Counterfactual Analysis in Economics: Using OSG to Solve Dynamic Games

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Economic Analysis and Public Policy

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- policy evaluation and
- "What if. . ." questions

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  Two questions: Why do we care about these issues? If we care, how do evaluate these policies/transactions before/after they happen?

Economic Policy Evaluation

Why do we care?

- Most policies affect millions of people: Medicare Part D, ACA, regulation (EPA, financial industry, education, etc), mergers, etc.
- Policies are often implemented under uncertainty.
- Business transactions may lead to decreasing the number of player. Prices and quality of products may be affected.

Economic Policy Evaluation: How do we do it?

1. Before: decide whether to implement a policy or challenge a transaction.
   - 1.1 Look for similar implementations elsewhere and try to extrapolate.
   - 1.2 Recover fundamentals of the specific situation and simulate behavior with the policy.

2. After: decide whether to expand a policy or implement an alternative.
   - 2.1 Compare situation before and after, controlling for confounding factors. Can't deal with "what if we had done something different".
   - 2.2 Recover fundamentals of the specific situation and simulate behavior with ~~the~~ an alternative policy.

Different approaches complement each other. OSG enters in 2.2.

Using OSG to Evaluate Policy

Consider the following scenario (note: could tell the same story with health insurance and many other things)

- Consumers/private investors (privately) saving for retirement.
  - U.S.: 401(k), 403(b)
  - Chile: national system of mandatory private accounts
  - 30+ countries with similar features.

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Questions: How many of you

- are in this situation? (hands up please!)
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- rebalanced your investment in the last year?

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Questions: How many of you

- are in this situation? (hands up please!)
- know who manages your savings/investments?
- know in what assets are your resources invested?
- rebalanced your investment in the last year?
- know how much you pay?

Using OSG to Evaluate Policy

In most markets,

- if consumers are not active, they pay more.
- if consumers stick to past decisions, they pay more.
- sticking to past decisions is not optimal:
  - wrong insurance plan
  - wrong investment portfolio
  - wrong cable/cellphone/Internet provider or plan.
  - etc.

Using OSG to Evaluate Policy

Policy question: If we were able to implement a policy that would make consumers more active, how would that affect the market?

Short answer: We don't know.

Long answer: Many things happen at the same time. To consider all of them, we need to know how consumers and firms behave.

Using OSG to Evaluate Policy

Normal approach in economics (using the retirement investment example).

- Use historical data to estimate people's preferences over funds, their willingness to pay, and their preferences over portfolios that differ on risk.

- Use the estimated preferences over "fundamentals", to study how people would behave in a different setting. Firms will adjust to the new context.

Using OSG to Evaluate Policy

Let's put numbers on this. I use 16 years of monthly contributions to show that

- 60 percent of people never changed a fund manager.

- People who switch fund managers more often
  - pay less than people who don't and
  - get the same returns

If we implement a policy that makes people more active, would this lead to lower fees?

- Maybe, but it could also lead to lower returns.

To answer the question, use OSG.

Using OSG to Evaluate Policy

1. Recover consumer preferences (no OSG here).
2. Simulate competition among funds in the context of active investors.

Focus on the second stage:

- Funds know that people tend to stay in their current fund. This increases prices.
- When choosing prices, funds not only consider current competition but also future competition.

In other words, each fund solves

$$V_j(\boldsymbol{s}_{t-1}, \boldsymbol{X}_t) = \max_{p_{jt}} \ \Pi_{jt}(\boldsymbol{s}_t, \boldsymbol{p}_t, \boldsymbol{X}_t) + \beta \mathbb{E}_t[V_j(\boldsymbol{s}_t, \boldsymbol{X}_{t+1})]. \quad (1)$$

The first-order condition is

$$\frac{\partial \Pi_{jt}}{\partial p_{jt}} + \beta \left[\frac{\partial \boldsymbol{s_t}}{\partial p_{jt}} \right]' \mathbb{E}_t \left[\frac{\partial V_j(\boldsymbol{s}_t, \boldsymbol{X}_t)}{\partial \boldsymbol{s}_t} \right] = 0, \quad (2)$$

Using OSG to Evaluate Policy

We need to solve

$$\frac{\partial \Pi_{jt}}{\partial p_{jt}} + \beta \left[\frac{\partial \boldsymbol{s}_t}{\partial p_{jt}} \right]' \mathbb{E}_t \left[\frac{\partial V_j(\boldsymbol{s}_t, \boldsymbol{X}_t)}{\partial \boldsymbol{s}_t} \right] = 0,$$

for every firm and combination of $\boldsymbol{s}_t$ and $\boldsymbol{X}_t$.

Need to compute $\mathbb{E}_t \left[\frac{\partial V_j(\boldsymbol{s}_t, \boldsymbol{X}_t)}{\partial \boldsymbol{s}_t} \right]$. How? Forward simulation.

OSG is what makes this possible for large state spaces.

Using OSG to Evaluate Policy

Two-step procedure

1. Estimate a policy function $p = p(\boldsymbol{s}_t, \boldsymbol{X}_t, \xi)$.
2. Use the sequential representation of the value function and simulate N paths of length T (many paths, for many, many years into the future).

$$V(\boldsymbol{s}_t, \boldsymbol{X}_t) = \frac{1}{N} \sum_{i=1}^{N} \sum_{t=0}^{T} \beta^t \Pi(\boldsymbol{s}_t, \boldsymbol{p}_t, \boldsymbol{X}_t).$$

We can do this for any given initial $\boldsymbol{s}_t$. Then, compute the derivative of the value function using

$$\frac{\partial V(\boldsymbol{s}_{t+1}, \boldsymbol{X}_t)}{\partial s_{jt}} = \frac{V(\boldsymbol{s}_t + \epsilon \boldsymbol{I}, \boldsymbol{X}_t) - V(\boldsymbol{s}_t - \epsilon \boldsymbol{I}, \boldsymbol{X}_t)}{2\epsilon},$$

With this, we can compute equilibrium fees for a given starting vector of shares $\boldsymbol{s}_t$. OSG allows to solve for all initial conditions separately, over a large state space. Difference here is between doing something in days versus years.

Using OSG to Evaluate Policy

We can compute equilibrium for a hundreds of thousands of $(\boldsymbol{s}_t, \boldsymbol{X}_t)$ combinations in a few days.

OSG allows to solve for all initial conditions separately, over a large state space.

Difference here is between doing something in days versus either years or never.

Using OSG to Evaluate Policy

Outcome: making people more active decreases prices and it does not affect returns.

Case	Mean and 95% CI
Base simulation	6.195% [6.181%,6.210%]
No enrollment cost	3.666% [3.660%,3.671%]
No decision cost	3.837% [3.833%,3.842%]
No switching costs	2.607%

Note: The table reports the mean expected fees and 95% confidence intervals for the different scenarios under study using $10,000$ random initial states.

Conclusions

1. Policy/transaction evaluation is critical in modern microeconomics.

2. Evaluations often require simulating consumer/firm behavior over a large state space.

3. In particular in the case of dynamic games, OSG could become a crucial tool, making the difference between being able to do something and not.