How Theory Can Inform Experiments (and vice-versa)

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Experiment
Apology

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- I’ll conduct a helicopter tour, touching down just once or twice on each of the main continents.
Theory

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- Left to itself, theory tends to build gossamer bridges to nowhere.
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- Left to itself, empirics wanders aimlessly in the swamp.
The Engine

Figure: aka Cycle of Creative Destruction (Al Roth), aka scientific hermeneutics, ...

Friedman
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- The interplay of theory and empirics propels science forward.
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- My own first encounter was with Vernon Smith’s work on markets.
- CE was the core theory of economics for over a century, but did not seem conducive to experiments.
  - Key primitives of the theory, preferences and beliefs, seemed unobservable;
  - even observing production functions seemed problematic.
Lab Markets

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- He saw notable departures from CE, but didn’t really bolster monopolistic competition.
- Smith realized that induced value enabled control of preferences and production fnns.
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- Now one could check convergence over time and as number of B, S increased.
Figure: From Smith, *Economic Inquiry* 1982: A scientific mystery in the making.
Lab Markets Results

- Shocking results: reliably got quick convergence even with as few as 3B+3S.
- Smith and later investigators found that this extends rather broadly, to odd S/D configs, to some asset markets, to other market trading formats e.g., Call and PO, ...
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- vice-versa: Why not $\sqrt{n}$?? A scientific mystery.
The engine turns

- Smith proposed excess rent dynamic, but it doesn’t solve the mystery.
- New theories of CDA convergence proposed in 1980s by Easley & Ledyard, by me, by Wilson, by Gjerstad & Dickhaut; and on CMs by Satterwaite & Williams, ...
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- We still await a full solution of the mystery, but see my 1995 EJ paper with Ostroy for 2 turns of the engine, drilling into Bertrand competition within period.
- Now market design is the hot spot here; cross-fertilized by different tradition (Gale-Shapley; Al Roth).
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- Tests go back to late 1940s, e.g. Estes’ 2 lightbulb guesses and “probability matching.”
- K-T Prospect Theory (like a raft of other non-EUTs) summarizes many (ir)regularities; with 5 or more free parameters it fits lots more data than Ew or EUT;
- A problem with both EUT and PT is that fitted parameters don’t seem stable across tasks (or even frames). An underexplored frontier for experimenters.
Social Preferences: Distributional

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- One way to rationalize: expand the object-of-choice set to entire allocations, e.g., income distributions.
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- In some social situations—Dictator “Game” is the simplest—human Ss sometimes don’t seem to max utility of own bundle.
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- In late 1990s, Bolton & Ockenfels, and Fehr & Schmidt developed testable models of distributional preferences. (Charness & Rabin straddle).
- But maybe such preferences are misspecified? After all, Ss don’t treat random strangers the same way outside the lab, and numerous studies show that Ss are far more generous with generous first movers than with greedy first movers.
Social Preferences: Reciprocal

- To capture positive and negative reciprocity, Cox, Friedman & X import the theoretical device of state-contingency.
- The contingency here is the emotional state—gratitude or resentment towards the first mover.
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- To compensate, they also import warhorses like convexity, MRS/tangency conditions, homothetic CES machinery.
- $X = \text{Gjerstad (GEB, 2007)}$ fits reciprocity sensitivity ($a$), convexity ($\alpha$) parameters, plus 2 or 3 others to capture individual idiosyncrasies, etc.
- Get fairly consistent fits across existing experiments.
Like dictators, second movers in a Stackelberg game choose joint payoff for their possible choices, but unlike dictators their utility may respond to first mover behavior. Huck, Muller, and Normann (2001) present an experiment in which randomly matched pairs of subjects play a Stackelberg duopoly game. The first mover ($F$) chooses a output level $x \in \{3, 4, 5, \ldots, 15\}$. The second mover ($S$) observes $x$ and chooses an output level $q \in \{3, 4, 5, \ldots, 15\}$. The price is $p = 30 - x - q$; both players have constant marginal cost 6 and no fixed cost, so the profit margin for each player is $M = 24 - x - q$. Payoff therefore are $m = Mq$ and $y = Mx$ or $m(x, q) = (24 - x - q)q$ and $y(x, q) = (24 - x - q)x$.

Given $F$'s choice $x$, the second mover's choices exist on the space trajectory by varying $q$ from 3 to 15. As illustrated in figure 3, it is a parabolic arc that opens toward the $y$-axis whose vertex $(m, y) = (\frac{1}{4}(24 - x), \frac{1}{2}(24 - x)x)$ corresponds to $q = \frac{1}{2}(24 - x)$.

In figure 3, $F$'s choice is $x = 4$; $S$'s choice $q = 3$ produce payoff vector $(m, y) = (51, 68)$ while $q = 10$ produces the vertex payoff vector $(m, y) = (100, 40)$. With $x = 4$, choices $q < 10$ reduce $m$ but increase $y$, while choices $q > 10$ reduce both $m$ and $y$.

Figure: Feasible Stackelberg joint profits when first mover output is $x=4$. 

$y$ \[ \begin{array}{c|c|c|c|c|c|c} 
 & 20 & 40 & 60 & 80 & 100 & 120 \\
\hline
m & 0 & \cdot & \cdot & \cdot & \cdot & \cdot \\
\hline
q = 3 & \cdot & \cdot & \cdot & \cdot & 60 & \cdot \\
\hline
q = 15 & \cdot & \cdot & \cdot & \cdot & \cdot & 20 \\
\hline
\end{array} \]

$q = \frac{1}{2}(24 - x)$
Panel (a) of figure 5 redraws $S$’s choice set from figure 3 given $x = 4$, and also includes a tangent indifference curve for positive $\theta$. Here $S$ chooses $q$ slightly below the selfish best reply $q = \frac{1}{2}(24 - 4) = 10$, reducing his payoff abit below $m(4) = \frac{1}{4}(24 - 4)^2 = 100$ to $m = 99$ while boosting $F$’s payoff noticeably above $y(4) = \frac{1}{2}(24 - 4)^4 = 40$ to $y = 44$.

Panel (b) shows $S$’s choice set given $F$’s much less generous choice $x = 12$. The tangent indifference curve is for negative $\theta$. Due again to the parabolic choice set, by increasing $q$ above the selfish best response, $S$ obtains a first-order decrease in $F$’s payoff from $y(12) = 72$ to $y = 60$ while sacrificing only as second-or-dramount from $m(12) = 36$ to $m = 35$. This illustrates the basic point that $S$ is more inclined to overproduce (relative to selfish best response) the larger is $F$’s output choice.

The model provides a natural explanation for heteroscedasticity in the choices of $q$ even though, by assumption A.2, $S$’s underlying individual variability $\epsilon$ is independent of first mover choice $x$. The explanation starts by noting that in panel (a) of figure 5, the choice set and the indifference curves for $x = 4$ have very different curvatures. Hence the tangency point doesn’t move much as one changes $\epsilon$. By contrast, in panel (b) for $x = 12$, the curvature of the choice set is much closer to the curvature of the indifference curve, so the same change in $\epsilon$ has a much larger impact on the tangency point. Thus the model implies that second mover choices $q$ will be more dispersed when the first mover choice $x$ is larger.

**Figure:** Feasible Stackelberg joint profits and contingent preferences when $x=4, 12$. Note endogenous heteroskedasticity.
▶ X = Sadiraj (E’tra, 2008) takes a different page from standard theory: revealed preference, non-parametric.
▶ MGT, MAT, Axiom R.
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  ▶ see previous diagram:
  ▶ a given SM choice set could be the more or the less generous.
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Current frontiers: What happens in equilibrium of multiplayer game?
  ▶ Equilibrium is assumed in other reciprocity models, but not very tractably.
  ▶ Emotional states in equilibrium?
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  - many of which can be accommodated by QRE or other stationary predictions.
- I’ll talk about 2 remaining puzzles today, and recent progress from my lab.
Puzzle 1: Finite Horizon Prisoner’s Dilemma

- Selten & Stoecker (1986) show that unravelling occurs but doesn’t go very far. Why?
- Gang4 motivated by lab results, but doesn’t actually predict observed behavior (Cooper et al., 1996).
Puzzle 1: Finite Horizon Prisoner’s Dilemma

- Selten & Stoecker (1986) show that unravelling occurs but doesn’t go very far. Why?
- Gang4 motivated by lab results, but doesn’t actually predict observed behavior (Cooper et al., 1996).
- Two hints from theory:
  - Nash defined Grim strategies in 1952, noted that they are an equilibrium in the infinitely repeated game and “very nearly” an equilibrium in finitely repeated game.
  - Radner (1986) noted that Grim is epsilon dominant among cutoff strategies.
We study three treatments of time: Continuous, One-Shot, and Grid. In all treatments, each period lasts 60 seconds, during which subjects are allowed to change their actions at will. In Continuous time, subjects observe the unfolding history of actions and payoffs, and at the end of the period they earn the integral of the flow payoffs shown in the lower right hand graph of Figure 1.

In One-Shot time, subjects do not observe their counterpart's action until the period's end. They earn the lump sum payoffs for the action profile chosen at that point.

Grid time divides each sixty second period into $n$ equal subperiods. Payoffs in each subperiod are determined only by the last action profile chosen in that subperiod. Only at the end of the subperiod does a player see her counterpart's choice, and that last profile becomes the initial profile of the next subperiod. Payoffs for the entire period are the average of the lump sum subperiod payoffs or, equivalently, the integral across subperiods of the piecewise constant flow payoffs. Thus One-Shot time is the same as Grid time with $n = 1$, and Continuous time is closely approximated by Grid time with $n = 1$.

**Figure:** Continuous time PD. 60 second pairings, Med-a parameters.
Continuous time PD: results

- Pulses destabilize all-D and stabilize all-C.
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- Often see “a little flurry of aggressiveness at the end and perhaps a few sallies, to test the opponent’s mettle...”
Continuous time PD: results

- Pulses destabilize all-D and stabilize all-C.
- Often see “a little flurry of aggressiveness at the end and perhaps a few sallies, to test the opponent’s mettle…”
- Overall, 90%+ mutual cooperation.
Puzzle 2: Nonconvergence to interior unique NE

- Stylized fact for > 50 years; decent ex post fits by QRE, IBE, TASP, ...
- but why?? The counterintuitive logic of mixing? Biased learning? something else?
Figure: Heatmaps represent a payoff bimatrix with unique NE. Pairings are for 120 seconds.
Figure: Typical pilot results hint that the problem may have been merely difficulty in mixing and inadequate learning opportunities.
Advertisement for ConG

- Evgame theory predicts behavior for population games in continuous time; tests await.
- RPS: convergence to NE or cycles? Theories differ.
- Qwerty controversy: is there lock-in?
- Does traditional theory predict oligopoly pricing dynamics? Cournot quantity adjustment?
The Role of Theory

▶ Traditional hardnosed economic theory takes as given the individual primitives and the social institution (or game or market, if you will), and predicts the equilibrium outcomes.

▶ Cognitive and social psychologists (and a sizeable fraction of new experimental economists) use theory rather differently.
Two styles of theory

Individual preferences + Equilibrium social outcomes

Social institutions

Social outcomes

Social pressures → Individual behavior

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How Theory Can Inform Experiments (and vice-versa)
A third way

**Figure:** Behavior adapts in response to SR equilibrium payoffs.
Lyrics from “Experiment!” by Cole Porter, 1933.

...do what all good scientists do.
Experiment!
Make it your motto day and night.
Experiment, and it will lead you to the light.
The apple on the top of the tree is never to high to achieve
So take an example from Eve— experiment.
Be curious, though interfering friends may frown
Get furious at each attempt to hold you down.
If this advice you always employ, the future can offer you infinite joy
And merriment.
Experiment, and you’ll see!