

## Curriculum Vitae

### Rajeeva Laxman Karandikar

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*Date of Birth* : **11 June 1956**

*Place of Birth* : **Indore, M.P.**

#### *Academic qualifications* :

Ph. D., December 1981, Indian Statistical Institute, Calcutta.

M. Stat., July 1978, Indian Statistical Institute, Calcutta.

B. Sc., June 1976, University of Indore, Indore.

#### *Awards, Fellowships* :

- Received Young Scientist Medal from The Indian National Science Academy, 1985.
- Elected Fellow of the Indian Academy of Sciences, 1994.
- Awarded S. S. Bhatnagar prize by the Council for Scientific and Industrial Research, 1999.
- Awarded National Award in Statistics in honour of Professor C. R. Rao by the Ministry of Statistics and Programme implementation, Government of India.
- Elected Fellow of the Indian National Science Academy, 2005.
- Awarded P. C. Mahalanobis Gold Medal by Indian Science Congress Association, 2014.

#### *Positions held*:

- Associate Professor, Indian Statistical Institute, Delhi (1984-1989).
- Professor, Indian Statistical Institute, Delhi (1989-2006).
- Executive Vice President, Cranes Software International Limited, Bangalore (2006-2010).
- Distinguished Professor, Chennai Mathematical institute (2010).
- Director, Chennai Mathematical institute - (Jan 2011 - Apr 2021). ).

#### *Other Administrative positions held*:

- Professor-in-Charge, Division of Theoretical Statistics and Mathematics, Indian Statistical Institute, Kolkata (2000-2002).
- Head, Delhi center, Indian Statistical Institute, (2000) and (2004-2006).

*Research interests:*

- Stochastic calculus, Semimartingales, General theory of processes, Pathwise approximations of solutions to Stochastic differential equations.
- Markov processes, Diffusion processes, Martingale problems.
- Filtering theory, linear and non linear.
- Finitely additive probability theory.
- Limit theorems.
- White noise calculus: finitely additive approach.
- Stochastic differential equations in infinite dimensions.
- Financial applications of Stochastic processes.
- Boltzman equation and associated Stochastic process.
- Psephology in the context of Indian Elections.
- Cryptography. Block ciphers.
- Monte Carlo simulation.
- Bioinformatics- gene identification.

*Courses taught (at graduate level):*

- Probability theory, Measure theory.
- Real Analysis.
- Complex Analysis.
- Markov chains, Applied stochastic processes.
- Martingale theory : discrete and continuous time.
- Semimartingales and Stochastic calculus.
- Diffusion processes and Markov processes.
- Large sample theory.
- Regression techniques.

*Other (visiting) positions held:*

- University of North Carolina at Chapel Hill, U. S. A. : June 1982 - June 1984; August 1986 - October 1986; November 1987 - December 1987; April 1990 - June 1990; March 1992 - July 1992, June 1994-July 1994, August 1996 - June 1997.
- Institute of Mathematics and applications, University of Minnesota at Minneapolis, U. S. A. : October 1985 - December 1985.
- Erasmus University, Rotterdam, Netherlands. : May 1989 - July 1989; April 1993 - June 1993.
- University of Twente, Enschede, Netherlands. : August 1991-September 1991.
- University of California, Santa Barbara, U. S. A. : September 1991 - March 1992.

## **Other activities involving Statistics, Sampling, Optimization and Consultancy**

- Was a member of the committee constituted by Election Commission (EC) of India to advice EC on the sampling scheme for EVM-VVPAT verification. The report was the basis of EC's final reply to the Supreme Court just before the 2019 parliamentary poll.
- Was a member of the expert committee constituted by the Supreme Court (with Justice Singhvi (Retd) as Chairman, Mr Nandan Nilkeni, Dr V. Bhatkar as members) regarding fraud in online examinations.
- Designed, Supervised and analyzed Nationwide opinion polls for Indian Parliamentary elections as well as opinion polls for various state assemblies since 1998. on behalf of several media companies in India including Doordarshan, T V Today (Aaj Tak), Network 18 (CNBC and CNN-IBN), ABP-News, Hindustan Times, Hindu, Indian express.
- During 2005-2014, had been responsible for all poll based predictions for Lok Sabha and various Vidhan Sabha elections on CNN-IBN.
- For the purpose of opinion polls in India, have designed scheme for sampling and overseen its implementation by CSDS (Center for studies in developing societies). I have also developed a new methodology and model for seat prediction. This has been quite successful over last 20 years.
- Conducted intensive training programs on Stochastic Calculus for ICICI and for personnel from other financial organizations.
- Developed a module on MCMC- Markov Chain Monte Carlo for SYSTAT (a general purpose statistical software)
- Was consulted by CBI (Central Bureau of Investigation, India) in a case involving cheating in a multiple choice examination (2005). The issues involved statistical model building, interpretation of data and arriving at conclusions.
- Was involved on behalf of Indian Statistical institute in Food Corporation of India's project on development of sampling methodology for estimation of stock in its godown.
- Was consulted by CBSE (Central Board for secondary education, India) for evolving a grading system for class X and XII examinations (2004-2006) based on the data from previous years examination.
- Was consultant to Gujarat state power board in a legal dispute involving statistical issues. The issues were concerning sampling of coal for checking quality.
- Developed secret Block ciphers for Indian defence (Indian Navy's WESEE).
- Was heading the product development group at Cranes Software.
- Have developed an algorithm for price determination and order matching for power exchange India limited (PXIL). Here the issues are of combinatorial algorithms and efficiently implementation of the final algorithm.

## Publications

### Books Published:

- **White Noise Theory of Prediction, Filtering and Smoothing.** (with G. Kallianpur) Gordon and Breach, London, 1988.
- **Introduction to Option Pricing Theory**(with G. Kallianpur) Birkhauser, Boston, 2000.
- **Introduction to Stochastic Calculus**(with B. V. Rao) Springer, Singapore, 2018.

### Books edited:

- Stochastic Processes : A Festschrift in honour of Gopinath Kallianpur(*edited jointly with S. Cambanis, J. K. Ghosh and P. K. Sen*) Springer Verlag, New York, 1992.
- Stochastics in Finite and Infinite Dimensions: In honour of G Kallianpur(*edited jointly with T Hida, H Kunita, B. S. Rajput, S Watanabe, J Xiong*) Birkhauser, Boston, 2000

### Published papers

1. Pathwise solution of stochastic differential equations. SANKHYA A, 43, 1981, pp.121-132.
2. A general principle for limit theorems in finitely additive probability. TRANSACTIONS OF THE AMERICAN MATHEMATICAL SOCIETY, 273, 1982, pp.541-550.
3. A. S. approximation results for multiplicative stochastic integrals. SEMINAIRE DE PROBABILITES XVI, Lecture notes in Mathematics 920, Springer-Verlag,Berlin, 1982, pp.384-391.
4. Multiplicative decomposition of non-singular matrix valued continuous semimartingales. THE ANNALS OF PROBABILITY, 10, 1982, pp.1088-1091.
5. A remark on paths of continuous martingales. EXPOSITIONE MATHEMATICAE, 1, 1983, pp. 67-69.
6. Towards a theory of non-commutative semimartingales adapted to Brownian motion and quantum Ito formula. (with K. R. Parthasarathy and R. L. Hudson) THEORY AND APPLICATIONS OF RANDOM FIELDS ed. G. Kallianpur *Lecture notes in control and information sciences* 49, Springer-Verlag,Berlin 1983, pp.96-110.
7. Stochastic integration w. r. t. continuous local martingales. STOCHASTIC PROCESSES AND THEIR APPLICATIONS, 15, 1983, pp.203-209.
8. On quadratic variation process of a continuous martingales. ILLINOIS JOURNAL OF MATHEMATICS, 27, 1983, pp.178-181.
9. Multiplicative stochastic integrals HARMONIC ANALYSIS AND PREDICTION THEORY (ed. Salehi and Manderekar), North Holland, Amsterdam, 1983, pp..

10. Girsanov type formula for a Lie group valued Brownian motion. SEMINAIRE DE PROBABILITES XVII, Lecture notes in Mathematics 986, Springer-Verlag, Berlin, 1983, pp. 198-204.
11. Interchanging the order of stochastic integration and ordinary differentiation. SANKHYA A, 45, 1983, pp.120-124.
12. A finitely additive white noise approach to non linear filtering. (with G. Kallianpur) APPLICATIONS OF MATHEMATICS AND OPTIMIZATION, 10, 1983, pp.159-185.
13. Measure valued equations for the optimal filter in finitely additive non linear filtering theory. (with G. Kallianpur) Z. WAHRSCH. VERW. GEBIETE, 66, 1984, pp.1-17.
14. Some recent developments in non linear filtering theory. (with G. Kallianpur) ACTA APPLICANDAE MATHEMATICAE, 1, 1983, pp.399-434.
15. The non linear filtering problem for the unbounded case. (with G. Kallianpur) STOCHASTIC PROCESSES AND THEIR APPLICATIONS, 18, 1984, pp.57-66.
16. The Markov property of the filter in the finitely additive white noise approach to non linear filtering theory. (with G. Kallianpur) STOCHASTICS, 213, 1984, pp.177-198.
17. Limiting distributions of functionals of Markov chains. (with V. G. Kulkarni) STOCHASTIC PROCESSES AND THEIR APPLICATIONS, 19, 1985, pp.225-235.
18. A finitely additive white noise approach to non linear filtering. (with G. Kallianpur) MULTIVARIATE ANALYSIS VI ed. P. R. Krishnaiah, North-Holland, Amsterdam, 1985 pp.335-344.
19. Analytic and sequential Feynman integrals on abstract Wiener and Hilbert spaces and the Cameron-Martin formula. (with G. Kallianpur and D. Kannan) ANNALS DE LA INSTITUT HENRI POINCARRE, 21, 1985, pp.323-361.
20. White noise calculus and non linear filtering theory. (with G. Kallianpur) **Special invited paper** THE ANNALS OF PROBABILITY, 13, 1985, pp.1033-1107.
21. On the Feynman-Kacs formula and its applications to filtering theory. APPLICATIONS OF MATHEMATICS AND OPTIMIZATION, 16, 1987, pp.263-276.
22. The filtering problem for infinite dimensional processes. (with G. Kallianpur) STOCHASTIC DIFFERENTIAL SYSTEMS, STOCHASTIC CONTROL THEORY AND APPLICATIONS ed. W. Fleming and P. L. Lions, Springer-Verlag, New-York, 1988 pp..
23. A general principle for limit theorems in finitely additive probability: the dependent case. JOURNAL OF MULTIVARIATE ANALYSIS, 24, 1988, pp.189-206.

24. Smoothness properties of conditional expectation in finitely additive probability. *(with H. Hucke and G. Kallianpur)* JOURNAL OF MULTIVARIATE ANALYSIS, 27, 1988, pp.261-269.
25. Embedding a stochastic difference equation into a continuous time process. *(with L. deHaan)* STOCHASTIC PROCESSES AND THEIR APPLICATIONS, 32, 1989, pp.225-235.
26. On Metivier-Pellaumail inequality, Emery topology and pathwise formulae in stochastic calculus. SANKHYA A, 51, 1989, pp.121-143.
27. Martingale problems associated with the Boltzman equation. *(with J. Horowitz)* SEMINAR ON STOCHASTIC PROCESSES (ed. Cinlar et al. ), Birkhauser,Boston, 1989 pp.75-122.
28. On a. s. convergence of modified Euler-Peano approximations to the solution of a stochastic differential equation SEMINAIRE DE PROBABILITES XXV, Lecture notes in Mathematics 1485, Springer-Verlag,Berlin, 1991, pp. 113-120.
29. Multiplicative decomposition of non-singular matrix valued semimartingales. SEMINAIRE DE PROBABILITES XXV, Lecture notes in Mathematics 1485, Springer-Verlag,Berlin, 1991, pp.262-269.
30. Convergence of moments of Markov and semi-Markov processes. *(with V. G. Kulkarni)* PROBABILITY, STATISTICS AND DESIGN OF EXPERIMENTS, PROCEEDINGS OF R. C. BOSE SYMPOSIUM, NEW DELHI (ed. Bahadur et al. ), Wiley Eastern, New Delhi, 1991 pp.453-459.
31. Martingale problems associated with the Boltzman equation. *(with J. Horowitz)* PROBABILITY, STATISTICS AND DESIGN OF EXPERIMENTS, PROCEEDINGS OF R. C. BOSE SYMPOSIUM, NEW DELHI (ed. Bahadur et al. ), Wiley Eastern, New Delhi, 1991 pp.383-390.
32. The maximum of n-independent processes. *(with A. A. Balkama and L. deHaan)* JOURNAL OF APPLIED PROBABILITY, 30, 1993, pp.66-81.
33. A Trotter type formula for semimartingales. SANKHYA A, 55, 1993, pp.202-213.
34. An introduction to white noise analysis and nonlinear filtering. *(with G. Kallianpur)* MATHEMATICAL THEORY OF CONTROL (ed. M. C. Joshi et al. ), Marcel Dekkar, New York, 1993 pp.173-184.
35. Weak Convergence to a Markov Process: the Martingale approach. *(with A. G. Bhatt)* PROBABILITY THEORY AND RELATED FIELDS, 96, 1993, pp.335-351.
36. Invariant measures and evolution equations for Markov processes characterized via Martingale Problems. *(with A. G. Bhatt)* THE ANNALS OF PROBABILITY, 21, 1993, pp.2246-2268.
37. White noise theory of robust nonlinear filtering with correlated state and observation noises. *(with A. Bagchi)* SYSTEMS AND CONTROL LETTERS, 23, 1994, pp.137-148.

38. Nonlinear transformations of the canonical Gauss measure on Hilbert space and absolute continuity. *(with G. Kallianpur)* ACTA APPLICANDAE MATHEMATICAE, 35, 1994, pp.63-102.
39. Mean rates of convergence of empirical measures in the Wasserstein metric *(with J. Horowitz)* JOURNAL OF COMPUTATIONAL AND APPLIED MATHEMATICS, 55, 1994, pp.261-274.
40. A generalized binomial model and option formulae for subordinated stock price processes *(with S. T. Rachev)* PROBABILITY AND MATHEMATICAL SCIENCES, POLISH ACADEMY OF SCIENCES, 15, 1995, pp. 427-447.
41. Evolution equations for Markov processes: Application to the white noise theory of filtering. *(with A. G. Bhatt)* APPLICATIONS OF MATHEMATICS AND OPTIMIZATION, 31, 1995, pp.327-348.
42. On pathwise stochastic integration STOCHASTIC PROCESSES AND THEIR APPLICATIONS, 57, 1995, pp.11-18.
43. Uniqueness and robustness of solution of measure-valued equations of nonlinear filtering *(with A. G. Bhatt and G. Kallianpur)* THE ANNALS OF PROBABILITY, 23, 1995, pp.1895-1938.
44. Second-order fluid flow model of a data-buffer in random environment *(with V. G. Kulkarni)* OPERATIONAL RESEARCH, 43, 1995, pp.77-88.
45. Some properties of the Kullback- Leibler number *(with N. R. Changanty)* SANKHYA A, 58, 1996, pp.69-80.
46. Evolving aspirations and cooperation *(with D. Mookherjee, D. Ray and F. Vega-Redondo)* JOURNAL OF ECONOMIC THEORY, 80, 1998, pp.292-331.
47. On Hilbert Space valued diffusions *(with A. G. Bhatt, G. Kallianpur and J. Xiong)* APPLICATIONS OF MATHEMATICS AND OPTIMIZATION, 37, 1998, pp.151-188.
48. Robustness of the nonlinear filter *(with A. G. Bhatt and G. Kallianpur)* STOCHASTIC PROCESSES AND THEIR APPLICATIONS, 81, 1999, pp.247-254.
49. Characterization of the optimal filter: the non-Markov case *(with A. G. Bhatt)* STOCHASTICS AND STOCHASTICS REPORTS, 66, 1999, pp.177-204.
50. Opinion Polls and Statistics CALCUTTA STATISTICAL ASSOCIATION BULLETIN, 49, 1999, pp.193-194.
51. Path continuity of the nonlinear filter *(with A. G. Bhatt)* STATIST. PROBAB. LETT. , 54, 2001, pp.75-78.

52. System identification: a learning theory approach (*with M. Vidyasagar*) CONTROL AND MODELING OF COMPLEX SYSTEMS (ed. Koichi Hashimoto et al. ), *Trends Math.* , *Birkh%ouser Boston, Boston, MA*, 2001 pp.89-104.
53. Predicting the 1998 Indian parliamentary election (*with Payne, C. and Yadav, Y.* ELECTORAL STUDIES, *21*, 2002, pp.69-89.
54. Robustness of the nonlinear filter: the correlated case. (*with A. G. Bhatt*) STOCHASTIC PROCESSES AND THEIR APPLICATIONS, *97*, 2002, pp.41-58.
55. Rates of uniform convergence of empirical means with mixing processes (*with M. Vidyasagar*) STATIST. PROBAB. LETT. , *58*, 2002, pp.297-307.
56. Martingale problems and Path properties of solutions (*with A. G. Bhatt*) SANKHYA, *65*, 2003, pp.733-743.
57. On filtering with Ornstein-Uhlenbeck process as noise (*with A. G. Bhatt*) J. INDIAN STATIST. ASSOC. , *41*, 2003, pp.205-220.
58. Measure free martingales (*with M. G. Nadkarni*) PROC. INDIAN ACADEMY OF SCIENCES, *115*, 2005, pp.111-116.
59. On characterization of Markov processes via martingale problems (*with A. G. Bhatt and B. V. Rao*) PROC. INDIAN ACADEMY OF SCIENCES, *116*, 2006, pp.83-96.
60. On almost sure convergence results in stochastic calculus SEMINAIRE DE PROBABILITES XLIII, Lecture notes in Mathematics *1874*, *Springer-Verlag, Berlin*, 2006, pp.137-147.
61. On the Markov Chain Monte Carlo (MCMC) method SADHANA, *31*, 2006, pp.81-104.
62. A Learning Theory Approach to System Identification (*with M. Vidyasagar*) PROBABILISTIC AND RANDOMIZED METHODS FOR DESIGN UNDER UNCERTAINTY (ed. Giuseppe Calafiore and Fabrizio Dabbene), *Birkhauser Boston, Boston, MA*, 2006 pp.265-302.
63. Introduction to Cryptography. E-BUSINESS PROCESS MANAGEMENT ((*ed. Jayavel Sounderpandian and Tapen Sinha*)), *IGI Publishing*, 2007, pp.28-44.
64. A learning theory approach to system identification and stochastic adaptive control (*with M. Vidyasagar*) JOURNAL OF PROCESS CONTROL, *18*, 2008, pp.421-430.
65. Uniqueness of solution to the Kolmogorov's forward equation: Applications to White Noise Theory of Filtering (*with A. G. Bhatt*) COMMUNICATIONS ON STOCHASTIC ANALYSIS, *4*, 2010, pp.115-128.
66. On multiple choice tests and negative marking CURRENT SCIENCE, *99*, 2010, pp.1042-1046.



67. Monotonicity of the matrix geometric mean (*with Rajendra Bhatia*) MATHEMATISCHE ANNALEN, *353*, 2012, pp.1453-1467.
68. Modelling in the spirit of Markowitz portfolio theory in a non-Gaussian world (*with Tapen Sinha*) CURRENT SCIENCE, *103*, 2012, pp.666-672.
69. On Quadratic Variation of Martingales (*with B. V. Rao*) PROC. INDIAN ACADEMY OF SCIENCES, *124*, 2014, pp.457-469.
70. On the Fundamental Theorem of Asset Pricing (*with Abhay Bhatt*) COMMUNICATIONS ON STOCHASTIC ANALYSIS, *9*, 2015, pp.251-265.
71. On The Second Fundamental Theorem Of Asset Pricing (*with B. V. Rao*) COMMUNICATIONS ON STOCHASTIC ANALYSIS, *10*, 2016, pp.57-81.
72. Remarks On The Stochastic Integral INDIAN JOURNAL OF PURE AND APPLIED MATHEMATICS, *48*, 2017, pp.469-493.
73. Normalization of marks in multi-session examinations (*with Abhay Bhatt and Sourish Das*) CURRENT SCIENCE, *118*, 2020, pp.34-39.
74. Mathematics and Elections PROCEEDINGS INDIAN NATIONAL SCIENCE ACADEMY, *86*, 2020, pp.1461-1479.
75. Mortality due to COVID-19 in different countries is associated with their demographic character and prevalence of autoimmunity (*with Bithika Chatterjee and Shekhar C. Mande*) CURRENT SCIENCE, *120*, 2021, pp.501-508.
76. The Role of Statistics in the Era of Data Science CURRENT SCIENCE, *121*, 2021, pp.1016-1021.