Engineering Economic Experiments

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MW24.2 Experimental Economics (SS2021)

Lecture Plan

- What makes a good experiment
- Engineering experiments

Daniel Friedman and Shyam Sunder. Experimental Methods: A Primer for Economists, Cambridge University Press, 1994 [chapter 3]

What Makes a Good Experiment

- Experiment is a systematic and scientific approach to research in which the researcher manipulates one or more variables, and controls and measures any changes in other variables
- A good experiment is one that controls for the most plausible alternative hypotheses that might explain what is being observed, and therefore allows you to distinguish among them
- Experiment is an act of balancing direct and indirect control

Direct control:

- selecting relevant factors as well as their levels to represent the situation of interest

Indirect control (randomization):

- collecting random samples from the population of interest to ensure eventual independence of nuisance factors and measured response

External validity:

- extent to which causal inferences made in a controlled experimental setting can be extrapolated to other settings (e.g., real life environment they are supposed to represent)

- Generalizability across situations
- Generalizability across people

Internal validity:

- extent to which causal inferences are warranted by a controlled experimental setting

Necessary conditions:

- temporal precedence
- covariation of the cause and effect
- elimination of alternative plausible explanations

"Scientia Potentia Est" (Sir Francis Bacon)

- Temporal precedence:

  Knowledge comes *before* power

- Covariation of the cause and effect:

  Lots of knowledge ⇒ *lots* of power (positive statement)
  Little knowledge ⇒ *little* power (contrapositive statement)

- Elimination of alternative plausible explanations:

  Perhaps, e.g., money is power?

Engineering Experiments

- Dependent (outcome) variable(s)

Direct Control

- Independent (treatment) variable(s)
- Control variable(s)

Indirect Control

- Uncontrolled (nuisance) variable(s)

(!) Confounding variable(s)

Type III error: correctly rejecting the null hypothesis for the wrong reason (Mosteller, 1948)

Engineering Experiments

Boys' shoe experiment (Box et al., 1978)

- Difference in measured wear between the soles

Direct Control

- Sole material: 'old' and 'new'
- Subject identity: activity profile etc.

Indirect Control

- Braking foot: left or right

Randomized Control(led) Trial(s)

- Trial: indivisible unit of experiment, unique and independent observation of the phenomenon of interest

- Random assignment is quintessential to the experimental method
- By randomly assigning trials to treatments, we can assume:
  - uncontrolled factors are eventually independent of treatment variables
  - there are no systematic differences across the groups

- How many trials is enough? $\leftarrow$ Power analysis
- Alternative to RCT – Blocking designs (e.g., twin studies, within-subject)

Types of Designs as far as Treatment Structure

- Treatment: an exogenously controlled set of procedures, instructions, incentives, rules, parameter values etc.

- Number of treatments as well as their structure allows to distinguish among:
  * one-cell design
  * one-factor design
  * factorial design

One-Cell Design

- Only one level of independent variable is considered
- Impossible to make any causal inferences
- Does not satisfy the criteria of an experiment
- Effectively, a parameter estimation

Dictator Game

* Forsythe et al. (1994)

In this experiment each of you will be paired with a different person who is in another room. You will not be told who these people are either during or after the experiment, and they will not be told who you are either during or after the experiment.

You will notice that there are other people in the same room with you who are also participating in the experiment. You will not be paired with any of these people. The decisions that they make will have absolutely no effect on you nor will any of your decisions affect them.

The experiment is conducted as follows: A sum of $5 has been provisionally allocated to each pair and the person in Room A can propose how much of this each person is to receive. To do this, the person in Room A must fill out a form titled "Proposal Form".

{1}	Identification Number __A	
{2}	Paired With __B	
{3}	Amount to divide	________
{4}	Person in Room B receives	________
{5}	Person in Room A receives {3} − {4}	________

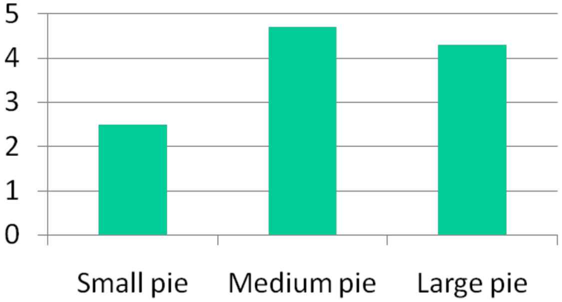
The person in room A makes the proposal. The proposal consists of an amount the person in Room B is to receive (entered on line {4}) and the amount the person in room A is to receive (entered on line {5}). The amount the person in Room A is to receive is simply the total amount to be divided, $5, minus the amount the person in Room B is to receive.

Dictator Game

- Treatment:
  - size of the pie
  - origin of the pie
  - socioeconomic characteristics of the players
  - incentive scheme
- Outcome:
  - share of the pie kept by the dictator

One-Factor Design

Independent Var.	X_1	X_2	X_3
Dependent Var.	Y_1	Y_2	Y_3
	Treatment 1 (Control)	Treatment 2	Treatment 3



Factorial Design

- Several factors, changing one at a time while holding the other(s) constant
- Allows to study interactions between factors

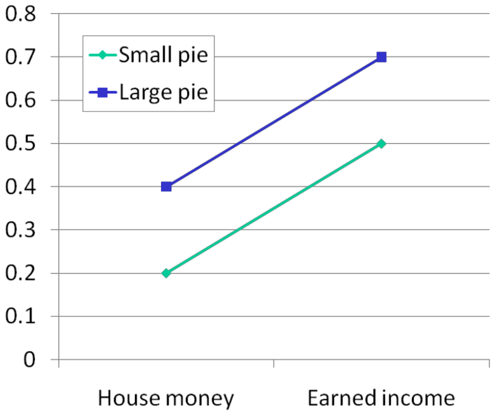
		Factor 1	
		X_1	X_2
Factor 2	W_1	Y_1	Y_2
	W_2	Y_3	Y_4

Dictator Game

- Treatment (factorial design):
  - * (size of the pie) $\times$ (origin of the pie)
  - * (size of the pie) $\times$ (incentive scheme)
  - * (origin of the pie) $\times$ (incentive scheme)
- Outcome:
  - * share of the pie kept by the dictator

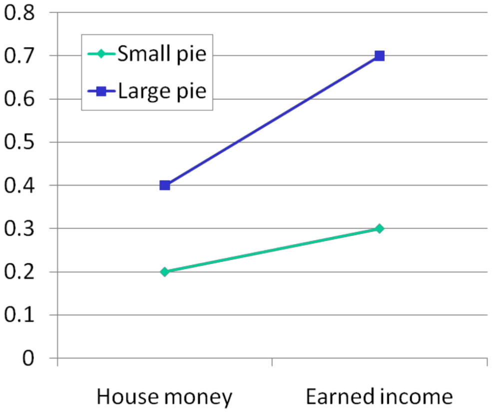
Factorial Design

- No interaction between the factors



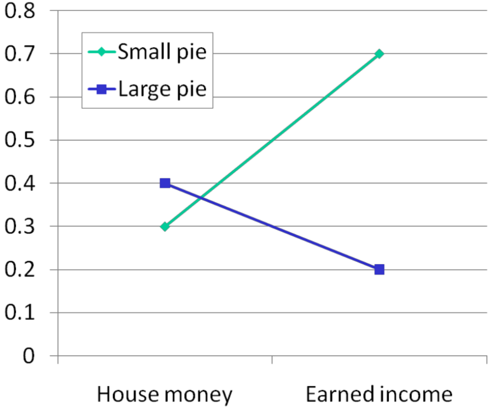
Factorial Design

- Positive interaction between the factors



Factorial Design

- Negative interaction between the factors



Full and Fractional Factorial Designs

- Using a lot of factors and levels leads to the dimensionality problem
  * for three factors with the number of levels equal to m, n, and k, respectively:

$$N = m \times n \times k$$

- Solution:
  * revise the experimental design
  * use a *fractional* factorial design

		Factor 1			
		X_1	X_2	X_3	X_4
	W_1	Y_1			
Factor 2	W_2		Y_2	Y_3	
	W_3		Y_4	Y_5	

Assigning Trials (Subjects) to Treatments

- *Between-Subject* Design:
  - one treatment per subject
  - random assignment of subjects to treatments (on top of blocking if any)

- *Within-Subject* Design:
  - each subject participates in all treatments

	Between-Subject	Within-Subject
Control of unobservable characteristics	Law of Large Numbers	Fixed by construction
Sample size	Large	Small
Ordering effects	N/A by construction	Experience, fatigue, history dependence
Treatment carryover	N/A by construction	Consistency bias, demand effects

One-Shot and Repeated/Recurring Interactions

- Reasons to repeat:
  - Dynamic scenario ⇒ *repeated setting*, ongoing interaction
  - Collecting more data ⇒ *recurring* setting, multiple independent instances of one-shot interaction

  - Also, can be justified by the necessity of subject learning

Prisoner's Dilemma

* Melvin Dresher and Merill Flood (1952, 1958)

	1	2
1	-1, 2	$\frac{1}{2}$, 1
2	0, $\frac{1}{2}$	1, -1

- 100 repetitions in fixed pairs
- Predicted earnings of 0 and 50
- Observed earnings of 40 and 65

> "If this experiment were conducted with various different players rotating the competition and with no information given to a player of what choices the others have been making until the end of all the trials, then the experimental results would have been quite different, for this modification of procedure would remove the interaction between the trials," Nash

One-Shot and Repeated/Recurring Interactions

- Subject matching protocols:
  * Partner: fixed over time
  * Stranger: re-matching after each repetition
  * Perfect (absolute) stranger: re-matching after each repetition while ruling out prior partnerships
  * Extra: re-matching after each repetition while ruling out prior partnerships of higher orders

One-Shot and Repeated/Recurring Interactions

- Contemplating repeated/recurring over one-shot design:
  - research objective
  - trade off between data costs and ease of implementation (e.g., matching protocol)
  - history dependence, fatigue etc. (similar to the within-subject protocol)
  - subject learning
  - reputation effects

Experimental Session

- Treatment:
  - * *Logical* unit of an experiment
  - * What is happening in the experiment conceptually?
- Session:
  - * *Logistic* unit of an experiment
  - * How is the experiment conducted in space and time?

- How many sessions to run?
  - * Ideally, just one – i.e., all the treatments with all the subjects in *one location* and at the *same time*
- Factors to consider when running multiple sessions:
  - * External events that could lead to loss of control
  - * Differences in information disclosure across treatments

Lecture Summary

- What makes a good experiment
  * Definition of an experiment
  * Principles of direct and indirect control
  * Causal inference w.r.t. external validity
  * Causal inference w.r.t. internal validity

- Engineering experiments
  * Basic building blocks (variable, trial, treatment, session)
  * Assigning subjects to treatments
  * Types of matching in repeated settings