Very Tentative Syllabus
March 7, 2016

Rutgers Business School, Spring 2017, 26:010:685

Theory of Evidence

Time: Wednesdays, 2:30–5:20.

Instructor: Glenn Shafer, `www.glennshafer.com`.

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

Week 1: Pitfalls in Evaluating Statistical Evidence. Classical statistical methodology was developed a century ago. Its pitfalls—spurious correlations, multicollinearity, and publication bias—have been with us just as long.

1. 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 7 March 2016 article in `http://fivethirtyeight.com`.
2. Correlations genuine and spurious in Pearson and Yule. John Aldrich. *Statistical Science* 10(4):364–376. `https://projecteuclid.org/download/pdf_1/euclid.ss/1177009870`
3. Can statistics do without artefacts? Jean-Bernard Chatelain. December 2010. `https://mpra.ub.uni-muenchen.de/42867/`
4. Statistics degrees continue strong growth. Steve Pierson. AMSTAT-NEWS, Issue #360, October 2015. `http://magazine.amstat.org/blog/2015/10/01/statistics-degrees-continue-strong-growth/`

Week 2: Recent Critiques of Accounting Research. Research in accounting, especially the empirical work on capital markets that dominates the field, has its own persistent pitfalls.

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

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

3. Using XBRL to conduct a large-scale study of discrepancies between the accounting numbers in Compustat and SEC 10-K filings. Roman Chychyla and Alex Kogan. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2304473. January 30, 2014.

Week 3: The Bayesian Alternative. Because classical statistical methodology is seen as objective, it remains the methodology of choice for most empirical research in academia. But the more subjective Bayesian alternative has become increasingly popular among theoreticians in statistics, economics, and computer science.

1. *Bayesian Statistics*. David Spiegelhalter and Kenneth Rice. Scholarpedia. http://www.scholarpedia.org/article/Bayesian

2. *The Theory That Would Not Die: How Bayes' Rule Cracked the Enigma Code, Hunted Down Russian Submarines, and Emerged Triumphant from Two Centuries of Controversy*. Sharon McGrayne. Yale University Press, 2011.

Week 4: 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

Week 5: Constructive Decision Theory. It is possible to develop a constructive methodology for decision making in the spirit of Dempster-Shafer theory.

1. Goals and plans in decision making. David Krantz and Howard Kunreuther. *Judgment and Decision Making* 2(3):137–168, 2007. `http://journal.sjdm.org/jdm7303b.pdf`
2. Constructive decision theory. Glenn Shafer. To appear in *International Journal of Approximate Reasoning*. `http://www.glennshafer.com/assets/downloads/decision.pdf`

Week 6: 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.

Week 7: Introduction to 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.

Week 8: Testing Predictions. In game-theoretic probability, we prove the classical theorems used for statistical testing by showing that Skeptic has strategies that multiply the capital he risks by a large or infinite factor if the tests reject.

1. Indeterminism in science and new demands on statisticians. Jerzy Neyman. *Journal of the American Statistical Association*, 55:625–639, 1960.
2. Frequentist probability and frequentist statistics. Jerzy Neyman. *Synthese* 36:97–131, 1977.
3. *Game-Theoretic Probability.* Glenn Shafer and Vladimir Vovk. To be published by Wiley. Chapter 1.

Week 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.

Week 10: Insuring Against Loss of Evidence. This idea, originally developed game-theoretically, can also be developed within classical probability.

1. Insuring against loss of evidence in game-theoretic probability. A. Philip Dawid, Steven de Rooij, Glenn Shafer, Alexander Shen, Nikolai Vereshchagin, and Vladimir Vovk. *Statistics and Probability Letters* 81:157–162, 2011. In the most general game-theoretic picture, testing is performed by a free agent (Skeptic) rather than by a prespecified nonnegative martingale. The result then becomes relevant to financial markets, where it provides strategies for insuring against loss of the accumulated capital. These strategies are alternatives to lookback options. `http://www.probabilityandfinance.com/articles/34.pdf`
2. Test martingales, Bayes factors, and p-values. Glenn Shafer, Alexander Shen, Nikolai Vereshchagin, and Vladimir Vovk. *Statistical Science* 26:84–101, 2011. A nonnegative martingale measures the changing evidence against a probabilistic hypothesis. Bayes factors and p-values can be considered special cases of such martingale testing. `http://www.probabilityandfinance.com/articles/33.pdf`

Week 11: Definition and Implications of 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. From Cournot's principle to market efficiency. Glenn Shafer. `http://www.probabilityandfinance.com/articles/15.pdf`, 2006.

2. Testing lead-lag effects under game-theoretic efficient market hypotheses. Wei Wu and Glenn Shafer. The game-theoretic approach allows us to measure the degree of market friction needed to account for the statistical significance of lead-lag anomalies. The authors find that market frictions provide adequate explanation. `http://www.probabilityandfinance.com/articles/23.pdf`, 2007)
3. Continuous-time trading and the emergence of probability. Vladimir Vovk, 2011. In continuous time, the game-theoretic approach allows us to understand how the Brownian-motion properties of prices arise from speculation. `http://www.probabilityandfinance.com/articles/28.pdf`, 2011.

Week 12: Game-theoretic updating and combination. Judgment is required for each use of the Bayesian conditioning or Dempster's rule of combination. The nature of this judgment can be understood game-theoretically.

1. Glenn Shafer. Bayes's two arguments for the rule of conditioning. Glenn Shafer *Annals of Statistics* 10:1075–1089, 1982. `https://projecteuclid.org/download/pdf_1/euclid.aos/1176345974`.
2. A betting interpretation for probabilities and Dempster-Shafer degrees of belief. Glenn Shafer. *International Journal of Approximate Reasoning* 52:127–136, 2011. `http://www.probabilityandfinance.com/articles/31.pdf`