

## TOPICS IN DECISION THEORY

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### Overview

This series of lectures will explore some of the most important contributions to decision theory. There is a huge literature on how decisions are made and how they should be made. I have tried to pick out some of the areas that remain an active focus for research, and/or those whose motivating questions seem particularly current. Topics to be covered include the theory of subjective probability, ambiguity, dynamic choice, updating and learning, unforeseen contingencies.

There is no exam. Grading will be based on problem sets plus a take home exam (50%) and a written report on a paper of your choice (50%). Many of the papers listed below are there because they are good candidates for a report.

The class will be based mostly on articles, but I recommend that you have:

L. J. Savage, *The Foundations of Statistics*, Dover, 1954.

D. Kreps, *Notes on the Theory of Choice*, Westview, 1988.

The following should help with the big picture.

I. Gilboa, *Theory of Decision under Uncertainty*, Cambridge, 2009.

E. Dekel & B. Lipman, *How (not) to do decision theory*, Annual Rev. Econ. 2 (2010), 257-82.

F. Gul & W. Pesendorfer, *The case for mindless economics, in The Foundations of Positive and Normative Economics: A Handbook*, A. Caplin & A. Schotter eds., Oxford, 2008.

W. Pesendorfer, *Behavioral economics comes of age*, JEL 44 (2006), 712-21.

### Contact

My office is in Badia (Room 024), but I am often around in the economics department. If you want to discuss the course material and/or problem sets either stop me in person or send me an email.

## Structure

The course will start with axiomatic foundations to decision theory and will progress to more realistic models that relax various axioms. Each lecture will take as its starting point at least one influential paper in the literature. You should make the effort to read these principal works in advance. The other readings listed below are a mixture of seminal articles, useful review pieces, and more recent research that will be discussed in the lectures. The broad subject matter for the lectures will be as follows:

### 1 Subjective Probability

#### THE ANSCOMBE-AUMANN MODEL

Kreps, Chs. 4 (domains of choice), 5 (the mixture-space theorem), Ch. 7

F. Anscombe & R. Aumann, A definition of subjective probability, *Ann. Math. Stat.* 34 (1963), 199-205.

#### THE SAVAGE MODEL

Savage: Chs. 1-6; Kreps: Chs. 8, 9 and 4; Gilboa: Part II

M. Machina & D. Schmeidler, A more robust definition of subjective probability, *Econometrica* 60 (1992), 745-780.

I. Kopylov, Simple axioms for countably additive subjective probability, *J. Math. Econ.* 46 (2010), 867-76.

Exchangeability (de Finetti): Kreps, Ch. 11

F. Echenique and K. Saito, Savage in the market, 2013

### 2 Ambiguity/Model Uncertainty

D. Ellsberg, Risk, ambiguity and the Savage axioms, *QJE* 75 (1961), 643-669.

Gilboa, Part III.

Gilboa, Postlewaite, & Schmeidler, Rationality of belief or: why Savage's axioms are neither necessary nor sufficient for rationality, *Synthese* 187 (2012), 11-31.

M. Siniscalchi, Ambiguity and ambiguity aversion, *Palgrave Dictionary of Economics*.

Hsu, ..., Camerer, Neural systems responding to degrees of uncertainty in human decision-making, *Science* 310 (2005), 1680-83.

## MODELS

- I. Gilboa & D. Schmeidler, Maxmin expected utility with non-unique prior, *JME* 18 (1989), 141-153.
- A. Kochov, Time and no lotteries: a simple axiomatization of maxmin expected utility, 2013.
- T. Bewley, Knightian decision theory: Part I, Cowles, 1986.
- D. Schmeidler, Subjective probability and expected utility without additivity, *Econometrica* 57 (1989), 571-587.
- F. Maccheroni, M. Marinacci & A. Rustichini, Ambiguity Aversion, robustness and the variational representation of preferences, *Econometrica* 74 (2006), 1447-98.
- P. Klibanoff, M. Marinacci & S. Mukerji, A smooth model of decision making under ambiguity, *Econometrica* 73 (2005), 1849-1892.
- C. Fox and A. Tversky, Ambiguity aversion and comparative ignorance, *QJE*, 1995.
- S.H. Chew and J. Sagi, Event exchangeability: probabilistic sophistication without monotonicity or continuity, *Econometrica* 74 (2006), 771-786; and Small worlds: modeling attitudes towards sources of uncertainty, *JET* 139 (2008), 1-24.
- H. Ergin & F. Gul, A theory of subjective compound lotteries, *JET* 144 (2009), 899-929.
- Gul & Pesendorfer, Expected uncertain utility and subjective sources, Princeton, 2013.
- T. Strzalecki, Axiomatic foundations of multiplier preferences, *Econometrica* 79 (2011), 47-73.

## EXTENSIONS AND CRITIQUES:

- Kota Saito, Preference for flexibility and preference for randomization under ambiguity, Cal Tech 2013.
- T. Hayashi, T. Gajdos, J.M. Tallon & J.C. Vergnaud, Attitude toward imprecise information, *JET* 140 (2008), 27-65.
- M. Machina, Risk, ambiguity and the rank-dependence axioms, *AER*, March 2009.
- Epstein and Halevy, No two experiments are identical, 2013.

## EXPERIMENTS/MEASUREMENTS

Y. Halevy, Ellsberg revisited: an experimental study, *Econometrica* 75 (2007), 503-536.

S.T. Trautman and Gijs van de Kuilen, Ambiguity attitudes, Tilberg 2013.

Dimmock, Kouwenberg, Mitchell and Peijnenberg, Ambiguity attitudes and economic behavior: evidence from a U.S. household survey, 2012; and Ambiguity aversion and household portfolio choice: empirical evidence, 2013.

#### SOME APPLICATIONS

##### Static settings:

T. Bewley, Knightian decision theory and econometric inference, *JET* 146 (2011), 1134-47.

S. Mukerji & J.M. Tallon, An overview of economic applications of David Schmeidler's models of decision making under uncertainty, in *Uncertainty in economic theory: a collection of essays in honor of D. Schmeidler's 65th birthday*, I. Gilboa ed., Routledge 2004.

G. Bryan, Ambiguity and insurance, 2010.

##### Finance:

J. Dow & S. Werlang, Uncertainty aversion, risk aversion and the optimal choice of portfolio, *Econometrica* 60 (1992), 197-204.

L. Epstein & M. Schneider, Ambiguity and asset markets, *Annual Rev. Finan. Econ.* 2, (2010).

Garlappi, Giammarino and Lazrak, Ambiguity, entrepreneurs and corporate finance, 2012.

##### General Equilibrium:

S. Mukerji & J.M. Tallon, Ambiguity aversion and incompleteness of financial markets, *RES* 68 (2001), 883-904.

S. Condie & J. Ganguli, Ambiguity and rational expectations equilibria, *Rev. Ec. Stud.* 78 (2011), 821-45.

M. Mandler, Endogenous indeterminacy and volatility of asset prices under ambiguity, *TE* 8 (2013), 729-750.

L. De Castro, M. Pesce and N. Yannelis, A new perspective on rational expectations, 2013.

##### Strategic Models:

S. Mukerji, Ambiguity aversion and incompleteness of contractual form, *AER* 88 (1998), 1207-31.

- S. Bose, E. Ozdenoren & A. Pape, Optimal auctions with ambiguity, *TE* 1 (2006), 411-438.
- F. Reidel and L. Sass, The strategic use of ambiguity, 2011.
- A. Di Tillio, N. Kos and M. Messner, The design of ambiguous mechanisms, 2011.
- A. Ellis, Condorcet meets Ellsberg, LSE 2013.
- S. Grant, I. Meneghel and R. Tourkey, Savage games: a theory of strategic interaction with purely subjective uncertainty, Queensland 2013.

### 3 Demand for Flexibility

- Kreps: A representation theorem for preference for flexibility, *Econometrica* 47 (1979), 565-578;
- Static choice in the presence of unforeseen contingencies, in Essays in Honour of F. Hahn, P.
- Dasgupta et al eds., MIT Press, 1992.
- Dekel, Lipman & Rustichini, A unique subjective state space for unforeseen contingencies, *Econometrica* 69 (2001), 891-934. Corrigendum with T. Sarver (2006).
- T. Strzalecki, Temporal resolution of uncertainty and recursive models of ambiguity aversion, *Econometrica* 81 (2013), 1039-1074.
- D. Ahn and T. Sarver, Preference for flexibility and random choice, *Econometrica* 81 (2013), 341-61.

Other menu-based models:

- K. Hyogo, A subjective model of experimentation, *JET* 2007.
- H. Ergin and T. Sarver, Hidden actions and preferences for timing of resolution of uncertainty, *Econometrica*, forthcoming.
- R.V. Krishna and P. Sadowski, Dynamic preference for flexibility, 2013.

### 4 Intertemporal Models - Recursive Utility

- M. Machina, Dynamic consistency and non-expected utility models of choice under uncertainty, *JEL* 27 (1989), 1622-1668.
- P. Ghirardato, Revisiting Savage in a conditional world, *ET* 20 (2002), 83-92.

Kreps & Porteus, Temporal resolution of uncertainty and dynamic choice theory, *Econometrica* 46 (1978), 185-200.

Epstein & Zin, Substitution, risk aversion and the temporal behavior of consumption and asset returns: a theoretical framework, *Econometrica* 57 (1989), 937-969.

Epstein & Schneider, Recursive multiple-priors, *JET* 113 (2003), 1-31.

M. Siniscalchi, Two out of three ain't bad ..., *Econ. and Philosophy*, November 2009.

Criticisms and extensions

D. Kreps. Anticipated utility and dynamic choice, in D. Jacobs, E. Kalai and M. Kamien eds. *Frontiers of Research in Economic Theory*, Cambridge U. Press, 1995.

P.J. Hammond, Schumpeterian innovation in modelling decisions, games and economic behavior, *History of Economic Ideas XV* (2007), 179-195.

A. Kochov, Small world representations and a behavioral definition of unforeseen contingencies, Rochester 2013.

J. Rust, Do people behave according to Bellman's principle of optimality, 1992.

Epstein, Farhi and Strzalecki, How much would you pay to resolve long-run risk? 2013

Applications: There have been many applications in macro/finance - for an overview and references, see: Epstein & Schneider, Ambiguity and asset markets. See also several recent papers by C. Ilut (Duke), M. Schneider, and coauthors.

## 5 Updating/Learning

A. Tversky and D. Kahneman, Judgement under uncertainty: heuristics and biases, *Science* 185 (1974), 1124-1131.

Epstein & Schneider, Learning under ambiguity, *Rev. Econ. Stud.* 2007; and Ambiguity, information quality and asset pricing, *J. Finance* 2008.

Epstein & K. Seo, Symmetry of evidence without evidence of symmetry, *TE* 2010; and Bayesian inference and non-Bayesian prediction and choice ..., 2013.

P. Ortoleva, Modeling the change of paradigm: non-Bayesian reaction to unexpected news, *AER* 102 (2012), 2410-36.

- I. Gilboa & D. Schmeidler, Inductive inference: an axiomatic approach, *Econometrica* 71 (2003), 1-26.
- A. Billot, I. Gilboa, D. Samet & D. Schmeidler, Probabilities as similarity-weighted frequencies, *Econometrica* 73 (2005), 1125-1136; and Gilboa, Part IV.

## 6 Bounded Rationality

- Articles by Harstad-Selten, V. Crawford, and M. Rabin in *JEL* 51 (2013).
- Tversky and Kahneman, The framing of decisions and the psychology of choice, *Science* 211 (1981), 453-8.
- D. Ahn & H. Ergin, Framing contingencies, *Econometrica* 78 (2010), 655-695.
- A. Ellis, Foundations for optimal inattention, 2012.
- X. Gabaix, A sparsity-based model of bounded rationality, applied to basic consumer and equilibrium theory, NYU 2012.