

SYLLABUS—WWS 458/ STC 458

“Quantitative Skills for Decision-Making in Regulatory, Clinical, and other Settings”

Mondays, 1:30 – 4:20, Robertson 011

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This course will provide a basic introduction to formal methods of statistical decision theory, with emphasis on how these methods could be used to improve an increasingly prominent type of decision—cost-benefit choices regarding risks to health and the environment. Students will be exposed to various techniques for structuring decision problems, quantifying probabilities, consequences, and preferences, identifying optimal policy choices and optimal research strategies to resolve uncertainties, and evaluating retrospectively the results of those decisions. Although appreciating uncertainty (deriving both from model choice and from parameter estimation) has always been a cornerstone of formal decision theory, this course will also emphasize the related but distinct phenomenon of interindividual variability, which also complicates personal and public decision problems. Frequent references will be made to the divergence between theoretical optima and the realities of contemporary decision-making, from the practitioner’s vantage point (the instructor is a former regulator and enforcement official at a federal agency, and various guest speakers will provide other perspectives on the craft of decision-making).

The course will be aimed at advanced undergraduates, particularly those planning further study in medicine, environmental sciences, and economics, and those contemplating careers in public service. *Note: WWS may elect to offer this course to MPA students; in that case, the instructor will provide a separate class session each week for MPA students, so that they will cover additional material particularly relevant to data analysis and the economic input to cost-benefit analysis. The “MPA track” would also contain an introduction to Monte Carlo simulation for quantitative analysis of uncertainty in cost, benefit, and risk, making extensive use of software available for this purpose.*

Textbook:

Making Hard Decisions, Robert T. Clemen and Terry Reilly, 2nd ed., Brooks/Cole Publishers, ISBN 0534365973.

Course Requirements:

- Two problem sets (one on decision analysis and probability theory, one on risk estimation and uncertainty)—20% *each*
- One oral/slide presentation (pairs of students debating a particular regulatory proposal or medical practice guideline in light of risk and cost analysis)—20%
- Final paper (exploration of a methodological debate in risk evaluation, multi-attribute utility theory, or cost-benefit analysis)—25%
- Class participation—15%

Prerequisites:

- ✓ Algebra (including logarithms/exponentials)
- ✓ Ability to construct “Excel” spreadsheets and graph results
- ✓ Basic calculus concepts (simple integrals, finding maxima/minima)

Tentative Syllabus: (required readings denoted by “♦”)**WEEK 1 (February 5) — Decision-Making as a Craft****Introduction:**

- Distinct evaluation of decision processes *versus* their outcomes
- Pitfalls that characterize poor decision processes
- Interplay of analysis and values; tension between “analysis-driven decisions” and “decision-driven analysis”
- Different types of decisions (personal/social, triage/control/research)
- Statistical and policy introduction to uncertainty

In-Class Exercise: Airplane Decision Rule

- Anecdotes about decision scientists (Raiffa; Frisch)

Identifying Objectives and Solutions:**In-Class Exercise: “Comparing Apples and Oranges”**

Readings:

- ◆ **Making Hard Decisions** (“MHD”), pages 1-9; 12-17; 21-30, 43-54, 217-228, 233-236.
- ◆ William D. Ruckelshaus (1985), “Risk, Science, and Democracy,” *Issues in Science and Technology*, **1**, pp. 19-38.
- ◆ Robert E. Rubin, “A Healthy Respect for Uncertainty,” commencement address at the University of Pennsylvania, May 17, 1999.
- ◆ Charles Vlek, et al. (1984). “What Constitutes ‘A Good Decision’?,” *Acta Psychologica*, **56**: 5-27.
- ◆ Jeffrey S. Stonebraker (2002). “How Bayer Makes Decisions to Develop New Drugs,” *Interfaces*, **32(6)**: 77-90.
- ◆ Stuart Wooler (1982). “A Decision Aid for Structuring Career Choice Options,” *The Journal of the Operational Research Society*, **33(4)**: 343-351.
- ◆ Robert Clemen and Robert Kwit (2001). “The Value of Decision Analysis at Eastman Kodak Company, 1990-1999,” *Interfaces*, **31(5)**: 74-92.

WEEK 2 (Feb. 12) — Introduction to Probability Theory

- Basic probability rules for independent events

In-Class Exercise: Drawing a Full House

- Bayes’ Theorem for discrete probabilities
- Expectation, variance, correlation, etc.

In-Class Exercise: “Caesar’s Last Breath”

Readings:

- ◆ Excerpts from **Chance: A Guide to Gambling, Love, the Stock Market and Just About Everything Else** by Amir D. Aczel (2004) (pp. 1-3; 11-16; 25-39; 95-111).
- ◆ **MHD**: pp. 321-326.

- ◆ Gerd Gigerenzer and Adrian Edwards (2003). “Simple Tools to Understand Risks: From Innumeracy to Insight,” *British Medical Journal*, **327**: 741-744.

<i>WEEK 3 (Feb. 19) — Decision Trees and Preference Functions</i>
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- “Pruning” decision trees to identify maximum expected value

In-Class Exercise: “Ewing Oil” problem
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- Expected utility (St. Petersburg paradox) as a refinement of expected-value choice
- Risk-aversion

In-Class Exercise: The Allais Paradox

- Decision regret as further refinement
- Prospect theory and other alternatives

Readings:

- ◆ **MHD**, pages 69-79; 111-126; 128-137; 531-546; 572-578; 584-588.
- ◆ Chapter 3 (“An Overview of Quantitative Policy Analysis”) in **Uncertainty**, M.G. Morgan and M. Henrion, 1990.
- ◆ D. Warner North “A Tutorial Introduction to Decision Theory,” *IEEE Transactions on Systems Science and Cybernetics*, **4(3)**, Sept. 1968, pp. 200-210.
- ◆ Baruch Fischhoff (1998). “Risk Perception and Communication Unplugged: Twenty Years of Progress.” In Löfstedt and Frewer, **The Earthscan Reader in Risk and Modern Society**, pp. 133-148.
- ◆ Bell, D. E. (1985). Disappointment in decision-making under uncertainty. *Operations Research*, **33**, 1-27.
- ◆ Savage, L. J. (1951). The theory of statistical decision. *Journal of the American Statistical Association*, **46**, 55-67.

<i>WEEK 4 (Feb. 26) — Framing, Biases, Heuristics (possible Guest Speakers: Eldar Shafir, W. Troy Tucker)</i>
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- Catalog of cognitive biases
- Recent findings from neuroeconomics
- Evolutionary reasons for “irrationality”

In-Class Exercise: Demonstration of the “Anchoring” Effect

Readings:

- ◆ MHD, pages 138-148.
- ◆ “Decisions, Decisions,” *Discover*, June 1985.
- ◆ **Additional reading(s) to be supplied by guests**

WEEK 5 (March 5) — Introduction to Quantitative Risk Assessment

- The spectrum of health effects associated with environmental exposures
- How models and monitoring data allow the estimation of human exposures
- How risk analysts use toxicological and epidemiological data to develop dose-response relationships

Readings:

- ◆ Excerpts (pages 1-14, 29-41, 53-84, and 139-152) from Lorenz Rhomberg (1996). “A Survey of Methods for Chemical Health Risk Assessment among Federal Regulatory Agencies” (report for the Presidential/Congressional Commission on Risk Assessment and Management).
- ◆ Tom McKone and P. Barry Ryan (1989). “Human Exposure to Chemicals through Food Chains,” *Environmental Science and Technology*, **23**, pp. 1154-63.
- ◆ Martha Crawford and Richard Wilson (1996). “Low-Dose Linearity: The Rule or the Exception?” *Human and Ecological Risk Assessment*, **2**, pp. 305-330.
- ◆ Rosemary Castorina and Tracey J. Woodruff (2003): “Assessment of Potential Risk Levels Associated with U.S. Environmental

Protection Agency Reference Values,” *Environmental Health Perspectives*, **111**, pp. 1318-1325.

WEEK 6 (March 12) — Uncertainty

- Different sources of uncertainty
- Overconfidence and calibration

In-Class Exercise: Are You Overconfident?

- Basic mathematics of probability density and cumulative distribution functions
- Pitfalls of ignoring uncertainty

In-Class Exercise: Buying stock for your grandchildren

- Uncertainty in risk comparisons (Alar/aflatoxin example)
- Reporting the results (costs and benefits of cellphone ban example)

Readings:

- ◆ Chapter 9 (“The Graphic Communication of Uncertainty”) in Morgan and Henrion
- ◆ Adam M. Finkel (1995). “Towards Less Misleading Comparisons of Uncertain Risks: The Example of Aflatoxin and Alar.” *Environmental Health Perspectives*, **103(4)**, 376-385.

WEEK 7 (March 26) — The Value of Information

- Bayes’ Theorem applied to continuous distributions
- The expected value of perfect information; the value of sample information

In-Class Exercise: Raiffa’s Urn

- Introduction to Monte Carlo methods

Readings:

- ◆ **MHD**, pages 436-445; 466-486.
- ◆ John S. Evans, Neil C. Hawkins, and John D. Graham (1988), “The Value of Monitoring for Radon in the Home: A Decision Analysis,” *JAPCA*, **38**, pp. 1380-1385.
- ◆ F. Yokota, K.M. Thompson 2004. “Value of Information Literature Analysis (VOILA): A Review of Applications in Health Risk Management.” *Medical Decision Making* 24(3):287-298
- ◆ F. Yokota, K.M. Thompson 2004. “Value of Information Analysis in Environmental Health Risk Management Decisions: Past, Present, and Future.” *Risk Analysis* 24(3):635-650.
- ◆ Scott M. Shafer (2006). “Using Spreadsheets and *Crystal Ball* to Assist in Understanding and Modeling Distributions of Random Variables,” *Decision Sciences Journal of Innovative Education*, **4(1)**: 153-162.

***WEEK 8 (April 2) — Interindividual Variability in Risk,
Economic Impact, and Preferences***

- Similarities and differences between uncertainty and variability
- Sources of human variability in exposure and susceptibility
- Conflicts between the promise of “individualized” medicine/regulation and concerns about genetic privacy/autonomy
- Variability and distributional equity
- Variation in preferences and its influence on optimal decision-making and analysis
- Sensitivity Analysis

Readings:

- ◆ Dale Hattis (2004). “The Conception of Variability in Risk Analysis: Developments since 1980.” Chapter 2(pp. 15-45) in **Risk Analysis and Society: An Interdisciplinary Characterization of the Field**, Timothy McDaniels and Mitchell J. Small, eds., Cambridge University Press.
- ◆ Stephen Jay Gould: “The Median Isn’t the Message,” *Discover*, June 1985
- ◆ Excerpts (Chapters 1, 7, 12, 14, and 20) from Stephen Schneider (2005), **The Patient from Hell: How I Worked with My Doctors to Get the Best of Modern Medicine and How You Can Too.**
- ◆ Finkel, A.M. (1990). “A Simple Formula for Calculating the ‘Mass Density’ of a Lognormally-Distributed Characteristic: Applications to Risk Analysis.” *Risk Analysis*, **10**(2), 291-301.
- ◆ **MHD**, pages 174-185.

<i>WEEK 9 (April 9) — Medical Decision-Making</i>
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- Cost-effectiveness
- Clinical practice guidelines
- Uncertainty in Bayes parameters
- Interindividual variability in risk and preferences

In-Class Exercise: Transferring Embryos for <i>In Vitro</i> Fertilization

Readings:

- ◆ S. Felder, A. Werblow, and B.P. Robra (2003). “A *Priori* Risk and Optimal Test Accuracy in Prenatal Diagnosis.” *Medical Decision Making*, **23**(5), 406-13.
- ◆ Ryan A. Harris, A. Eugene Washburn, Robert F. Nease Jr., and Miriam Kuppermann (2004). “Cost Utility of Prenatal Diagnosis and the Risk-Based Threshold,” *The Lancet*, **363**: 276-282, plus letters on p. 1164-5.

- ◆ Donald A. Redelmeier, Paul Rozin, and Daniel Kahneman (1993). “Understanding Patients’ Decision: Cognitive and Emotional Perspectives,” *JAMA*, **270(1)**: 72-76.
- ◆ Alexander A. Kon (2006). “Answering the Question: ‘Doctor, If This Were Your Child, What Would You Do?’,” *Pediatrics*, **118(1)**: 393-397.
- ◆ **ADD ONE CHAPTER FROM SOX, MEDICAL DECISION MAKING**

<i>WEEK 10 (April 16) — Cost-Benefit Analysis</i>
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- How economists convert estimates of health effects into monetary equivalents
- How economists estimate the costs of regulatory and other interventions to control hazards; uncertainties therein and interindividual variability
- Discounting of future harms
- Ethical critiques of cost-benefit analysis
- The “precautionary principle”: pros and cons
 - ◆ Michael Harris (1996), “For the Student: Environmental Economics,” *Australian Economic Review*, 4th Quarter 1996, pp. 449-465.
 - ◆ Eban Goodstein and Hart Hodges (1997), “Polluted Data: Overestimating Environmental Costs,” *The American Prospect*, **35**, Nov./Dec., pp. 64-69.
 - ◆ John D. Graham (2003). “Valuing Health: an OMB Perspective,” speech given at Resources for the Future, Washington, D.C., Feb. 13.
 - ◆ Excerpts (Chapters 2 and 9) from Frank Ackerman and Lisa Heinzerling (2004), **Priceless: On Knowing the Price of Everything and the Value of Nothing**, The New Press, New York.
 - ◆ Alon Tal (1997), “A Failure to Engage,” *The Environmental Forum*, Jan/Feb., pp. 13-21.

- ◆ Excerpts (Executive Summary, Chapter 3, and Chapter 6) from Lisa Robinson (2004), “Current Federal Agency Practices for Valuing the Impacts of Regulations on Human Health and Safety,” report to the IOM Committee to Evaluate Measures of Health Benefits for Environmental, Health, and Safety Regulation.
- ◆ Lisa Heinzerling (2000), “The Rights of Statistical People,” *Harvard Environmental Law Review*, **24**, pp.189-207.
- ◆ Robert H. Frank (2000). “Why is Cost-Benefit Analysis So Controversial?” *Journal of Legal Studies*, **29(2)**: 913-930.

<i>WEEK 11 (April 23) — Decision-Making in Organizations</i>

- Various models of organizational behavior
- Case Study: The launch of Space Shuttle *Challenger*
- Multi-criteria decision analysis
- Brief discussion of game theory/negotiation

In-Class Exercise: Buying a Mountain Bike
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Readings:

- ◆ **MHD**, pages 345-348.
- ◆ Excerpts from Allison, Graham, and Philip Zelikow (1999), **Essence of Decision: Explaining the Cuban Missile Crisis** (pp. 1-27; 379-397)
- ◆ Diane Vaughan (2004). “Theorizing Disaster: Analogy, Historical Ethnography, and the *Challenger* Accident,” *Ethnography*, **5(3)**: 315-347.
- ◆ Diane Vaughan (2005). “System Effects: On Slippery Slopes, Repeating Negative Patterns, and Learning from Mistake,” in **Organization at the Limit: NASA and the Columbia Disaster**. William Starbuck and Moshe Farjoun, eds., 25 pp.
- ◆ Pages from “The Ethical Spectacle” (Sept. 1995) on the “Prisoners’ Dilemma (handout)
- ◆ Tables from John D. Sterman, “Learning from Evidence in a Complex World,” ms. May 2005.

WEEK 12—Regulation as Social Decision-Making

- Introduction to agency administrative process
- (Possible) separation of science from values
- Pros/Cons of basic regulatory designs
- Negotiated rulemaking, “enforceable partnerships,” corporate social responsibility, and other alternatives to traditional rulemaking

Readings:

- ◆ Nicholas A. Ashford (1988), “Science and Values in the Regulatory Process,” *Statistical Science*, **3(3)**, pp. 377-383.
- ◆ Cary Coglianese and David Lazer (2003), “Management-Based Regulation: Prescribing Private Management to Achieve Public Goals,” *Law and Society Review*, **37**, pp. 691-730.
- ◆ Cass R. Sunstein (1996). “Health-Health Tradeoffs,” *University of Chicago Law and Economics Working Paper*, No. 42.
- ◆ Gregory A. Kiker, et al. (2005). “Application of Multicriteria Decision Analysis in Environmental Decision Making,” *Integrated Environmental Assessment and Management*, **1(2)**: 95-108.