

Welcome back!

Nameplates please. And technology encouraged today!

All TF materials are available at github.com/nolankav/api-202.

If you want to follow along, download the dataset here:

In R: `df <- read.csv ("http://tinyurl.com/api-202-tf-3")`

In Excel: http://tinyurl.com/api-202-tf-4

Dummy variables and interactions

API 202: TF Session 3

EXCEL

Nolan M. Kavanagh
February 14, 2025



Goals for today

- 1. Review core concepts in regression analysis.**
- 2. Review the principles of interactions in regression.**
- 3. Learn how to run interacted regressions.**
- 4. Practice interpreting interaction terms.**

We'll treat this session like a workshop with an interactive example.

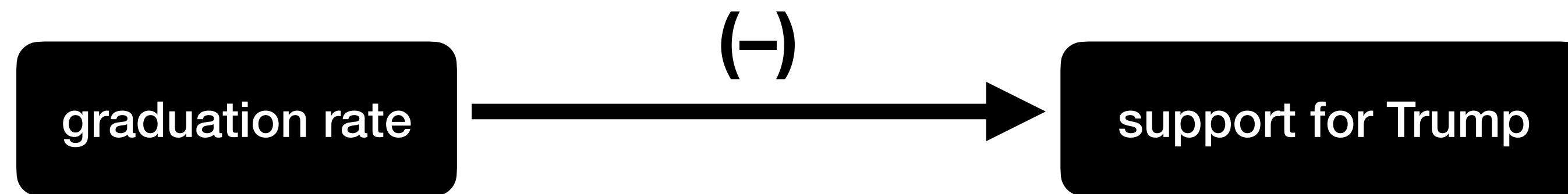
Overview of our sample data

Dataset of U.S. county-level characteristics in 2020

state	State of county	<i>Administrative</i>
county_fips	County FIPS identifier	<i>Administrative</i>
pc_under_18	Percent of county under age 18	<i>American Community Survey (2016–2020)</i>
pc_over_65	Percent of county over age 65	<i>American Community Survey (2016–2020)</i>
pc_male	Percent of county that is male	<i>American Community Survey (2016–2020)</i>
pc_black	Percent of county that is Black	<i>American Community Survey (2016–2020)</i>
pc_latin	Percent of county that is Hispanic/Latino	<i>American Community Survey (2016–2020)</i>
pc_hs_grad	Percent of county that graduated high school	<i>American Community Survey (2016–2020)</i>
unemploy_rate	County unemployment rate (%)	<i>American Community Survey (2016–2020)</i>
med_income_000s	County median income (\$1,000s)	<i>American Community Survey (2016–2020)</i>
pc_uninsured	Percent of county without health insurance	<i>American Community Survey (2016–2020)</i>
pc_trump	Percent of county votes for Trump in 2020	<i>MIT Election Lab</i>

Let's revisit the Trump story.

We've learned that high school graduation rates were an important predictor of Trump's support in 2020.

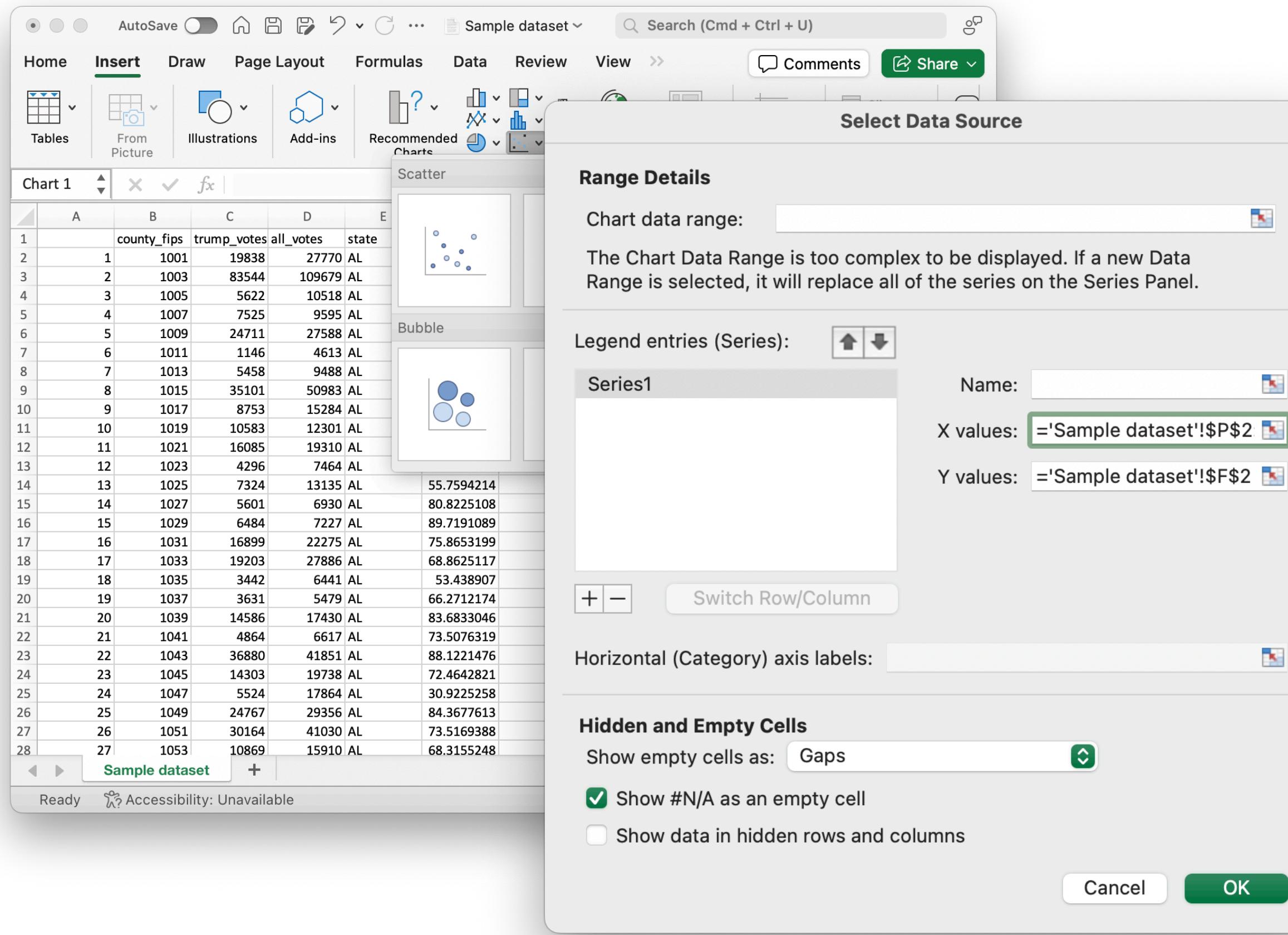


In Season 4 Episode 19, we learn that Homer never technically graduated high school (even though he does later in the episode).

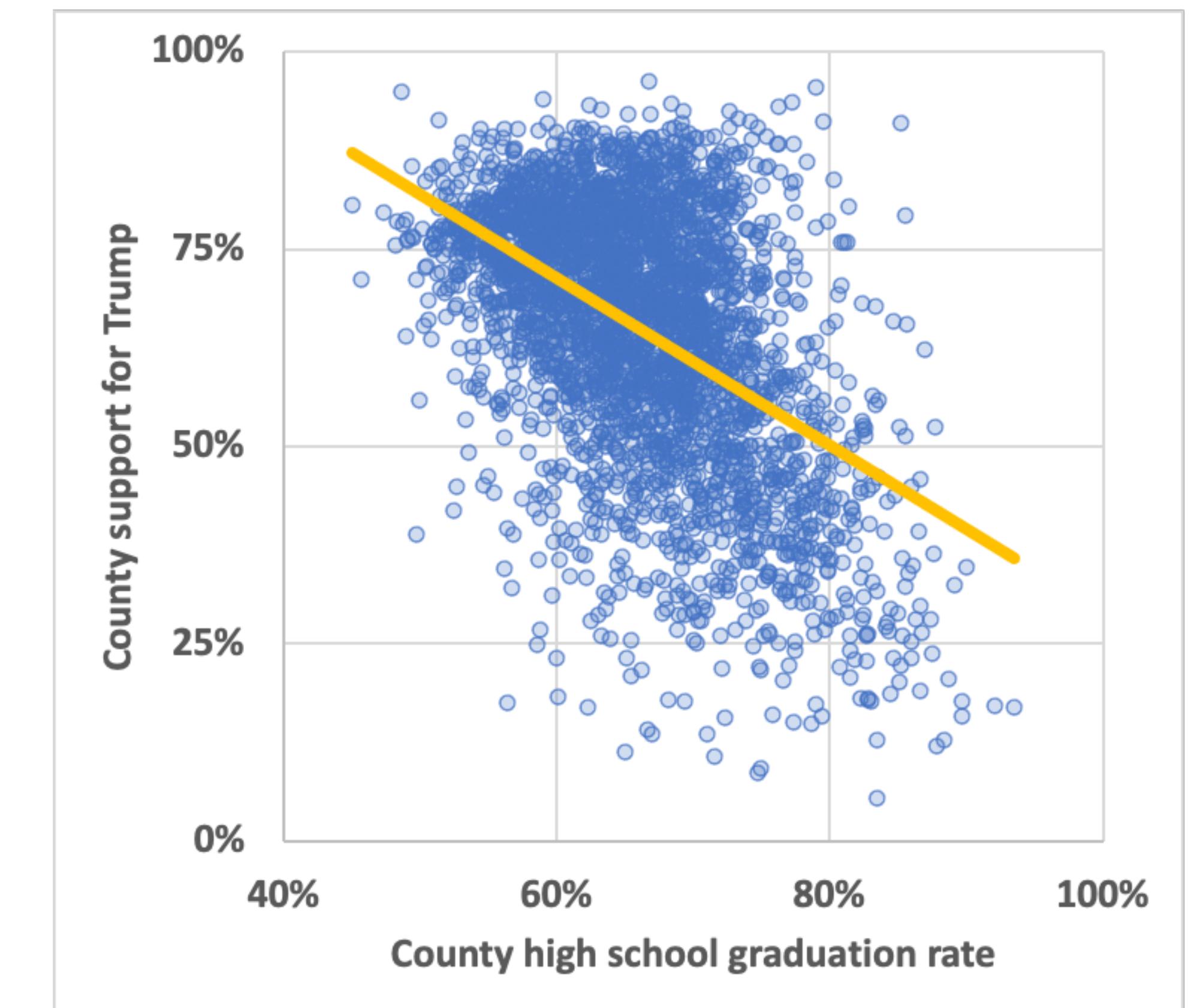
This screenshot is from later in the series, but would he be more or less likely to support Trump than someone who graduated high school?



We've seen this graph before.



X values: ='Sample dataset'!\$G\$2:\$G\$3115
Y values: ='Sample dataset'!\$F\$2:\$F\$3115



Note: pc_hs_grad and pc_trump are scaled 0–100, not 0–1.

We've seen this regression before.

SUMMARY OUTPUT							
Regression Statistics							
Multiple R	0.4832049						
R Square	0.23348698						
Adjusted R S	0.23324067						
Standard Err	14.1346772						
Observations	3114						
ANOVA							
	df	SS	MS	F	Significance F		
Regression	1	189388.892	189388.892	947.944069	6.07E-182		
Residual	3112	621743.678	199.7891				
Total	3113	811132.57					
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0% Upper 95.0%
Intercept	134.921115	2.28637329	59.0109742	0	130.438162	139.404068	130.438162 139.404068
pc_hs_grad	-1.0588226	0.03438998	-30.7887	6.07E-182	-1.126252	-0.9913933	-1.126252 -0.9913933

Note: pc_hs_grad and pc_trump are scaled 0–100, not 0–1.

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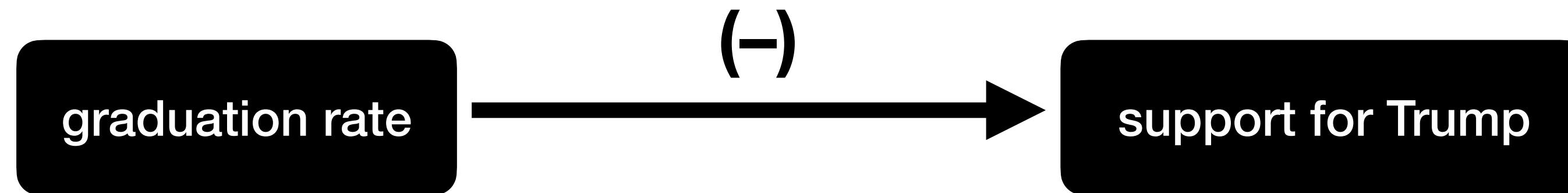
For each 1 percentage point (pp) increase in a county's high school graduation rate, there is an associated 1.1 pp decrease in support for Trump.

The association is statistically significant.

Note: pc_hs_grad and pc_trump are scaled 0–100, not 0–1.

Let's revisit the Trump story.

We've learned that high school graduation rates were an important predictor of Trump's support in 2020.



But is this true for every community?

In Season 4 Episode 19, we learn that Homer never technically graduated high school (even though he does later in the episode).

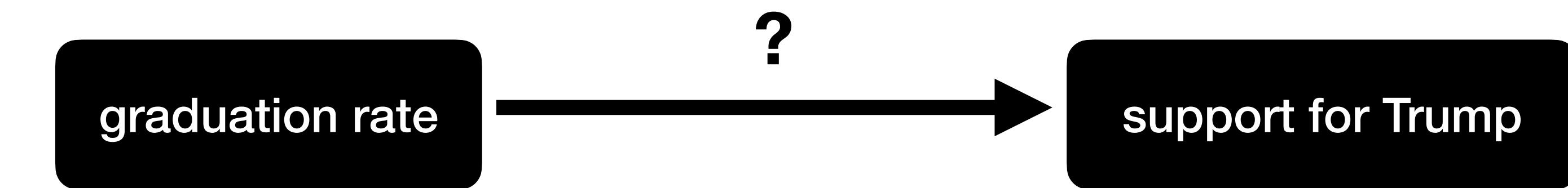
This screenshot is from later in the series, but would he be more or less likely to support Trump than someone who graduated high school?



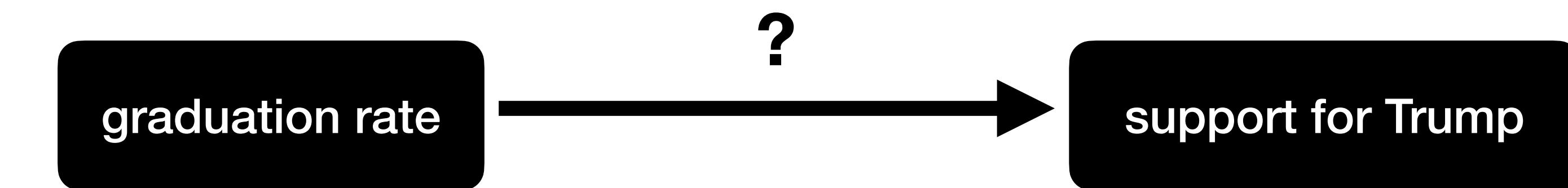
Let's consider minoritized communities.

Is the association different for majority-Black or Latin counties, compared to majority-white counties?

**Majority-Black or
Latin counties**



Other counties



OK, let's make a dummy variable.

It should equal 1 for counties that are majority-Black or Latin.

Meanwhile, it should equal 0 for all other counties.

N	O	P	Q	R
pc_black	pc_latin	med_inc_000s	majority	
20.5	2.9	57.982	=IF(OR(N2>=50,O2>=50),1,0)	
9.3	4.6	61.756	0	
48.5	4.4	34.99	0	
22.7	2.7	51.721	0	
1.9	9.3	48.922	0	
69.2	8.1	33.866	1	
45.3	1.5	44.85	0	
22.3	3.9	50.128	0	

=IF(OR(N2>=50, O2>=50), 1, 0)

OR([can be this], [or can be this])

IF([criterion], [value if true], [value if false])

Note: Don't use quotation marks around 0 or 1. Excel interprets "0" as a character, rather than a number, and cannot use it in a regression.

OK, let's make an interacted variable.

This is easier.

Just multiply our graduation rate
and dummy columns together.

G	Q	R
pc_hs_grad	majority	majority_hs_grad
68.6	0	=Q2*G2
72.8	0	0
64.3	0	0
54.9	0	0
64.9	0	0
58.6	1	58.6
53.5	0	0
65.6	0	0
62.9	0	0

Let's consider our regression function.



Let's consider our regression function.

$$(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + \beta_2(majority)_i + \beta_3(HS_grad * majority)_i + u_i$$

high school graduation rate
measured in percent (0–100)

dummy for majority-Black/Latin
1 = majority-Black/Latin county
0 = all other counties

interaction between
our two predictors

Let's consider our regression function.

Other counties $(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + \beta_2(majority)_i + \beta_3(HS_grad * majority)_i + u_i$
here, majority = 0

**Majority-Black or
Latin counties**

here, majority = 1

$$(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + \beta_2(majority)_i + \beta_3(HS_grad * majority)_i + u_i$$

Let's consider our regression function.

Other counties
here, majority = 0

$$(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + \beta_2(majority)_i + \beta_3(HS_grad * majority)_i + u_i$$

these terms go to 0

$$(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + u_i$$

Majority-Black or Latin counties

here, majority = 1

$$(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + \beta_2(majority) + \beta_3(HS_grad * majority)_i + u_i$$

these terms are just 1

$$(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + \beta_2 + \beta_3(HS_grad)_i + u_i$$

$$(Trump)_i = (\beta_0 + \beta_2) + (\beta_1 + \beta_3)(HS_grad)_i + u_i$$

rearrange our terms

Let's consider our regression function.

Other counties
here, majority = 0

$$(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + u_i$$

**Majority-Black or
Latin counties**
here, majority = 1

$$(Trump)_i = (\beta_0 + \beta_2) + (\beta_1 + \beta_3)(HS_grad)_i + u_i$$

Let's consider our regression function.

Other counties
here, majority = 0

$$(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + u_i$$

β_2 gives us the difference in intercepts
i.e. the difference in predicted Trump support for majority-Black/Latin vs. other counties with graduation rates of 0%.

Majority-Black or Latin counties
here, majority = 1

$$(Trump)_i = (\beta_0 + \beta_2) + (\beta_1 + \beta_3)(HS_grad)_i + u_i$$

Let's consider our regression function.

Other counties
here, majority = 0

$$(Trump)_i = \beta_0 + \beta_1(HS_grad)_i + u_i$$

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Majority-Black or Latin counties
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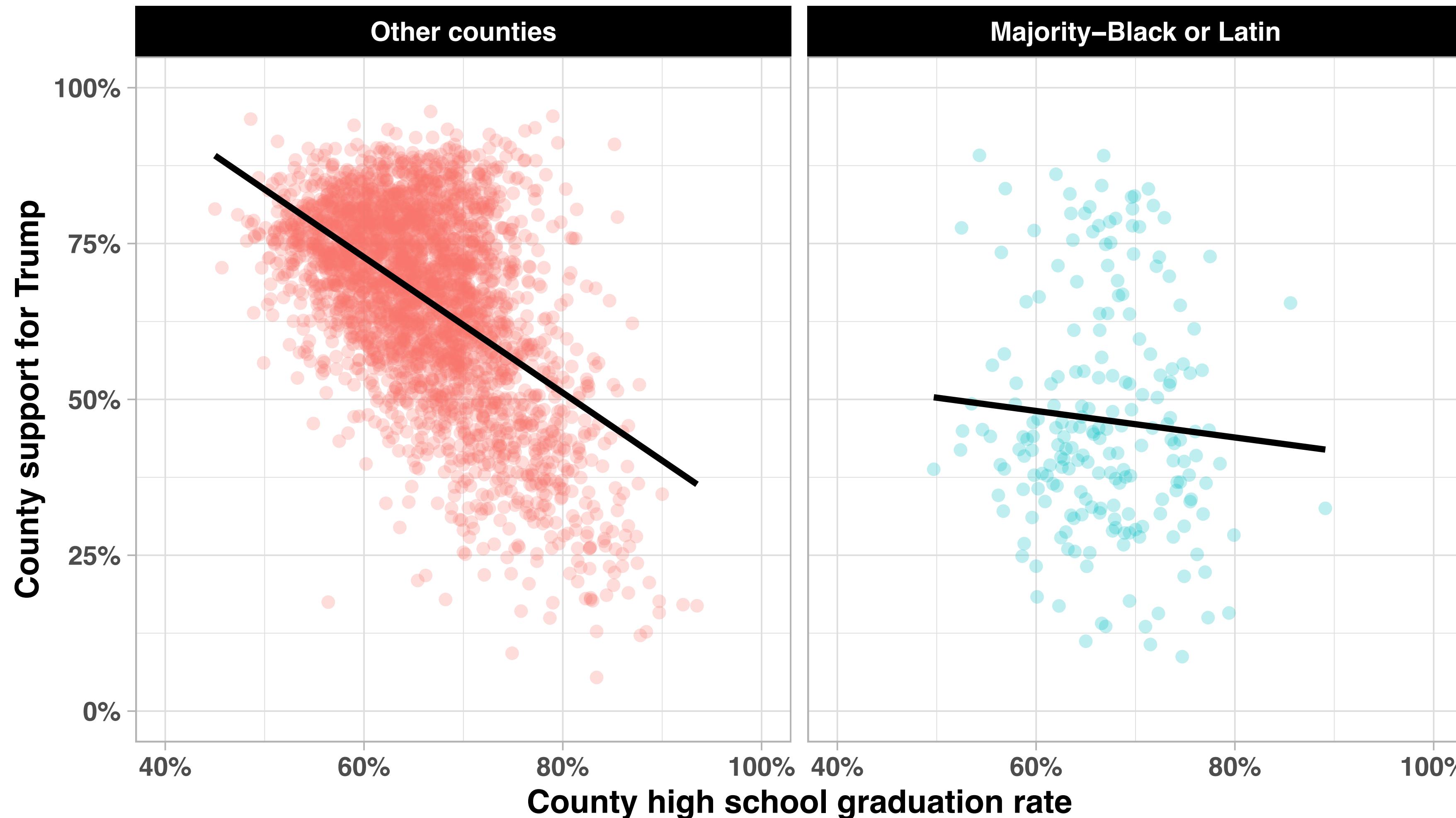
$$(Trump)_i = (\beta_0 + \beta_2) + (\beta_1 + \beta_3)(HS_grad)_i + u_i$$

β_3 gives us the difference in slopes

i.e. the difference in the association between graduation rates and Trump support for majority-Black/Latin vs. other counties.

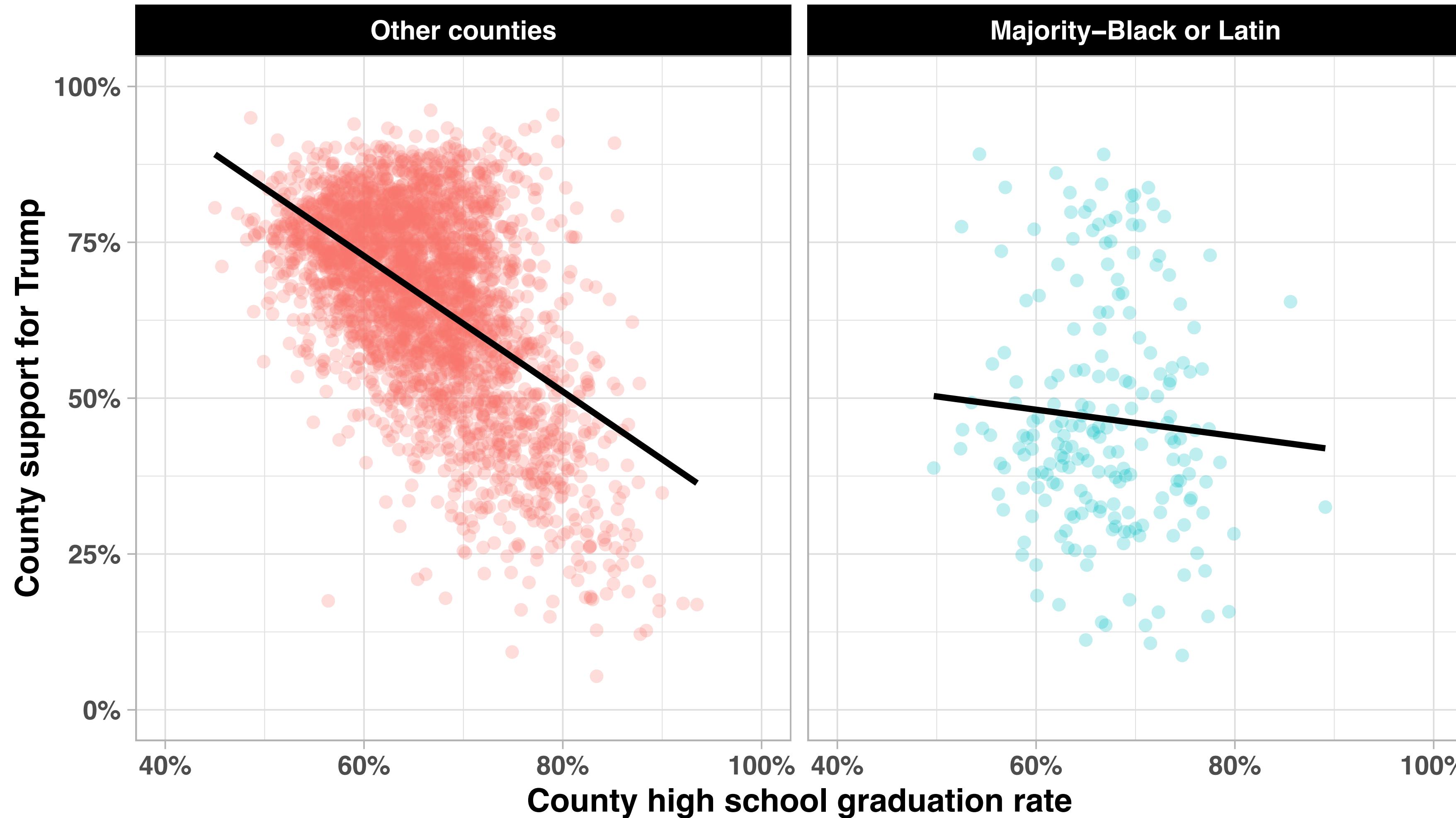


Show me the graph already!



See the online script file for the code to make these graphs.

Show me the graph already!



**Clearly, these
are different
relationships!**

See the online script file for the code to make these graphs.

Show me the regression already!

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.5697146					
R Square	0.32457472					
Adjusted R S	0.32392319					
Standard Err	13.2725503					
Observations	3114					
ANOVA						
	df	SS	MS	F	Significance F	
Regression	3	263273.13	87757.71	498.168797	2.495E-264	
Residual	3110	547859.44	176.160592			
Total	3113	811132.57				
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	138.042414	2.20351028	62.6465942	0	133.721932	142.362897
pc_hs_grad	-1.0873224	0.03316569	-32.784555	9.642E-203	-1.1523512	-1.0222935
majority	-77.126184	9.8181767	-7.8554487	5.4412E-15	-96.376948	-57.875419
majority_hs_	0.87450095	0.14638393	5.97402289	2.5768E-09	0.58748201	1.16151988

Note: pc_hs_grad and pc_trump are scaled 0–100, not 0–1.

Show me the regression already!

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The predicted support for Trump in an “other” county with a high school graduation rate of 0% is 138%.

It's significantly different from 0.

It's also not especially meaningful.

Note: pc_hs_grad and pc_trump are scaled 0–100, not 0–1.

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For “other” counties, a 1 pp increase in the graduation rate is associated with 1.1 pp lower support for Trump.

It's significantly different from 0.

Note: pc_hs_grad and pc_trump are scaled 0–100, not 0–1.

Show me the regression already!

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A majority-Black or Latin county with 0% graduation has, on average, 77 pp less support for Trump than an “other” county with 0% graduation.

It's significantly different from 0.

Doing the math: $138 - 77 = 61\%$ support.

Note: pc_hs_grad and pc_trump are scaled 0–100, not 0–1.

Show me the regression already!

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The association between graduation rates and Trump support is 0.87 pp more positive for majority-Black or Latin counties, compared to “other counties.”

It's significantly different from 0.

Doing the math: $-1.09 + 0.87 = -0.22$, which is a much flatter slope.

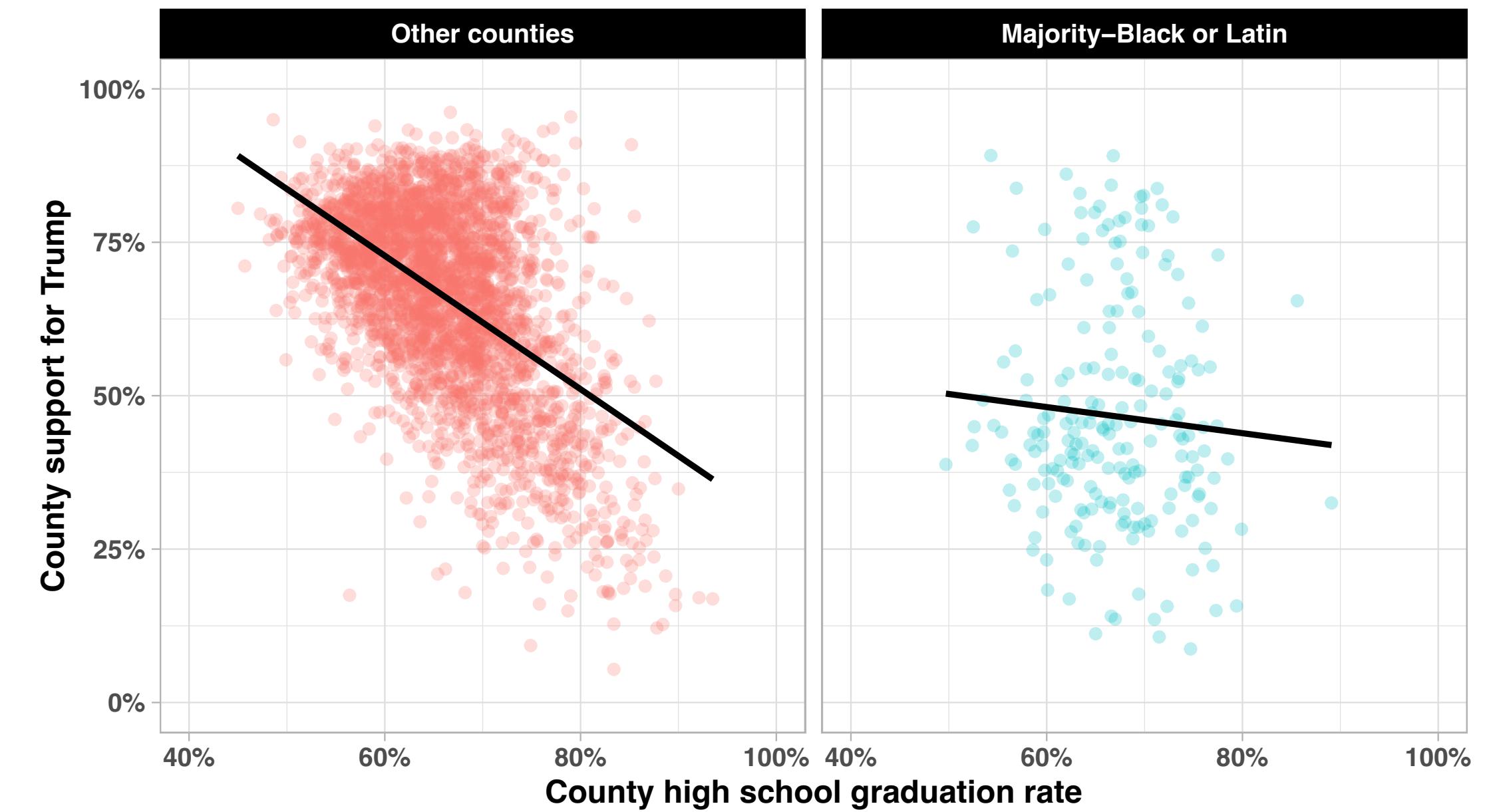
Note: pc_hs_grad and pc_trump are scaled 0–100, not 0–1.

Putting it all together

	Model 1	Model 2
Intercept	134.92*** (2.29)	138.04*** (2.20)
County graduation rate	-1.06*** (0.03)	-1.09*** (0.03)
Majority-Black or Latin county		-77.13*** (9.82)
Grad. rate * Majority-Black or Latin		0.87*** (0.15)
Num.Obs.	3114	3114
R2	0.233	0.325
R2 Adj.	0.233	0.325

*p<0.05, **p<0.01, ***p<0.001

$$(Trump)_i = \hat{\beta}_0 + \hat{\beta}_1(HS_grad)_i + \hat{u}_i$$



$$(Trump)_i = (\hat{\beta}_0 + \hat{\beta}_2) + (\hat{\beta}_1 + \hat{\beta}_3)(HS_grad)_i + \hat{u}_i$$

$$\beta_0 + \beta_2 = 138 - 77 = 61$$

$$\beta_1 + \beta_3 = -1.09 + 0.87 = -0.22$$

Note: pc_hs_grad and pc_trump are scaled 0–100, not 0–1.

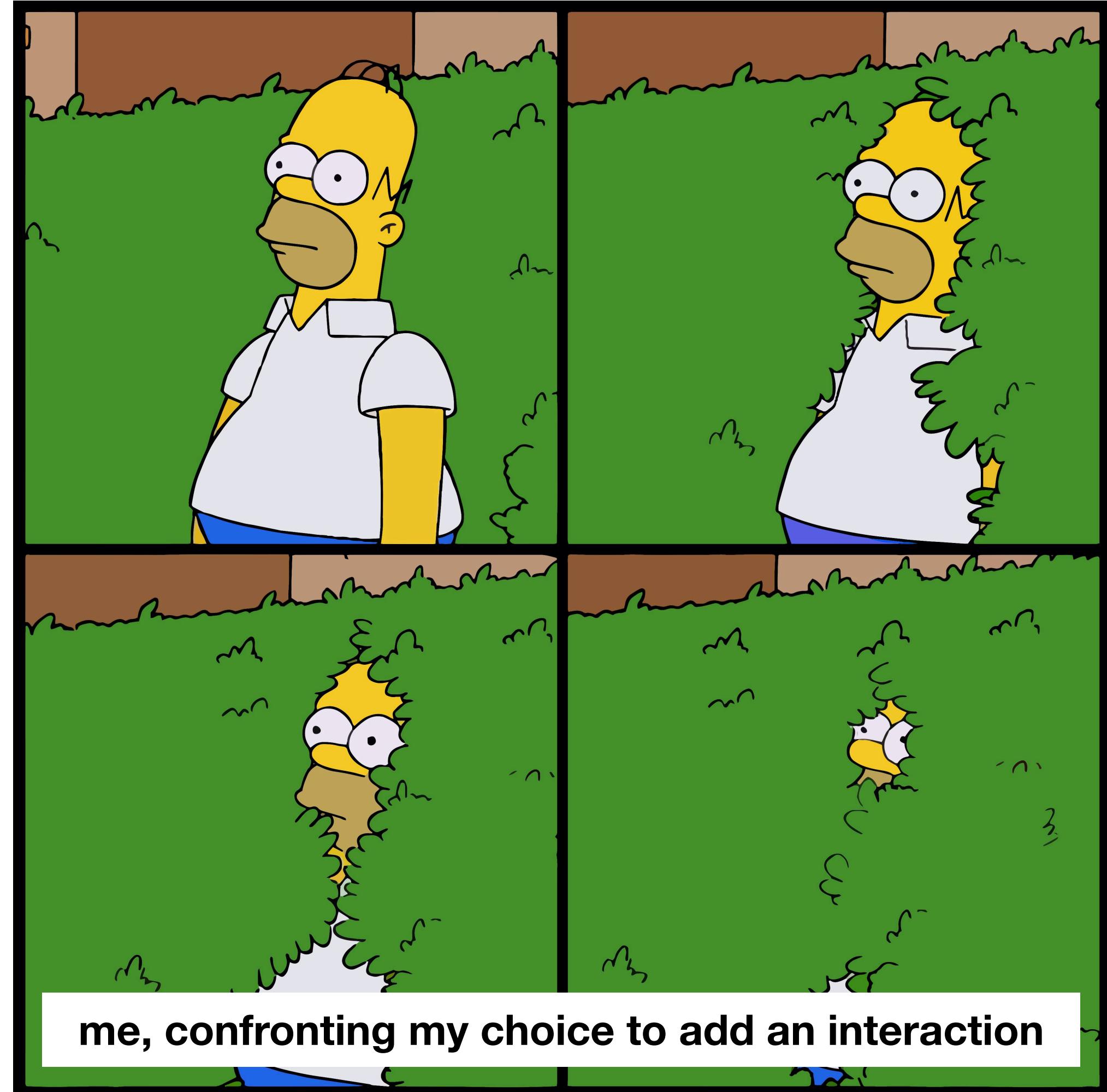
What did we learn?

Interactions are hard to interpret.

Start by writing out the regression functions.

We don't always need interactions.

But they can add richness to our models.



However, watch out for statistical power. We need much larger samples to estimate interactions than main effects.