

SHELDON M. ROSS

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Education

B.S., Mathematics, Brooklyn College, 1963
M.S., Mathematics, Purdue University, 1964
Ph.D, Statistics, Stanford University, 1968

Professional Experience

Assistant Professor, Department of Industrial Engineering and Operations
Research (IEOR), University of California, Berkeley, 1968-1971
Associate Professor, IEOR, University of California, Berkeley, 1971- 1976
Professor, IEOR, University of California, Berkeley, 1976 - 8/2004
Daniel J. Epstein Chair Professor, Epstein Department of Industrial and
Systems Engineering, University of Southern California, 8/2004 - present

Honors

Humboldt US Senior Scientist Award, 1984
Founding editor of *Probability in the Engineering and Informational Sciences*
Cambridge University Press, 1986
Kloosterman Lecturer, Leiden University, The Netherlands, 1988
Fellow of the Institute of Mathematical Statistics, 1994
Informs Expository Writing Award Winner, 2006
Fellow of INFORMS, 2013
IFORS Distinguished Lecturer, 2014
Purdue University Department of Mathematics Alumni of the Year, 2016

Research Interests

Stochastic Dynamic Programming
Simulation
Applied Probability Models

Journal Affiliations

Founding and Continuing Editor in Chief, *Probability in the Engineering and Informational Sciences*, 1984 to present

Current Research Funding

PI of grant with National Science Foundation

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Books

1. *Applied Probability Models with Optimization Applications*, Holden-Day, 1970
2. *Introduction to Stochastic Dynamic Programming*, Academic Press, 1983
3. *Stochastic Processes*, second ed., John Wiley, 1996
4. *Statistical Aspects of Quality Control*, with C. Derman, Academic Press, 1997
5. *Topics in Finite and Discrete Mathematics*, Cambridge University Press, 2000
6. *Probability Models for Computer Science*, Academic Press, 2002
7. *An Elementary Introduction to Mathematical Finance: Options and Other Topics*, third ed., Cambridge University Press, 2011
8. *Introduction to Probability and Statistics for Engineers and Scientists*, fifth ed., Academic Press, 2014
9. *Introductory Statistics*, fourth ed., Elsevier Academic Press, 2017
10. *A First Course in Probability*, tenth ed., Prentice-Hall, 2019
11. *Simulation*, sixth ed., Academic Press, 2023
12. *Introduction to Probability Models*, thirteenth ed., Academic Press, 2024
13. *A Second Course in Probability*, with E. Pekoz, Cambridge University Press, 2023

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Publications

1. Non-Discounted Denumerable Markovian Decision Models, *Ann. of Math. Stat.*, **39**, 412-423, 1968
2. An example in Denumerable Decision Processes, with L. Fisher, *Ann. of Math. Stat.*, **39**, 674-675, 1968
3. Arbitrary State Markovian Decision Models, *Ann. of Math. Stat.*, **39**, 2118-2122, 1968
4. A Markovian Replacement Model with a generalization to Include Stocking, *Management Science*, **15** 702-716, 1969
5. A Problem in Optimal Search and Stop, *Operations Research*, **17**, 984-992, 1969
6. Some Results for Infinite Server Poisson Queues, with M. Brown, *Jour. of Appl. Prob.*, **6**, 604-611, 1969
7. Optimal Dispatching of a Poisson Process, *Jour. of Appl. Prob.*, **6**, 692-699, 1969
8. Average Cost Semi-Markov Decision Processes, *Jour. of Appl. Prob.*, **7**, 649-656, 1970
9. Identifiability in GI/G/k Queues , *Jour. of Appl. Prob.*, **7**, 1970
10. Infinitesimal Look-Ahead stopping Rules, *Ann. of Math. Stat.*, **42**, 297-303, 1971
11. Quality Control under Markovian Deterioration, *Management Science*, **17**, 587-596, 1971
12. The Sreetwalkers Dilemma: A Job Shop Model, with S. Lippman, *SIAM Jour. Appl. Math.*, **20**, 336-342, 1971
13. Goofspiel- the Game of Pure Strategy, *Jour. of Appl. Prob.*, **8**, 621-625, 1971
14. Confidence Intervals for Independent Exponential Series Systems, with G. J. Lieberman, *Jour. of Amer. Stat. Assoc.*, **66**, 837-841, 1971

15. On the Nonexistence of Epsilon Optimal Randomized Stationary Policies in Average Cost Markov Decision Models, *Ann. of Math. Stat.*, **42**, 5, 1971
16. On the Maximum of a Stationary Independent Increment Process, *Jour. of Appl. Prob.*, **9**, 677-680, 1972
17. Asymptotic Properties of Cumulative Processes, with M. Brown, *SIAM Jour. Appl. Math.*, **22**, 1, 1972
18. A Sequential Stochastic Assignment Problem, with C. Derman and G. J. Lieberman, *Management Science*, **18**, 349-355, 1972
19. On Optimal Assembly of Systems, with C. Derman and G. J. Lieberman, *Naval Res. Log. Quart.*, **19**, 569-574, 1972
20. Optimal Issuing Policies, with M. Brown, *Management Science*, **19**, 1292-1295, 1973
21. Assembly of Systems having Maximum Reliability, with C. Derman and G. J. Lieberman, *Naval Res. Log. Quart.*, **21**, 1, 1974
22. Dynamic Programming and Gambling Models, *Advances in Appl. Prob.*, **6**, 593-606, 1974
23. Bounds on the Delay Distribution in GI/G/1 Queues, *Jour. of Appl. Prob.*, **11**, 417-421, 1974
24. Optimal Allocations in the construction of k-out-of-n Reliability Systems, with C. Derman and G. J. Lieberman, *Management Science*, **21**, 3, 1974
25. Multicomponent Reliability Systems, *Conference on Reliability and Fault Tree Analysis*, SIAM Publ, 1975
26. Evacuation of a Yule Process with Immigration, with M. Brown and R. Shorrock, *Jour. of Appl. Prob.*, **12**, 807-812, 1975
27. A Note on Optimal Stopping for Success Runs, *Annals of Stat.*, **3**, 793-795, 1975

28. A Stochastic Sequential Allocation Model, with C. Derman and G. J. Lieberman, *Operations Research*, Nov., 1975
29. On Time to First Failure in Multicomponent Exponential Reliability Systems, *Jour. of Stoch. Proc. and its Applic.*, **4**, 167-173, 1976
30. Optimal System Allocation with Penalty Costs, with C. Derman and G. J. Lieberman, *Management Science*, 554-562, 1978
31. Queueing Models for Multiple Locks, with C. R. Glassey, *Transportation Science*, **10**, 391-404, 1976
32. A Renewal Decision Problem, with C. Derman and G. J. Lieberman, *Management Science*, 554-562, 1978
33. A Heterogeneous Arrival and Service Queueing Loss Model, with S. Fond, *Naval Res. Log. Quart.*, **25**, 483-488, 1978
34. Average Delay in Queues with Nonstationary Poisson Arrivals, *Jour. of Appl. Prob.*, **15**, 682-692, 1978
35. Approximations in Finite Capacity Multi-Server Queues, with S. Nozaki, *Jour. of Appl. Prob.*, **15**, 826-834, 1978
36. Multi-Valued State component Reliability Systems *Annals of Prob.*, **7**, 379-383, 1979
37. Adaptive Disposal Models, with C. Derman and G. J. Lieberman, *Naval Res. Log. Quart.*, **26**, 33-40, 1979
38. On the First Time a Separately Maintained Parallel System has been Down for a Fixed Time, with J. Schechtman, *Naval Res. Log. Quart.*, **26**, 285-290, 1979
39. On the Number of Component Failures in Systems whose Component Lives are Exchangeable, with M. Shahshahani and G. Weiss, *Math. of Operations Res.*, **5**, 358-365, 1980
40. On the Duration of the Problem of the Points, with M. Shahshahani and G. Weiss, *Jour. of Amer. Statist. Assoc.*, **75**, 663-666, 1980

41. On the Optimal Assignment of Servers and a Repairman, with C. Derman and G. J. Lieberman, *Jour. of Appl. Prob.*, **17**, 577-581, 1980
42. Scheduling Jobs Subject to Nonhomogeneous Shocks, with M. Pinedo, *Mgmt. Science*, **26**, 1250-1247, 1980
43. Optimal List Order under Partial Memory constraints, with Y. C. Kan, *Jour. of Appl. Prob.*, **17**, 1004-1016, 1980
44. Generalized Poisson Shock Models, *Annals of Prob.*, **9**, 896-898, 1981
45. A Random Graph, *Jour. of Appl. Prob.*, **18**, 309-316, 1981
46. On the Consecutive k-of-n System, with C. Derman and G. J. Lieberman, *IEEE Trans. on Reliability*, **R-31**, 1, 1982
47. Multi-Server Queues, *Deterministic and Stochastic Scheduling*, ed. by Dempster, Lenstra, and Rinnooy Kan, Riedel, 1982
48. Minimizing Expected Makespan in Stochastic Open Shops, with M. Pinedo, *Jour. of Appl. Prob.*, , 1982
49. A Simple Heuristic Approach to Simplex Efficiency, *European Jour. of Oper. Res.*, **9**, 344-348, 1982
50. The Observed Hazard and Multicomponent Systems, with M. Brown, *Naval Res. Log. Quart.*, **29**, 679-683, 1982
51. A Note on First Passage Times in Birth and Death and Nonnegative Diffusion Processes, with C. Derman and G. J. Lieberman, *Naval Res. Log. Quart.*, **30**, 283-285, 1983
52. Some Reliability Applications of the Variability Ordering, with Z. Schechner, *Oper. Res.*, **32**, 679-688, 1984
53. On the Use of Replacements to Extend System Life, with C. Derman and G. J. Lieberman, *Oper. Res.*, **32**, 616-627, 1984
54. A Model in which Component Failure Rates Depend on the Working Set, *Naval Res. Log. Quart.*, **31**, 297-301, 1984
55. Using Simulation to Estimate First Passage Distributions, with Z. Schechner, *Mgmt. Sci.*, **31**, 224-235, 1985

56. Statistical Estimation of software Reliability, [*IEEE Trans. Software Eng.*, **SE-11**, 479-483, 1985
57. Software Reliability: The Stopping Rule Problem, , *IEEE Trans. Software Eng.*, **SE-11**, 1472-1477, 1985
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60. On Sampling Inspection in the Presence of Inspection Error, with C. Derman and G. J. Lieberman, *Prob. in Eng. and Inf. Sci.*, **1**, 2, 237-249, 1987
61. Approximations in Renewal Theory, *Prob. in Eng. and Inf. Sci.*, **1**, 3, 255-264, 1987
62. Approximating Transition Probabilities an Mean Occupation Times in Continuous Time Markov Chains, *Prob. in Eng. and Inf. Sci.*, **1**, 3, 251-265, 1987
63. A Note on Approximating Mean Occupation Times in Continuous Time Markov Chains, *Prob. in Eng. and Inf. Sci.*, **2**, 267-268, 1988
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72. System Reliability by Simulation: Random Hazards versus Importance Sampling, with C. H. Jun, *Prob. in Eng. and Inf. Sci.*, **6**, 119-126, 1992
73. Some Pitfalls of Black Box Queueing Inference: The Case of State Dependent Server Queues, with J. G. Shanthikumar and X. Zhang, *Prob. in Eng. and Inf. Sci.*, **7**,2, 1993
74. A Two-Armed Bandit Problem with One Arm Known under Some Constraints, with T. Hamada, *Jour of Oper. Res. Soc. Japan*, **36**, 220-233, 1993
75. Estimating a Convolution Tail Probability by Simulation, Chapter 13 of PROBABILITY, STATISTICS, AND OPTIMIZATION, A Tribute to Peter Whittle, Wiley, 1994
76. Improving Poisson Approximations, with E. Pekoz, *Prob. in Eng. and Inf. Sci.*, **8**, 449-462, 1994
77. Variance Reduction in Simulation of a State-Dependent Queueing System using Total Hazard, with C. H. Jun, *International Journal Continuing Eng. Educ.*, **4**, 69-80, 1994
78. A New Simulation Estimator of System Reliability, *Jour. of Appl. Math. and Stoch. Anal.*, **7**, 331-336, 1994
79. Extending Blackwell's Strengthening of Azuma's Martingale Inequality, *Prob. in Eng. and Inf. Sci.*, **89**, 493-496, 1995
80. Reliability for a System with Dependent Components, with C. Derman, *Prob. in Eng. and Inf. Sci.*, **9**, 59-63, 1995

81. An Improved Estimator of σ in Quality Control, with C. Derman, *Prob. in Eng. and Inf. Sci.*, **9**, 411-415, 1995
82. A Simple Derivation of Exact Reliability Formulas for Linear and Circular Consecutive k-of-n Systems, with E. Pekoz, *Jour. of Appl. Prob.*, **32**, 411-415, 1995
83. Policies without Memory for the Infinite Armed Bernoulli Bandit under the Average Reward Criterion, with S. Herschkorn, and E. Pekoz, *Prob. in Eng. and Inf. Sci.*, **10**, 21-28, 1996
84. Bayesians Should Not Resample a Prior Sample to Learn about the Posterior, *The American Statistician*, **50**, 116, 1996
85. Estimating the Mean Cover Time of a Semi-Markov process via Simulation, with E. Pekoz, *Prob. in Eng. and Inf. Sci.*, **11**, 267-271, 1997
86. The Distribution of the Time of the First k-Record, with I. Adler, *Prob. in Eng. and Inf. Sci.*, **11**, 273-279, 1997
87. Using the Importance Sampling Identity to Bound Tail Probabilities, *Prob. in Eng. and Inf. Sci.*, **12**, 444-452, 1998
88. The Mean Waiting Time for a Pattern, *Prob. in Eng. and Inf. Sci.*, **13**, 1-9, 1999
89. Average Run Lengths for Moving Average Control Charts, *Prob. in Eng. and Inf. Sci.*, **13**, 209-220, 1999
90. A Pseudo Counterexample to a Simulation Metatheorem, with K. Lin, *Prob. in Eng. and Inf. Sci.*, **13**, 329-332, 1999
91. Hitting Time in an M/G/1 Queue, with S. Seshadri, *Jour. of Appl. Prob.*, **36**, 934-940, 1999
92. Mean Cover Times for Coupon Collectors and Star Graphs, with E. Pekoz, Chapter 7 of APPLIED PROBABILITY AND STOCHASTIC PROCESSES, J. G. Shanthikumar and U. Sumita ed., Kluwer Publ. 1999

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95. Applying Variance Reduction Ideas in Queueing Simulations, with K. Lin *Prob. in Eng. and Inf. Sci.*, **15**, 481-495, 2001
96. On the Maximum Number of Hamiltonian Tournaments, with Adler, I., and N. Alon, *Random Structures and Algorithms*, **18**, 291-296, 2001
97. A Probabilistic Approach to Identifying Positive Value Cash Flows, with I. Adler, *The Mathematical Scientist*, **26**, 103-107, 2001
98. The Coupon Subset Selection Problem, with I. Adler, *Jour. of Appl. Prob.*, **38**, 737-747, 2001
99. Bounding System Reliability, with J. Hagstrom, in SYSTEMS AND BAYESIAN RELIABILITY: ESSAYS IN HONOR OF R.E. BARLOW, Hayakawa, Y., Irony, T., and M. Xie, editors, *World Scientific Publishers*, Series on Reliability , Quality, and Engineering Statistics, **5**, 2001
100. Hitting Time in an Erlang Loss System, with S. Seshardi, *Prob. in Eng. and Inf. Sci.*, **16**, 167-184, 2002
101. A Simple Derivation of a Mean and Variance in a Truncated Inverse Sampling Problem, *Propogations in Probability and Statistics*, **2**, 123-125, 2002
102. Conditions for Arbitrage in Investment Selection, with I. Ader, *Journal of Bond Trading and Management*, **1**, 20-27, 2002
103. The Inspection Paradox, *Prob. in Eng. and Inf. Sci.*, **17**, 47-52, 2003
104. A Note on the Insurance Ruin Problem, *Prob. in Eng. and Inf. Sci.*, **17**, 199-203, 2003
105. The Coupon Collector's Problem Revisited, with I. Adler, and S. Oren, *Jour. of Appl. Prob.*, **40**, 513-518, 2003

106. Coalescing Times for IID Random Variables with Applications to Population Biology, with I. Adler, H. S. Ahn, and R. M. Karp, *Random Structures and Algorithms*, **23**, 155-166, 2003
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110. A Note on Generating Systems Composed of Binary and Ternary Random Variables, with H. Block and M. Mazumdar, *Prob. in Eng. and Inf. Sci.*, **19**, 215-220, 2005
111. Extending Simulation uses of Antithetic Variables: Partially Monotone Functions, Random Permutations, and Random Subsets, *Mathematics of Operations Research*, **62**, 351-356, 2005
112. A Probabilistic Model for the Survivability of Cells, with I. Adler, H. S. Ahn, and R. M. Karp, *Jour. of Appl. Prob.*, **42**, 919-931, 2005
113. On Increasing failure Rate Random Variables, with J. G. Shanthikumar, and Z. Zhu, *Jour. of Appl. Prob.*, **42**, 797-809, 2005
114. Making Simulations more Efficient when Analyzing Poisson Arrival Systems and Means of Monotone Functions, *Prob. in Eng. and Inf. Sci.*, **20**, 251-256, 2006
115. Bounding the Stationary Distribution of the M/G/1 Queue Size, *Prob. in Eng. and Inf. Sci.*, **20**, 571-575, 2006
116. The Hypergeometric Coupon Collecting Problem and its Dual, *Journal of Industrial and Syst. Eng.*, **1**, 1-7, 2007
117. The Multiple Subset Coupon Collecting Problem, with K-C Chang, *Prob. in Eng. and Inf. Sci.*, **21**, 435-440, 2007
118. A Weakest Link Marked Stopping Problem, with S. A. Lippman and S. Seshadri, *Jour. of Appl. Prob.*, **44**, 843-851, 2007

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121. Relating Time and Customer Averages for Queues using “Forward” Coupling from the Past, with E. Pekoz, *Jour. of Appl. Prob.*, **45**, 568-574, 2008
122. Variability is Beneficial in Marked Stopping Problems, with S. A. Lippman, *Economic Theory*, **35**, 333-342, 2008
123. Efficient Simulation of a Random Knockout Tournament, with S. Ghamami, *Journal of Industrial and Syst. Eng.*, **2**, 88-96, 2008
124. A Random Permutation Model arising in Chemistry, with M. Brown and E. Pekoz, *Jour. of Appl. Prob.*, **45**, 1060-1070, 2008
125. How Nearly do Arriving Customers see Time Average Behavior?, with E. Pekoz and S. Seshadri, *Jour. of Appl. Prob.*, **45**, 963-971, 2008
126. A Simple Solution to a Multiple Player Gamber’s Ruin Problem, *American Math Monthly*, 77-81, 2009
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129. Efficient Monte Carlo Barrier Option Pricing when the Underlying Security Price follows a Jump-Diffusion Process, with S. Ghamami, *The Journal of Derivatives*, **17**, 45-52, 2010
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134. Distribution of Minimal Path Lengths when Edge Lengths are Independent Heterogeneous Exponential Random Variables, *Jour. of Appl. Probability*, **49**, 3, 895-900, 2012
135. Improving the Asmussen-Kroese Type Simulation Estimators, with S. Ghamami, *Jour. of Appl. Probability*, **49**, 4, 188-1193, 2012
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137. A Markov Chain Choice Problem, *Prob. in Eng. and Inf. Sci.*, **27**, 1, 53 - 55, 2013
138. A Generalized Coupon Collecting Model as a Parsimonious Optimal Stochastic Assignment Model, with D. Teng Wu, *Annals of Operations Research*, **208**, 133-146, 2013
139. On the life and work of Cyrus Derman, with M.N. Katehakis, I. Olkin, and J. Yang, *Annals of Operations Research*, **208**, 5-26, 2013
140. Bayesian Selling Problem with Partial Information, with Yen-Ming Lee, *Naval Research Logistics* , Volume 60, Issue 7, pages 557-570, October 2013
141. Simulation Analysis of System Life when Component Lives are Determined by a Marked Point Process, *Jour. of Appl. Prob.*, Volume 51, 377-386, 2014.
142. An Adaptive Stochastic Knapsack Problem, with K. Chen, *European Journal of Operations Research*, Volume 239, Issue 3, 625-635, 2014.
143. The Burglar Problem with Multiple Options, with K. Chen, *Naval Research Logistics*, Volume 61, Issue 5, 359-364, 2014

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145. A Queueing Loss Model with Heterogeneous Skill Based Servers under Idle Time Ordering Policies, with B. Haji, *Jour. of Appl. Probability*, Vol. 52, No. 1, 269-277, 2015
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148. An Individual and Socially Optimal Policy Minimizing Expected Flow Times, *Prob. in Eng. and Inf. Sci.*, Vol. 29, No. 2, 147-151, 2015
149. Static Stochastic Knapsack Problems, with K. Chen, *Prob. in Eng. and Inf. Sci.*, Vol. 29, number 4, 527-546, 2015
150. Tollbooth Tandem Queues with Infinite Homogeneous Servers, with X. Chao, and Q.M He, *Jour. of Appl. Probability*, Volume 52, No. 4, 941-961, 2015.
151. A Sequential Scheduling Problem with Impatient Jobs, *Naval Research Logistics*, Volume 62, Issue 8, pages 659-663, 2015
152. The Friendship Paradox, with Y. Cao, *The Mathematical Scientist*, Vol. 41 Issue 1, pp. 61-64, June 2016
153. Optimality Results for Coupon Collection, with M. Brown, *Jour. of Appl. Probability*, Volume 53, Issue 3, 930-937, 2016
154. Improved Chen-Stein Bounds on the Probability of a Union, *Jour. of Appl. Probability*, Volume 53, Issue 4, 1265-1270, 2016
155. Random Knockout Tournaments, with I. Adler, Y. Cao, R. Karp, and E. Pekoz, *Operations Research*, Volume 65, Issue 6, 2017
156. A Conjecture on the Feldman Bandit Problem, with M. Nouiehed, *Jour. of Appl. Probability*, Volume 55, Issue 1, pp. 318-324, 2018

157. Winner Plays Structure in Random Knockout Tournaments, with Y. Cao, *Prob. in Eng. and Inf. Sci.*, Volume 33, Issue 4, pp. 500-510, 2019
158. Minimizing Expected Discounted Cost in a Queueing Loss Model with Discriminating Arrivals, with B. Haji, *European Journal of Operational Research*, Volume 282, Issue 2, 16, Pages 593-601, 2020
159. Dynamic Search Models with Multiple Items, with R. Dizon-Ross, *Annals of Operations Research*, Volume 288: 223-245, 2020
160. A Stochastic Assignment Problem with Unknown Eligibility Probabilities, with G. Weiss and Z. Zhang, *Operations Research*, Volume 69, Issue 1, pp 266-272, January-February 2021
161. An Optimal Stocking Problem to Minimize the Expected Time to Sell-out, with S. Seshadri, *Operations Research Letters*, 49, 1, pp 69-75, January 2021
162. Winner Plays Competition Models, with Y. Cao, *Prob. in Eng. and Inf. Sci.*, **35**, 2, 236-241, 2021
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165. A Probabilistic Friendship Network Model, with R. Dizon-Ross, *Prob. in Eng. and Inf. Sci.*, **36**, pp 1-16, 2022
166. Dueling Bandits, with E. Peköz and Z. Zhang, *Prob. in Eng. and Inf. Sci.*, **36**, 2, pp 264-275, 2022
167. Fair Gambler's Ruin Stochastically Maximizes Playing Time, with E. Pekoz, *Advances in Appl. Probability*, **54**, 2, pp 656-659, 2022
168. Team's Seasonal Win Probabilities, *Prob. in Eng. and Inf. Sci.*. **36**, 4, pp 988-99, 2022

169. Using a Chen-Stein identity to obtain low variance simulation estimators, *Prob. in Eng. and Inf. Sci.*, **37**, 1, pp 232-244, 2023
170. Choosing the Best Arm with Guaranteed Confidence, with Z. Zhang and M. J. Azizi, *Journal of Statistical Theory and Practice*, **16**, Article 71, 2022
171. Finding the Best Dueler, with Z. Zhang, *Mathematics*, 11(7), 1568; <https://doi.org/10.3390/math11071568>, 2023
172. On the Duration of a Gambler's Ruin Problem, *Operations Research Letters*, Volume 51, Issue 6, November 2023,
173. Optimal Activation of Halting Multi-Armed Bandit Models, with Cowan, W. and M.N Katehakis, accepted for publication *Naval Research Logistics*, 2023