

Economics 2099 – Market Design (= HBS 4150)

Scott Duke Kominers

Logistics

Time. Tuesdays, 15:00–17:45+ ϵ (beginning September 4, 2018).

Location. Harvard Hall 104.

Office Hours.

- In clusters – Wednesdays 11:00–11:50 in Littauer 309, except as otherwise specified.
- By appointment – <https://2099-officehours.youcanbook.me/>.
- Over dinner – After class each week, there will be an *optional*, informal “design dinner” in Harvard Square. (Restaurants will be selected via social choice mechanism.)

Course Webpage.

- http://www.scottkom.com/courses/Market-Design_2018-2019/.

Teaching Assistants.

- Ravi Jagadeesan (ravi.jagadeesan@gmail.com).
- Erica Moszkowski (emoszkowski@g.harvard.edu).

Course E-mail Address.

- econ2099@gmail.com.

Overview

Description. This course explores the theory and practice of market design. Key topics include auctions, labor market matching, school choice programs, online markets, organ exchange systems, financial market design, and matching with contracts. The first half of the course will introduce market design and its technology; subsequent weeks will discuss recent papers alongside their classical antecedents.

Quasi-Prerequisites. Courses in microeconomics (Economics 1011a, 1080, and/or 2010a,b) and game theory (Economics 1052, 2052 and/or 2087hf) will provide useful context and technical background. Some understanding of algorithms, complexity, and/or combinatorics (e.g., Computer Science 121, 124, and/or 224, Math 152, and/or Applied Math 107) will at times be useful. Courses at the intersection of economics and computation (e.g., Computer Science 136, 234, and/or 236r) are highly complementary. However, I do not believe in formal prerequisites—these observations are made only for the purpose of guidance.

If you are interested in taking the course and are concerned about the difficulty of the material, please *see enrollment information below* and then get in touch early in (or before) the fall semester. I am inclined to reward individuals for taking risks and stretching themselves.

Enrollment. GSAS and HBS doctoral students may enroll directly; students in other programs and schools require permission of the instructor. Permission will be granted automatically to anyone who has taken at least one graduate-level economic theory course (Economics 20**), a course on economics and computation (e.g., Computer Science 136, 234, or 236r), or at least one graduate-level Mathematics course. All other students will need to file a brief application (at <https://tinyurl.com/2099app/>) detailing their backgrounds and reasons for wanting to enroll. There will be two deadline tranches: Thursday, September 6, at 05:00; and Monday, September 10, at 02:00.

Requirements. Evaluation will be primarily based upon class participation and discussion. Additionally, each student will prepare a written “research proposal” detailing a novel problem in market design and an approach to a solution. A short proposal summary/plan will be due on October 17, 2018. The final proposal will be due on December 10, 2018 (the last day of Reading Period).

Section. There will be an optional discussion section each week that will conduct a deep dive into either a paper discussed briefly in class or a related paper with complementary material.

How to Read this Syllabus. “Background” readings will be presented in class. Readings listed as “For Class Discussion” will be discussed intensively, and thus should be read in advance. (I will give specific advance reading guidance.) “Further Reading” references may be touched upon in class sessions, but are mostly provided as suggestions for students who wish to explore in more depth.

Topics

Introduction/Overview – September 4, 2018.

For Class Discussion.

David Gale and Lloyd S. Shapley. College admissions and the stability of marriage. *American Mathematical Monthly*, 69:9–15, 1962.

Background.

Ronald H. Coase. The problem of social cost. *Journal of Law and Economics*, 3:1–44, 1960.

Alvin E. Roth. The evolution of the labor market for medical interns and residents: A case study in game theory. *Journal of Political Economy*, 92:991–1016, 1984.

Alvin E. Roth. The economist as engineer: Game theory, experimentation, and computation as tools for design economics. *Econometrica*, 70:1341–1378, 2002.

Alvin E. Roth. Deferred acceptance algorithms: History, theory, practice, and open questions. *International Journal of Game Theory*, 36:537–569, 2008.

Scott Duke Kominers, Alexander Teytelboym, and Vincent P. Crawford. An invitation to market design. *Oxford Review of Economic Policy*, 33:541–571, 2017.

Further Reading.

Christopher Avery, Christine Jolls, Richard A. Posner, and Alvin E. Roth. The market for federal judicial law clerks. *University of Chicago Law Review*, 68:793–902, 2001.

L. E. Dubins and D. A. Freedman. Machiavelli and the Gale-Shapley algorithm. *American Mathematical Monthly*, 88:485–494, 1981.

John H. Kagel and Alvin E. Roth. The dynamics of reorganization in matching markets: A laboratory experiment motivated by a natural experiment. *Quarterly Journal of Economics*, 115:201–235, 2000.

Muriel Niederle and Alvin E. Roth. Unraveling reduces mobility in a labor market: Gastroenterology with and without a centralized match. *Journal of Political Economy*, 111:1342–1352, 2003.

Alvin E. Roth and Xiaolin Xing. Jumping the gun: Imperfections and institutions related to the timing of market transactions. *American Economic Review*, 84:992–1044, 1994.

Alvin E. Roth and Elliott Peranson. The redesign of the matching market for American physicians: Some engineering aspects of economic design. *American Economic Review*, 89:748–780, 1999.

The Market Designer’s Toolbox – September 11, 2018.

For Class Discussion.

Parag A. Pathak and Tayfun Sönmez. Leveling the playing field: Sincere and sophisticated players in the Boston mechanism. *American Economic Review*, 98:1636–1652, 2008.

Background.

Parag A. Pathak and Tayfun Sönmez. School admissions reform in Chicago and England: Comparing mechanisms by their vulnerability to manipulation. *American Economic Review*, 103:80–106, 2013.

Nicole Immorlica and Mohammad Mahdian. Incentives in large random two-sided markets. *ACM Transactions on Economics and Computation*, 3:#14, 2015.

Fuhito Kojima and Parag A. Pathak. Incentives and stability in large two-sided matching markets. *American Economic Review*, 99:608–627, 2009.

Eduardo M. Azevedo and Jacob D. Leshno. A supply and demand framework for two-sided matching markets. *Journal of Political Economy*, 124:1235–1268, 2016.

Alexander S. Kelso, Jr. and Vincent P. Crawford. Job matching, coalition formation, and gross substitutes. *Econometrica*, 50:1483–1504, 1982.

Ravi Jagadeesan, Scott Duke Kominers, and Ross Rheingans-Yoo. Strategy-proofness of worker-optimal matching with continuously transferable utility. *Games and Economic Behavior*, 108:287–294, 2018.

Scott Duke Kominers. Respect for improvements and comparative statics in matching markets. Harvard University Working Paper, in preparation.

Avinatan Hassidim, Assaf Romm, and Ran Shorrer. Need vs. merit: The large core of college admissions markets. 2017b. Pennsylvania State University Working Paper.

Jonathan M. V. Davis and B. Pablo Montagnes. Designing organizational versus public markets. University of Chicago Working Paper, 2016.

Benjamin N. Roth and Ran I. Shorrer. Making it safe to use centralized markets: Dominant individual rationality and applications to market design. MIT Working Paper, 2017.

Avinatan Hassidim, Ran I. Shorrer, and Assaf Romm. “Strategic” players in a strategy-proof environment. Hebrew University Working Paper, 2015.

Georgy Artemov, Yeon-Koo Che, and Yinghua He. Strategic ‘mistakes’: Implications for market design research. 2017.

Further Reading.

Itai Ashlagi, Yash Kanoria, and Jacob D. Leshno. Unbalanced random matching markets: The stark effect of competition. *Journal of Political Economy*, 125:69–98, 2017.

John William Hatfield, Fuhito Kojima, and Scott Duke Kominers. Strategy-proofness, investment efficiency, and marginal returns: An equivalence. Becker Friedman Institute Working Paper, 2017.

Avinatan Hassidim, Déborah Marciano, Assaf Romm, and Ran I. Shorrer. The mechanism is truthful, why aren’t you? *American Economic Review Papers & Proceedings*, 107: 220–224, 2017a.

Food Supply, Scrip, and Pseudo-Markets – September 18, 2018. (Featuring Erica Moszkowski.)

For Class Discussion.

Canice Prendergast. The allocation of food to food banks. Booth School of Business Working Paper, 2017a.

Canice Prendergast. How food banks use markets to feed the poor. *Journal of Economic Perspectives*, 31:145–62, 2017b.

Scott Duke Kominers and Alan Lam. Feeding America (A) and (B). Harvard Business School Case 818-130 and Supplement 818-131, 2018.

Background.

- Joan Sweeney and Richard James Sweeney. Monetary theory and the great Capitol Hill Baby Sitting Co-op crisis: Comment. *Journal of Money, Credit and Banking*, 9:86–89, 1977.
- Ian A. Kash, Eric J. Friedman, and Joseph Y. Halpern. Optimizing scrip systems: crashes, altruists, hoarders, sybils and collusion. *Distributed Computing*, 25:335–357, 2012.
- Ian A. Kash, Eric J. Friedman, and Joseph Y. Halpern. An equilibrium analysis of scrip systems. *ACM Transactions on Economics and Computation*, 3:#13, 2015.
- Tayfun Sönmez and M. Utku Ünver. Course bidding at business schools. *International Economic Review*, 51:99–123, 2010.
- Eric Budish. The combinatorial assignment problem: Approximate competitive equilibrium from equal incomes. *Journal of Political Economy*, 119:1061–1103, 2011.
- Eric Budish and Estelle Cantillon. The multi-unit assignment problem: Theory and evidence from course allocation at Harvard. *American Economic Review*, 102:2237–2271, 2012.

Further Reading.

- Mohammad Akbarpour and Afshin Nikzad. Approximate random allocation mechanisms. Stanford University Working Paper, 2017.
- Eduardo M. Azevedo, E. Glen Weyl, and Alexander White. Walrasian equilibrium in large, quasilinear markets. *Theoretical Economics*, 8:281–290, 2013.
- Anna Bogomolnaia and Hervé Moulin. A new solution to the random assignment problem. *Journal of Economic theory*, 100:295–328, 2001.
- Eric Budish, Yeon-Koo Che, Fuhito Kojima, and Paul Milgrom. Designing random allocation mechanisms: Theory and applications. *American Economic Review*, 103:585–623, 2013.
- Eric Budish and Judd B. Kessler. Bringing real market participants’ real preferences into the lab: An experiment that changed the course allocation mechanism at Wharton. NBER Working Paper No. 22448, 2016.
- Yinghua He, Antonio Miralles, Marek Pycia, and Jianye Yan. A pseudo-market approach to allocation with priorities. Toulouse School of Economics (TSE) Working Paper, 2015.
- Aanund Hylland and Richard Zeckhauser. The efficient allocation of individuals to positions. *Journal of Political Economy*, 87:293–314, 1979.
- Andreu Mas-Colell. Indivisible commodities and general equilibrium theory. *Journal of Economic Theory*, 16:443–456, 1977.

School Choice – September 25, 2018.

For Class Discussion.

- Yan Chen and Onur Kesten. Chinese college admissions and school choice reforms: Theory and experiments. Tepper School of Business Working Paper, 2014.

Background.

- Michel Balinski and Tayfun Sönmez. A tale of two mechanisms: Student placement. *Journal of Economic Theory*, 84:73–94, 1999.
- Atila Abdulkadiroğlu and Tayfun Sönmez. School choice: A mechanism design approach. *American Economic Review*, 93:729–747, 2003.
- Atila Abdulkadiroğlu, Nikhil Agarwal, and Parag A. Pathak. The welfare effects of coordinated assignment: Evidence from the New York City high school match. *American Economic Review*, 107, 2017.

- Atila Abdulkadiroğlu, Parag A. Pathak, and Alvin E. Roth. Strategyproofness versus efficiency in matching with indifference: Redesigning the NYC high school match. *American Economic Review*, 99:1954–1978, 2009.
- Onur Kesten. School choice with consent. *Quarterly Journal of Economics*, 125:1297–1348, 2010.
- Fuhito Kojima. School choice: Impossibilities for affirmative action. *Games and Economic Behavior*, 75:685–693, 2012.
- Isa Emin Hafalir, M. Bumin Yenmez, and Muhammed Ali Yildirim. Effective affirmative action in school choice. *Theoretical Economics*, 8:325–363, 2013.

Further Reading.

- Atila Abdulkadiroğlu, Parag A. Pathak, and Alvin E. Roth. The New York City high school match. *American Economic Review*, 95:364–367, 2005a.
- Atila Abdulkadiroğlu, Parag A. Pathak, Alvin E. Roth, and Tayfun Sönmez. The Boston public school match. *American Economic Review*, 95:368–371, 2005b.
- Caterina Calsamiglia and Maia Güell. The illusion of school choice: Empirical evidence from Barcelona. CEPR Discussion Paper No. DP10011, 2014.
- Battal Doğan and M. Bumin Yenmez. Unified enrollment in school choice: How to improve student assignment in Chicago. Boston College Working Paper, 2017.
- Umut Dur, Scott Duke Kominers, Parag A. Pathak, and Tayfun Sönmez. Reserve design: Unintended consequences and the demise of Boston’s walk zones. *Journal of Political Economy*, forthcoming.
- Umut Dur, Parag A. Pathak, and Tayfun Sönmez. Explicit vs. statistical preferential treatment in affirmative action: Theory and evidence from Chicago’s exam schools. 2016.
- Federico Echenique and M. Bumin Yenmez. How to control controlled school choice. *American Economic Review*, 105:2679–2694, 2015.
- Roland G. Fryer, Jr. and Glenn C. Loury. Valuing diversity. *Journal of Political Economy*, 121:747–774, 2013.
- John William Hatfield, Fuhito Kojima, and Yusuke Narita. Improving schools through school choice: A market design approach. *Journal of Economic Theory*, 166:186–211, 2016.
- Onur Kesten and M. Utku Ünver. A theory of school-choice lotteries. *Theoretical Economics*, 10:543–595, 2015.
- Scott Duke Kominers and Tayfun Sönmez. Matching with slot-specific priorities: Theory. *Theoretical Economics*, 11:683–710, 2016.
- Parag A. Pathak. The mechanism design approach to student assignment. *Annual Review of Economics*, 3:513–536, 2011.
- Parag A. Pathak and Jay Sethuraman. Lotteries in student assignment: An equivalence result. *Theoretical Economics*, 6:1–17, 2011.
- Parag A. Pathak. What really matters in designing school choice mechanisms. In Bo Honoré, Ariel Pakes, Monika Piazzesi, and Larry Samuelson, editors, *Advances in Economics and Econometrics, 11th World Congress of the Econometric Society*, pages 176–214. 2017.
- Parag A. Pathak and Peng Shi. How well do structural demand models work? Counterfactual predictions in school choice. NBER Working Paper No. 24017, 2017.
- Peng Shi. Guiding school-choice reform through novel applications of operations research. *Interfaces*, 45:117–132, 2015.

Generalized Matching – October 2, 2018.

(Featuring Ravi Jagadeesan.)

For Class Discussion.

Avinatan Hassidim, Assaf Romm, and Ran I. Shorrer. Redesigning the Israeli psychology master's match. *American Economic Review Papers & Proceedings*, 107:205–209, 2017c.

Background.

John William Hatfield and Paul Milgrom. Matching with contracts. *American Economic Review*, 95:913–935, 2005.

John William Hatfield and Fuhito Kojima. Substitutes and stability for matching with contracts. *Journal of Economic Theory*, 145:1704–1723, 2010.

John William Hatfield and Scott Duke Kominers. Contract design and stability in many-to-many matching. *Games and Economic Behavior*, 101:78–97, 2017a.

John William Hatfield and Scott Duke Kominers. Hidden substitutes. Harvard University Working Paper, 2017b.

Michael Ostrovsky. Stability in supply chain networks. *American Economic Review*, 98: 897–923, 2008.

John William Hatfield and Scott Duke Kominers. Matching in networks with bilateral contracts. *American Economic Journal: Microeconomics*, 4:176–208, 2012.

John William Hatfield, Scott Duke Kominers, Alexandru Nichifor, Michael Ostrovsky, and Alexander Westkamp. Stability and competitive equilibrium in trading networks. *Journal of Political Economy*, 121:966–1005, 2013.

Tayfun Sönmez and Tobias B. Switzer. Matching with (branch-of-choice) contracts at United States Military Academy. *Econometrica*, 81:451–488, 2013.

Tayfun Sönmez. Bidding for army career specialties: Improving the ROTC branching mechanism. Boston College Working Paper, 2011.

Ravi Jagadeesan. Cadet-branch matching in a Kelso–Crawford economy. Harvard University Working Paper, 2016.

Further Reading.

Hiroyuki Adachi. On a characterization of stable matchings. *Economics Letters*, 68:43–49, 2000.

Eduardo M. Azevedo and John William Hatfield. Existence of stable matchings in large markets with complementarities. University of Texas at Austin Working Paper, 2015.

Orhan Aygün and Tayfun Sönmez. Matching with contracts: Comment. *American Economic Review*, 103:2050–2051, 2013.

Elizabeth Baldwin and Paul Klempner. Understanding preferences: “demand types”, and the existence of equilibrium with indivisibilities. Oxford University Working Paper, 2018.

Yeon-Koo Che, Jinwoo Kim, and Fuhito Kojima. Stable matching in large economies. *Econometrica*, forthcoming.

Federico Echenique. Contracts vs. salaries in matching. *American Economic Review*, 102: 594–601, 2012.

Tamás Fleiner. A fixed-point approach to stable matchings and some applications. *Mathematics of Operations Research*, 28:103–126, 2003.

Tamás Fleiner, Ravi Jagadeesan, Zsuzsanna Jankó, and Alexander Teytelboym. Trading networks with frictions. Oxford University Working Paper, 2017.

Ravi Jagadeesan. Complementary inputs and the existence of stable outcomes in large trading networks. Harvard University Working Paper, 2017.

Frank Gul and Ennio Stacchetti. Walrasian equilibrium with gross substitutes. *Journal of Economic Theory*, 87:95–124, 1999.

- Yuichiro Kamada and Fuhito Kojima. Efficient matching under distributional constraints: Theory and applications. *American Economic Review*, 105:67–99, 2015.
- Jonathan Ma and Scott Duke Kominers. Bundling incentives in (many-to-many) matching with contracts. Harvard University Working Paper, 2018.
- Ning Sun and Zaifu Yang. Equilibria and indivisibilities: Gross substitutes and complements. *Econometrica*, 74:1385–1402, 2006.
- M. Bumin Yenmez. A college admissions clearinghouse. *Journal of Economic Theory*, 176: 859–885, 2018.

Markets for Intellectual Property – October 9, 2018.

For Class Discussion.

- Lauren Cohen, Umit G. Gurun, and Scott Duke Kominers. Patent trolls: Evidence from targeted firms. *Management Science*, forthcoming.
- Scott Duke Kominers. One thing you don't need is stronger patents. *Bloomberg View*, July 6, 2017.

Background.

- Andrei Hagiu and David B. Yoffie. The new patent intermediaries: Platforms, defensive aggregators, and super-aggregators. *Journal of Economic Perspectives*, 27:45–65, 2013.
- Joshua S. Gans and Scott Stern. Designing markets for ideas. In Nir Vulkan, Alvin E. Roth, and Zvika Neeman, editors, *The Handbook of Market Design*, pages 222–248. Oxford University Press, 2013.
- Robin Feldman and Mark A. Lemley. Do patent licensing demands mean innovation? *Iowa Law Review*, 101:137–189, 2015.
- Eric Budish, Benjamin N. Roin, and Heidi L. Williams. Do firms underinvest in long-term research? Evidence from cancer clinical trials. *American Economic Review*, 105: 2044–2085, 2015.
- Michele Boldrin and David K. Levine. The case against patents. *Journal of Economic Perspectives*, 27:3–22, 2013.
- Colleen Chien. Why it's time to open up our patent system. *The Washington Post*, June 30, 2015.
- Michael Kremer. Patent buyouts: A mechanism for encouraging innovation. *Quarterly Journal of Economics*, 113:1137–1167, 1998.
- Lauren Cohen, John M. Golden, Umit G. Gurun, and Scott Duke Kominers. 'Troll' check? A proposal for administrative review of patent litigation. *Boston University Law Review*, 97:1775–1841, 2017.

Further Reading.

- James E. Bessen, Michael J. Meurer, and Jennifer Ford. The private and social costs of patent trolls. *Regulation*, 34:26–35, 2011.
- Lauren H Cohen and Umit G Gurun. Buying the verdict. NBER Working Paper No. 24542, 2018.
- Lauren H. Cohen, Umit G. Gurun, Scott Duke Kominers, and George Hou. Patent trolling. Harvard Business School Background Note 218-085, 2018.
- Christopher A. Cotropia, Jay P. Kesan, and David L. Schwartz. Unpacking patent assertion entities (PAEs). *Minnesota Law Review*, 99:649–703, 2014.
- Gaétan De Rassenfosse, Adam B. Jaffe, and Elizabeth Webster. Low-quality patents in the eye of the beholder: Evidence from multiple examiners. NBER Working Paper No. 22244, 2016.

- Timo Fischer and Jan Leidinger. Testing patent value indicators on directly observed patent value – an empirical analysis of Ocean Tomo patent auctions. *Research Policy*, 43:519–529, 2014.
- Alberto Galasso and Mark Schankerman. Patent thickets, courts, and the market for innovation. *RAND Journal of Economics*, 41:472–503, 2010.
- Josh Lerner and Jean Tirole. The economics of technology sharing: Open source and beyond. *Journal of Economic Perspectives*, 19:99–120, 2005.
- Josh Lerner and Jean Tirole. Standard essential patents. *Journal of Political Economy*, 123:547–586, 2015.
- Catherine E. Tucker. Patent trolls and technology diffusion: The case of medical imaging. 2014. MIT Working Paper.
- Heidi L. Williams. Intellectual property rights and innovation: Evidence from the human genome. *Journal of Political Economy*, 121:1–27, 2013.
- Heidi L. Williams. How do patents affect research investments? *Annual Review of Economics*, 9:441–469, 2017.

Auction Theory – October 16, 2018.

(Featuring Shengwu Li.)

For Class Discussion.

- Benjamin Edelman, Michael Ostrovsky, and Michael Schwarz. Internet advertising and the generalized second-price auction: Selling billions of dollars worth of keywords. *American Economic Review*, 97:242–259, 2007.
- Susan Athey and Glenn Ellison. Position auctions with consumer search. *Quarterly Journal of Economics*, 126:1213–1270, 2011.

Background.

- R. Preston McAfee and John McMillan. Auctions and bidding. *Journal of Economic Literature*, 25:699–738, 1987.
- Roger B. Myerson. Optimal auction design. *Mathematics of Operations Research*, 6:58–73, 1981.
- Roger B. Myerson and Mark A. Satterthwaite. Efficient mechanisms for bilateral trading. *Journal of Economic Theory*, 29:265–281, 1983.
- Jeremy Bulow and John Roberts. The simple economics of optimal auctions. *Journal of Political Economy*, 97:1060–1090, 1989.
- Jeremy Bulow and Paul Klemperer. Auctions versus negotiations. *American Economic Review*, 86:180–194, 1996.
- Michael Ostrovsky and Michael Schwarz. Reserve prices in Internet advertising auctions: A field experiment. Stanford Graduate School of Business Working Paper, 2016.
- Jiafeng Chen and Scott Duke Kominers. Auctions with entry versus entry in auctions. Harvard University Working Paper, 2018.
- Shengwu Li. Obviously strategy-proof mechanisms. *American Economic Review*, 107:3257–3287, 2018.
- Mohammad Akbarpour and Shengwu Li. Credible mechanisms. Stanford Graduate School of Business Working Paper, 2018.

Further Reading.

- Nikhil Agarwal, Susan Athey, and David Yang. Skewed bidding in pay-per-action auctions for online advertising. *American Economic Review*, 99:441–447, 2009.
- John Asker. A study of the internal organization of a bidding cartel. *American Economic Review*, 100:724–762, 2010.
- Susan Athey and Jonathan Levin. Information and competition in US Forest Service timber auctions. *Journal of Political Economy*, 109:375–417, 2001.

- Jeremy Bulow and Paul Klemperer. Why do sellers (usually) prefer auctions? *American Economic Review*, 99:1544–1575, 2009.
- Dirk Bergemann and Juuso Välimäki. Information acquisition and efficient mechanism design. *Econometrica*, 70:1007–1033, 2002.
- Benjamin Edelman and Michael Ostrovsky. Strategic bidder behavior in sponsored search auctions. *Decision Support Systems*, 43:192–198, 2007.
- Jerry Green and Jean-Jacques Laffont. Characterization of satisfactory mechanisms for the revelation of preferences for public goods. *Econometrica*, 45:427–438, 1977.
- Paul Milgrom. Assignment messages and exchanges. *American Economic Journal: Microeconomics*, 1:95–113, 2009.
- Paul R. Milgrom and Robert J. Weber. A theory of auctions and competitive bidding. *Econometrica*, 50:1089–1122, 1982.
- Steven R. Williams. A characterization of efficient, Bayesian incentive compatible mechanisms. *Economic Theory*, 14:155–180, 1999.
- Robert A. Wilson. Bidding. In John Eatwell, Murray Milgate, and Peter Newman, editors, *The New Palgrave: A Dictionary of Economics*, pages 238–242. Palgrave Macmillan, 1st edition, 1987.

The US Spectrum Incentive Auction – October 23, 2018.

For Class Discussion.

- Kevin Leyton-Brown, Paul Milgrom, and Ilya Segal. Economics and computer science of a radio spectrum reallocation. *Proceedings of the National Academy of Sciences*, 114:7202–7209, 2017.

Background.

- FCC Staff. The broadcast television spectrum incentive auction: Innovation in policy to ignite innovation for consumers and business, 2013.
- Scott Duke Kominers. To improve wireless networks, auction the airwaves. *Bloomberg View*, July 24, 2017.
- Paul Milgrom. *Discovering Prices: Auction Design in Markets with Complex Constraints*. Columbia University Press, 2017.
- Paul Klemperer. Using and abusing auction theory. In Nir Vulkan, Alvin E. Roth, and Zvika Neeman, editors, *The Handbook of Market Design*, pages 62–89. Oxford University Press, 2013.
- Gregory Rosston. Incentive auctions. *Communications of the ACM*, 55:24–26, 2012.
- Scott Duke Kominers and E. Glen Weyl. Holdout in the assembly of complements: A problem for market design. *American Economic Review Papers & Proceedings*, 102:360–365, 2012.
- Ulrich Doraszelski, Katja Seim, Michael Sinkinson, and Peichun Wang. Ownership concentration and strategic supply reduction. NBER Working Paper No. 23034, 2017.

Further Reading.

- Lawrence M. Ausubel and Paul Milgrom. The lovely but lonely Vickrey auction. In Peter Cramton, Yoav Shoham, and Richard Steinberg, editors, *Combinatorial Auctions*, pages 17–40. MIT Press, 2006.
- Robert Day and Paul R. Milgrom. Core-selecting auctions. *International Journal of Game Theory*, 36:393–407, 2008.
- Paul Milgrom, Lawrence Ausubel, Jonathan Levin, and Ilya Segal. Incentive auction rules option and discussion. Appendix to the FCC’s 28-Sep-2012 NPRM on Incentive Auctions, 2012.

Paul R. Milgrom and Ilya Segal. Deferred-acceptance auctions and radio spectrum reallocation. Stanford University Working Paper, 2017.

Neil Newman, Alexandre Fréchet, and Kevin Leyton-Brown. Deep optimization for spectrum repacking. *Communications of the ACM*, 61:97–104, 2018.

Organ Allocation – October 30, 2018.

For Class Discussion.

Michael A. Rees, Ty B. Dunn, Christian S. Kuhr, Christopher L. Marsh, Jeffrey Rogers, Susan E. Rees, Alejandra Cicero, Laurie J. Reece, Alvin E. Roth, Obi Ekwenna, et al. Kidney exchange to overcome financial barriers to kidney transplantation. *American Journal of Transplantation*, 17:782–790, 2017.

A. C. Wiseman and J. S. Gill. Financial incompatibility and paired kidney exchange: Walking a tightrope or blazing a trail? *American Journal of Transplantation*, 17:597–598, 2017.

Background.

Stephen Leider and Alvin E. Roth. Kidneys for sale: Who disapproves, and why? *American Journal of Transplantation*, 10:1221–1227, 2010.

Alvin E. Roth, Tayfun Sönmez, and M. Utku Ünver. Kidney exchange. *Quarterly Journal of Economics*, 119:457–488, 2004.

Alvin E. Roth, Tayfun Sönmez, and M. Utku Ünver. Efficient kidney exchange: Coincidence of wants in markets with compatibility-based preferences. *American Economic Review*, 97:828–851, 2007.

Itai Ashlagi and Alvin E. Roth. New challenges in multihospital kidney exchange. *American Economic Review*, 102:354–359, 2012.

Itai Ashlagi, David Gamarnik, Michael Rees, and Alvin E. Roth. The need for (long) chains in kidney exchange. NBER Working Paper No. 18202, 2012.

Mohammad Akbarpour, Shengwu Li, and Shayan Oveis Gharan. Thickness and information in dynamic matching markets. Stanford University Working Paper, 2015.

Nikhil Agarwal, Itai Ashlagi, Eduardo Azevedo, Clayton R Featherstone, and Ömer Karaduman. Market failure in kidney exchange. NBER Working Paper No. 24775, 2018b.

Gary S. Becker, Julio J. Elias, and Karen Ye. The shortage of kidneys for transplant: Altruism, exchanges, opt in versus opt out, and the market for kidneys. Becker Friedman Institute Working Paper, 2013.

Tayfun Sönmez, M. Utku Ünver, and M. Bumin Yenmez. Incentivized kidney exchange. Boston College Working Paper, 2017.

Further Reading.

Nikhil Agarwal, Itai Ashlagi, Eduardo Azevedo, Clayton Featherstone, and Ömer Karaduman. What matters for the productivity of kidney exchange? *AEA Papers & Proceedings*, 108:334–340, 2018a.

Nikhil Agarwal, Itai Ashlagi, Michael Rees, Paulo Somaini, and Daniel Waldinger. An empirical framework for sequential assignment: The allocation of deceased donor kidneys. MIT Working Paper, 2018c.

Nikhil Agarwal, Itai Ashlagi, Paulo Somaini, and Daniel Waldinger. Dynamic incentives in wait list mechanisms. *AEA Papers & Proceedings*, 108:341–347, 2018d.

Sandro Ambuehl. An offer you can't refuse? Incentives change what we believe. Rotman School of Management Working Paper, 2016.

Atila Abdulkadiroğlu and Tayfun Sönmez. House allocation with existing tenants. *Journal of Economic Theory*, 88:233–260, 1999.

Itai Ashlagi and Alvin E. Roth. Free riding and participation in large scale, multi-hospital kidney exchange. *Theoretical Economics*, 9:817–863, 2014.

- Haluk Ergin, Tayfun Sönmez, and M Utku Ünver. Dual-donor organ exchange. *Econometrica*, forthcoming.
- Judd B. Kessler and Alvin E. Roth. Don't take 'no' for an answer: An experiment with actual organ donor registrations. NBER Working Paper No. 20378, 2014.
- Jacob Leshno. Dynamic matching in overloaded systems. Harvard University Working Paper, 2015.
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(Featuring Edward L. Glaeser.)

Readings to be announced.

New Horizons – November 20, 2018.

(Featuring Zoë Cullen, Andrey Fradkin, David Parkes, M. Utku Ünver, and Kate Vredenburg.)

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Refugees, Immigration, and Economic Development – November 27, 2018.

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Miscellany

Food for Thought.

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Interesting Properties of the Course Number(s).

- The course number is a “safe prime” – that is, 2099 is prime and $(2099 - 1)/2 = 1049$ is also prime.
- The binary representation of the course number (100000110011) is also the decimal representation of a prime.
- The course number is the smallest prime that is the sum of 29 consecutive primes ($2099 = 13 + 17 + \dots + 139$).
- The course number is in the four-step Fibonacci sequence starting with 0, 1, 1, and 1.
- The course number is the least number having exactly 37 representations in the form $ab + ac + bc$ with $0 < a < b < c$.
- Assuming no changes in our calendar system, the year 2099 will have exactly three “Fridays the Thirteenth.”
- The HBS cross-listing number is the first “5-powerful number” – that is, 4150 is the smallest number that is the sum of the fifth powers of its digits ($4150 = 1024 + 1 + 3125 + 0 = 4^5 + 1^5 + 5^5 + 0^5$).
- The HBS cross-listing number is the smallest integer k such that $\frac{50!+k}{50}$ is prime.
- The HBS cross-listing number is a Rothian number.
- The HBS cross-listing number satisfies a Spironacci-style recurrence.