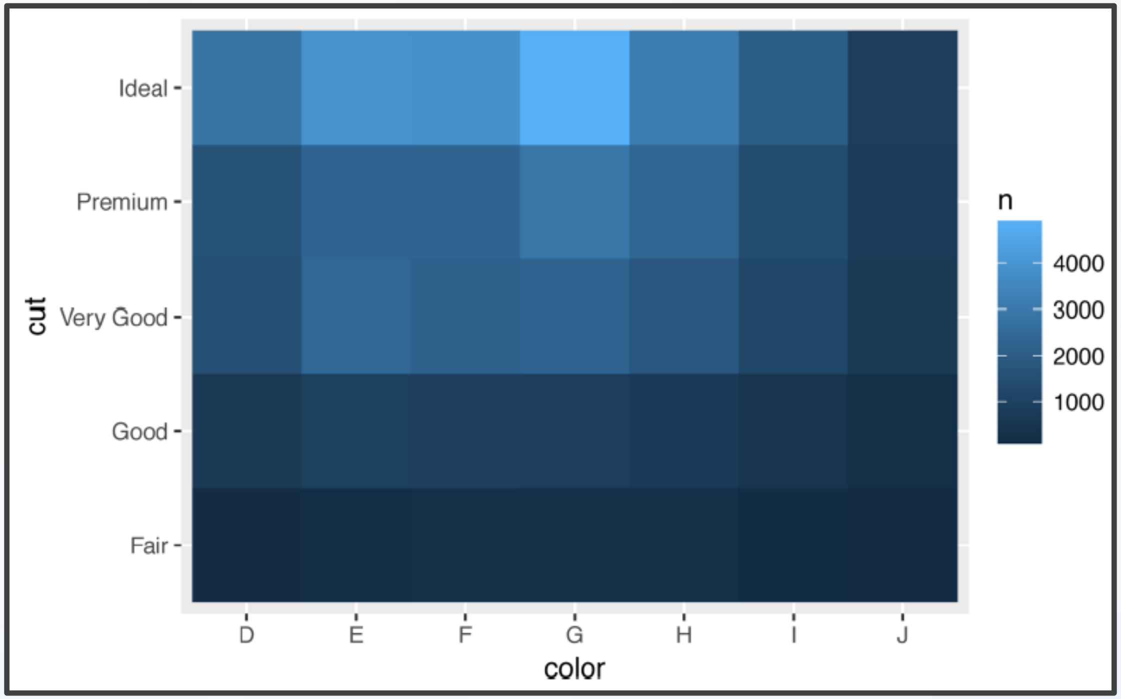
color <ord>	Fair <int>	Good <int>	Very Good <int>	Premium <int>	Ideal <int>
D	163	662	1513	1603	2834
E	224	933	2400	2337	3903
F	312	909	2164	2331	3826
G	314	871	2299	2924	4884
H	303	702	1824	2360	3115
I	175	522	1204	1428	2093
J	119	307	678	808	896

Visualize Summarize

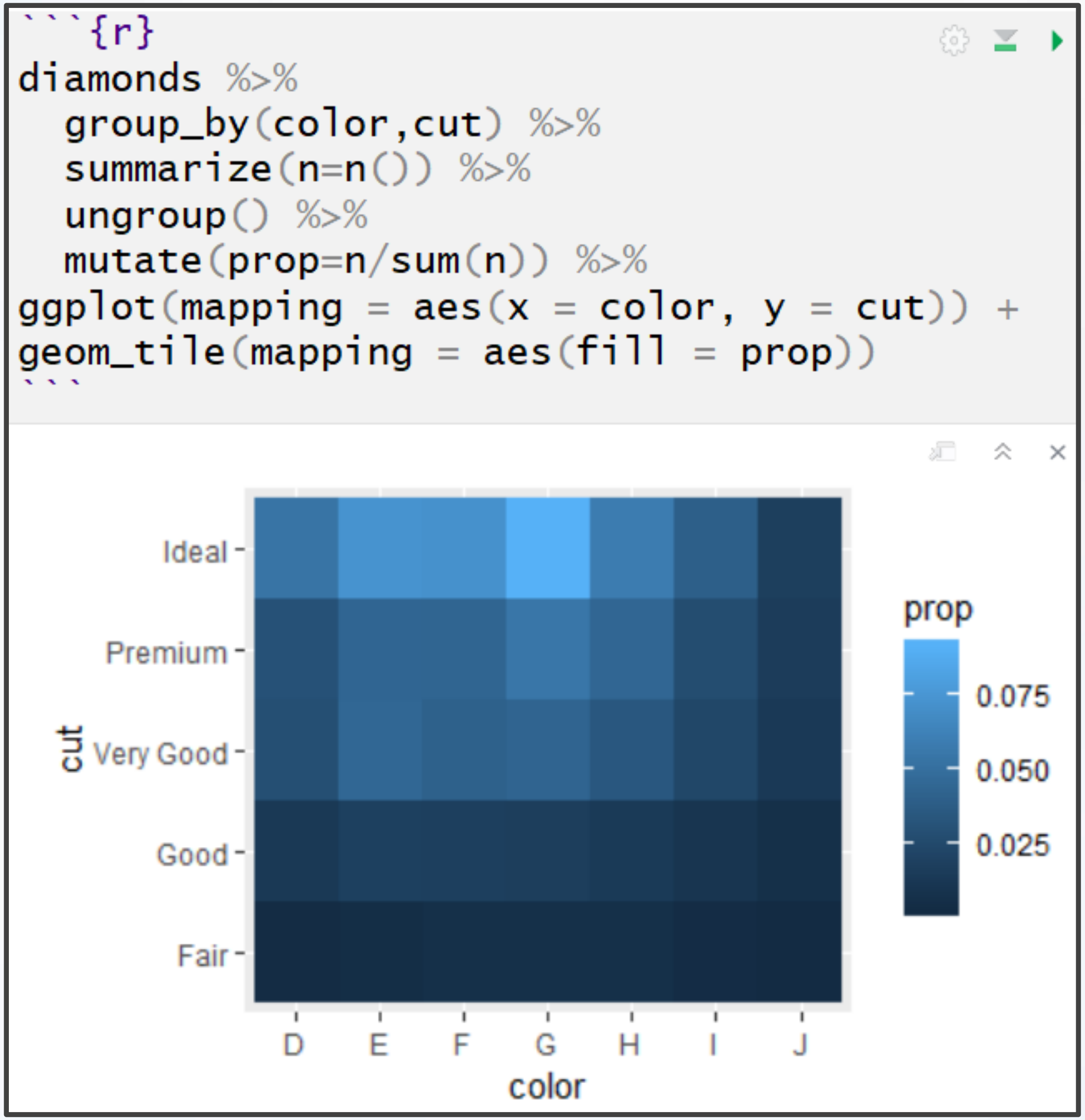
- Categorical and Categorical



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



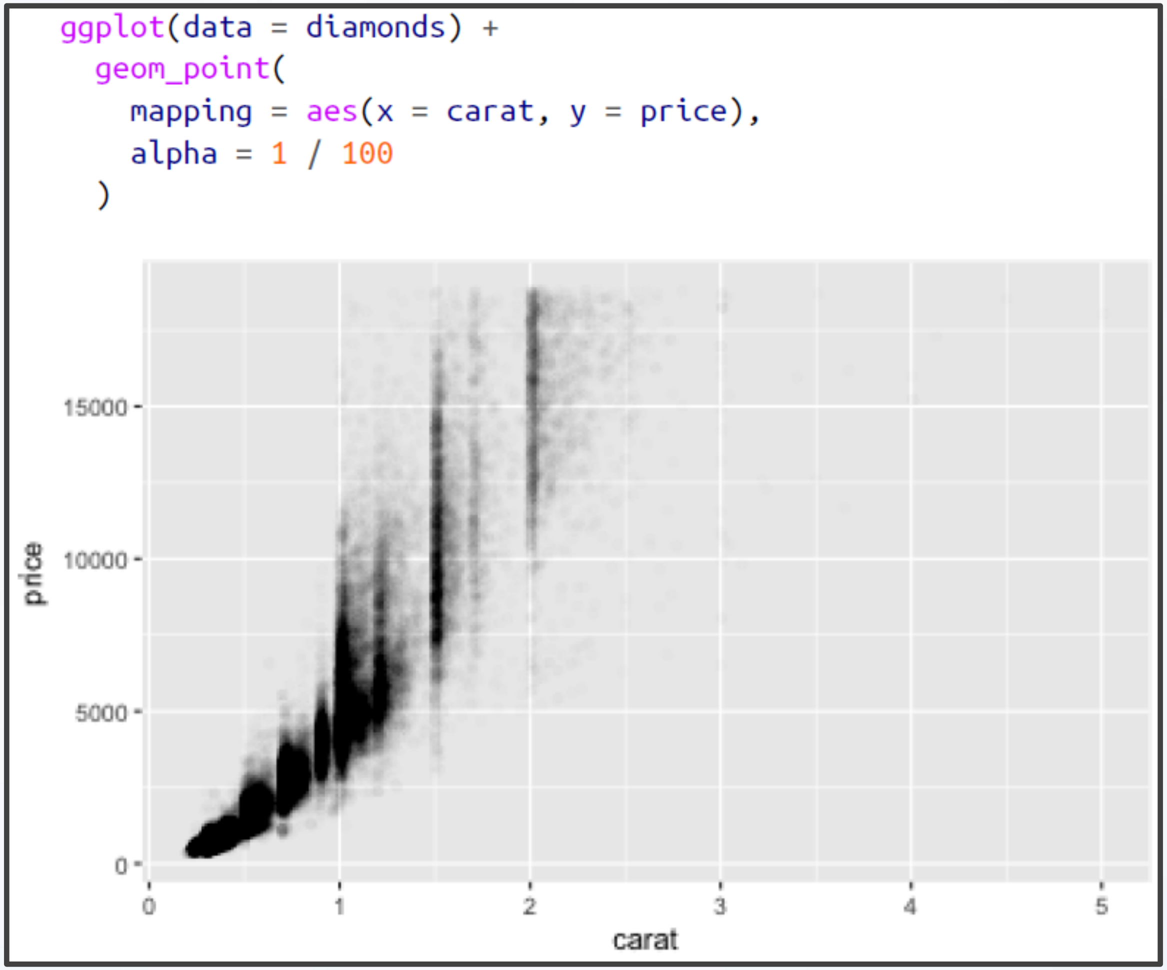
- Categorical and Categorical



~~~
```{r}
diamonds %>%
  group_by(color,cut) %>%
  summarize(n=n()) %>%
  ungroup() %>%
  mutate(prop=n/sum(n)) %>%
ggplot(mapping = aes(x = color, y = cut)) +
geom_tile(mapping = aes(fill = prop))
```
~~~

Visualize Summarize

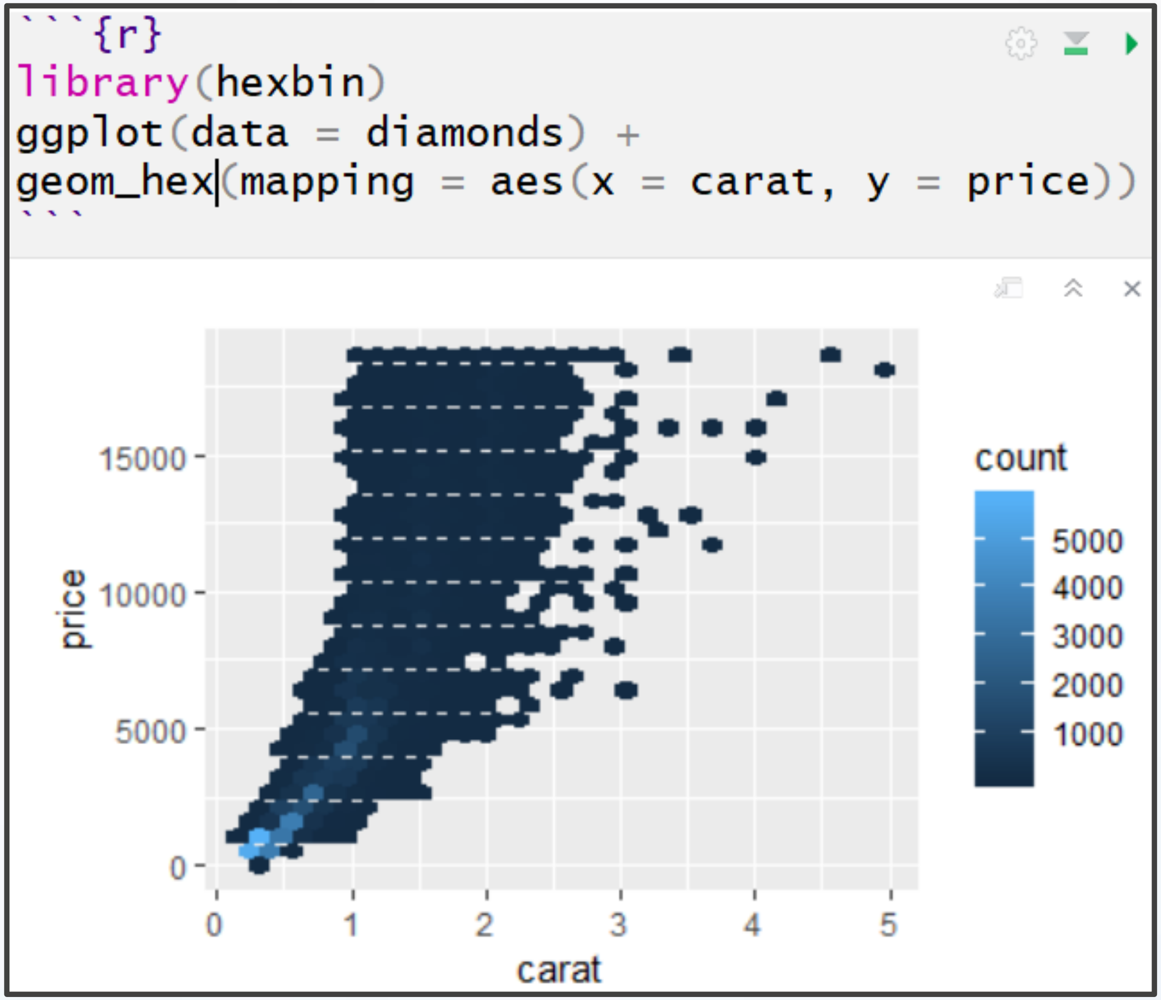
- Continuous and Continuous



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

Visualize Summarize

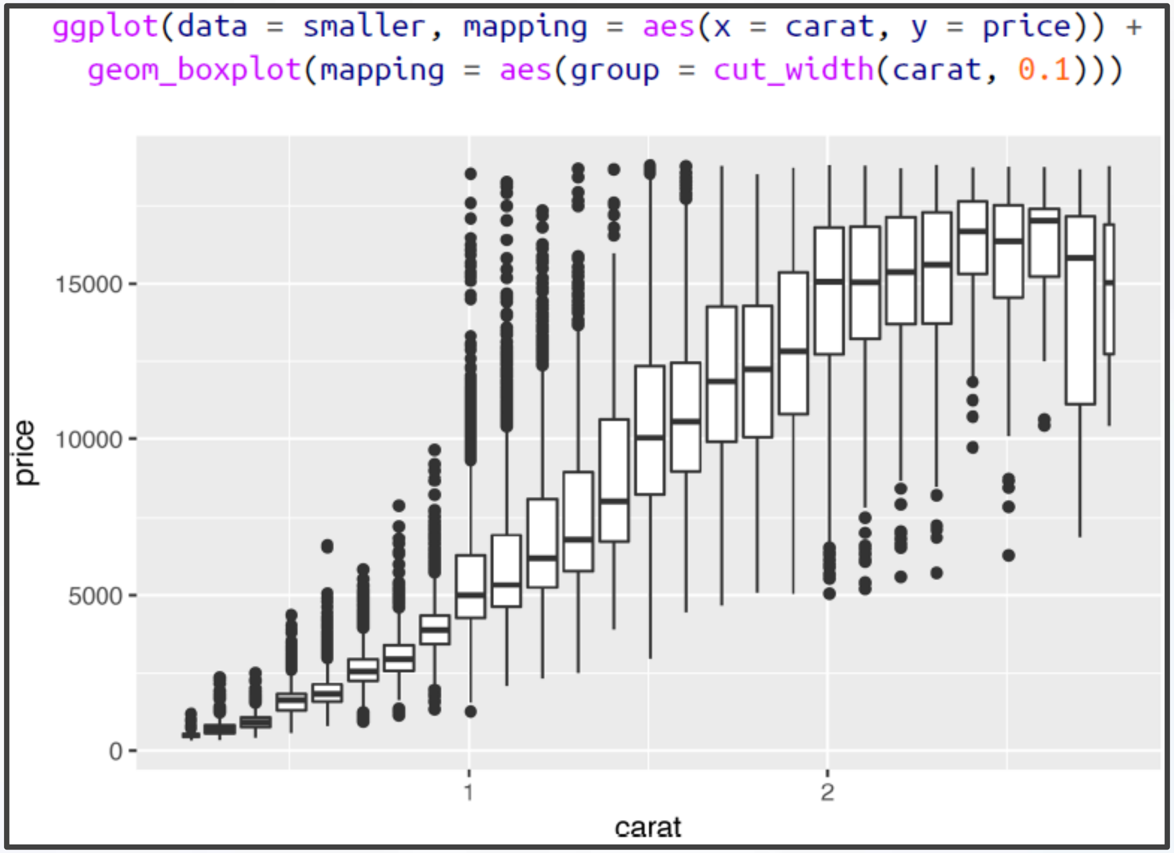
- Continuous and Continuous



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

Visualize Summarize

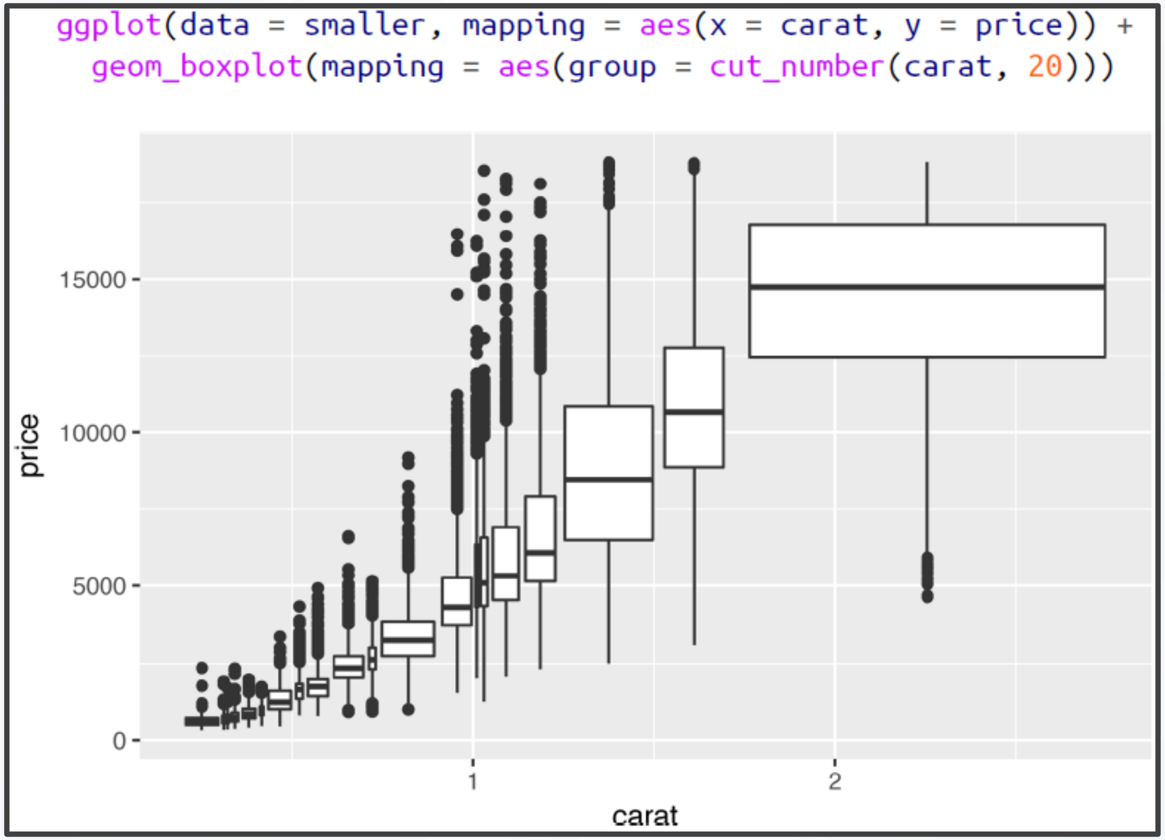
- Continuous and Continuous



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

Visualize Summarize

- Continuous and Continuous



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

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?

Question

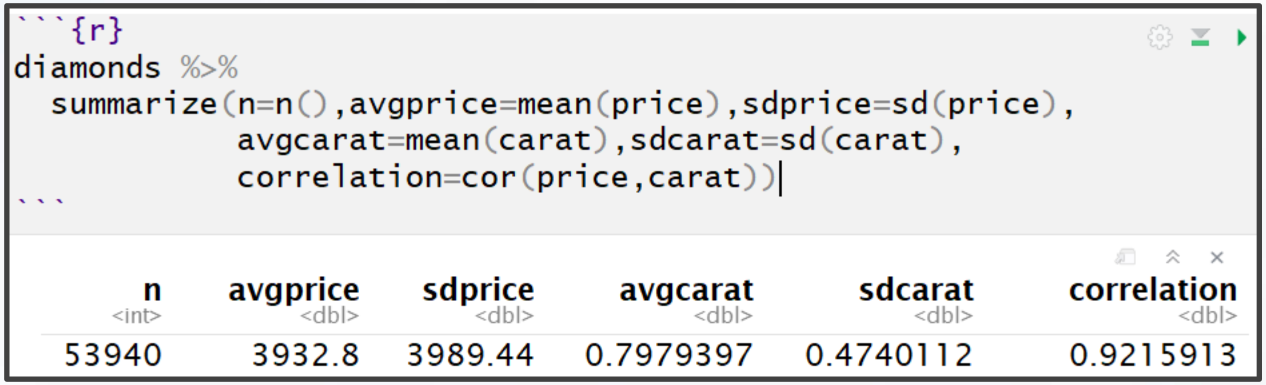
What is the relationship between

the size of the

and

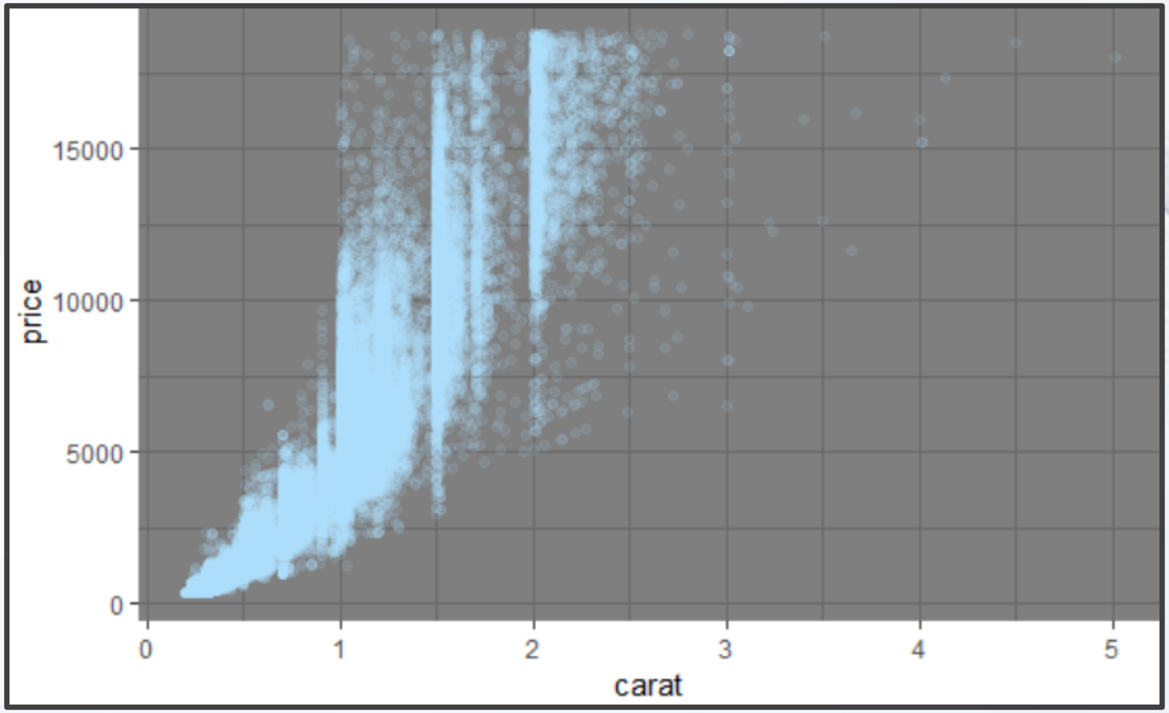
the price of the ?

Visualize Summarize



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

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

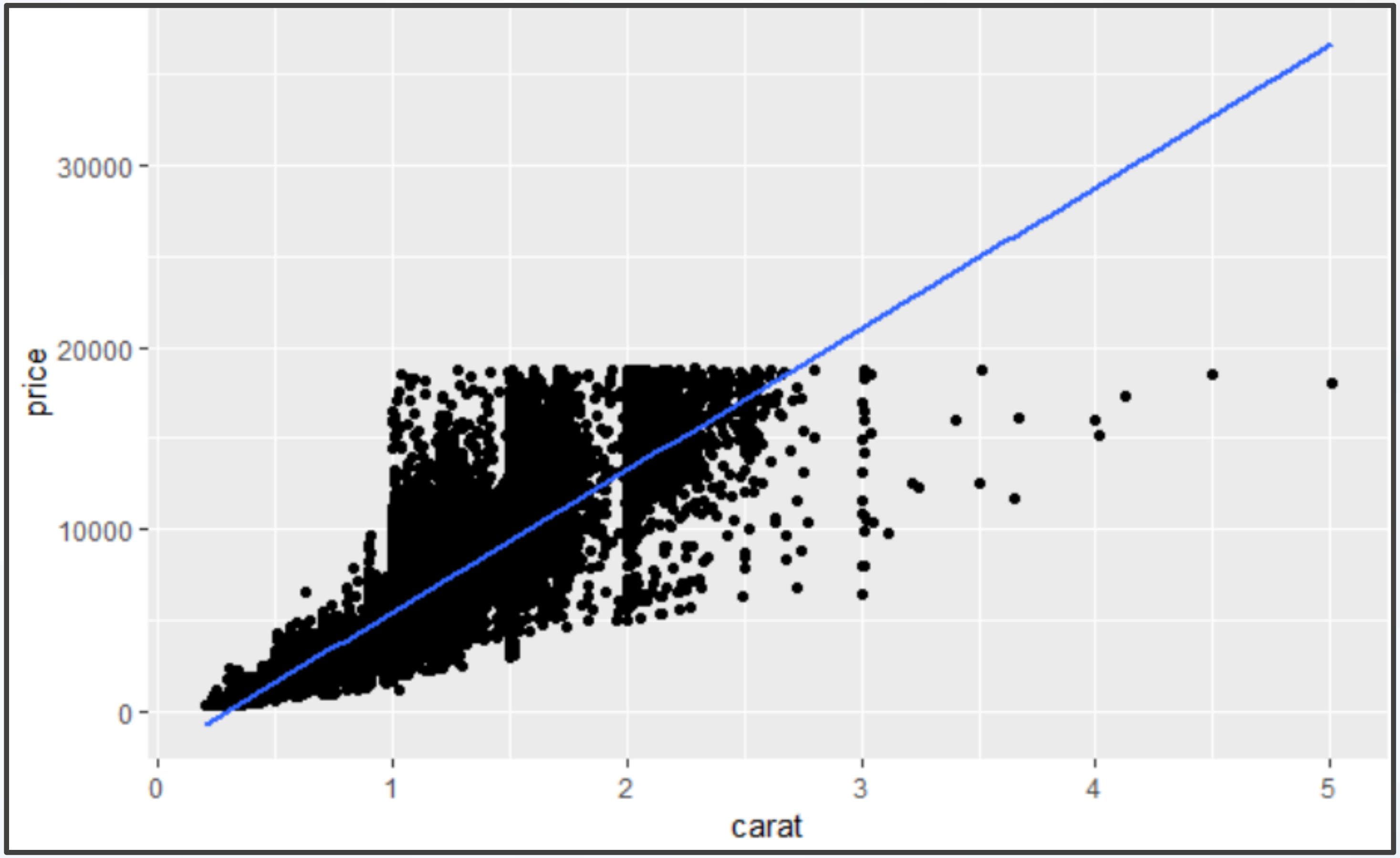


Question

- 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?

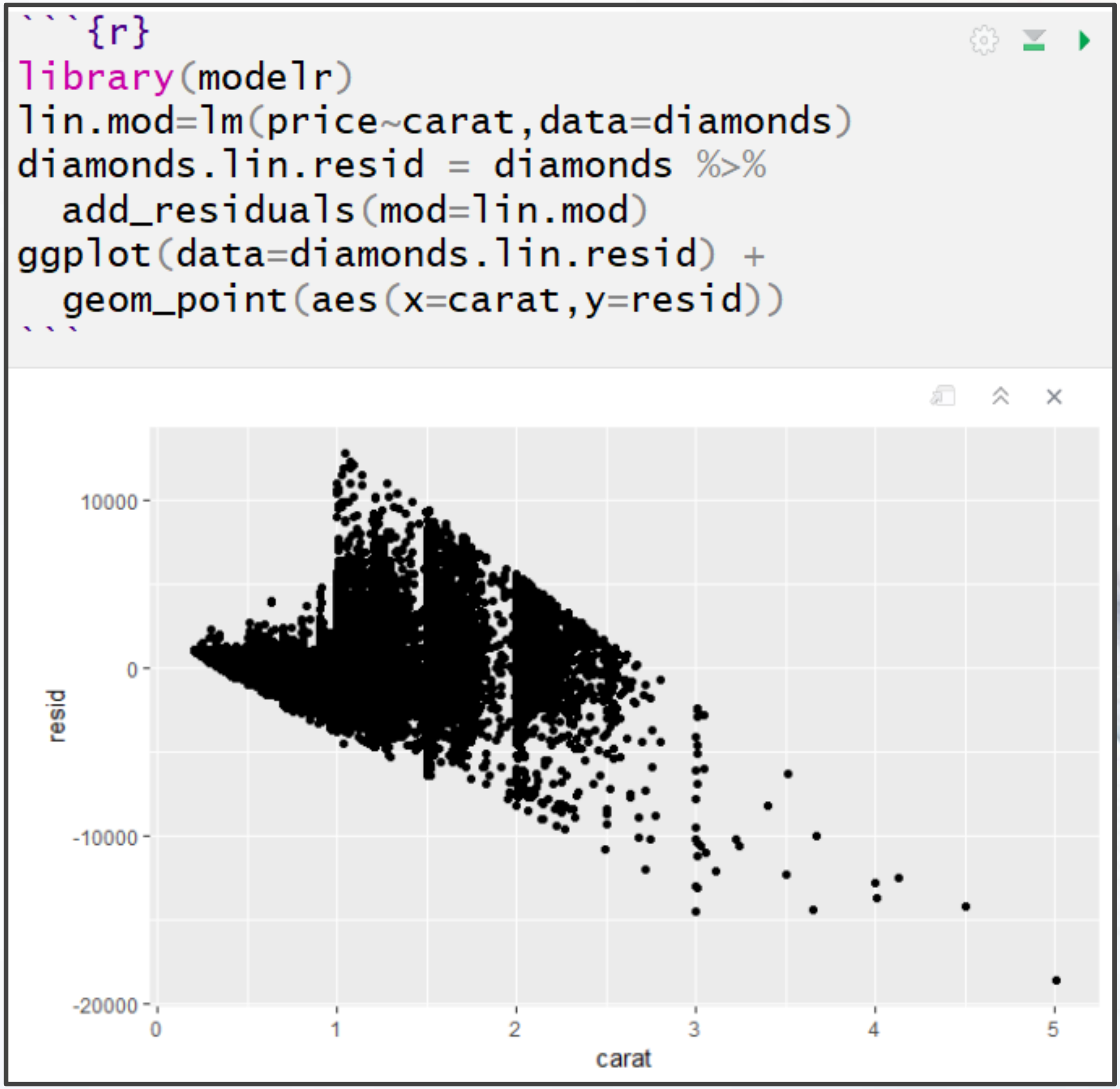
Model

- Linear Model



Model

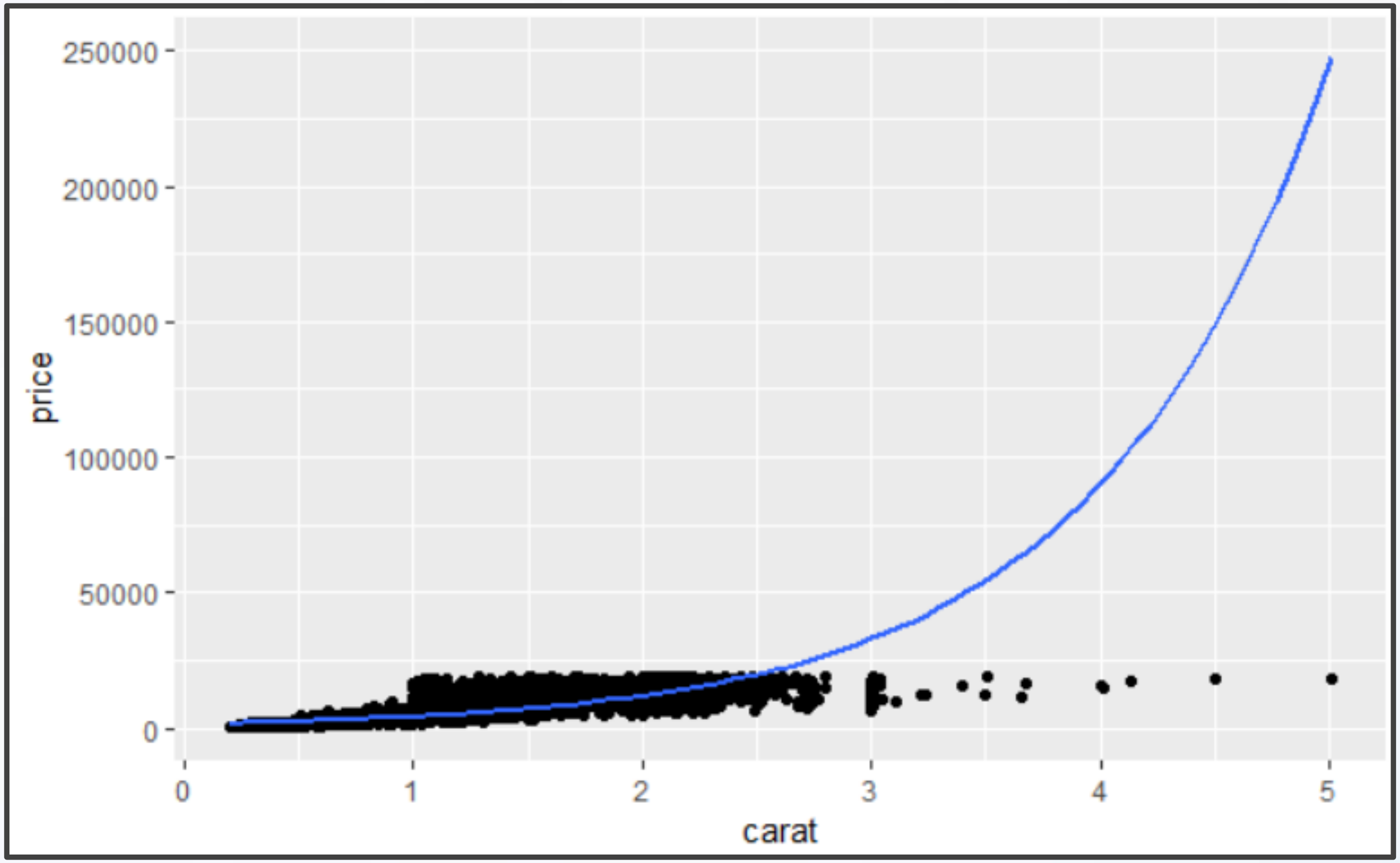
- Linear Model



~~~
```{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))
```
~~~

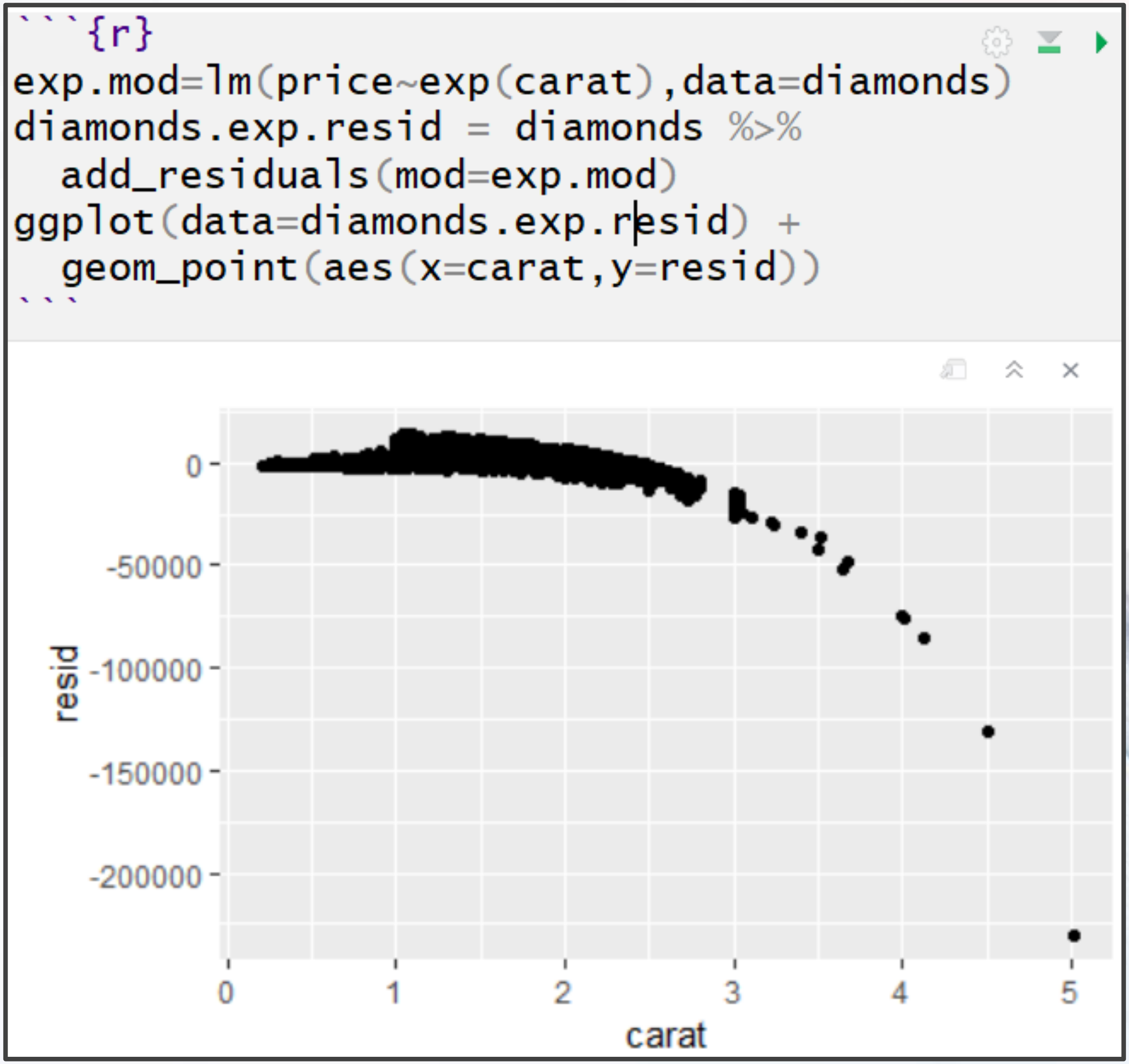
Model

- Exponential Model



Model

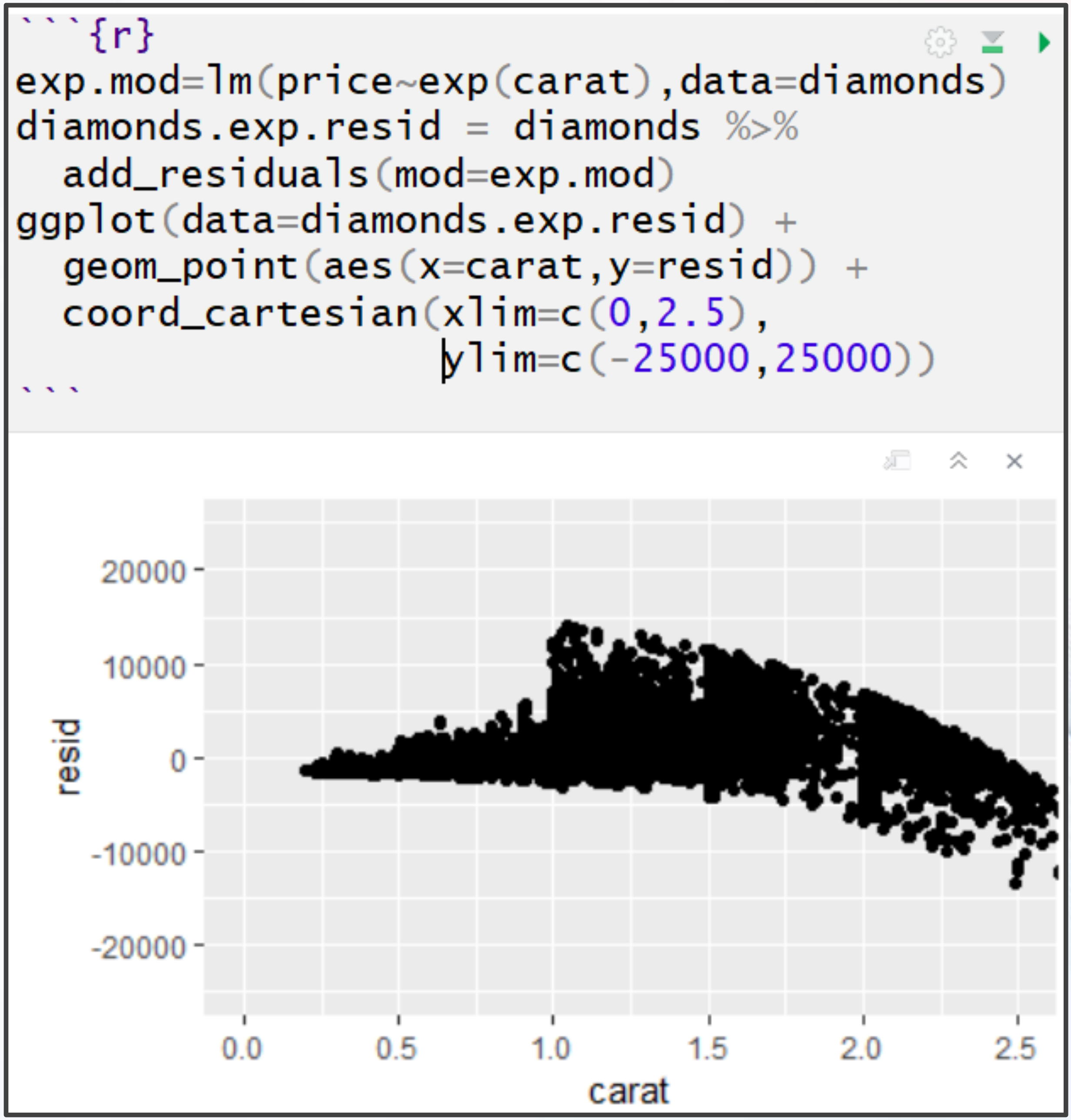
- Exponential Model



~~~
```{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))
```
~~~