

JUGAL GARG

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RESEARCH INTERESTS

Computational Aspects of Economics, Fair Division, and Game Theory; Design and Analysis of Algorithms; Mathematical Programming

EDUCATION

- **Post-doctoral Research Fellow** (2014-16), Algorithms and Complexity Group, Max-Planck-Institut für Informatik, Saarbrücken, Germany. (Mentor: Prof. Kurt Mehlhorn)
- **Post-doctoral Research Fellow** (2012-14), College of Computing, Georgia Tech, USA. (Mentor: Prof. Vijay V. Vazirani)
- **Ph.D.** (2012), Computer Science and Engineering, Indian Institute of Technology, Bombay, India. (Advisors: Prof. Milind Sohoni and Prof. Bharat Adsul)
- **B.Tech.** (2001), Computer Science and Engineering, Indian Institute of Technology, Bombay, India.

APPOINTMENTS

- **Assistant Professor** (2018-), Dept. of Industrial and Enterprise Systems Engineering, Univ. of Illinois at Urbana-Champaign, USA.
- **Affiliate Research Assistant Professor** (2016-), Dept. of Computer Science, Univ. of Illinois at Urbana-Champaign, USA.
- **Research Assistant Professor** (2016-18), Dept. of Industrial and Enterprise Systems Engineering, Univ. of Illinois at Urbana-Champaign, USA.

HONORS AND AWARDS

- The James Franklin Sharp Outstanding Teaching Award, 2019.
- NSF CRII Award, 2017.
- Featured in the List of Teachers Ranked as Excellent for Spring 2016 and Fall 2018.
- Algorithms and Randomness Center (ARC) Postdoctoral Fellowship, Georgia Tech, 2012-14.
- MSR India Rising Star Award, 2011.
- Shantanu Deshpande Memorial Scholarship for 2009-12.

PUBLICATIONS (papers with students are marked with *)

Refereed Journal Papers

- J14. Bharat Adsul, Jugal Garg, Ruta Mehta, Milind Sohoni, and Bernhard von Stengel. Fast Algorithms for Rank-1 Bimatrix Games. *Operations Research*, forthcoming, 2019.

- *J13. Jugal Garg and Peter McGlaughlin. Improving Nash Social Welfare Approximations. *Journal of Artificial Intelligence Research*, forthcoming, 2019.
- J12. Xiaohui Bei, Jugal Garg, Martin Hoefer, and Kurt Mehlhorn. Earning and Utility Limits in Fisher Markets. *ACM Transactions on Economics and Computation*, 7(2): 10:1-10:35 (2019).
- J11. Xiaohui Bei, Jugal Garg, and Martin Hoefer. Ascending-Price Algorithms for Unknown Markets. *ACM Transactions on Algorithms*, 15(3): 37:1-37:33 (2019).
- *J10. Omkar Thakoor, Jugal Garg, and Rakesh Nagi. Multi-Agent UAV Routing: A Game Theory Analysis with Tight Price of Anarchy Bounds. *IEEE Transactions on Automation Science and Engineering*, DOI: 10.1109/TASE.2019.2902360 (2019).
- J9. Jugal Garg, Ruta Mehta, and Vijay Vazirani. Substitution with Satiation: A New Class of Utility Functions and a Complementary Pivot Algorithm. *Mathematics of Operations Research*, 43(3): 996-1024, 2018.
- J8. Jugal Garg, Ruta Mehta, Vijay Vazirani, and Sadra Yazdanbod. ETR-Completeness for Decision Versions of Multi-Player (Symmetric) Nash Equilibria. *ACM Transactions on Economics and Computation*, 6(1): 1:1-1:23, 2018.
- *J7. Reshmina William, Jugal Garg, and Ashlynn Stillwell. A Game Theory Analysis of Green Infrastructure Implementation Policies. *Water Resources Research*, 53:9 8003-8019, 2017. **(featured in an Editor's Highlight)**.
- J6. Jugal Garg. Market Equilibrium under Piecewise Leontief Concave Utilities. *Theoretical Computer Science*, 703: 55-65, 2017.
- J5. Nikhil Devanur, Jugal Garg, and László Végh. A Rational Convex Program for Linear Arrow-Debreu Markets. *ACM Transactions on Economics and Computation* 5(1): 6:1-6:13, 2016.
- J4. Jugal Garg, Ruta Mehta, and Vijay Vazirani. Dichotomies in Equilibrium Computation, and Membership of PLC markets in FIXP. *Theory of Computing*12(1): 1-25, 2016.
- J3. Jugal Garg, Ruta Mehta, Milind Sohoni, and Vijay Vazirani. A Complementary Pivot Algorithm for Market Equilibrium under Separable, Piecewise-Linear Concave Utilities. *SIAM Journal on Computing* 44(6): 1820-1847, 2015.
- J2. Bharat Adsul, Ch. Sobhan Babu, Jugal Garg, Ruta Mehta and Milind Sohoni. A Simplex-like Algorithm for Fisher Markets. *Current Science*, 103(9): 1033-1042, 2012.
- J1. Narayan Rangaraj, Milind Sohoni, Prashant Puniya, and Jugal Garg. Rake Linking for Suburban Train Services. *Opsearch*, 43(2), 2006.

Refereed Conference Papers

- *C26. Jugal Garg, Pooja Kulkarni, and Rucha Kulkarni. Approximating Nash Social Welfare under Submodular Valuations through (Un)Matchings. *To Appear in the Proceedings of the 31st Annual ACM-SIAM Symposium on Discrete Algorithms (SODA)*, 2020.
- *C25. Jugal Garg and Peter McGlaughlin. Improving Nash Social Welfare Approximations. *Proceedings of the 28th International Joint Conference on Artificial Intelligence (IJCAI)*, 2019.
- C24. Jugal Garg and László Végh. A Strongly Polynomial Algorithm for Linear Exchange Markets. *Proceedings of the 51st Symposium on Theory of Computing (STOC)*, 2019. **(Invited to SICOMP special issue for STOC 2019)**.
- *C23. Jugal Garg, Peter McGlaughlin, and Setareh Taki. Approximating Maximin Share Allocations. *Proceedings of the Symposium on Simplicity in Algorithms (SOSA)*, 2019.

- C22. Bhaskar Chaudhuri, Yun Kuen Cheung, Jugal Garg, Naveen Garg, Martin Hoefer, and Kurt Mehlhorn. On Fair Division of Indivisible Items. *Proceedings of the 38th Annual Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS), 2018.*
- *C21. Rahul Swamy, Timothy Murray, and Jugal Garg. Network Cost-Sharing Games: Equilibrium Computation and Applications to Election Modeling. *Proceedings of the 12th International Conference on Combinatorial Optimization and Applications (COCOA), 2018.*
- *C20. Jugal Garg and Peter McGlaughlin. A Truthful Mechanism for Interval Scheduling. *Proceedings of the 11th International Symposium on Algorithmic Game Theory (SAGT), 2018.*
- C19. Jugal Garg, Martin Hoefer, and Kurt Mehlhorn. Approximating the Nash Social Welfare with Budget-Additive Valuations. *Proceedings of the 29th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA), 2018.*
- C18. Nikhil Devanur, Jugal Garg, Ruta Mehta, Vijay Vazirani and Sadra Yazdanbod. A New Class of Combinatorial Markets with Covering Constraints: Algorithms and Applications. *Proceedings of the 29th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA), 2018.*
- C17. Jugal Garg, Ruta Mehta, Vijay Vazirani, and Sadra Yazdanbod. Settling the Complexity of Leontief and PLC Exchange Markets under Exact and Approximate Equilibria. *Proceedings of the 49th Symposium on Theory of Computing (STOC), 2017.*
- C16. Xiaohui Bei, Jugal Garg, Martin Hoefer, and Kurt Mehlhorn. Earning Limits in Fisher Markets with Spending-Constraint Utilities. *Proceedings of the 10th International Symposium on Algorithmic Game Theory (SAGT), 2017.*
- C15. Xiaohui Bei, Jugal Garg, Martin Hoefer, and Kurt Mehlhorn. Computing Equilibria in Markets with Budget-Additive Utilities. *Proceedings of the 24th European Symposium on Algorithms (ESA), 2016.*
- C14. Xiaohui Bei, Jugal Garg, and Martin Hoefer. Ascending-Price Algorithms for Unknown Markets. *Proceedings of the 17th ACM Conference on Economics and Computation (EC), 2016.*
- C13. Ran Duan, Jugal Garg, and Kurt Mehlhorn. An Improved Combinatorial Polynomial Algorithm for the Linear Arrow-Debreu Market. *Proceedings of the 27th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA), 2016.*
- C12. Xiaohui Bei, Wei Chen, Jugal Garg, Martin Hoefer, and Xiaoming Sun. Learning Market Parameters using Aggregate Demand Queries. *Proceedings of the 30th AAAI Conference on Artificial Intelligence (AAAI), 2016.*
- C11. Jugal Garg, Ruta Mehta, Vijay Vazirani, and Sadra Yazdanbod. ETR-Completeness for Decision Versions of Multi-Player (Symmetric) Nash Equilibria. *Proceedings of the 42nd International Colloquium on Automata, Languages and Programming (ICALP), 2015.*
- C10. Jugal Garg and Ravi Kannan. Markets with Production: A Polynomial Time Algorithm and a Reduction to Exchange. *Proceedings of the 16th ACM Conference on Economics and Computation (EC), 2015.*
- C9. Jugal Garg, Ruta Mehta, and Vijay Vazirani. Dichotomies in Equilibrium Computation, and Complementary Pivot Algorithms for a New Class of Non-Separable Utility Functions. *Proceedings of the 46th Symposium on Theory of Computing (STOC), 2014.*
- C8. Jugal Garg and Vijay Vazirani. On Computability of Equilibria in Markets with Production. *Proceedings of the 25th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA), 2014.*
- C7. Jugal Garg. Market Equilibrium under Piecewise Leontief Concave Utilities. *Proceedings of the 10th Conference on Web and Internet Economics (WINE), 2014.*

- C6. Jugal Garg, Ruta Mehta, Milind Sohoni, and Nisheeth Vishnoi. Towards Polynomial Simplex-Like Algorithms for Market Equilibria. *Proceedings of the 24th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA), 2013.*
- C5. Jugal Garg, Ruta Mehta, Milind Sohoni, and Vijay V. Vazirani. A Complementary Pivot Algorithm for Market Equilibrium under Separable, Piecewise-Linear Concave Utilities. *Proceedings of the 44th Symposium on Theory of Computing (STOC), 2012.*
- C4. Bharat Adsul, Jugal Garg, Ruta Mehta, and Milind Sohoni. Rank-1 Bi-matrix Games: A Homeomorphism and a Polynomial Time Algorithm. *Proceedings of the 43rd Symposium on Theory of Computing (STOC), 2011.*
- C3. Jugal Garg, Albert Jiang and Ruta Mehta. Bilinear Games: Polynomial Time Algorithms for Rank Based Subclasses. *Proceedings of the 7th Workshop on Internet and Network Economics (WINE), 2011.*
- C2. Bharat Adsul, Ch. Sobhan Babu, Jugal Garg, Ruta Mehta, and Milind Sohoni. A Simplex-like Algorithm for Fisher Markets. *Proceedings of the 3rd International Symposium on Algorithmic Game Theory (SAGT), 2010.*
- C1. Bharat Adsul, Ch. Sobhan Babu, Jugal Garg, Ruta Mehta, and Milind Sohoni. Nash Equilibria in Fisher Market. *Proceedings of the 3rd International Symposium on Algorithmic Game Theory (SAGT), 2010.*

Manuscripts and Submitted Papers

- *P3. Jugal Garg and Peter McGlaughlin. *A Complementary Pivot Algorithm for Competitive Allocation of a Mixed Manna.*
- P2. Jugal Garg, Edin Husic, and Laszlo Vegh. *Auction Algorithms for Market Equilibrium with Weak Gross Substitute Demands.*
- *P1. Jugal Garg and Setareh Taki. *An Improved Approximation Algorithm for Maximin Shares.*

MENTORSHIP

- PhD students
 - Peter McGlaughlin (2016 -)
 - Setareh Taki (2017 -)
 - Timothy Murray (co-advised with Rakesh Nagi; 2017 -)
 - Pooja Kulkarni (CS; CJ Desai and Hina Desai Computer Science Fellowship; 2018 -)
- Masters students
 - Aniket Murhekar (MS CS; **Siebel Scholar 2020**)
 - Omkar Thakoor (MS CS, Graduated in May 2017; currently a PhD student at USC)
- Undergraduate students
 - Xiao Tan (BA, Economics; Funded by REU)

TEACHING

- IE 405: Computing for ISE, Fall 2019.
- IE 498: Computing for ISE, Spring 2016, Spring 2017, Spring 2018, Fall 2018. (Featured in the *List of Teachers Ranked as Excellent* for Spring 2016, Fall 2018)

- IE 598: Games, Markets, and Mathematical Programming, Fall 2016, Fall 2017, Spring 2020.
- CS 8803: Advanced Topics in Algorithmic Game Theory, Spring 2013 (co-taught at Georgia Tech).

INVITED AND CONFERENCE TALKS

- Invited talk at INFORMS Annual Meeting, Seattle, October 20 - 23, 2019, *An Improved Approximation Algorithm for Maximin Shares*.
- The 51st ACM Symposium on Theory of Computing (STOC), Phoenix, June 2019, *A Strongly Polynomial Algorithm for Linear Exchange Markets*.
- Tutorial (co-organized) on *Nash welfare, Market Equilibrium, and Stable Polynomials* at STOC 2019, Phoenix, June 23-26, 2019.
- Invited talk at UCI, Irvine, May 16, 2019, *A Strongly Polynomial Algorithm for Linear Exchange Markets*.
- Invited talk at LSE, London, UK, March 12-28, 2019, *A Strongly Polynomial Algorithm for Linear Exchange Markets*.
- Invited talk at Purdue University, West Lafayette, October 17, 2018, *Fisher Markets and Nash Social Welfare*.
- Plenary talk at Bellairs Workshop on Algorithmic Game Theory, Barbados, April 2018, *Fisher Markets and Nash Social Welfare*.
- Seminar on Combinatorics, Games and Optimisation, LSE, London, UK, March 2018, *Fisher Markets and Nash Social Welfare*.
- The 29th ACM-SIAM Symposium on Discrete Algorithms (SODA), New Orleans. January 2018, *Approximating the Nash Social Welfare with Budget-Additive Valuations*.
- Invited talk, Workshop on Algorithms and Optimization, ICTS, Bangalore, January 2018, *Fisher Markets and Nash Social Welfare*.
- The 21st Conference of the International Federation of Operational Research Societies (IFORS), Quebec City, Canada, July 2017, *A New Class of Combinatorial Markets with Covering Constraints: Algorithms and Applications*.
- The 49th ACM Symposium on Theory of Computing (STOC), Montreal, Canada, June 2017, *Settling the Complexity of Leontief and PLC Exchange Markets under Exact and Approximate Equilibria* (poster).
- INFORMS 2016 Annual Conference, Nashville, November 2016, *A Market Model for Scheduling with Applications to Cloud Computing*.
- The 5th International Conference on Continuous Optimization (ICCOPT), Tokyo, Japan, August 2016, *Polynomial-Time Complementary Pivot Algorithms for Market Equilibria*.
- CS Theory Seminar, UIUC, February 2016, *A Market for Scheduling, with Applications to Cloud Computing*.
- Game Theory Workshop, Bonn, Germany, December 2015, *ETR-Completeness for Decision Versions of Multi-Player (Symmetric) Nash Equilibria*.
- Operations Research Seminar, UCL, Louvain-la-Neuve, Belgium, October 2015, *Complementary Pivot Algorithms for Market Equilibria*.
- The 8th International Symposium on Algorithmic Game Theory (SAGT), Saarbrücken, Germany, September 2015, *Settling Some Open Problems on 2-Player Symmetric Nash Equilibria*.

- Operations Research Seminar, LSE, London, UK, September 2015, *Polynomial-Time Complementary Pivot Algorithms for Market Equilibria*.
- The 22nd International Symposium on Mathematical Programming (ISMP), Pittsburgh, July 2015, *Polynomial-Time Complementary Pivot Algorithms for Market Equilibria*.
- The International Colloquium on Automata, Languages and Programming (ICALP), Kyoto, Japan, July 2015, *ETR-Completeness for Decision Versions of Multi-Player (Symmetric) Nash Equilibria*.
- The 16th ACM Conference on Economics and Computation (EC), Portland, USA, June 2015, *Markets with Production: A Polynomial Time Algorithm and a Reduction to Exchange*.
- ISE Seminar, UIUC, May 2015, *Complementary Pivot Algorithms for Market Equilibria*.
- CSE Seminar, IIT-Bombay, India, March 2015, *Equilibrium in Markets: Algorithms and Complexity*.
- CSE Seminar, IIT-Kanpur, India, March 2015, *Equilibrium in Markets: Algorithms and Complexity*.
- School of Technology and Computer Science Seminar, Tata Institute of Fundamental Research, Mumbai, India, March 2015, *Equilibrium in Markets: Algorithms and Complexity*.
- The 10th Conference on Web and Internet Economics (WINE), Beijing, China, December 2014, *Market Equilibrium under Piecewise Leontief Concave Utilities* (Poster).
- CSE Seminar, IIT-Bombay, India, December 2014, *Leontief Exchange Markets Can Solve Multivariate Polynomial Equations, Yielding FIXP and ETR Hardness*.
- School on Algorithmic Game Theory, Sangli, India, December 2014, *Lectures on Equilibrium Computation*.
- MPI Seminar, Germany, November 2014, *Leontief Exchange Markets Can Solve Multivariate Polynomial Equations, Yielding FIXP and ETR Hardness*.
- Dagstuhl Seminar on Equilibrium Computation, Germany, August 2014, *Leontief Exchange Markets Can Solve Multivariate Polynomial Equations, Yielding FIXP and ETR Hardness*.
- The 46th ACM Symposium on Theory of Computing (STOC), New York, June 2014, *Dichotomies in Equilibrium Computation, and Complementary Pivot Algorithms for a New Class of Non-Separable Utility Functions*.
- The 25th ACM-SIAM Symposium on Discrete Algorithms (SODA), Portland. January 2014, *On Computability of Equilibria in Markets with Production*.
- ACO Seminar, Georgia Tech, Atlanta, October 2013, *On Computability of Equilibria in Markets with Production*.
- The 24th ACM-SIAM Symposium on Discrete Algorithms (SODA), New Orleans, January 2013, *Towards Polynomial Simplex-Like Algorithms for Market Equilibria*.
- The 21st International Symposium on Mathematical Programming (ISMP), Berlin, Germany, August 2012, *A Complementary Pivot Algorithm for Market Equilibrium under Separable, Piecewise-Linear Concave Utilities*.
- China Theory Week 2012, Aarhus University, Denmark, August 2012, *Linear Complementarity Problem and Market Equilibria*.
- Mysore Park Theory Workshop 2012, Mysore, India, August 2012, *Linear Complementarity Problem and Market Equilibria*.
- IBM T. J. Watson Research Center, New York, May 2012, *A Complementary Pivot Algorithm for Market Equilibrium under Separable, Piecewise-Linear Concave Utilities*.

- The 44th ACM Symposium on Theory of Computing (STOC), New York, May 2012, *A Complementary Pivot Algorithm for Market Equilibrium under Separable, Piecewise-Linear Concave Utilities*.
- Microsoft Research, India, March 2012, *A Complementary Pivot Algorithm for Market Equilibrium under Separable, Piecewise-Linear Concave Utilities*.
- Microsoft Research, India, June 2011, *Rank-1 Bi-matrix Games: A Homeomorphism and a Polynomial Time Algorithm*.
- Workshop on Innovations in Algorithmic Game Theory, Israel, May 2011, *Rank-1 Bi-matrix Games: A Homeomorphism and a Polynomial Time Algorithm* (Poster).
- The 3rd International Symposium on Algorithmic Game Theory (SAGT), Athens, Greece, October 2010, *Nash Equilibria in Fisher Market*.
- International Summer School on Algorithmic Game Theory, Shanghai, China, July 2010, *Nash Equilibria in Fisher Market*.

PROFESSIONAL ACTIVITIES

- **Program Committee:** EC 2020, AAAI 2020, SODA 2020, FAMAS 2019, EC 2019, ESA 2019, FSTTCS 2018, EC 2018, WINE 2017, WINE 2016
- **Tutorial** (co-organized) on *Nash welfare, Market Equilibrium, and Stable Polynomials* at STOC 2019, Phoenix, June 23-26, 2019.
- **Journal Refereeing:** Journal of the ACM, Mathematical Programming, Annals of Operations Research, International Journal on Game Theory, Information and Computation, SIAM Journal on Discrete Mathematics, Mathematical Methods of Operations Research, IEEE Transactions on Cloud Computing, ACM Transactions on Economics and Computation, Information Processing Letters, Operations Research Letters, Theoretical Computer Science
- **Conference Refereeing:** APPROX, FOCS, ICALP, SAGT, SODA, STACS, STOC, WINE, ITCS
- **Committee Memberships:** Faculty Meeting Secretary 2018-19, Graduate Committee 2018-20, Engineering – Computer Science Liaison (UIUC) 2016-20.
- **Member of Ph.D. Examining Committee:**
 1. Menglong Li, ISE, UIUC (Advisor: Xin Chen)
 2. Arun Raman, ISE, UIUC (Advisor: RS Sreenivas)
 3. Tung Mai, College of Computing (ACO program), Georgia Tech (Advisor: Vijay Vazirani), Defended on May 17, 2018 (Member)
 4. Ioannis Panageas, College of Computing (ACO program), Georgia Tech (Advisor: Prasad Tetali), Defended in July 2016 (Reader)
- Part of organizing committee of FSTTCS 2011.