Quantitative Analysis and Empirical Methods

2) Research Design

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Introduction

- We have learned about converting concepts into variables
- Our key interest is to understand relationships between variables
- And even more importantly, understand how changes in one variable affect changes in another variable
- To do this, we must first consider the design of our research and consider the threats to our research validity

Explaining Relationships

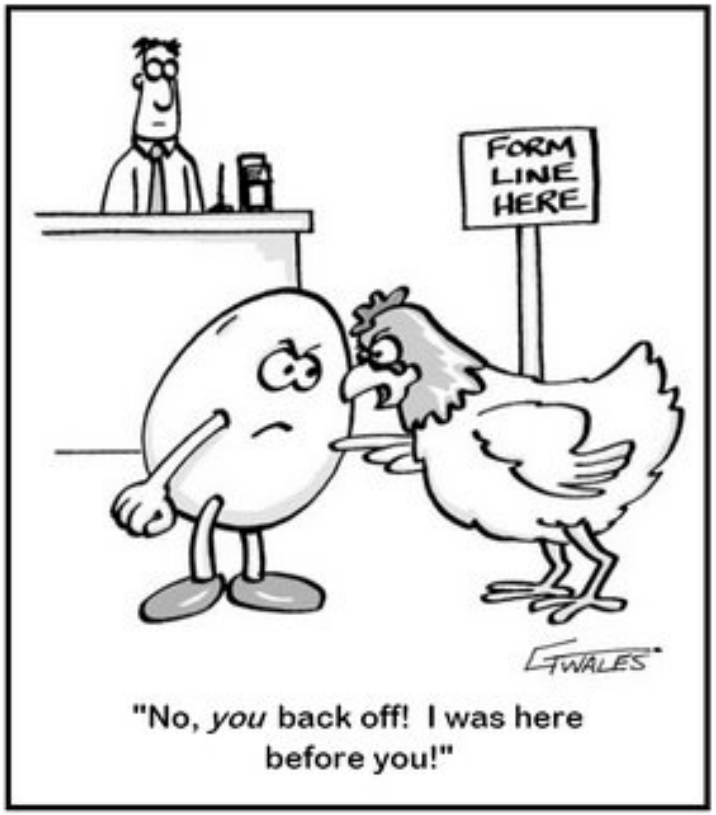
Dependent and Independent Variables

- Dependent variable: values you are trying to explain
- Independent variable (predictor, regressor, explanatory variable):
  what we think causes or is causally related to the dependent variable

$$\text{Hypothesis} \begin{cases} \text{Independent variable} \rightarrow \text{Relationship} \rightarrow \text{Dependent variable} \\ \text{or} \\ \text{Dependent variable} = \text{f(Independent variable)} \end{cases}$$

Hypothesis

- Hypothesis is an explicit testable statement
- Usually associates the dependent and an independent variable
- It can be about a single variable



Characteristics of Hypotheses 1

- 1) Hypotheses should be as specific as possible and provide a clear tendency between the variables
  - H1.1 Economic development is related to democracy.
  - H2.1 Democracies are more peaceful.
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  - H3.3 Income inequality has grown since 1990 in eastern Europe.

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  - H2.2 More junior judges impose stricter punishment on convicted defendants.

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  - H1.2 It was better passing that led to Portugal winning the Euro Cup.

The Bigger Picture

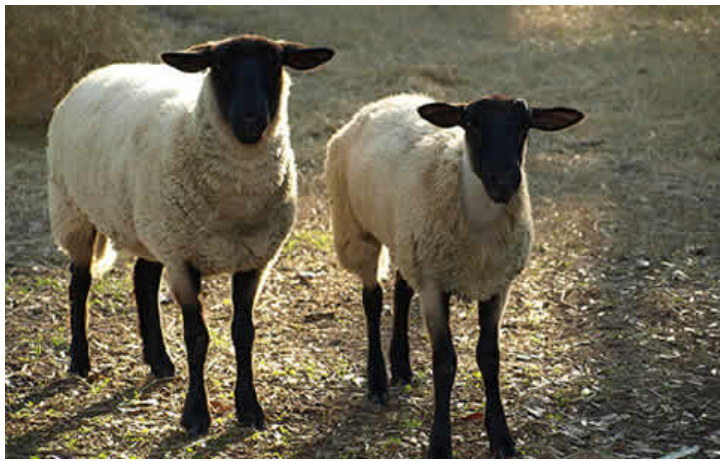
- A set of propositions – some of which are testable hypotheses – is a theory
- Not all propositions are testable, we call these assumptions
- A simplified form of a theory is called a model, which can be expressed verbally, graphically or mathematically.
- We will learn to model hypotheses and theories using Stata.

Model Example 1

Theory: Economic liberalization causes democratization

Model:

- liberalization $\rightarrow$ investment
- investment $\rightarrow$ profit
- profit $\rightarrow$ bourgeoisie
- bourgeoisie $\rightarrow$ political interests
- political interests $\rightarrow$ democratization



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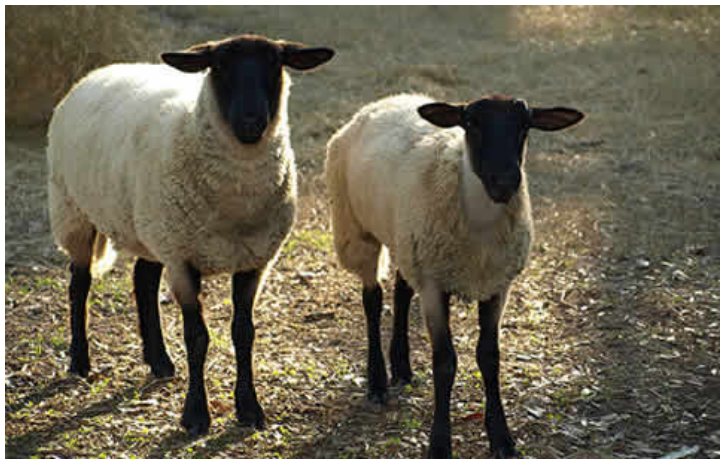


- sheep $\rightarrow$ commercial mindedness of aristocracy $\rightarrow$ economic liberalization (with apologies to Barrington Moore)

Model Example 2

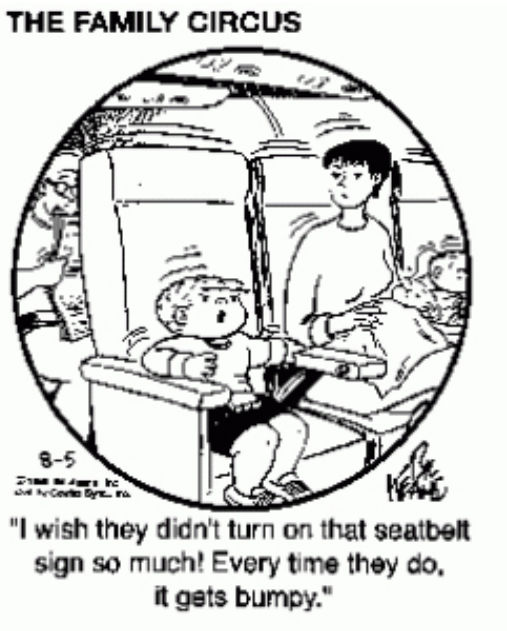
Theory: Vote choice is determined an individual's socio-economic profile

Model:

$$vote = \beta_0 + \beta_1 gender + \beta_2 age + \beta_3 education + \beta_4 income + \beta_5 religiosity + \beta_6 community$$

Causality

- The goal of social sciences is to provide causal explanations
- These are explanations that state that A causes B (rather than the opposite)
- Causality is impossible to prove (statistically), it is only possible to argue
- Correlation $\neq$ Causation!!!



Causal Explanation

- 1) Time order
  - Cause must precede effect
  - Granger Causality
- 2) Covariation
  - ΔY must be associated with ΔX
  - Cannot explain change with a constant
- 3) Non-spuriousness
  - The relationship between X and Y should not be driven by a third variable
  - Problem of proving a negative
  - Problem of multiple causation
- 4) Theoretical consistency
  - It needs to make sense...
  - Problem of data-mining

Research Design

Research Design

- Research design is a set of procedures for testing a hypothesis about a relationship.
- It is the method of assessing the effect(s) of the independent variable(s) or treatments on the dependent variable or outcome

Counterfactual

- A way of assessing causality
- Idea that each individual can be exposed to two alternative states of a cause
- Assumption is that each individual has a potential outcome under each treatment
- That is, individual i can have an outcome y_i^1 and y_i^0
- Individual level causal effect can be defined as $y_i^1 - y_i^0$
- However, we cannot observe both y_i^1 and y_i^0 at individual level
- We can only measure y_i,
- $y_i = y_i^1$ in treatment state, $y_i = y_i^0$ in control state

Example

What is the effect of taking the math camp (C) on your math skills (S)?

- Take two groups of students: 1 and 0 (ideally identical)
- Measure initial skill: $S_{0,t0}, S_{1,t0}$
- Group 1 takes C (treatment)
- Measure skills again: $S_{0,t1}, S_{1,t1}$
- The effect of C on S is the difference between the differences in skills $= (S_{1,t1} - S_{1,t0}) - (S_{0,t1} - S_{0,t0})$

Forms of Validity

- Internal Validity
  - Considers whether our claims are valid (correct) in the particular experiment at hand
  - Experiment specific logic of design and validity of claims
  - Assessment is based on the 4 criteria of assessing causal explanations
- External Validity
  - Considers the extent to which the results obtained in a given study are generalizable to different populations, contexts, times...

Forms of Research Design

- True Experiments
  - Researcher has control over sample selection, treatment, measurement and analysis
  - Typically division into experimental and control group with randomized or matched assignment before experimental treatment.
- Quasi-Experiments
  - No control over sample selection or treatment
  - Natural experiments (before / after some shock); panel data; cross-sectional data; controlled comparisons

True Experiments

Group	Assignment	Obs 1	Treatment	Obs 2	Comparison
Experimental	Random	O_{e1}	Yes	O_{e2}	$O_{e2} - O_{e1}$
Control	Random	O_{c1}	No	O_{c2}	$O_{c2} - O_{c1}$

- Excel at internal validity but have limited external validity
  - Context
  - Non-representative sample

Quasi-Experiments

Design							
Cross-section	X	O					
Panel study	O_1	X	O_2				
Trend study	O_1	X	O_2	O_3	X	O_4	O_5

- Stronger external validity, weaker internal validity
- Use of statistics to establish association between cause and effect
- With longitudinal studies may be able to establish time-order, but not always (cointegration)
- Problem of possible spuriousness threatens internal validity
- To deal with spuriousness we employ statistical control techniques

Common threats to Internal Validity

- Omitted Variables (spuriousness)
- Regression to the mean
  - Groups selected on the basis of extreme scores will tend to display lower scores next time
- Non-random sample selection
  - Difference in comparison groups is not due to treatment but because groups were different to start with
  - Selecting on the dependent variable

Example 1

At the age of 5 your parents give you an algebra exam and you fail. Rather than being punished, you argue with your parents that you need greater incentives to study. They agree to give you an ice cream every time you do your homework for the next 10 years. At the age of 15 you take another algebra exam and you do well. You claim that it is thanks to the ice cream.

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- What is the underlying research design?
- What are the possible validity problems?

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- Omitted variables (age, school attendance)

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- 100% of heroine addicts have drunk milk

Common threats to External Validity

- Selection
  - Groups are not representative of the larger population (not randomized)
  - Example: A study on our class
- Out of sample extrapolation
  - Setting is out of bounds of treatment
  - Example: a study that administers dosages from 0 to 40ml when doctors administer 100.

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