Reading Regression Output Without Taking Econometrics

James Woods

The Goal

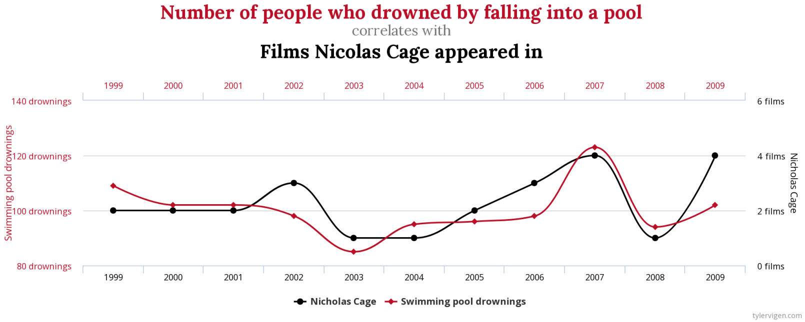
Most of the papers you read are looking for evidence that something caused something else.

- Some of this evidence is from hypothesis tests.
- Some is through how the data is collected

Cause

- What we usually want to know is what is the effect of changing one variable on another variable.
- We want cause, not just correlation (https://www.tylervigen.com/spurious-correlations)

Please Stop Nicolas Cage



Ideal

Run an experiment (Randomized Control Trial or RTC):

- Get a well mixed relativly homogenous group.
- Randomly subdivide in to two or more groups.
- One group is the control
- Treat the others.
- Observe response.
- Difference response between control and each group is the average response, which has a mean and variance and you can do stats with.

Easy Right

What if the groups are not quite the same, the technical term is unbalanced, which is just one definition of the unbalanced?

- One group has more old people or poor people.
- You need to make sure you take into account these differences.
- Because treating things that are different as if they are the same is bad.
- Simpson's Paradox

Example

Votes in the U.S. House of Representatives in favor of passing the Civil Rights Act of 1964:

Democrat	Republican
61%	80%

On average, Republicans tended to vote for passage more than Democrats

But there is another factor

	Democrat	Republican
North	94% (145/154)	85% (138/162)
South	7% (7/94)	0% (0/10)
Overall	61% (152/248)	80% (138/172)

In *both* North and South, Democrats are more likely to vote for passage than Republicans. We treated Northerners and Southerners the same in the first chart – Here they are shown to be different.

How Easy is That?

- You know how to do Chi-squared test?
- Just gather factors and ...
  - Eye color (8)
  - Hair color (8)
  - D2/D4 (2)
  - 128 cells so far.

You just found the curse of dimensionality. You need to combine or ignore some of these because you will not have enough observations.

Continuous Variables

Height:

- Less than or equal to 5’5“, greater than 5’5”
- But 5’5" and 4’ 11" are in the same category and 5’4" and 5’ 6" are not?

Need a way of matching with continuous variables. Regression allows you to do this.

Just Basics

Doing Econometrics well is hard.

- EC 460 will teach you the basics of single-equation regression, e.g., demand estimation, and how to fix some things.
- Make you overconfident.
- Functional work requires:
  - Systems equation estimation, e.g., supply and demand at the same time.
  - Discrete choice, e.g., Yes/No or make and model of a car.
  - Knowledge of how to get causality, experimental, e.g., RCT, and quasi-experimental methods, e.g., regression discontinuity.

BASICS Single Equation

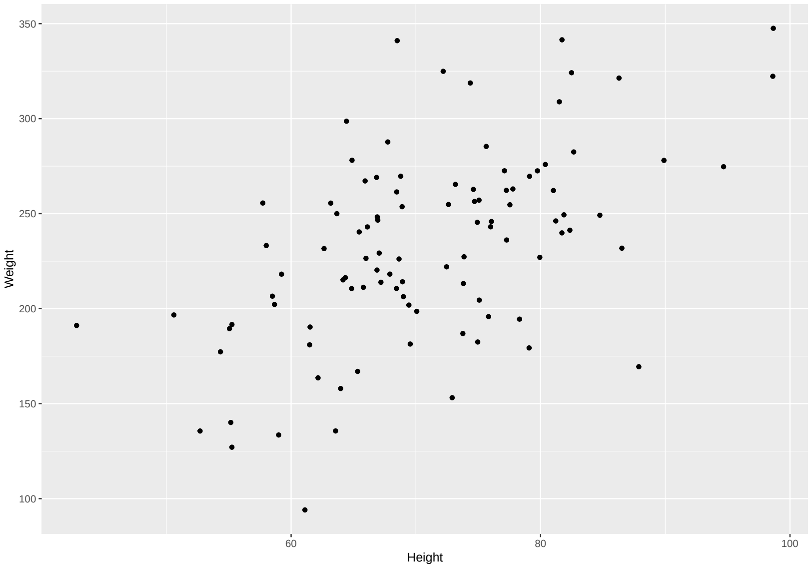
Explain something, often called the left-hand side or endogenous variable, with explanatory, right-hand side or exogenous variables.

$$Weight = \alpha + \beta Height + \epsilon$$

- Weight is left-hand side
- α intercept term, expected weight given you have no height.
- β How much your weight increases for every inch of height.
- ϵ How far off we were.
- All the greek letters are random variables. We estimate the means and variances of those.

Generating Fake Data with Weight = 20 + 2.75 Height + n(0,40)

Fake Data



Regression Output

Table 1:

	Dependent variable:
	Weight
Height	2.724^{***}
	(0.418)
Constant	39.626
	(29.903)
Observations	100
R^2	0.303
Adjusted R^2	0.296
Residual Std. Error	42.317 (df = 98)
F Statistic	42.555^{***} (df = 1; 98)
Note:	*p<0.1; **p<0.05; ***p<0.01

The parameters

The Parameter Estimates:

- Estimates of the line through the data
  $Weight = 39.6260832 + 2.7241226 Height$
- The True values are: $Weight = 20 + 2.75 Height + n(0, 40)$

Note that the values are not the same. Each of the estimated values comes with uncertainty. It is a random variable. Those are the numbers in parentheses are standard deviations of the estimate.

With Confidence Intervals

Table 2:

	Dependent variable:
	Weight
Height	2.724^{***}
	(1.906, 3.543)
Constant	39.626
	(-18.983, 98.236)
Observations	100
R^2	0.303
Adjusted R^2	0.296
Residual Std. Error	42.317 (df = 98)
F Statistic	42.555^{***} (df = 1; 98)
Note:	*p<0.1; **p<0.05; ***p<0.01

Of Note

- 95% confidence intervals are about $+/$- 2 standard deviations
- There is a 95% that the true value is in that interval
- Asterix indicate that the probability of seeing this value by chance alone is small. Commonly called significance.

The Lower Part of the Table

Table 3:

	Dependent variable:
	Weight
Height	2.724^{***}
	(0.418)
Constant	39.626
	(29.903)
Observations	100
R^2	0.303
Adjusted R^2	0.296
Residual Std. Error	42.317 (df = 98)
F Statistic	42.555^{***} (df = 1; 98)
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Overall

Regression as a whole:

- R^2 fraction of variation in LHS explained by variation in RHS.
  - Because if you add more variables R^2 goes up, Adjusted R^2, penalizes for having more variables.
- Residual Std. Error is the standard deviation of the error term. We generated the data with N(0, 40)
- F Difference between model that is mean of LHS alone, just the intercept, vs model with RHS. IOW, things other than the constant explain things.

Complications

- Dummy Variables, which indicate categories like eye color
- Transformations like log and powers

Categories

- They usually leave one out, often the control or most common category.
- These get accumulated in the constant term
  - The constant could be Blue eyes, Short, non-economist
  - Additional coefficients would indicate the difference between brown eyes and blue. Another would be tall vs short.
- Always figure out who the constant represents.

The reason is a math thing about minimization or maximization.

Transformations

- Usually these are because reality works this way, the amount of light from a source decreases by the square of the distance.
- Sometimes it solves a problem with residuals (heterskedasticity)
- Often come with interpretation
  - $Y = \alpha + \beta x$
  - $ln(Y) = \alpha + \beta x$: A 1% increase in x increases y by β%.
  - $ln(Y) = \alpha + \beta ln(x)$: β is an elasticity. 1% increase in x increases y by β%.

When Reading a Table

- Never just go, this is significant and this isn't. Understand how it fits in the story.
- Some of the variables are "just controls" and others are the key variables.
- Tell the story of the key variables.

Problems

- LHS is a dummy variable, e.g., buy or don't buy, then we use a probit or logit.
- One of the RHS variables is endogenous, like how renting or buying is determined by income credit and cost of living in the area. We use instrumental variables for this.

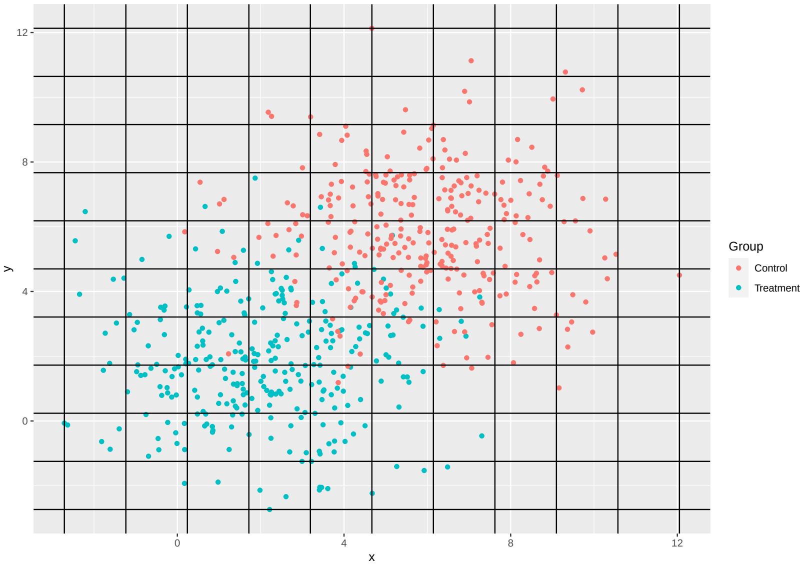
How We Use Regression for Causality

- In real randomized experiments like RTC, to balance taking into account that the randomly generated groups could have slightly different characteristics that are important.
- With Quasi-Controls
  - Matching like caliper or coarsened exact matching.
  - With outside pseudo-randomizer like regression discontinuity test.
  - Difference-in-Difference, match pre-treatment movements and parameters with a control group and then look for differences post intervention

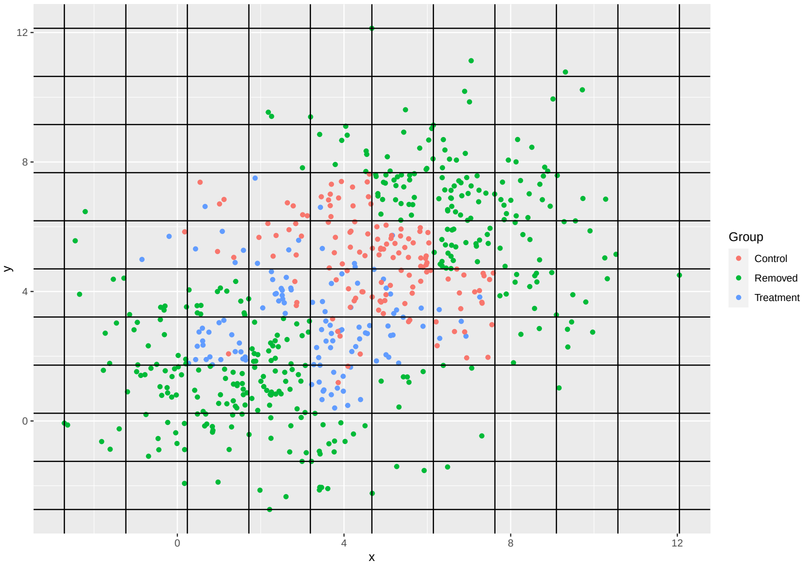
Coarsened Exact Matching (CEM)

- Break RHS variables into histograms.
- Multivariate histograms
- Remove observations that do not have a treatment and a control observation.
- Remove influence of observations not in joint support.
- Balance the cells for treated and not treated.

Hypothetical Data



With Unmatched Observations Removed



Differences-in-Differences (DID)

Start with a treated group and go looking for an untreated controls group.

- Test if there is parallel movement, basically all the parameters except the constant term are the same.
- Check if the treated group reacts differently after the intervention.

Example

Relationship between height and weight. One group got free passes to the gym if they went a few times a month and the other did not

$$\begin{aligned}
Weight = \alpha_{treated} + \alpha_{control} + \\
\beta_{treated,pre} Height + \beta_{control,pre} Height + \\
\beta_{treated,post} Height + \beta_{control,post} Height
\end{aligned} \tag{1}$$

- Parallel movement test is $\beta_{treated,pre} = \beta_{control,pre}$ but not $\alpha_{treated} = \alpha_{control}$.
- Average effect is $\beta_{treated,post} - \beta_{control,post}$
- Can be more complex than this if the treatment changes multiple terms – including the intercepts.

Lets Pull Some of Your Regessions