

Economics 712: Fall 2017

Topics in Economic Theory: Learning, Information and Dynamic Games

This is an advanced topics course in microeconomic theory. We will study learning, information theory, information design, information aggregation, and dynamic games. The goal is to provide you with tools and techniques to transition from coursework to research. We will examine foundational contributions, recent developments, and open questions in the literature, and discuss applications of these ideas to political economy, industrial organization and development.

Course Logistics

Instructor. Aislinn Bohren

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Office. McNeil 450

Lecture. M 5:30-8:30pm in McNeil 286-7 (no class on 10/23).

Office Hours. By appointment, or when my door is open.

Prerequisites. You should have taken the first year Ph.D. sequence in the Economics department or have received consent from me. In general, you should be comfortable with real analysis, probability theory, and standard equilibrium concepts in dynamic games.

Course Content

All course material will be posted on Canvas.

Reading. Readings will consist of journal articles (there is no text for the course). The Reading Lists posted on Canvas list the papers for each part of the course. You should read all of the papers that we cover in class: many of these are “classics”, both for their formal innovation and because they have a powerful intuition and economic story. Reading papers at this stage is a great way to help you think about how to ask and answer research questions, and exposit your ideas. I don’t expect to cover all the papers mentioned and will adjust which papers to study based on our interests, pace, and progress.

Problem Sets. I will assign several problem sets based on the material we cover in class. They are due in my mailbox by 5pm on the due date, and will count for 20% of the grade. You are encouraged to work together on these problems, but the goal is that every student understands the relevant material. As such, assignments should be submitted individually acknowledging all those with whom problems were discussed.

Referee report. Each of you will write one referee report. This should be about 2-3 pages, briefly summarizing the main results and techniques in the paper, evaluating the technical and conceptual contributions, and listing any suggested improvements or additions. I will send you a list of potential papers to referee. This will comprise 20% of your grade.

Presentation. I will ask each of you to present a paper. Presentations should be about an hour and will be organized throughout the semester. They will focus on recent job market papers and working papers so you can get a sense of what makes a good theory paper in today's market. This will comprise 20% of your grade.

Final project. The final project will be a toy model of a topic you find interesting or plan to study further, with the goal that this will give you something concrete to work on in terms of research over the summer. The focus will be on developing and solving a model, rather than the accompanying verbiage. You don't need to write a lengthy intro, discussion of applications, lit survey, etc., but instead should develop a model of an interesting game, and a thorough examination of its equilibrium set, or one equilibrium (if that equilibrium happens to be complex to describe / prove optimality of, etc.). Solving and generalizing these toy models is what gets us started in writing papers. I'll meet with each of you throughout the semester to provide guidance with this process. Presentations of the final project will take place during the last week of class (20 minutes), and the paper is due during exam week. The final project will comprise the remaining 40% of your grade.

Economics 712: Topics in Economic Theory
Learning, Information and Dynamic Games
Schedule of Readings
Fall 2017

“Economic theories should be judged by three criteria: generality, congruence with reality, and tractability.”

- George Stigler, *Essays in the History of Economics* (1965).

1 Learning

1. Social Learning:

- (a) Sequential Observational Learning: [Banerjee \[1992\]](#); [Bikhchandani, Hirshleifer, and Welch \[1992, 1998\]](#); [Lee \[1993\]](#); [Smith and Sorensen \[2000\]](#); [Ali \[2017b\]](#)
 - Boundedly Rational: [Eyster and Rabin \[2010\]](#); [Guarino and Jehiel \[2013\]](#); [Bohren \[2016a\]](#); [Bohren and Hauser \[2017\]](#)
 - Financial Markets: [Park and Sabourian \[2011\]](#)
 - Costly Information Acquisition: [Mueller-Frank and Pai \[2016\]](#); [Ali \[2017a\]](#)
 - Position Uncertainty: [Monzón and Rapp \[2014\]](#)
 - Learning from Payoffs: [Wolitzsky \[2017\]](#)
- (b) Repeated Decisions
 - [Ellison and Fudenberg \[1993, 1995\]](#)
- (c) Networks
 - Observational Learning: [Bala and Goyal \[1998\]](#); [Acemoglu, Dahleh, Lobel, and Ozdaglar \[2011\]](#)
 - Communicating Beliefs: [DeGroot \[1974\]](#); [Demarzo, Vayanos, and Zwiebel \[2003\]](#); [Golub and Jackson \[2010\]](#)
- (d) Costly Communication: [Niehaus \[2011\]](#)

2. Experimentation

- (a) Single Agent: [Aghion, Bolton, Harris, and Jullien \[1991\]](#); [Moscarini and Smith \[2001\]](#)
- (b) Strategic: [Bolton and Harris \[1999\]](#); [Keller, Rady, and Cripps \[2005\]](#); [Keller and Rady \[2015\]](#); [Bonatti and Hörner \[2017\]](#)
- (c) Social Learning: [Murto and Välimäki \[2011\]](#); [Frick and Ishii \[2016\]](#); [Che and Horner \[2017\]](#)

- (d) Delegation: [Guo \[2016\]](#)
- 3. Boundedly Rational Information Processing
 - (a) Theory: [Epstein, Noor, and Sandroni \[2010\]](#); [Rabin and Schrag \[1999\]](#); [Gottlieb \[2011\]](#); [Bénabou \[2013\]](#); [Wilson \[2014\]](#); [Schwartzstein \[2014\]](#); [Bohren and Hauser \[2017\]](#)
 - (b) Empirical Evidence: [Enke and Zimmermann \[2017\]](#); [Eyster and Weizsacker \[2010\]](#)
- 4. Other Learning Models
 - (a) Views in Society: [Piketty \[1995\]](#)
 - (b) Fact-Free Learning: [Aragones, Gilboa, Postlewaite, and Schmeidler \[2005\]](#)

2 Value of Information

- 1. Single Agent Decision Problem
 - (a) Information Orders
 - Blackwell's: [Blackwell \[1951\]](#); [Leshno and Spector \[1992\]](#); [Lehrer and Shmaya \[2008\]](#)
 - Signals as Complements or Substitutes: [Börger, Hernando-Veciana, and Krähmer \[2013\]](#)
 - Entropy and Prices: [Cabrales, Gossner, and Serrano \[2013\]](#)
 - (b) Monotone Likelihood Ratio
 - Foundations: [Karlin and Rubin \[1956\]](#); [Whitt \[1979\]](#)
 - Classifying Information as “Good” or “Bad”: [Milgrom \[1981\]](#)
 - (c) Marginal Value of Information
 - Non-Concavity: [Radner and Stiglitz \[1984\]](#); [Chade and Schlee \[2002\]](#); [De Lara and Gilotte \[2007\]](#)
 - Demand: [Moscarini and Smith \[2002\]](#); [Keppo, Moscarini, and Smith \[2008\]](#)
 - (d) Monotone Decision Problems
 - [Athey and Levin \[2001\]](#)
- 2. Strategic Settings:
 - (a) Social Value of Information: [Morris and Shin \[2002\]](#); [Angeletos and Pavan \[2004, 2007\]](#)
 - (b) Comparison of Information Structures: [Gossner \[2000\]](#)

3 Information Design

- 1. Foundations: [Bergemann and Morris \[2016b, 2017\]](#)
 - (a) Bayes Correlated Equilibria: [Bergemann and Morris \[2013, 2016a\]](#)

- (b) Bayesian Persuasion (single agent): [Kamenica and Gentzkow \[2011\]](#)
- (c) Games (multiple agents): [Taneva \[2016\]](#); [Mathevet, Peregó, and Taneva \[2017\]](#)
- (d) Dynamic: [Ely \[2017\]](#)

2. Applications

- (a) Price Discrimination: [Bergemann, Brooks, and Morris \[2015\]](#)
- (b) Selling Information: [Horner and Skrzypacz \[2016\]](#); [Bergemann, Bonatti, and Smolin \[2016\]](#)
- (c) Belief-based Utility: [Ely, Frankel, and Kamenica \[2015\]](#)

4 Information Aggregation

1. Strategic Voting and Elections:

- (a) Common Values: [Austen-smith and Banks \[1996\]](#); [Feddersen and Pesendorfer \[1998\]](#)
- (b) Private Values: [Feddersen and Pesendorfer \[1996, 1997, 1999\]](#); [Bouton and Castanheira \[2012\]](#); [Bhattacharya \[2013\]](#)

2. Polarization: [Sunstein \[2002, 2005\]](#); [Andreoni and Mylovanov \[2012\]](#); [Benoit and Dubra \[2014\]](#); [Sobel \[2014\]](#)

3. Markets: [Ostrovsky \[2012\]](#); [Lambert, Ostrovsky, and Panov \[2017\]](#)

5 Information in Continuous Time Games

1. Stochastic Calculus Tools: [Sannikov \[2009\]](#)

2. Role of Timing: [Abreu, Milgrom, and Pearce \[1991\]](#); [Fudenberg and Levine \[2007, 2009\]](#); [Skrzypacz and Sannikov \[2007\]](#); [Sannikov and Skrzypacz \[2010\]](#)

3. Repeated Games: [Sannikov \[2007\]](#)

4. Reputation: [Faingold and Sannikov \[2011\]](#); [Faingold \[2013\]](#); [Board and Meyer-ter vehn \[2013, 2014\]](#); [Bohren \[2016b\]](#)

5. Optimal Monitoring: [Varas, Marinovic, and Skrzypacz \[2017\]](#)

Survey Articles

- Before information economics (see how far we have come!): [Stigler \[1961\]](#)
- An overview of information in economics: [Stiglitz \[2000\]](#)

References

- ABREU, D., P. MILGROM, AND D. PEARCE (1991): “Information and Timing in Repeated Partnerships,” *Econometrica*, 59(6), 1713–1733.
- ACEMOGLU, D., M. A. DAHLEH, I. LOBEL, AND A. OZDAGLAR (2011): “Bayesian learning in social networks,” *Review of Economic Studies*, 78(March), 1201–1236.
- AGHION, P., P. BOLTON, C. HARRIS, AND B. JULLIEN (1991): “Optimal Learning by Experimentation,” *Review of Economic Studies*, 58(4), 621–654.
- ALI, S. N. (2017a): “Herding With Costly Information,” .
- (2017b): “On the Role of Responsiveness in Rational Herds,” .
- ANDREONI, J., AND T. MYLOVANOV (2012): “Diverging Opinions,” *American Economic Journal: Microeconomics*, 4(1), 209–232.
- ANGELETOS, G.-M., AND A. PAVAN (2004): “Transparency in Economies of Information and Coordination Transparency with Investment Complementarities,” *American Economic Review, P&P*, 94(2), 91–98.
- ANGELETOS, G. M., AND A. PAVAN (2007): “Efficient use of information and social value of information,” *Econometrica*, 75(4), 1103–1142.
- ARAGONES, E., I. GILBOA, A. POSTLEWAITE, AND D. SCHMEIDLER (2005): “Fact-Free Learning,” *American Economic Review*, 95(5), 1355–1368.
- ATHEY, S., AND J. LEVIN (2001): “The Value of Information in Monotone Decision Problems,” .
- AUSTEN-SMITH, D., AND J. S. BANKS (1996): “Information Aggregation, Rationality, and the Condorcet Jury Theorem,” *The American Political Science Review*, 90(1), 34–45.
- BALA, V., AND S. GOYAL (1998): “Learning from Neighbors,” *Review of Economic Studies*, 65(3), 595–621.
- BANERJEE, A. (1992): “A Simple Model of Herd Behavior,” *Quarterly Journal of Economics*, 107(3), 797–817.
- BÉNABOU, R. (2013): “Groupthink: Collective delusions in organizations and markets,” *Review of Economic Studies*, 80, 429–462.
- BENOIT, J. P., AND J. DUBRA (2014): “A Theory of Rational Attitude Polarization,” .
- BERGEMANN, D., A. BONATTI, AND A. SMOLIN (2016): “The Design and Price of Information,” .
- BERGEMANN, D., B. BROOKS, AND S. MORRIS (2015): “The Limits of Price Discrimination,” *American Economic Review*, 105(3), 921–957.

- BERGEMANN, D., AND S. MORRIS (2013): “Robust Predictions in Games With Incomplete Information,” *Econometrica*, 81(4), 1251–1308.
- (2016a): “Bayes correlated equilibrium and the comparison of information structures in games,” *Theoretical Economics*, 11(2), 487–522.
- (2016b): “Information Design, Bayesian Persuasion and Bayes Correlated Equilibrium,” *American Economic Review, P&P*, 106(5), 1–23.
- (2017): “Information Design: A Unified Perspective,” .
- BHATTACHARYA, S. (2013): “Preference Monotonicity and Information Aggregation in Elections,” *Econometrica*, 81(3), 1229–1247.
- BIKHCHANDANI, S., D. HIRSHLEIFER, AND I. WELCH (1992): “A Theory of Fads , Fashion , Custom , and Cultural Change as Informational Cascades,” *The Journal of Political Economy*, 100(5), 992–1026.
- (1998): “Learning from the Behavior of Others: Conformity, Fads, and Informational Cascades,” *Journal of Economic Perspectives*, 12(3), 151–170.
- BLACKWELL, D. (1951): “Comparison of Experiments,” *Proceedings of the 2nd Berkeley Symposium on Mathematical Statistics and Probability*, pp. 93–102.
- BOARD, S., AND M. MEYER-TER VEHN (2013): “Reputation for Quality,” *Econometrica*.
- (2014): “A Reputational Theory of Firm Dynamics,” .
- BOHREN, A. (2016a): “Informational Herding with Model Misspecification,” *Journal of Economic Theory*, (163), 222–247.
- BOHREN, J. A. (2016b): “Using Persistence to Generate Incentives in a Dynamic Moral Hazard Problem,” .
- BOHREN, J. A., AND D. HAUSER (2017): “Boundedly Rational Learning: A Framework and a Robustness Result,” .
- BOLTON, P., AND C. HARRIS (1999): “Strategic Experimentation,” *Econometrica*, 67(2), 349–374.
- BONATTI, A., AND J. HÖRNER (2017): “Learning to disagree in a game of experimentation,” *Journal of Economic Theory*, 169, 234–269.
- BÖRGERS, T., A. HERNANDO-VECIANA, AND D. KRÄHMER (2013): “When are signals complements or substitutes?,” *Journal of Economic Theory*, 148(1), 165–195.
- BOUTON, L., AND M. CASTANHEIRA (2012): “One Person, Many Votes: Divided Majority and Information Aggregation,” *Econometrica*, 80(1), 43–87.
- CABRALES, A., O. GOSSNER, AND R. SERRANO (2013): “Entropy and the Value of Information for Investors,” *American Economic Review*, 103(1), 360–377.

- CHADE, H., AND E. SCHLEE (2002): “Another Look at the Radner-Stiglitz Nonconcavity in the Value of Information,” *Journal of Economic Theory*, 107(2), 421–452.
- CHE, Y.-K., AND J. HORNER (2017): “Recommender Systems as Incentives for Social Learning,” .
- DE LARA, M., AND L. GILOTTE (2007): “A tight sufficient condition for Radner-Stiglitz non-concavity in the value of information,” *Journal of Economic Theory*, 137(1), 696–708.
- DEGROOT, M. (1974): “Reaching A Consensus,” *Journal of the American Statistical Association*, 69(345), 118–121.
- DEMARZO, P. M., D. VAYANOS, AND J. ZWIEBEL (2003): “Persuasion Bias, Social Influence, and Unidimensional Opinions,” *Quarterly Journal of Economics*, (August), 909–968.
- ELLISON, G., AND D. FUDENBERG (1993): “Rules of Thumb for Social Learning,” *Journal of Political Economy*, 101(4), 612–643.
- (1995): “Word-of-Mouth Communication and Social Learning,” *Quarterly Journal of Economics*, 110(1), 93–125.
- ELY, J., A. FRANKEL, AND E. KAMENICA (2015): “Suspense and Surprise,” *Journal of Political Economy*, 123(1), 215–260.
- ELY, J. C. (2017): “Beeps,” *American Economic Review*, 107(1), 31–53.
- ENKE, B., AND F. ZIMMERMANN (2017): “Correlation Neglect in Belief Formation,” *Review of Economic Studies*.
- EPSTEIN, L. G., J. NOOR, AND A. SANDRONI (2010): “Non-Bayesian Learning,” *The B.E. Journal of Theoretical Economics*, 10(1).
- EYSTER, E., AND M. RABIN (2010): “Naïve Herding in Rich-Information Settings,” *American Economic Journal: Microeconomics*, 2(November), 221–243.
- EYSTER, E., AND G. WEIZSACKER (2010): “Correlation neglect in financial decision-making,” pp. 1–39.
- FAINGOLD, E. (2013): “Reputation and the Flow of Information in Repeated Games,” .
- FAINGOLD, E., AND Y. SANNIKOV (2011): “Reputation in Continuous Time Games,” *Econometrica*, 79(3), 773–876.
- FEDDERSEN, T., AND W. PESENDORFER (1996): “The Swing Voter’s Curse,” *American Economic Review*, 86(3), 408–424.
- (1997): “Voting Behavior and Information Aggregation in Elections With Private Information,” *Econometrica*, 65(5), 1029–1058.
- (1998): “Convicting the Innocent: The Inferiority of Unanimous Jury Verdicts under Strategic Voting,” *The American Political Science Review*, 92(1), 23–35.

- (1999): “Abstention in Elections with Asymmetric Information and Diverse Preferences,” *American Political Science Review*, 93(2), 381–398.
- FRICK, M., AND Y. ISHII (2016): “Innovation Adoption by Forward-Looking Social Learners,” .
- FUDENBERG, D., AND D. LEVINE (2009): “Repeated games with frequent signals,” *Quarterly Journal of Economics*, (February), 233–265.
- FUDENBERG, D., AND D. K. LEVINE (2007): “Continuous time limits of repeated games with imperfect public monitoring,” *Review of Economic Dynamics*, 10(2), 173–192.
- GOLUB, B., AND M. O. JACKSON (2010): “Naïve Learning in Social Networks and the Wisdom of Crowds,” *American Economic Journal: Microeconomics*, 2, 112–149.
- GOSSNER, O. (2000): “Comparison of Information Structures,” *Games and Economic Behavior*, 30, 44–63.
- GOTTLIEB, D. (2011): “Will you never learn? Self deception and biases in information processing,” .
- GUARINO, A., AND P. JEHIEL (2013): “Social Learning with Coarse Inference,” *American Economic Journal: Microeconomics*, 5(1), 147–174.
- GUO, Y. (2016): “Dynamic delegation of experimentation,” *American Economic Review*, 106(8), 1969–2008.
- HORNER, J., AND A. SKRZYPACZ (2016): “Selling Information,” *Journal of Political Economy*, 124(6).
- KAMENICA, E., AND M. GENTZKOW (2011): “Bayesian persuasion,” *American Economic Review*, (101), 2590–2615.
- KARLIN, S., AND H. RUBIN (1956): “Distributions Possessing a Monotone Likelihood Ratio,” *Journal of the American Statistical Association*, 51(276), 637–643.
- KELLER, G., AND S. RADY (2015): “Breakdowns,” *Theoretical Economics*, 10(1), 175–202.
- KELLER, G., S. RADY, AND M. CRIPPS (2005): “Strategic experimentation with exponential bandits,” *Econometrica*, 73(1), 39–68.
- KEPPO, J., G. MOSCARINI, AND L. SMITH (2008): “The demand for information: More heat than light,” *Journal of Economic Theory*, 138(1), 21–50.
- LAMBERT, N., M. OSTROVSKY, AND M. PANOV (2017): “Strategic Trading in Informationally Complex Environments,” *NBER Working Paper*.
- LEE, I. H. (1993): “On the Convergence of Informational Cascades,” *Journal of Economic Theory*, 61, 395–411.
- LEHRER, E., AND E. SHMAYA (2008): “Two Remarks on Blackwell’s Theorem,” *Journal of Applied Probability*, 45(2), 580–586.

- LESHNO, M., AND Y. SPECTOR (1992): “An elementary proof of Blackwell’s theorem,” *Mathematical Social Sciences*, 25, 95–98.
- MATHEVET, L., J. PEREGO, AND I. TANEVA (2017): “On Information Design in Games,” .
- MILGROM, P. (1981): “Good News and Bad News: Representation Theorems and Applications,” *The Bell Journal of Economics*, 12(2), 380–391.
- MONZÓN, I., AND M. RAPP (2014): “Observational Learning with Position Uncertainty,” *Journal of Economic Theory*, 154, 375–402.
- MORRIS, S., AND H. S. SHIN (2002): “Social Value of Public Information,” *American Economic Review*, 92(5).
- MOSCARINI, G., AND L. SMITH (2001): “The Optimal Level of Experimentation,” *Econometrica*, 69(6), 1629–1644.
- (2002): “The Law of Large Demand for Information,” *Econometrica*, 70(6), 2351–2366.
- MUELLER-FRANK, M., AND M. M. PAI (2016): “Social learning with costly search,” *American Economic Journal: Microeconomics*, 8(1), 83–109.
- MURTO, P., AND J. VÄLIMÄKI (2011): “Learning and information aggregation in an exit game,” *Review of Economic Studies*, 78(4), 1426–1461.
- NIEHAUS, P. (2011): “Filtered Social Learning,” *Journal of Political Economy*, 119(4), 686–720.
- OSTROVSKY, M. (2012): “Information Aggregation in Dynamic Markets With Strategic Traders,” *Econometrica*, 80(6), 2595–2647.
- PARK, A., AND H. SABOURIAN (2011): “Herding and contrarian behavior in financial markets,” *Econometrica*, 79(4), 973–1026.
- PIKETTY, T. (1995): “Social Mobility and Redistributive Politics,” *The Quarterly Journal of Economics*, 110(3), 551–584.
- RABIN, M., AND J. L. SCHRAG (1999): “First Impressions Matter: A Model of Confirmatory Bias,” *The Quarterly Journal of Economics*, 114(February), 37–82.
- RADNER, R., AND J. E. STIGLITZ (1984): “A Nonconcavity in the Value of Information,” *Bayesian Models in Economic Theory*.
- SANNIKOV, Y. (2007): “Games With Imperfectly Observable Actions in Continuous Time,” *Econometrica*, 75(5), 1285–1329.
- (2009): “Notes on Stochastic Calculus,” .
- SANNIKOV, Y., AND A. SKRZYPACZ (2010): “The Role of Information in Repeated Games With Frequent Actions,” *Econometrica*, 78(3), 847–882.

- SCHWARTZSTEIN, J. (2014): “Selective Attention and Learning,” *Journal of the European Economic Association*, 12(6), 1423–1452.
- SKRZYPACZ, A., AND Y. SANNIKOV (2007): “Impossibility of Collusion Under Imperfect Monitoring with Flexible Production,” *American Economic Review*, 97(5), 1794–1823.
- SMITH, L., AND P. SORENSEN (2000): “Pathological Outcomes Observational Learning,” *Econometrica*, 68(2), 371–398.
- SOBEL, J. (2014): “On the relationship between individual and group decisions,” *Theoretical Economics*, 9, 163–185.
- STIGLER, G. (1961): “The Economics of Information,” *The Journal of Political Economy*, 69(3), 213–225.
- STIGLITZ, J. (2000): “The Contributions of the Economics of Information to Twentieth Century Economics,” *The Quarterly Journal of Economics*, 115(4), 1441–1478.
- SUNSTEIN, C. R. (2002): “The Law of Group Polarization,” *Journal of Political Philosophy*, 10(2), 175–195.
- SUNSTEIN, C. R. (2005): “Group Judgements: Statistical means, deliberation and information markets,” *New York University Law Review*, 80.
- TANEVA, I. (2016): “Information Design,” .
- VARAS, F., I. MARINOVIC, AND A. SKRZYPACZ (2017): “Random Inspections and Periodic Reviews: Optimal Dynamic Monitoring,” .
- WHITT, W. (1979): “A Note on the Influence of the Sample on the Posterior Distribution,” *Journal of the American Statistical Association*, 74(366), 424–426.
- WILSON, A. (2014): “Bounded Memory and Biases in Information Processing,” *Econometrica*, 82(6), 2257–2294.
- WOLITZSKY, A. (2017): “Learning from Others’ Outcomes,” .