Exploring Variation and Interaction Terms

ECON 490

Taylor Mackay || Email: tmackay@fullerton.edu

Slides Overview

In these slides, we'll discuss:

- Interaction terms in regression analysis
- An application from an R in-class activity using the capstone data sets

Exploring Variation with Interaction Terms

Regression models typically estimate average relationships across all observations

- For example, in $Y = \beta_0 + \beta_1 X + u$, everyone shares the ***same*** β_1
- What if this relationship varies across groups, regions, or time periods, etc.?

Interaction terms allow us to capture and quantify these differences

Let's consider the following question: *"Does the relationship between unemployment and crime differ across regions of the United States?"*

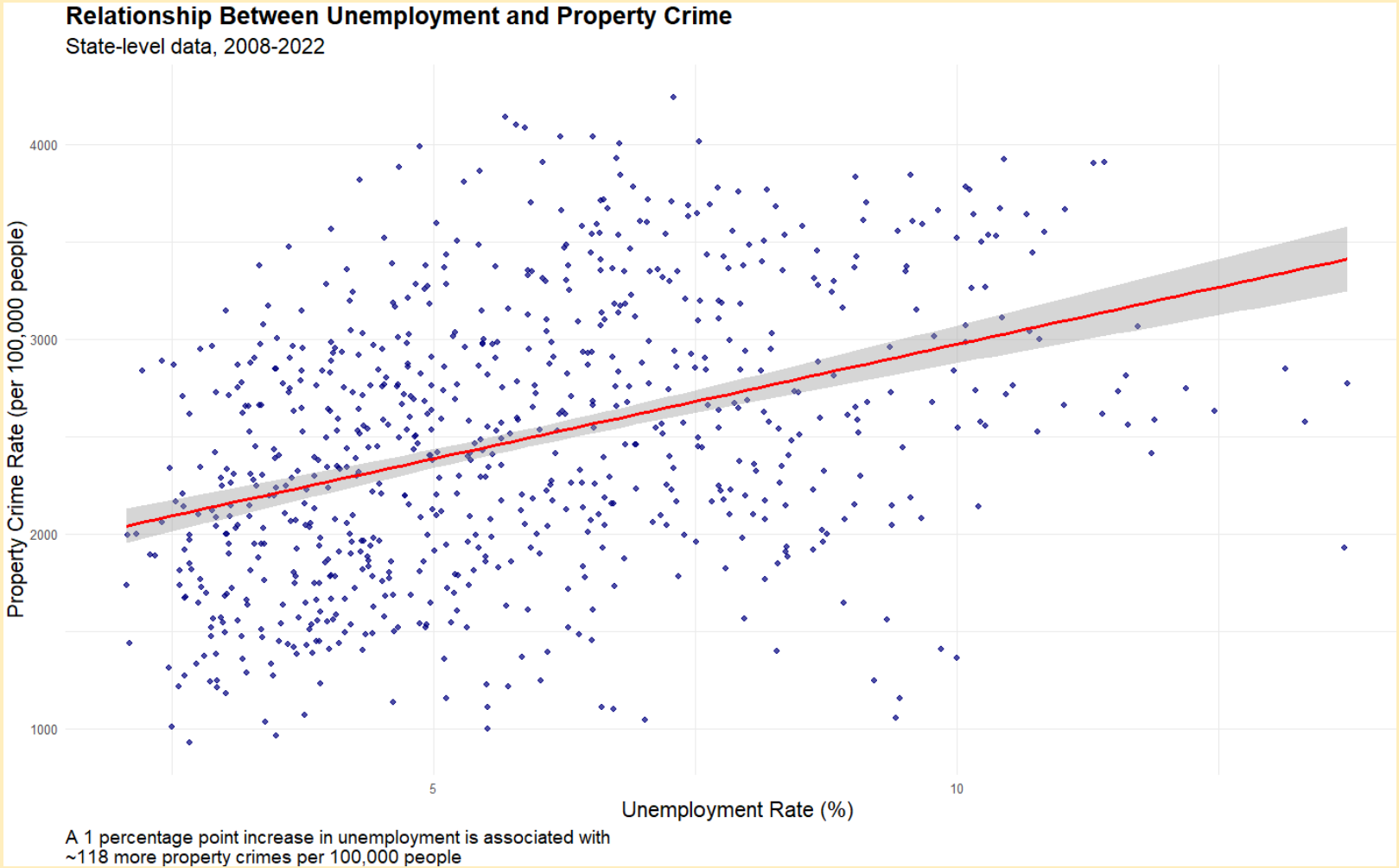
Baseline Model: Unemployment and Property Crime

Let's start with the following:

$$Property\ Crime\ Rate = \beta_0 + \beta_1 Unemployment\ Rate\ (UR) + u$$

In words, we want to predict or generate conditional means of crime given UR

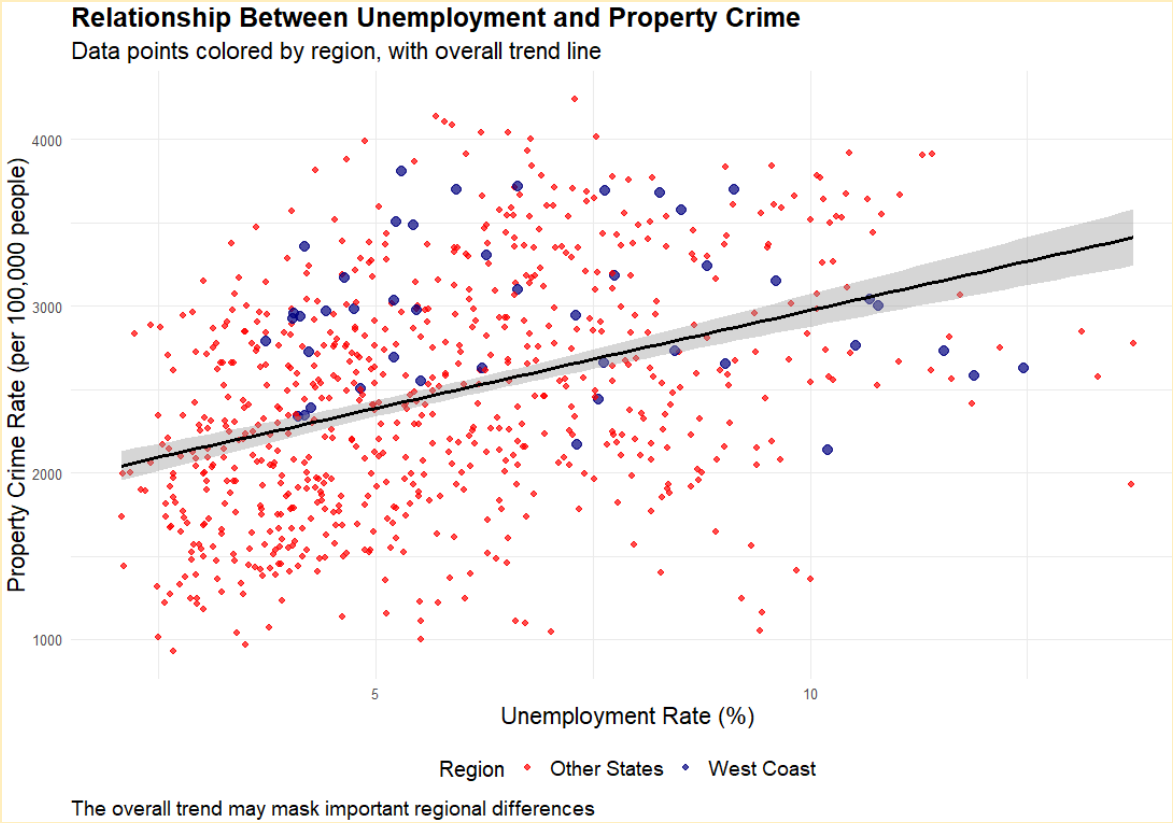
- Key point – our prediction does ***not*** depend on what state you consider
- I.e., given $UR = 4\%$, we'll get the same prediction for California and Arkansas


Relationship Between Unemployment and Property Crime
State-level data, 2008-2022
Property Crime Rate (per 100,000 people)
4000
3000
2000
1000
5
10
Unemployment Rate (%)
A 1 percentage point increase in unemployment is associated with
~118 more property crimes per 100,000 people

Does the Relationship Vary by Region?

Bolded points represent CA + WA + OR

Notice they don't quite follow the overall trend



Exploring Variation

We can use an interaction term to see how this relationship varies

- Create a binary indicator for being a West Coast (WC) state
- Include 1) this new variable and 2) the interaction of this variable and UR:

$$Crime\ Rate = \beta_0 + \beta_1 UR + \beta_2 I(West\ Coast) + \beta_3 UR \times I(West\ Coast) + u$$

From our fixed effects discussion, $I(WC)$ is a fixed effect for being a WC state

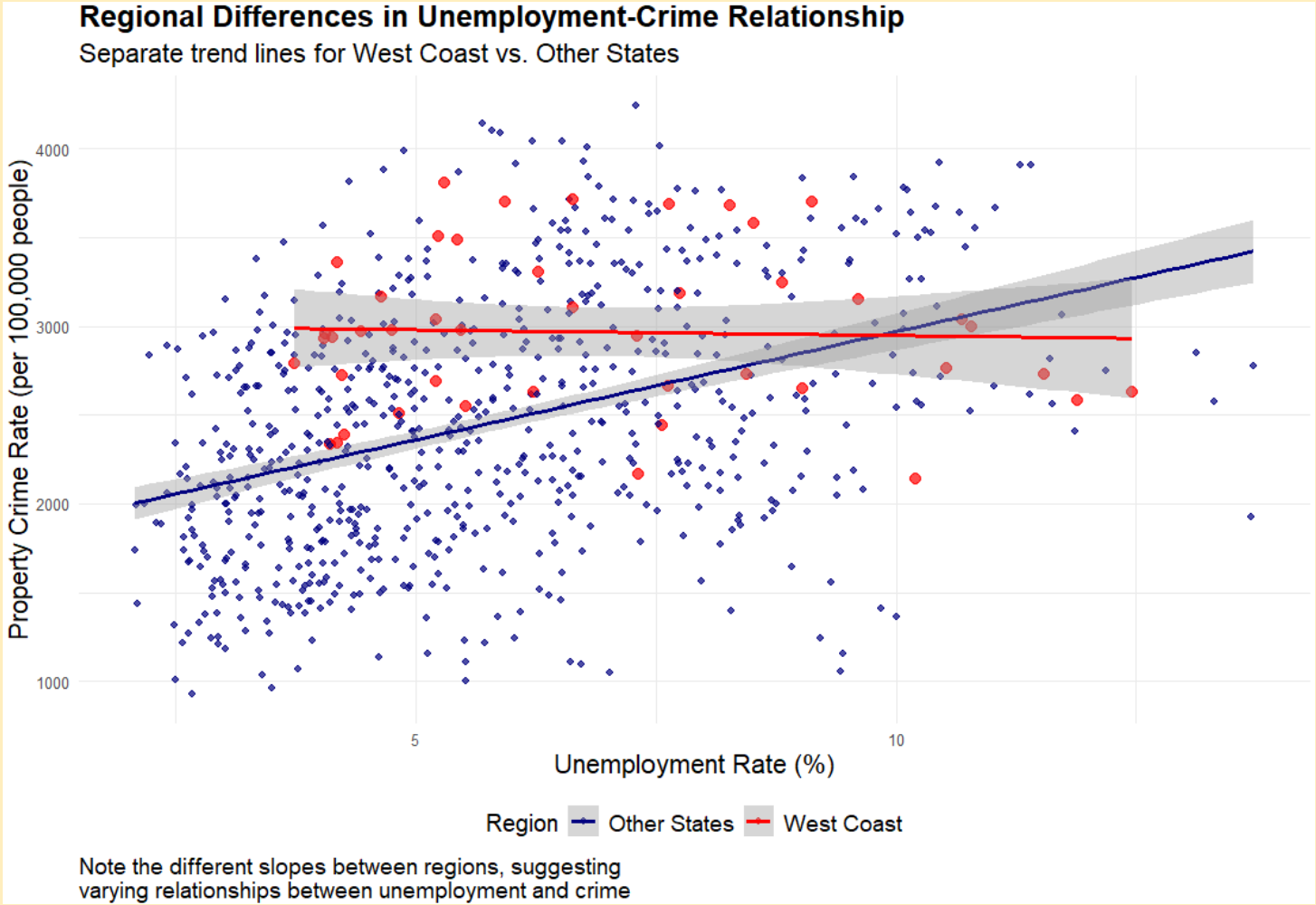
- Now, we get two predicted values for crime rates given a value for UR
- Make sure you can calculate both values by setting $WC = 0, 1$

Interactions in R

Run this regression using ":" in R: `lm(crime ~ UR + WC + UR:WC, data)`

- This tells R to create the interaction of UR and WC
- Intuitively, imagine R adding two new columns to our data:

State	Year	Crime Rate	Unemployment Rate (%)	WC	$UR \times I(WC)$
Arizona	2010	1,700	4	0	0
Alabama	2015	2,100	3	0	0
California	2017	2,000	6	1	6


Regional Differences in Unemployment-Crime Relationship
Separate trend lines for West Coast vs. Other States
Property Crime Rate (per 100,000 people)
4000
3000
2000
1000
5
10
Unemployment Rate (%)
Region
Other States
West Coast
Note the different slopes between regions, suggesting
varying relationships between unemployment and crime

Things to Remember

Interactions allow you to flexibly explore variation across groups

- Technically, you can interact two continuous variables
- However, for this class, we want groups to be defined by factor variables

Ideally, this factor variable is binary or has a “limited” number of levels

- How many levels is too many? Context matters – think about interpretation

SOMETHING TO REMEMBER: Interactions increase the amount of data you need

- Too little data and we’ll lose precision relative to simple OLS
- Key point – need data across groups (i.e., observations in both WC & non-WC)