Very Tentative Syllabus
April 16, 2017

Rutgers Business School, Spring 2018, 26:010:685

Game Theory for Causality and Prediction

This course will explore how game-theoretic probability can be used to understand causality, prediction, and the combination of evidence.

Most of the topics will occupy us for a week or two. We will select from the later topics in the list depending on the interests of the students in the class.

Time: Wednesdays, 9:00–11:50.

Instructor: Glenn Shafer, `www.glennshafer.com`, gshafer@business.rutgers.edu.

Deliverables: Class presentations (60%), term paper (40%)

Academic Integrity: Students are expected to adhere to Rutgers' academic integrity policy, described at `http://academicintegrity.rutgers.edu/`.

Prerequisite: Previous doctoral course in probability or statistics and permission of the instructor. Enrollment will be limited to ten students.

Tentative Schedule

GTP Working Papers are at `http://www.probabilityandfinance.com/articles/index.html`.

Topic 1: The two schools of statistical inference. To understand current debates, we need to understand the historical divide between frequentist and Bayesian methods of handling statistical evidence.

1. Bayesian. frequentist, and fiducial commonalities, by Glenn Shafer. GTP Working Paper 50.
2. Why most published research findings are false, by John P. A. Ioannidis, *PLoS Medicine*, 2005(8):0696–0701 `http://journals.plos.org/plosmedicine/article/file?id=10.1371/journal.pmed.0020124&type=printable`

Topic 2: Significance testing The use of p-values has been debated for centuries.

1. Game-theoretic significance testing, by Glenn Shafer. GTP Working Paper 49.

2. Ronald L. Wasserstein and Nicole A. Lazar (2016): The ASA's statement on p-values: context, process, and purpose, *The American Statistician* http://dx.doi.org/10.1080/00031305.2016.1154108, See also "Statisticians found one thing they can agree on...", 7 March 2016 at http://fivethirtyeight.com.
3. Using effect size–or why the P value is not enough, by Gail M. Sullivan and Richard Feinn, *J Grad Med Educ* 2012 Sep; 4(3):279–282, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3444174/.

Topic 3: The pitfalls of multiple regression. Multiple regression was invented a century ago. Its pitfalls—spurious correlations, multicollinearity, and publication bias—have been with us just as long.

1. Regression, by Stephen M. Stigler, Chapter 5 in *The Seven Pillars of Statistical Wisdom*, Harvard, 2016.
2. Can statistics do without artefacts? By Jean-Bernard Chatelain. December 2010. https://mpra.ub.uni-muenchen.de/42867/

Topic 4: Instead of multiple regression. James Ohlson has suggested that linear fit be measured in a different way.

1. Accounting research and common sense. James A. Ohlson. *Abacus* 51(4):525–535. http://onlinelibrary.wiley.com/doi/10.1111/abac.12059/abstract.

Topic 5: Meta-analysis in business research. Researchers have begun to apply the lessons of meta-analysis to empirical research in finance and economics.

1. The scientific outlook in financial economics, Presidential Address to the American Finance Association, by Campbell R. Harvey, 2017, http://dx.doi.org/10.2139/ssrn.2893930.
2. ...and the cross-section of expected returns. Campbell R. Harvey, Yan Liu, and Hequing Zhu. *Review of Financial Studies* 29:5–68, 2016. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2249314. http://rfs.oxfordjournals.org/content/29/1/5.full.pdf+html

Topic 6: Econometrics always in crisis. The history of econometrics has been characterized by repeated disappointment.

1. Haavelmo and the birth of modern econometrics: A review of *The History of Econometric Ideas* by Mary Morgan, by James J. Heckman, *Journal of Economic Literature* 30(2):876–886, 1992, http://www.jstor.org/stable/2727705
2. Resurgence of instrument variable estimation and fallacy of endogeneity, by Duo Qin. Economics Discussion Papers, No. 2014-42,

https://www.econstor.eu/bitstream/10419/103207/1/799013978.pdf.

3. The trouble with macroeconomics, by Paul Romer, 14 September 2016, https://paulromer.net/wp-content/uploads/2016/09/WP-Trouble.pdf.

Topic 7: Introduction to Game Theory. Modern game theory, first introduced to academia in a classic book by John von Neumann and Oscar Morgenstern in 1944, has steadily grown in influence in academia. It now dominates economics and is increasingly important in computer science.

1. Game theory. Theodore L. Turocy and Bernhard von Stengel, 2001. http://www.cdam.lse.ac.uk/Reports/Files/cdam-2001-09.pdf
2. *Game Theory: A Very Short Introduction.* Ken Binmore, Oxford, 2007.

Topic 8: Game-Theoretic Probability. In 1654, Blaise Pascal and Pierre Fermat launched the mathematical theory of probability. They had different ways of solving basic probability problems: Pascal reasoned about bets, while Fermat counted cases. Fermat's approach developed into the dominant framework for probability, which is combinatorial and measure-theoretic. Pascal's approach was revived in my book with Vovk in 2001. Our aim is to develop a alternative framework based on modern game theory.

The approach can be illustrated with this simple example. Three players, Forecaster, Skeptic, and Reality, move in turn, seeing each others' moves. Reality moves last on each round, giving a number between -1 and 1. Before that, Forecaster predicts Reality's move, and Skeptic bets on how much Forecaster's prediction will err. Skeptic is testing Forecaster; Forecaster is discredited if Skeptic multiplies the capital he risks by a large or infinite factor.

1. *Probability and Finance: It's Only a Game.* Glenn Shafer and Vladimir Vovk, Wiley, 2001, Chapters 1–3.
2. How to base probability theory on perfect-information games. Glenn Shafer, Vladimir Vovk, and Roman Chychyla. http://www.probabilityandfinance.com/articles/32.pdf 2009.

Topic 9: Defensive Forecasting. By playing against a strategy for Forecaster, Skeptic can often produce probabilities and more general probabilistic forecasts that pass statistical tests, regardless of how Reality behaves.

1. Game-theoretic probability and its uses, especially defensive forecasting. Glenn Shafer. http://www.probabilityandfinance.com/articles/22.pdf, 2007.

2. Defensive forecasting. Vladimir Vovk, Akimichi Takemura, and Glenn Shafer.http://www.probabilityandfinance.com/articles/08.pdf, 2005.

Topic 10: Market Efficiency. In the last analysis, Eugene Fama's celebrated definition of market efficiency is circular. The game-theoretic framework allows us to measure market efficiency quantitatively.

1. What is accomplished by successful non-stationary stochastic prediction? By Glenn Shafer. GTP Working Paper 51.
2. How speculation can explain the equity premium, by Glenn Shafer. GTP Working Paper 47.

Topic 11: Dempster-Shafer Theory. My 1976 book developed a method of evaluating and combining evidence that I called the theory of belief functions. In the early 1980s, it also became known as the Dempster-Shafer theory. Its theorists and practitioners formed the Belief Functions and Applications Society (http://www.bfasociety.org/) in 2010. The numerous articles on the theory include several on my own website, http://www.glennshafer.com/cv.html#articles.

1. Two theories of probability. Glenn Shafer *PSA 1978* 2:441-464. Peter D. Asquith and Ian Hacking, eds. Philosophy of Science Association, East Lansing, Michigan. 1981. http://www.glennshafer.com/assets/downloads/articles/article07_TwoTheories1981.pdf
2. Languages and designs for probability judgment (with Amos Tversky). *Cognitive Science* 9:309–339, 1985. http://www.glennshafer.com/assets/downloads/articles/article19_languages.pdf
3. *A Mathematical Theory of Evidence*. Glenn Shafer, Princeton University Press, 1976. Chapters 1–3.
4. The Bayesian and belief-function formalisms: A general perspective for auditing. Glenn Shafer and Rajendra Srivastava. *Auditing: A Journal of Practice and Theory* 9(Supplement):110–148, 1990. http://www.glennshafer.com/assets/downloads/articles/article41_bayesian.pdf