GENERAL

applied game theory stata

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Applied Game Theory in Stata: A Comprehensive Guide

Game theory, the mathematical study of strategic interactions, has become an indispensable tool for economists, political scientists, and data analysts. While many researchers rely on specialized software, Stata offers a robust, versatile environment for implementing game-theoretic models. This article explores how to apply game theory within Stata, covering theory fundamentals, practical commands, estimation techniques, simulations, and real-world applications. Whether you are a graduate student, a seasoned researcher, or a data analyst looking to deepen your strategic modeling skills, this guide will walk you through the entire process from data preparation to result interpretation.

1. Understanding Applied Game Theory

1.1 What Is Applied Game Theory?

Applied game theory takes the abstract principles of game theory—players, strategies, payoffs, and equilibria—and translates them into empirical, data-driven analyses. Instead of purely theoretical models, researchers use real datasets to estimate strategic behavior, test hypotheses, and predict outcomes in competitive environments.

1.2 Core Concepts You Need to Know

- Nash Equilibrium – A set of strategies where no player can benefit by unilaterally changing their choice.
- Strategic Complementarity and Substitutability – How one player's action affects the incentives of others.
- Repeated and Dynamic Games – Models that incorporate time, learning, and evolving strategies.
- Information Structure – Whether players have complete or incomplete information.
- Bayesian Games – Games with probabilistic beliefs about opponents' types.

Having a solid grasp of these concepts is essential before diving into Stata implementations.

2. Why Use Stata for Game Theory?

2.1 Stata's Strengths

Stata excels in handling large datasets, performing complex regressions, and providing a user-friendly command interface. Its extensive library of user-contributed commands further expands its capabilities, making it an ideal platform for game-theoretic analysis.

2.2 Integration with Econometric Tools

Game-theoretic models often require simultaneous estimation of multiple equations, handling of endogenous variables, and robust standard errors. Stata's **system GMM**, **IV/2SLS**, and **mixed-effects**estimation procedures integrate seamlessly with game-theoretic models.

2.3 Reproducibility and Documentation

Stata's do-files and ado-files provide a clear, reproducible workflow. Researchers can share scripts that automatically generate figures, tables, and diagnostics, ensuring transparency and replicability.

3. Key Stata Commands and Packages for Game Theory

3.1 Built-in Commands

- regress – For linear models.
- xtreg – Panel data estimation.
- ivregress – Instrumental variable estimation.
- gmm – Generalized method of moments.
- nl – Nonlinear least squares, useful for equilibrium models.

3.2 User-Contributed Packages

- game – A collection of routines for estimating strategic interaction models.
- gmm2s – Two-step GMM for simultaneous equations.
- bayesmh – Bayesian hierarchical modeling, adaptable for Bayesian games.
- simul – Monte Carlo simulation utilities.

Installing packages is straightforward: ssc install game, adoupdate, etc. Once installed, you can access specialized functions like **game::nash** for computing equilibria.

4. Step-by-Step Example: A Two-Player Cournot Duopoly

4.1 Theoretical Setup

Consider two firms producing a homogeneous product. Each firm chooses a quantity, q1 and q2, to maximize profit:

Profit_i = (P(Q) - c) * q_i, where Q = q1 + q2, P(Q) = a - bQ.

The Nash equilibrium occurs where each firm's marginal revenue equals marginal cost.

4.2 Preparing the Data

Assume we have a panel dataset of firm-level sales, costs, and market characteristics. First, load the data:

use "duopoly_data.dta", clear

Check for missing values and create derived variables:

gen Q = q1 + q2

gen P = a - b*Q

gen MR1 = P + (a - b*Q)*(-b) // Marginal revenue for firm 1

gen MR2 = P + (a - b*Q)*(-b) // Marginal revenue for firm 2

4.3 Estimating the Strategic Interaction Model

We use a simultaneous equation approach. Firm 1's profit-maximizing condition:

MR1 = c1

Similarly for firm 2. In Stata, we can estimate this using **gmm**:

gmm (MR1 - c1 = 0) (MR2 - c2 = 0), instruments(q2 q1)

The instruments q2 and q1 are lagged or exogenous variables that help address simultaneity bias.

4.4 Computing the Nash Equilibrium

After estimation, we can compute the equilibrium quantities analytically using the estimated parameters:

scalar q1_hat = (a - c1) / (2*b) - (c2 - c1) / (2*b)

scalar q2_hat = (a - c2) / (2*b) - (c1 - c2) / (2*b)

Alternatively, the **game** package offers a direct routine:

game::nash (q1 q2) (c1 c2) (a b)

4.5 Interpreting Results

Use **esttab** or **outreg2** to export coefficients and standard errors. Visualize equilibrium outcomes with **twoway scatter** plots:

twoway (scatter q1 q2, mcolor(blue)) (scatter q1_hat q2_hat, mcolor(red)), legend(label(1 "Observed") label(2 "Equilibrium"))

5. Advanced Techniques

5.1 Bayesian Game Theory

Stata's **bayesmh**allows Bayesian estimation of strategic models. Define priors for parameters and let the MCMC sampler draw posterior distributions.

bayesmh (MR1 - c1 = 0) (MR2 - c2 = 0), ///\n prior(a, normal(0,10)) ///\n prior(b, lognormal(0,1)) ///\n prior(c1, normal(0,10)) ///\n prior(c2, normal(0,10)) ///\n iter(5000)

Posterior predictive checks help assess model fit.

5.2 Dynamic and Repeated Games

Dynamic games involve state variables that evolve over time. Use **xtset**to declare panel structure and estimate transition equations:

xtset firm_id year

xtreg q1 L.q1 L.q2, fe

Here, L.q1 denotes the lagged quantity of firm 1, capturing inertia.

5.3 Simulations and Monte Carlo

To evaluate estimator properties, simulate data under known parameters and run the estimation routine repeatedly:

program define simulate_duopoly

    tempvar q1 q2 P MR1 MR2

    forvalues i = 1/1000 {

        // Generate random costs and demand parameters

        gen a = rnormal(100,10)

        gen b = rnormal(1,0.1)

        gen c1 = rnormal(20,5)

        gen c2 = rnormal(20,5)

        // Compute equilibrium quantities analytically

```
        gen q1 = (a - c1)/(2*b) - (c2 - c1)/(2*b)
        gen q2 = (a - c2)/(2*b) - (c1 - c2)/(2*b)
        // Add noise to mimic real data
        replace q1 = q1 + rnormal(0,0.5)
        replace q2 = q2 + rnormal(0,0.5)
        // Estimate using gmm
        gmm (MR1 - c1 = 0) (MR2 - c2 = 0), instruments(q2 q1)
        // Store estimates
        matrix results = e(b)
        // ...
    }
end
```

Run the program: simulate_duopoly. Summarize the results to assess bias and variance.

6. Data Preparation and Cleaning

6.1 Handling Missing Data

Missing values can distort equilibrium calculations. Use **mi** commands for multiple imputation:

```
mi set wide
mi register imputed q1 q2
mi impute chained (regress) q1 q2 = a b c1 c2, add(5)
```


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