Amy R. Ward
Rothman Family Professor of Operations Management
The University of Chicago Booth School of Business
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Research Overview

My main interest is in service operations management. One common issue is the need to design and implement operating policies that account for uncertainty and/ or variability (for example, in customer arrivals). This requires incorporating stochasticity (randomness in time and space) in mathematical models that are relevant for management decisions, such as staffing and workload routing. I develop and analyze such models, which requires tools from statistics, optimization, probability theory, queueing theory, game theory, decision analysis, and simulation.

Education

2001	Ph.D.	Stanford University	Management Science and Engineering
		Dissertation: Queues with Reneging	
		Primary Advisor: Peter Glynn, Co-advisor: Nicholas Bambos	
1997	M.S.	Stanford University	Engineering-Economic Systems and Operations Research
1996	B.A.	Claremont McKenna College	Mathematics with a Computer Science Option

Professional Experience

7/2018 - present	The University of Chicago Booth School of Business
	Rothman Family Professor 1/2019-present
	Full Professor 7/2018-present
	Charles M. Harper Faculty Fellow 2019-2020 academic yr
	William S. Fishman Faculty Scholar 2018-2019 academic yr
7/2006 - 6/2018	University of Southern California, Marshall School of Business
	Full Professor 12/2015-present
	Associate Professor (with tenure) 4/2010-12/2015
	Assistant Professor 7/2006-4/2010
Fall, 2012	Cal Tech, Computing and Mathematical Sciences Department
	Visiting Associate Professor
2001 - 2006	Georgia Institute of Technology, School of Industrial and Systems Engineering
	Assistant Professor
2005 - 2006	Gilder, Gagnon, Howe, & Co. (On leave from Georgia Tech)
	Researcher for a hedge fund managing over $5 billion.
1997-1998	DEC Western Research Labs (now owned by Compaq), Honorary Researcher
1995-1998	AT&T Laboratories, Summer Intern
	1998, IP Network Management and Performance Department
	1997, Innovative Services Research Department
	1996, Mathematical Sciences Research Center
	1995, Visualization Department

Publications

(Co-author names of *Ph.D. students* under my supervision when the paper was written are highlighted in different font.)

Journal Publications Accepted or Appeared

1. Lee, Chihoon, A. R. Ward, and Heng-Qing Ye. 2020. Stationary Distribution Convergence of the Offered Waiting Processes for $GI/GI/1+GI$ Queues in Heavy Traffic. *Queueing Systems*, **94** (1-2) 147-173.

2. *Cui, Hailong*, S. Rajagopalan, and A. R. Ward. 2019. An Empirical Study of the Impact of Specialization, Workload, and Product Personalization on Consumer Returns. Accepted to *Manufacturing & Service Operations Management*.

3. *Cui, Hailong*, S. Rajagopalan, and A. R. Ward. 2019. Predicting Product Return Volume using Machine Learning Methods. *European Journal of Operational Research*, **281** (3) 612-627.

4. A. R. Ward. 2019. Open Problem - Regarding Static Priority Scheduling for Many-Server Queues with Reneging. Published in *Stochastic Systems* as part of a special section on open problems, **9** (3) 313-314.

5. *Ozkan, E.* and A. R. Ward. 2019. Dynamic Matching for Real-Time Ridesharing. Published online in *Stochastic Systems* Feb 2020.

   - An early version of this paper was a finalist in the 2017 George Nicholson Student Paper Competition.

6. Lee, Chihoon and A. R. Ward. 2019. Pricing and Capacity Sizing of a Service Facility: Customer Abandonment Effects. *Production and Operations Management*, **28** (8) 2031-2043.

7. *Zhan, D.* and A. R. Ward. 2019. Incentive-Based Service System Design: Staffing and Compensation to Trade-Off Speed and Quality. *Operations Research* **67** (6) 1738-1751.

8. *Ozkan, E.* and A. R. Ward. 2019. On the Control of Fork-Join Networks. *Mathematics of Operations Research*, **44** (2), 532-564.

9. *Zhan, D.* and A. R. Ward. 2018. The $M/M/1+M$ Queue with a Utility-Maximizing Server. *Operations Research Letters*, **46** 518-522.

10. *Kim, J.*, R. Randhawa, and A. R. Ward. 2018. Dynamic Scheduling in a Many-Server Multiclass System: The Role of Customer Impatience in Large Systems. *Manufacturing & Service Operations Management*, **20** (2) 285-301.

11. Gopalakrishnan, R., S. Doroudi, A. R. Ward, and A. Wierman. 2016. Routing and Staffing when Servers are Strategic. *Operations Research*, **64** (4) 1015-1032.

- An earlier version of this paper was accepted to the 15th ACM Conference on Economics and Computation, June 8-12, 2014, at Stanford University.

12. *Kocaga, L.*, Armony, M., and A. R. Ward. 2015. Staffing Call Centers with Uncertain Arrival Rates and Co-sourcing. *Production and Operations Management*, **24** (7) 1101-1117.

13. *Honnappa, H.* and R. Jain and A. R. Ward. 2015. A Queueing Model with Independent Arrivals, and its Fluid and Diffusion Limits. *Queueing Systems*, **80** (1/2) 71-103.

14. Lee, C. and A. R. Ward. 2014. Optimal Pricing and Capacity Sizing for the $GI/GI/1$ Queue. *Operations Research Letters*, **42** (8) 527-531.

15. Gurvich, I. and A. R. Ward. 2014. On the Dynamic Control of Matching Queues. *Stochastic Systems*, **4** (2) 479-523.

   - This article ranked 6th for number of hits on the *Stochastic Systems* web site amongst all articles published between April 20, 2010 and Summer, 2017 (when the journal is switching from being an IMS-supported journal to being under the INFORMS umbrella).

16. *Zhan, D.* and A. R. Ward. 2014. Threshold Routing to Trade-off Waiting and Call Resolution in Call Centers. *Manufacturing & Service Operations Management*, **16** (2) 220-237.

17. *Ghamami, S.* and A. R. Ward. 2013. Dynamic Scheduling of a Two-Server Parallel Server System with Complete Resource Pooling and Reneging in Heavy Traffic: Asymptotic Optimality of a Two-Threshold Policy. *Mathematics of Operations Research*, **38** (4) 761-824.

18. Ward, A. R. and M. Armony. 2013. Blind Fair Routing in Large-Scale Service Systems with Heterogeneous Customers and Servers. *Operations Research*, **61** (1) 228-243.

   - This paper was a finalist in the MSOM 2016 Service SIG best paper competition.

19. *Kim, J.* and A. R. Ward. 2013. Dynamic Scheduling of a GI/GI/1+GI Queue with Multiple Customer Classes. *Queueing Systems*, **75** (2-4) 339-384.

20. Reed, J. and A. R. Ward and *D. Zhan*. 2013. On the Generalized Skorokhod Problem. *Journal of Applied Probability*, **50** (1) 16-28.

21. A. R. Ward. 2011. Asymptotic Analysis of Queueing Systems with Reneging: A Survey of Results for FIFO, Single Class Models, *Surveys in Operations Research and Management Science*, **16** (1) 1-14.

   - This paper served as the basis for my invited tutorial talk at the 2011 INFORMS National Meeting.

22. *Kocaga, Y. L.* and A. R. Ward. 2010. Admission Control for a Multiserver Queue with Abandonment. *Queueing Systems* **65** (3) 275-323.

23. Armony, M., and A. R. Ward. 2010. Fair Dynamic Routing in Large-Scale Heterogeneous-Server Systems. *Operations Research* **58** (3) 624-637.

   - This paper received the 2011 Best of WORMS (Women in OR and MS) Paper Award, which was given to the 3 papers written by women that have the most number of citations in INFORMS journals in 2011.

24. *Kostami, V.* and A. R. Ward. 2009. Managing Service Systems with an Offline Waiting Option and Customer Abandonment. *Manufacturing & Service Operations Management* **11** (4) 644-656.

25. Plambeck, E. and A. R. Ward. 2008. Optimal Control of a High-Volume Assemble-to-Order System with Maximum Leadtime Quotation and Expediting. *Queueing Systems* **60** (1-2) 1-69.

26. *Reed, J. E.* and A. R. Ward. 2008. Approximating the GI/GI/1+GI Queue with a Nonlinear Drift Diffusion: Hazard Rate Scaling in Heavy Traffic. *Mathematics of Operations Research* **33** (3) 606-644.

27. Ward, A. R. and S. Kumar. 2008. Asymptotically Optimal Admission Control of a Queue with Impatient Customers. *Mathematics of Operations Research* **33** (1) 167-202.

28. Plambeck, E. and A. R. Ward. 2006. Note: A Separation Principle for a Class of Assemble to Order Systems with Expediting. *Operations Research* **55** (3) 603-609.

29. Plambeck, E. and A. R. Ward. 2006. Optimal Control of a High-Volume Assemble-to-Order System. *Mathematics of Operations Research* **31** (3) 453-477.

30. Ward, A. R., and P. W. Glynn. 2005. A Diffusion Approximation for a GI/GI/1 Queue with Balking or Reneging. *Queueing Systems* **50** (4) 371-400.

31. Ward, A. R., and P. W. Glynn. 2003. A Diffusion Approximation for a Markovian Queue with Reneging. *Queueing Systems* **43** (1-2) 103-128.

32. Ward, A. R., and P. W. Glynn. 2003. Properties of the Reflected Ornstein-Uhlenbeck Process. *Queueing Systems* **44** (2) 109-123.

33. Ward, A. R., and N. Bambos. 2003. On Stability of Queueing Networks with Job Deadlines. *Journal of Applied Probability* **40** (2) 293-304.

34. Teh, Y. C. and A. R. Ward. 2002. Critical Thresholds for Dynamic Routing in Queueing Networks. *Queueing Systems* **42** (3) 297-316.

35. Ward, A. R. and P. W. Glynn and K. Richardson. 1998. Internet service performance failure detection. *Performance Evaluation Review* **26** (3) 38-43.

Submitted Journal Papers

36. Puha, A. and A. R. Ward. Fluid Limit for Multiclass Many Server Queues with General Reneging Distributions and Head-of-Line Scheduling. Submitted to *Mathematics of Operations Research.*

Additional Refereed Publications

1. Puha, A. and A. R. Ward. 2019. Tutorial Paper: Scheduling an Overloaded Multiclass Many-Server Queue with Impatient Customers. *Tutorials in Operations Research: Operations Research & Management Science in the Age of Analytics* 189-217.

2. Ward, A.R. and W. Whitt. 2000. Predicting Response Times in Processor-Sharing Queues. In D. MacDonald and S.R.E. Turner, editors, *Analysis of Communication Networks: Call Centres, Traffic, and Performance.* Fields Institute Communication Series **28** American Mathematical Society 1-29.

Refereed Conference Proceedings

1. Ward, A.R. and P. W. Glynn and K. Richardson. 1998. Internet Service Performance Failure Detection. *Proceedings of the 1998 Internet Server Performance Workshop*, Madison, WI, 103-109.

2. Ward, A.R., and S. G. Eick. 1995. An Interactive Visualization for Message Sequence Charts. *Proceedings for the Fourth Workshop on Program Comprehension.* IEEE Computer Society Press 2-8.

Other Publications

1. *Reed, J. E.* and A. R. Ward. Sept. 29 - Oct. 1, 2004. A Diffusion Approximation for a Generalized Jackson Network with Reneging. *Proceedings of the 42nd Annual Allerton Conference on Communication, Control, and Computing.*

2. VandeVate, J.H. and A. R. Ward. March, 2005. "The "Ins" and "Outs" of Outsourcing. *Frontline Solutions: Managing Supply Chain Strategies with Technology.*

Keynote Presentations

1. Staffing, Routing, and Payment to Trade Off Speed and Quality in Large Service Systems (Lecture 1), and
A Fluid Limit for an Overloaded Multi-class Many Server Queue with General Reneging Distribution (Lecture 2)
Lunteren Conference.
Lunteren, The Netherlands.
January 14-15, 2019.

2. Dynamic Matching for Real-Time Ridesharing.
Young European Queueing Theorists (YEQT) X.
Eurandom/ TU Eindhoven.
November 7-9, 2016.

Invitation Only Conference and Workshop Presentations

1. Scheduling an Overloaded Multiclass Many-Server Queue with Impatient Customers.
Tutorial Talk at INFORMS National Meeting, Seattle, Washington.
Oct. 20-23, 2019.

2. Staffing and Incentives for Strategic Employees.
Stochastic Networks Conference in The Netherlands.
June 23, 2014.

3. Routing and Staffing to Incentivize Servers in Many Server Service Systems.
Workshop on Modern Probabilistic Techniques for Stochastic Systems and Networks at the
Newton Institute, Cambridge, England.
August 12, 2013.

4. Blind Fair Routing in Large-Scale Service Systems.
Mostly OM Converence, Beijing, China.
May 30, 2011.

5. On the Analysis of Queueing Models with Abandonment.
Tutorial Talk at INFORMS National Meeting, Charlotte, North Carolina.
Nov. 13-16, 2011.

6. Fair Dynamic Routing in Large-Scale Heterogeneous Server Systems.
Kellogg Operations Workshop, Northwestern University.
Sept. 5, 2008.

Invitation Only Discussant Presentations

1. Discussant for the 2013 INFORMS APS Markov Lecture given by Marty Reiman on Assemble-
to-Order Systems.
October 6, 2013.

University Seminars

1. Scheduling Impatient Customers in a Multiclass Many Server Queue.
Cornell University Operations Research and Information Engineering (ORIE) Department.
September 10, 2019.

2. Staffing, Routing, and Payment to Trade Off Speed and Quality in Large Service Systems.
Carroll School of Management at Boston College.
April 11, 2019.

3. Staffing, Routing, and Payment to Trade Off Speed and Quality in Large Service Systems.
   Ivey Business School at Western University.
   March 1, 2019.

4. The Impact of Customer Patience on Scheduling Decisions.
   Kellogg School of Management at Northwestern University.
   November 11, 2017.

5. The Impact of Customer Patience on Scheduling Decisions.
   Industrial and Systems Engineering Department, North Carolina State University.
   September 22, 2017.

6. Dynamic Matching for Real-Time Ridesharing.
   CS Theory Lunch Talk, Carnegie Mellon University.
   September 20, 2017.

7. Routing and Staffing to Incentivize Servers in Many Server Service Systems.
   The University of Chicago Booth School of Business.
   September 18, 2017.

8. Dynamic Matching for Real-Time Ridesharing.
   Foster School of Business at the University of Washington.
   May 19, 2017.

9. Dynamic Matching for Real-Time Ridesharing.
   Ross School of Business at the University of Michigan.
   October 7, 2016.

10. Incentive-Based Service System Design: Staffing and Compensation to Trade-Off Speed and
    Quality.
    Kellogg School of Management at Northwestern University.
    November 18, 2015.

11. Incentive-Based Service System Design: Staffing and Compensation to Trade-Off Speed and
    Quality.
    Stanford Graduate School of Business.
    October 28, 2015.

12. Incentive-Based Service System Design: Staffing and Compensation to Trade-Off Speed and
    Quality.
    Sauder School of Business, University of British Columbia.
    September 21, 2015.

13. Staffing and Incentives for Strategic Employees.
    Tuck School of Business, Dartmouth College.
    May 14, 2015.

14. Staffing and Incentives for Strategic Employees.
    Wisconsin School of Business, University of Wisconsin.
    April 24, 2015.

15. Routing and Staffing to Incentivize Servers in Many Server Service Systems.
    Kenan-Flagler Business School, University of North Carolina.
    November 1, 2013.

16. Routing to Minimize Waiting and Callbacks in Large Call Centers.
    Management Science and Innovation Group, University College London.
    March 21, 2013.

17. Routing to Minimize Waiting and Callbacks in Large Call Centers.
    London Business School.
    March 21, 2013.

18. On the Dynamic Control of Matching Queues
    Industrial Engineering and Logistics Management - Business School Joint Seminar.
    Hong Kong University of Science and Technology.
    December 7, 2012.

19. Routing to Minimize Waiting and Callbacks in Call Centers.
    National University of Singapore Business School.
    November 27, 2012.

20. On the Dynamic Control of Matching Queues.
    Statistics Department, George Mason University.
    November 8, 2012.

21. On the Dynamic Control of Matching Queues.
    Rigorous Systems Research Group, Deptartment of Computing and Mathematical Sciences,
    Cal Tech.
    October 10, 2012.

22. Dynamic Scheduling of a GI/GI/1+GI Queue.
    Statistics Department, Colorado State University.
    September 24, 2012.

23. Blind Fair Routing in Large-Scale Service Systems.
    The University of Chicago Booth School of Business.
    November 17, 2009.

24. Blind Fair Routing in Large-Scale Service Systems.
    Kellogg School of Management, Northwestern University.
    November 18, 2009.

25. The Effect of Customer Abandonment on Queueing System Approximation and Control.
    ITO Seminar, The Rady School of Management, UC San Diego
    June 5, 2009.

26. The Effect of Customer Abandonment on Queueing System Approximation and Control.
    Joint IEOR-DRO Seminar, Columbia University.
    May 12, 2009.

27. Optimal Control of a High Volume Assemble-to-Order System
    Advanced Network Sciences Summer Lecture Series, UC San Diego.
    Aug. 18, 2008.

28. Managing Service Systems with an Offline Waiting Option and Customer Abandonment.
    Stern School of Business, New York University.
    Oct. 5, 2007.

29. Optimal Control of High Volume Assemble-to-Order Systems.
    Computer Science Department, Carnegie Mellon University.
    Dec. 15, 2004.

30. Optimal Control of High Volume Assemble-to-Order Systems.
    MEDS Dept., Kellogg School of Management, Northwestern University.
    Nov. 12, 2004.

31. Service Systems with Delay Sensitive Customers.
    Stern School of Business, New York University.
    Dec. 3, 2003.

32. Optimal Control of Assemble-to-Order Systems with Delay Guarantees.
    IBM T.J. Watson Research Center.
    April 11, 2003.

33. Optimal Control of Assemble-to-Order Systems with Delay Guarantees
    Stern School of Business, New York University.
    April 9, 2003.

34. Optimal Control of Assemble-to-Order Systems with Delay Guarantees
    Industrial and Operations Engineering Department, U. of Michigan.
    Jan. 29, 2003.

35. Performance Measure Approximations for GI/GI/1 Queues with Reneging.
    Stanford University
    March 15, 2002.

36. Queues with Reneging.
    Cambridge University.
    May 11, 2001.

Ph.D. Student Supervision

1. Hailong Cui (co-advised with Raj Rajagopalan at USC Marshall). Expected graduation in 2019.

2. Erhun Ozkan (co-advised with Raman Randhawa at USC Marshall). Graduated Summer, 2018.
   Employment: Assistant Professor at Koc University Graduate School of Business

   - Erhun was a finalist in the 2017 George Nicholson Student Paper Competition.

3. Jeunghyun Kim (co-advised with Raman Randhawa at USC Marshall). Graduated Summer, 2016.
   Employment: Assistant Director at Moody's Analytics.

4. Dongyuan Zhan. Graduated 2015.
   Employment: Assistant Professor in the Management Sciences and Innovation Department at University College London.

5. Harsha Honnappa (co-advised with Rahul Jain at USC Electrical Engineering). Graduated 2014.
   Employment: Assistant Professor in the Industrial and Systems Engineering Department at Purdue Univeristy.

   - Harsha won the 2016 Takacs award for outstanding PhD thesis in queueing theory and its applications. The award is given bi-annually, at the European conference on queueing theory.

6. Levent Kocaga. Graduated 2010.
   Employment: Associate Professor in the Sy Syms School of Business at Yeshiva University.

7. Vasiliki Kostami (co-advised with Raj Rajagopalan at USC Marshall). Graduated 2010.
   Employment: Associate Professor at HEC Paris.

8. Samim Ghamami (co-advised with Sheldon Ross at USC Industrial and Systems Engineering). Graduated 2009.
   Employment: The Quantitative Risk and Analysis Section at the Federal Reserve Board.

9. Josh Reed (co-advised with Jim Dai, formerly at Georgia Tech). Graduated 2007.
   Employment: Associate Professor at the Stern School of Business at New York University.

   - Josh was awarded First Place in the 2006 Nicholson Student Paper Competition.

10. Tolga Tezcan (co-advised with Jim Dai, formerly at Georgia Tech). Graduated 2006. Employment: Associate Professor at the London Business School.

Professional Service

1. Stochastic Models Area Editor for *Operations Research*, term 1/2018 - present.

2. INFORMS Publication Committee, term 1/2019-present.

3. Best Student Paper 2020 Prize Chair for the *Applied Probability Society.*

4. Best Student Paper 2019 Prize Chair for the *Applied Probability Society.*

5. Service SIG Chair for the *MSOM*[1] Society, term 6/2017 - 6/2019.

6. Chair, *Applied Probability Society*, term 11/2016 - 11/2018.

7. 2017 *MSOM* Conference Service SIG Workshop Co-Chair (with Philippe Afeche)

8. Vice Chair, *Applied Probability Society*, term 11/2014 - 11/2016.

9. Guest Editor (joint with Guodong Pang) for *Queueing Systems* Vol. 89, Issue1-2, June 2018 Special Issue in honour of Ward Whitt reaching 75.

10. Associate Editor for:

    (a) *Operations Research*, 2011 - 2018 (term ended when promoted to Area Editor).
    (b) *Operations Research Letters*, 2013 - present.
    (c) *Stochastic Systems*, 2014 - present.
    (d) *M&SOM*, 2012 - 2015.
    (e) *IIE Transactions, Service Operations Engineering Department*, 2010 - 2013.

11. NSF review panels, May 2015 and October 2011.

12. 2008, 2009, 2014, 2015 Nicholson Prize Committee Member.

13. Program Committee, Applied Probability Conference, 2009 and 2011.

14. Track Chair, Service Operations, 2010 POMS Conference

15. MSOM Student Paper Competition Judge, 2010 and 2011.

16. MSOM Service SIG Paper Judge, 2012, 2014, and 2015.

17. Co-organizer (with Hao Zhang) of the 2008 Southern California OR/OM Day.

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[1]The *society* Manufacturing & Service Operations Management is abbreviated to MSOM. In contrast, the *journal* Manufacturing & Service Operations Management is abbreviated to M&SOM.

18. Cluster co-chair (with Steve Kou) of Applied Probability Sessions, INFORMS National Meeting, Denver, CO 2004.

19. Council member, Applied Probability Society of INFORMS, 2004 and 2005.

20. Reviewer for *Annals of Applied Probability*, *IEEE Transactions on Automatic Control*, *Management Science*, *Mathematical Methods of Operations Research*, *Mathematics of Operations Research*, *M&SOM*, *Naval Research Logistics*, *Operations Research*, *Operations Research Letters*, *Probability in the Engineering and Information Sciences*, *Queueing Systems*.

Funding

1. $40,000 grant from the Department of Homeland Security through CREATE at USC to study passenger screening in airports.

Honors and Awards

1. Deans Award for Research Excellence, Marshall School of Business, USC, May 2015.

2. M&SOM Meritorious Service Award, 2011.

3. Operations Research Meritorious Service Award, 2002.

4. Patent # 5850531. Joint with Kenneth Charles Cox, Stephen Gregory Eick, and Diana Kyra Hackborn. Application filed on December 15, 1995 as application Serial No. 08/572979 and Patent awarded 12/15/1998.

5. Valedictorian (highest 4 year GPA) of Senior Class.
Claremont McKenna College, 1996.