

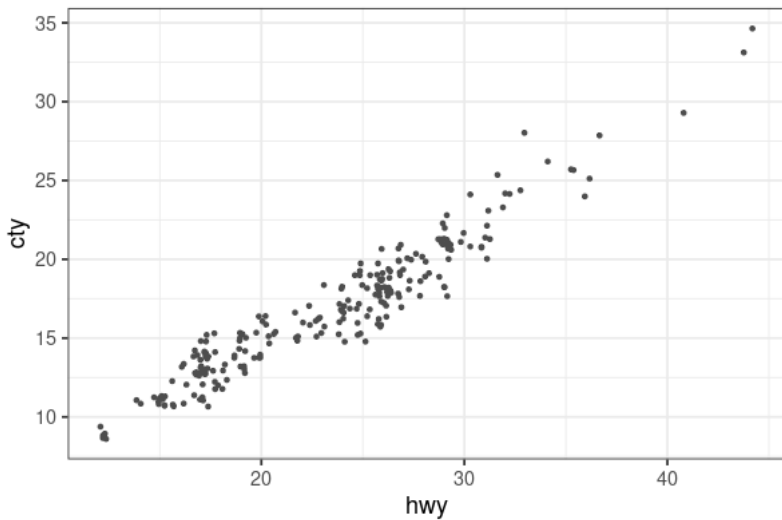
# SLR – Categorical Predictors

Grinnell College

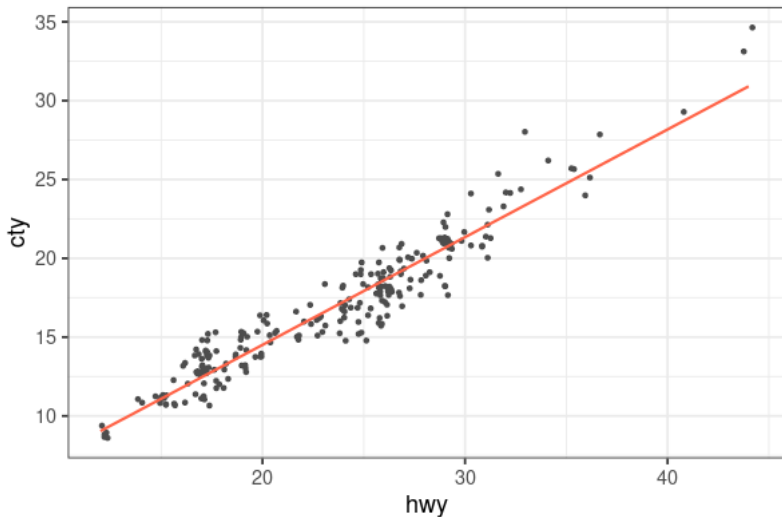
September 23, 2024

$$\hat{y} = \hat{\beta}_0 + X\hat{\beta}_1$$

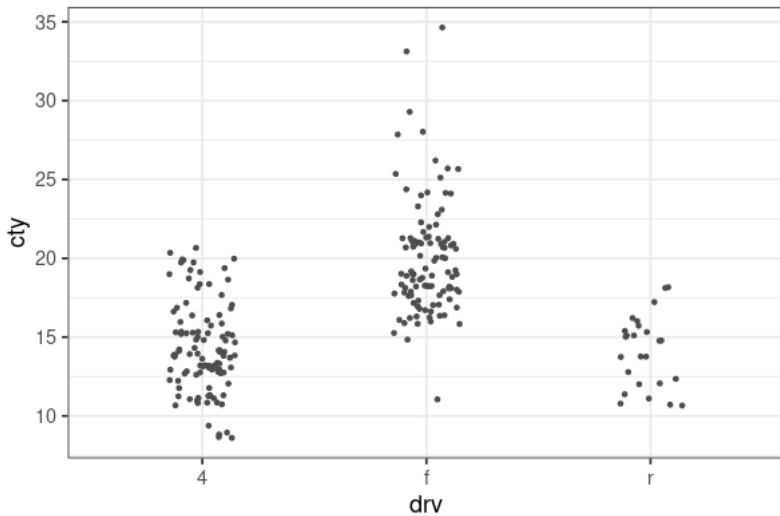
- ▶ Describe how correlation and regression related
- ▶ Why regression?
- ▶ Be able to predict an outcome, given a predictor
- ▶ Interpret the slope and intercept (if applicable)
- ▶ Assess the quality of a fitted line



$$\widehat{\text{City mpg}} = 0.844 + 0.683 \times \text{Highway mpg}$$



$$\hat{y} = \dots$$



# Indicator Variables

Consider how data is stored in our data frames in R

Model	Transmission
audi a4	auto
audi a4	manual
chevrolet c1500 suburban 2wd	auto
dodge dakota pickup 4wd	auto
ford explorer 4wd	manual
hyundai sonata	auto

How might these be used in regression?

# Indicator Variables

Model	Trans
audi a4	auto
audi a4	manual
chevrolet c1500	auto
dodge pickup 4wd	auto
ford explorer 4wd	manual
hyundai sonata	auto

Model	Manual	Auto
audi a4	0	1
audi a4	1	0
chevrolet c1500	0	1
dodge pickup 4wd	0	1
ford explorer 4wd	1	0
hyundai sonata	0	1

# Indicator Variables

Model	Manual	Auto
audi a4	0	1
audi a4	1	0
chevrolet c1500	0	1
dodge pickup 4wd	0	1
ford explorer 4wd	1	0
hyundai sonata	0	1

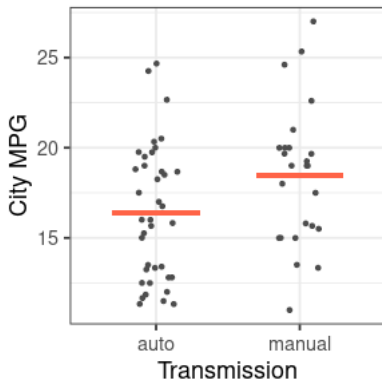
$$\mathbb{1}_{\text{Manual}} = \begin{cases} 1 & \text{if Manual} \\ 0 & \text{if Automatic} \end{cases}$$

$$\mathbb{1}_{\text{Automatic}} = \begin{cases} 1 & \text{if Automatic} \\ 0 & \text{if Manual} \end{cases}$$



# Indicator Variables

$$\widehat{\text{City mpg}} = 16.370 \times \mathbb{1}_{\text{Automatic}} + 18.457 \times \mathbb{1}_{\text{Manual}}$$



Model	Manual	Auto	cty
audi a4	0	1	18.250
audi a4	1	0	19.667
chevy c1500	0	1	12.800
dodge pickup	0	1	12.500
ford explorer	1	0	15.000
hyundai sonata	0	1	19.000

Transmission	Average City MPG
auto	16.370
manual	18.457

# Linear Model in R

By default, the first indicator will be absorbed into an intercept, making it the *reference variable*

```
1 > lm(cty ~ trans, mpg2)
2
3 Coefficients:
4 (Intercept)  transmanual
5      16.37          2.09
```

Compare

$$\widehat{\text{City mpg}} = 16.37 \times \mathbb{1}_{\text{Automatic}} + 18.457 \times \mathbb{1}_{\text{Manual}}$$

$$\widehat{\text{City mpg}} = 16.37 + 2.09 \times \mathbb{1}_{\text{Manual}}$$

# Practice

What are my indicator variables going to look like?

model	cty	drv
new beetle	21	f
gti	19	f
mustang	18	r
grand cherokee 4wd	11	4
sonata	21	f
civic	24	f
toyota tacoma 4wd	15	4

# Practice

What are my indicator variables going to look like?

model	cty	drv
new beetle	21	f
gti	19	f
mustang	18	r
grand cherokee	11	4
sonata	21	f
civic	24	f
toyota tacoma	15	4

model	cty	drvf	drv4	drv4
new beetle	21	1	0	0
gti	19	1	0	0
mustang	18	0	1	0
grand cherokee	11	0	0	1
sonata	21	1	0	0
civic	24	1	0	0
toyota tacoma	15	0	0	1

# Practice

```
1 > lm(cty ~ drv, mpg)
2
3 Coefficients:
4 (Intercept)      drvf      drvr
5      14.33       5.64     -0.25
```

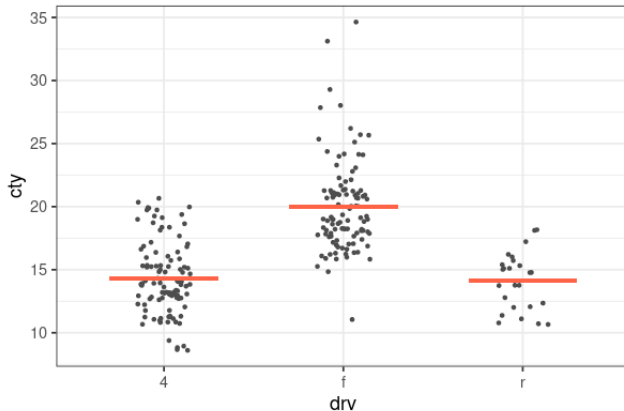
- ▶ What is the *reference variable*
- ▶ Equation for line?
- ▶ Interpretation of intercept? Slope?
- ▶ What is the average city mileage for:
  - ▶ 4-wheel drive?
  - ▶ Front-wheel drive?
  - ▶ Rear-wheel drive?

# Practice

```
1 > lm(cty ~ drv, mpg)
```

```
2  
3 Coefficients:
```

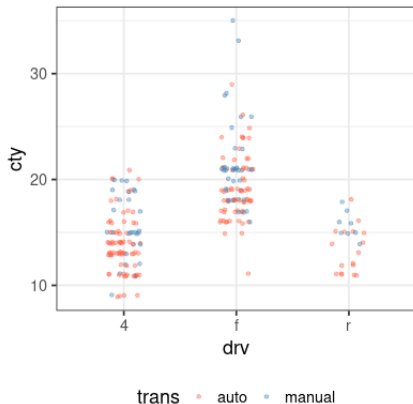
```
4 (Intercept)      drvf      drvr  
5      14.33       5.64     -0.25
```



## Extending to Multiple Variables

Here we have the average city miles per gallon for each combination of drive train and transmission

Transmission	4wd	fwd	rwd
Automatic	13.85	19.11	13.29
Manual	15.61	21.34	15.75



## Extending to Multiple Variables

```
1 > lm(cty ~ drv + trans, mpg)
2
3 Coefficients:
4 (Intercept)      drvf      drvr  transmanual
5      13.77       5.40      -0.35       2.07
```

- ▶ What is the *reference variable*
- ▶ Equation for line?
- ▶ Interpretation of intercept? Slope?
- ▶ What is the average city mileage for:
  - ▶ Automatic 4-wheel drive?
  - ▶ Manual Front-wheel drive?



# Observed vs Predicted Means

```
1 > lm(cty ~ drv + trans, mpg)
2
3 Coefficients:
4 (Intercept)      drvf      drvr  transmanual
5      13.77      5.40     -0.35       2.07
```

Observed:

Transmission	4wd	fwd	rwd
Automatic	13.85	19.11	13.29
Manual	15.61	21.34	15.75

Predicted:

Transmission	4wd	fwd	rwd
Automatic	13.69	19.17	13.42
Manual	15.83	21.24	15.49

