



International Indian Statistical Association Newsletter



Contents

About Us	3
From the Editor's desk	4
Message from the IISA President	5
Spotlight: Professor Calyampudi Radhakrishna Rao	6
Obituaries	17
Report on IISA 2022 Conference	21
IISA Lifetime Achievement Award for 2021	22
IISA Lifetime Achievement Award for 2022	23
IISA Early Career Award in Statistics and Data Science	24
IISA Junior Service Award 2023	25
Excellence Amplified: Celebrating Global Accolades	26
IISA 2023 Student Awards	28
Appreciation Letters for IISA 2023 Conference	29
Member News and Announcements	31
Celebrating 70 years of Prof. Dipak Dey	35
Treasurer's Report	36
IISA at JSM 2023	37

Cover Art: Sayantan Banerjee

IISA 2023 Conference photographs courtesy: Subhashis Ghoshal, Gourab Hore

IISA is a nonprofit organization that is exempt from federal income tax in the USA under Internal Revenue Code (IRC) Section 501(c)(3). It is classified as a public charity under the relevant IRC Section. Donors can deduct contributions they make to IISA under IRC Section 170. IISA is also qualified to receive tax deductible bequests, devises, transfers or gifts under Section 2055, 2106, or 2522.

©2023 International Indian Statistical Association

ABOUT US

Board of Trustees

Jaya Satagopan (Chair)
Rutgers University
satmaiaagopj@sph.rutgers.edu

Ram Tiwari
Bristol Myers Squibb
Ram.Tiwari@bms.com

P.G. Sankaran
Cochin University of Science and Technology
sankaran.pg@gmail.com

Advisors

Snigdhanshu Chatterjee
University of Minnesota

Subrata Kundu
George Washington University

Executive Board

President
Subhashis Ghoshal
North Carolina State University
president@intindstat.org

Past President
Sandeep Menon
Pfizer

President-Elect
Saonli Basu
University of Minnesota

Executive Director
Sanjay Chaudhuri
University of Nebraska-Lincoln
executive.director@intindstat.org

Executive Administrator
Hiya Banerjee
Eli Lilly and Co.
secretary@intindstat.org

Newsletter Editor
Sayantan Banerjee
IIM Indore
newsletter@intindstat.org

Treasurer
Abhyuday Mandal
University of Georgia
treasurer@intindstat.org

India Chapter President
Debjit Biswas
Pfizer India

India Chapter

President	Debjit Biswas Pfizer India
Treasurer	Shibasish Dasgupta Pfizer India, and CMI Asha Gopalakrishnan Cochin University treasurer.india@intindstat.org

Newsletter Committee

Editor-in-Chief	Sayantan Banerjee IIM Indore newsletter@intindstat.org
-----------------	--

Membership and Outreach Committee

India Committee	Asha Gopalakrishnan (Chair) Sourish Das Ashok Nanda Angshuman Sarkar
USA Committee	Arvind Rao (Chair) Sourav Santra Shailaja Suryawanshi Lasitha Rathnayake Shariq Mohammed Jyotishka Datta Siddhesh Kulkarni

From the Editor's desk Spring Newsletter is here

Dear IISA members,

Welcome to the Spring edition of our newsletter. It is an exciting time for the statistics community as we celebrate the remarkable achievements of one of the greatest statisticians of our time and pay tribute to a revered figure who has left an indelible mark on the field.

We are thrilled to highlight the extraordinary achievement of Professor C.R. Rao, who recently became the recipient of the prestigious *International Prize in Statistics*. This highly coveted award, often referred to as the "Nobel Prize in Statistics," is a testament to Professor Rao's outstanding contributions to the field. For several decades, Professor Rao has shaped the discipline of statistics through his groundbreaking research, transformative methodologies, and unwavering commitment to advancing statistical science.

As a tribute to Professor Rao's exceptional career, we are delighted to present a special feature dedicated to his life and work. We are grateful to Prof. T.J. Rao and Prof. T. Krishna Kumar for their contributing articles exploring the remarkable impact of Professor Rao's contributions to statistical theory, multivariate analysis, and experimental designs. Professor Rao's accomplishments serve as an inspiration to statisticians worldwide, and we are privileged to have the opportunity to honor his remarkable achievements.

In addition to celebrating Professor Rao's success, it is with a heavy heart that we share the news of the passing of Prof. K.R. Parthasarathy, a distinguished academician and an esteemed member of our community. KRP, as he was fondly referred to, was not only an accomplished scholar but also a beloved mentor and friend to many within the field. His pioneering work in stochastic analysis, particularly in the areas of probability theory and quantum probability, has left an indelible mark on the statistical landscape. We offer our deepest condolences to his family, friends, and colleagues during this difficult time. We also invite our readers to share their memories and tributes to honor his significant contributions.

Furthermore, we are deeply saddened to acknowledge the demise of Prof. K.B. Athreya, a luminary in the field of statistics. Prof. Athreya was widely regarded as an authority in probability theory, stochastic processes, and their applications. His profound expertise and passion for the subject were evident in his extensive body of work, which continues to inspire generations of statisticians. We extend our heartfelt condolences to his family, friends, and colleagues, and we invite our readers to honor his memory by reflecting on his significant impact on statistical science.

It is through the collective efforts of statisticians like Professors Rao, Athreya and Parthasarathy that our field continues to grow and flourish. Their groundbreaking research and dedication have paved the way for new discoveries and applications across various domains, ranging from healthcare and finance to social sciences and environmental studies. As we celebrate Professor Rao's triumph and commemorate Prof. Athreya's and Prof. Parthasarathy's legacy, we are reminded of the profound impact statisticians can have on society and the crucial role they play in shaping our understanding of the world.

We are celebrating global accolades received by Professors S.R.S. Varadhan, Kanti Mardia and Arup Bose. We are elated by their feats. The statistics community is also celebrating 70 years of Prof. Dipak K Dey, who has been a true guiding light for us.

As we conclude this editorial, we invite you to immerse yourself in the captivating stories of these exceptional individuals, and the remarkable achievements of other members of our community. Let us reflect on these achievements and draw inspiration from their passion for statistical science. Moreover, let us remember the importance of collaboration, mentorship, and the pursuit of knowledge in our own statistical endeavors.

We would also like to express our gratitude to our readers for their continued support and engagement with our newsletter. If you have any suggestions, contributions, or feedback, please do not hesitate to reach out to us. IISA Newsletter is undergoing a significant paradigm shift becoming more frequent starting this September, introducing new featured columns, and other exciting stuff. We shall reach out to you with more information soon. We are also in constant search of volunteers. If you feel you would like to help in any capacity, please feel free to reach out to us.

Thank you for joining us on this journey of discovery, celebration, and remembrance. Together, we can build a brighter future for statistical science.

Warm regards,
Sayantan Banerjee
Editor-in-Chief

Message from the IISA President



The annual conference of the International Indian Statistical Association (IISA) was held recently between June 1 to June 4 in Golden, Colorado. It was co-organized with the Applied Mathematics and Statistics Department of the Colorado School of Mines. The conference was a huge success with nearly three hundred participants and well over two hundred paper and poster presentations. IISA Conferences are crucial for accomplishing IISA's mission of providing an essential platform for interactions between probabilists, mathematical statisticians, applied statisticians, and data scientists. Diversity and student participation are among the top priorities of IISA. IISA seeks participant support travel grants and contributions from industry and other organizations to achieve this. IISA successfully obtained a significant travel grant from the US National Science Foundation this year. IISA Conferences include student paper and poster competitions which recognize several winners and present them with cash prizes. To promote diversity, IISA Conferences also have panel discussions on various diversity issues in collaboration with organizations such as the Committee on Women in Statistics, a branch organization of the American Statistical Association. The 2023 IISA Conference also included a session devoted to the collaboration among statisticians of African and Indian descent, which will undoubtedly increase future interactions between these two groups of researchers. IISA recognized Professors Dipak K. Dey, Sati Mazumdar, and J.V. Deshpande for their lifetime achievements. IISA also gave its inaugural Junior Service Award to Dr. Debashis Mondal for his outstanding service to the IISA in various forms, especially for successfully obtaining federal grants for IISA.

Organizing a conference of the size of IISA 2023 involves a lot of work by many people. Apart from the office bearers of IISA, the local organizing committee, scientific committee members, and volunteers spent numerous hours making the conference successful. Our co-organizer, The Colorado School of Mines, extended their full support to make the conference successful.

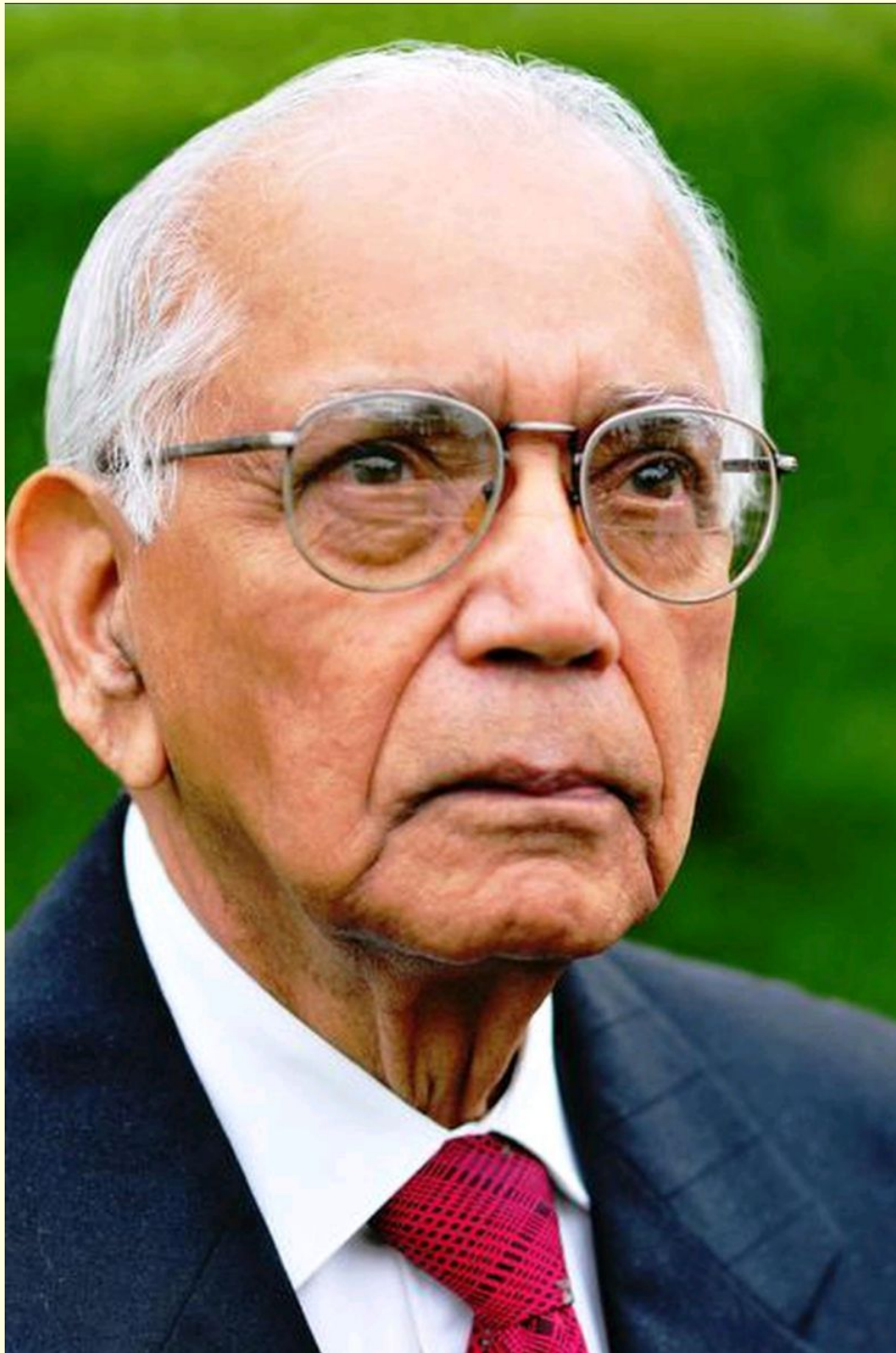
IISA will undertake several steps for smooth functioning and to achieve its goals. A few new committees will be formed to review constitutional provisions, address member needs and obtain grants. IISA also has several new exciting agenda, including publishing its flagship journal in collaboration with the Institute of Mathematical Statistics, and organizing a conference to celebrate the birth centenaries of two iconic statisticians of Indian origin, Professor D. Basu and R. R. Bahadur. The IISA Newsletter will also come out more frequently with new features such as feature columns, problem corners, and letters to the editor, among others, along with the usual features. IISA will have a strong presence at the Joint Statistical Meeting (JSM) in Toronto, with three invited and three topic-contributed sessions sponsored by IISA. Many more IISA members will participate at the JSM. IISA will set up a booth at the JSM and organize a mixer session. If you will be at the JSM, please visit the IISA booth, attend the IISA Mixer, and sign up for the volunteering effort. If you have yet to become a life member, please consider becoming one. IISA runs solely on volunteering efforts. Please help IISA to build a strong and lively community by volunteering for IISA activities and sharing your ideas for improvements.

— Subhashis Ghoshal

President, International Indian Statistical Association

Goodnight Distinguished Professor of Statistics, North Carolina State University

Spotlight: Professor Calyampudi Radhakrishna Rao



IISA is elated to announce that legendary statistician Prof. C.R. Rao has been awarded the 2023 International Prize in Statistics.

Guy Nason, chair of the International Prize in Statistics Foundation, said, “In awarding this prize, we celebrate the monumental work by C.R. Rao that not only revolutionized statistical thinking in its time but also continues to exert enormous influence on human understanding of science across a wide spectrum of disciplines.”

Our heartiest congratulations to Prof. Rao for this award, as we look in awe at his towering contributions.

Read more here: <https://statprize.org/2023-International-Prize-in-Statistics-Awarded-to-C-R-Rao.cfm>

Calyampudi Radhakrishna Rao—A Living Legend in Statistical Science

by PROF. T.J.RAO, RETIRED PROFESSOR, INDIAN STATISTICAL INSTITUTE, CALCUTTA.

Around seven decades ago, a passenger travelling to Calcutta by the Madras-Howrah Mail was asked what he did for a living. Perhaps, feeling that an accurate reply would not be understood, he seems to have replied, "I work in a school and I am the Head Master of the school." The school referred to is the world-famous Research and Training School (RTS) of the Indian Statistical Institute (ISI) and the unassuming passenger was none other than the living legend Professor C.R. Rao, who was indeed the Head of the School for almost a quarter of a century, whose Centennial Birthday we celebrated last September 2020. Today we are celebrating 'his work over 75 years which continues to exert a profound influence on science and which has been awarded the prestigious 2023 International Prize in Statistics.'

Childhood and Education

Calyampudi Radhakrishna Rao, well known as C.R. Rao (and Dr. Rao to his students) was born on 10 September, 1920 in Huvanna Hadagali, now in the Indian state of Karnataka. He studied in various schools in Andhra Pradesh wherever his father working as an Inspector of Police got posted. He had a flair for numbers even from the days of elementary school and when he was six, his teacher would ask him to recite multiplication tables (which young Rao had memorized up to twentieth table) and the other students would repeat after him. At the age of sixteen, Mrs AVN College (Visakhapatnam) magazine had a caption under his photo saying "he has had the unique distinction of knocking off the most coveted prizes in every class until now. We hope he will continue to maintain the high efficiency of his mental and academic facilities in the years to come." And indeed he did so with 14 books (two of them translated into 7 and 6 languages respectively), 470 plus research papers, 51 Ph.D. students, 48 edited Volumes of Handbook of Statistics and 39 honorary doctorates from universities in 19 countries spanning 6 continents. Rao did the 3 year post graduate B.A.(Hons.) degree in Mathematics from Andhra University, the course being popular among bright students in South India at that time and was awarded M.A. degree (First Class First) by efflux of time after one year in 1941. His (sole) application for a research scholarship at Andhra University was rejected by both the Principal and Vice Chancellor on officious grounds. (Little did Rao know that the same University would offer him a Professorship a few years later and after some years an honorary doctorate). He then responded to an advertisement from army for a mathematician and when called for a test and interview went to Calcutta where he was found to be under-aged and not accepted. Alas! A Loss to the Army, but a Glorious Gain to the Statistics Fraternity! In the hotel he was staying, he came to know of the In-

dian Statistical Institute (ISI) which was being run from a room in the Presidency College by Prof. Mahalanobis who by then introduced the subject of Statistics in India by way of organizing large scale sample surveys and experimental designs which are speedy, cost effective and efficient. Mahalanobis also started the Masters Course in Statistics in Calcutta University in which Rao, who had already joined as a trainee at ISI, got admitted as a student of the first batch and obtained an M.A. degree in Statistics, again with a First Class First. Soon after, he joined the ISI as a technical apprentice and started working in the areas of Design of Experiments and Multivariate Analysis having been inspired by RC Bose, KR Nair and SN Roy who were senior scholars at the Institute. He collaborated with the anthropologist DN Majumdar and analysed the anthropometric data based on a survey of the United Provinces using the concept of Mahalanobis' D^2 , a measure of distance between two populations. At the request of JC Trevor, a Cambridge University anthropologist, C.R. Rao was deputed to Cambridge University to apply Mahalanobis Distance analysis on skeletal data from North Africa collected by the university museum. Rao also worked in the Genetics laboratory of RA Fisher, the founder of Modern Statistics and under his guidance obtained the Ph. D. degree in 1948 from the University of Cambridge. Later on, by peer review of published work, the same university awarded him the Sc.D. degree. For a detailed Biography of CR Rao, we refer to Nalini Krishnakutty's "Putting Chance to Work....a life in Statistics" and Julian Champkin's article "C.R.Rao-a life in Statistics" which appeared in Significance, 2011, 175-178 and the ET interview by Anil Bera, Econometric Theory, 19, 2003, 331-400, among others.

Positions held

Rao started as a Superintending Statistician (1944-48) on a meagre salary of Rs. 75 per month at the ISI. He worked for almost 40 years till he retired at the mandatory age of 60 holding important positions as Professor and Head, Research and Training School, widely known as RTS (1949-63), Director and Secretary of ISI (1972-76, an unsatisfactory period for Rao when he decided to move to the Delhi Campus), Jawaharlal Nehru Professor (1976-84), National Professor (1987-92). Throughout his tenure, world class research facilities were made available at ISI. He arranged long and short time visits by renowned experts, organized lecture series, encouraged publication of monographs and thus this period came to be known as the Golden Period of ISI. Since post retirement scenario in India was not much conducive for continuing research, he moved to USA and continued research with renewed vigour, first to the University of Pittsburgh and later to Pennsylvania State University where he was the Director of Center for Multivariate Analysis as well as Eberly (Chair) Professor of Statistics. In the US, he is currently a Research Professor at the University at Buffalo.

Awards

Dr. Rao received numerous international and national awards. He was elected to the Royal Society, UK as a Fellow(FRS), National Academy of Sciences, USA, Third World Academy of Sciences, Lithuanian Academy of Science, and three major science academies in India. Kings College, Cambridge gave him an exclusive Honorary Life Membership (given to only eleven persons at any time). He was awarded Padma Vibhushan, the second highest civilian award by the Government of India. As a recipient of Shanti Swaroop Bhatnagar Memorial Award at a time when the China-India war was waging on, he donated the entire prize money to Prime Minister's National Defence Fund saying that "the country's need is greater than that of an individual scientist in times of war." At the Berlin Session of the International Statistical Institute, Rao was awarded the Mahalanobis Prize in recognition of lifetime achievements in Statistics in 2003. The Government of Andhra Pradesh conferred the prestigious 'Genome Valley Excellence Award 2010' to CR Rao for his research contributions to statistical methods towards better understanding of health and disease. He has also received the 'Sardar Patel Life Time Achievement Award', 2015.

Right from the school and college days, CR Rao was collecting numerous Medals. He received the Gold Medal from Calcutta University, Wilk's Memorial Medal from American Statistical Society, Wilks' Army Medal (USA), Guy Medal in Silver from Royal Statistical Society (UK), Meghnath Saha and Ramanujan Medals of the National Science Academy (India), JC Bose Gold Medal of Bose Institute, Mahalanobis Centenary Gold Medal of the Indian Science Congress, University of Zielona Go'ra Medal(Poland).

Special Awards

C.R. Rao was honoured by President Bush as a "prophet of a better age" at the White House and was awarded the National Medal of Science, USA "for his pioneering contributions to the foundations of statistical theory and multivariate statistical methodology, and their applications, enriching the physical, biological, mathematical, economic, and engineering sciences." Former Prime Minister Dr. Manmohan Singh conferred on C.R. Rao the highest and most prestigious INDIA SCIENCE AWARD in recognition of "his significant contributions to the field of statistical science that had profound influence on the Theory and Application of Statistics, well recognized all over the world."

For his outstanding achievements, C.R. Rao has been honoured with the establishment of an institute named after him C.R. Rao Advanced Institute of Mathematics, Statistics and Computer Science (CRRAO AIMSCS). The Institute, located in the campus of the University of Hyderabad, is expected to play an important role in improving the quality of teaching, encouraging basic research in mathematical and social sciences, and promoting applications of science and technology in all areas of human endeavour. Within the Institute there is a 'C.R.Rao Gallery', designed by Rao's daughter, Dr. Tejaswini Rao, which

was inaugurated by Nobel Laureate Sir Venkataraman in 2013. The Gallery is open to visitors and students. "C.R. Rao, an Indian professor whose work over 75 years ago continues to exert a profound influence on science, has been awarded the 2023 International Prize in Statistics." Thus the recent announcement on www.statprize.org starts. It continues, "In his remarkable 1945 paper published in the Bulletin of the Calcutta Mathematical Society, Calyampudi Radhakrishna (C.R.) Rao demonstrated three fundamental results that paved the way for the modern field of Statistics and provided statistical tools heavily used in science today. These are 'Cramér-Rao lower bound', Rao-Blackwell Theorem and the third result now flourished as 'information geometry'."

"In awarding this prize, we celebrate the monumental work by C.R. Rao that not only revolutionized statistical thinking in its time but also continues to exert enormous influence on human understanding of science across a wide spectrum of disciplines," said Guy Nason, Chair of the International Prize in Statistics Foundation.

Significant Contributions

It would be an impossible task to write about CR Rao's research contributions in a couple of paragraphs in an article of few pages. We shall attempt to briefly indicate some of his contributions known to have made significant impact in different fields of science as well as official statistics.

Mathematical Statistics: At the very young age of 24, C.R. Rao completed a landmark paper which appeared in the 1945 Bulletin of Calcutta Mathematical Society, now regarded as one of the Breakthroughs in Statistics that gave raise to so many technical terms bearing Rao's name such as Cramér-Rao Lower Bound (CRLB) with applications in Statistics, Signal Processing, Bayesian Risk Theory. In the sixties, during RTS tea club sessions, Dr. Rao used to say, if you need a grant, use the terms 'Signal and Noise'. Little did he know then, that his CRLB of the 1945 Breakthrough paper is quoted in a number of papers on Signal Processing. Terms unknown to some of us, statisticians, such as pixel array detectors, spectroscopic measurements, PET detector designs, SBP methods for 3D event positioning and quantum physics which use CRLB are popular now. Again, applications of the other Breakthrough work popularized as Rao-Blackwellization are abundantly used in addition to improving estimators in conventional sampling theory, in adaptive sampling, link-tracing, size-biased sampling theories, Dynamic Bayesian Networks, Post Simulation Improvement of Monte Carlo Methods, Cross Validation and Non Parametric Bootstrap, particle filtering, stereology, data compression, Quantum Rao-Blackwell Theorem, Rao-Blackwellized Gaussian Smoothing, Rao-Blackwellized Parts-Constellation Tracker, Rao-Blackwellized Tempered Sampling (RTS), Assessment of California Condor recovery, Rao-Blackwellized Field Goal percentage estimator (RB-FG%), and a host of others including possibly Rao-Blackwellized WhatsApp (RB-WA). Rao's 1945 results

now known as 'Information Geometry' had an application at the Large Hadron Collider at the CERN in understanding the Higgs Boson measurements. (also, see Information Geometry, Vol. 45(2021) (eds.: ASR Rao, CR Rao, A Plastino), Elsevier). His work in Multivariate Analysis led to Rao's F-test, Rao's U-test and Canonical Coordinates while his results in Testing of Hypotheses produced Rao's Score Test, a member of the Holy Trinity (besides Likelihood Ratio and Wald's Tests) which again found place in Breakthroughs in Statistics. Some other terms that appear in text books are Fisher-Rao Theorem, Rao's Theorem on Second Order Efficiency, Kagan-Linnik-Rao Characterizations, Lau-Rao-Shanbhag Theorem, Rao's Damage Model, Rao-Rubin theorem, Khatri-Rao inequalities, Burbea-Rao Divergence Measures, Rao's paradox in multivariate analysis, just to quote a few.

Dr. Rao is known as the 'Scientist's Statistician' and some of his statistical tests and other contributions continue to guide scientists all over the globe. It may be interesting to the readers who are not aware of this anecdote as narrated by Dr. Rao himself to Anil Bera (Econometric Theory, 19, 2003, 331–400): "...I may mention some anecdotes in connection with the Rao–Blackwell theorem and Rao–Blackwellization. Blackwell independently discovered this method two years after the publication of my paper. In 1953, I attended a conference where Berkson presented a paper using conditional expectation with respect to a sufficient statistic to improve an estimate, attributing the method to Blackwell and calling the method Blackwellization. When I told him that the method was first given by me, Berkson remarked that Raoization by itself does not sound nice; in a later paper I found that Berkson used the term Rao–Blackwellization. Another instance was a review of a book by Lindley, where he attributed my result on the use of a sufficient statistic to Blackwell only. When I wrote to him about my priority of the result, he replied, "Yes, I read your paper. Although the result was in your paper, you did not realize its importance because you did not mention it in the introduction to your paper." I replied to Lindley saying that it was my first full-length paper and I did not know that the introduction to a paper is written for the benefit of those who read only the introduction and do not go through the paper..."

Applied Statistics: Rao's early contributions consisted of problems of Confounding and Factorial Experiments. It is interesting to note that a couple of early papers of 1943 and 1945 on experimental arrangements in Quasi-Latin Squares and Familial Correlations respectively, appeared in the Indian journal Current Science. C.R. Rao introduced Orthogonal Arrays (OA) in the late forties which in the hands of Taguchi, who visited ISI around that time had a profound effect on industrial experimentation for determining the optimum combination of factors. OA have been referred to as a new Mantra for American Industries in an article published in Forbes magazine in 1996. OA have an important application in Cryptology

as well.

Influence of Rao on Theory and Practice of Sample Surveys was discussed by T.J. Rao in the Jour. Ind. Soc.Prob.Stat. (2021) This paper notes that Rao's justification of their sample selection in the 1941 United Provinces Anthropometric Survey is a prelude to Randomized Permutation Model Theory. CR Rao is also the first to notice that the design of the Bengal Anthropometric Survey, 1945 amounted to stratified sampling and not a simple random sampling technique, thereby heralding the need for Analysis of Complex Survey Data. Rao's Paradox in Sample Surveys refers to the situation that "if one wants to use the likelihood principle, it pays to throw away part of the observed data." Rao edited 4 of the Volumes in Sample Surveys in the Elsevier Series Handbook of Statistics. The review of his book "Advanced Statistical Methods in Biometric Research" (ASMBR), first published by Wiley in 1952 and later by Hafner Press in (1970,74) by CAB Smith (The Eugenics Review, 1953) says "It is one of the best books in this series; Indeed, it is one of the best text books in statistics available anywhere.... ASMBR will be of especial interest to those human geneticists who have occasion to use multivariate analysis." Cabdirect review states "In the latter part of the book the author is dealing with his own researches, but it is an advantage to the reader that difficult multidimensional mathematical problems are written round actual data, which are worked through in illustration of the methods."

C.R. Rao's contributions to Econometrics were discussed in detail by T Krishna Kumar, HD Vinod and S Deman in 2010 ([dx.doi.org/10.2139/ssrn.1722743](https://doi.org/10.2139/ssrn.1722743)). The Volume No. 41 of Handbook of Statistics, 2019 (eds.: HD Vinod and C. R. Rao) is devoted for Financial, Macro and Micro Econometrics using R shows his interest in the use of software.

Rao's sequential tests of Null Hypothesis have an application in Quality Control. Some of his other applied work includes: Problems in Biological Classification, Methods of Scoring on Linkage data in Genetics, Principal Component Analysis and Factor Analysis in Psychometry, Quantitative Studies in Sociology, and the list goes on.

Official Statistics: We start by quoting Rao (2001): "...When I joined the Indian Statistical Institute (ISI) in 1941, there was considerable activity in conducting sample surveys. Mahalanobis was designing a large scale sample survey for estimating the acreage under jute crop in Bengal..." It was but natural that CR Rao should get attracted to the survey operations. Subsequently Mahalanobis established the National Sample Survey (NSS) in 1950 at the Indian Statistical Institute, Calcutta. CR Rao joined the team comprising DB Lahiri, S Raja Rao, MN Murthy among others and took an active part in "designing sample surveys, preparing schedules for recording data and collecting data as an investigator." Post independence of India, Mahalanobis initiated country wide National Sample Survey in 1950. He also created the

Central Statistical Organisation in 1951 to coordinate the data collected by various official channels of the states of India. Dr. Rao recalls

"...I remember Prof. Mahalanobis sending me to different states in India to help the local governments in setting up State Statistical Bureaus (SSB's) and district level statistical offices, and training the required staff." "...Nothing is more frustrating to the investigator than to discover that the observations collected at a considerable expense of money and energy are worthless because of obvious inconsistencies or failure to furnish complete details," he warns the investigators.

Mahalanobis established the International Statistical Education Centre (ISEC) at the Indian Statistical Institute (ISI), Calcutta in 1950 under the auspices of UNESCO and Government of India (GoI) and was the Chairman of Board of Directors till 1973 and then CR Rao became the Chairman and continued to act so till 2016. With the growing need for modernizing the Official Statistics and training of the officers, especially in South East Asia, a UN Committee for development of Statistics was constituted by the Secretary-General, chaired by CR Rao and thus the Asian Statistical Institute (ASI) was inaugurated in 1970 in Tokyo. This is now renamed as Statistical Institute for Asia and the Pacific (SIAP) and from 1999 shifted to Chiba. At home, Dr. Rao chaired or acted as a member of several committees of the government namely Committee on Statistics, Committee on Demographic and Communication for Population Control, Committee on Science and Technology and also advised Reserve Bank of India, Atomic Energy Commission and the Indian Heart Association. He also acted as the Chairman of the Science and Health Allied Research and Education (SHARE), an organisation set up in Hyderabad and initiated Longitudinal Health Surveys on the lines of Framingham Surveys. Data from these surveys supplements NFHS data (Kusneniwar et al., *Int. Jour. Epidem.*, 46,788–789, 2016).

In 1948 after his return from Cambridge, Rao himself got an attractive offer from ECAFE - UN office in Bangkok. However, since he was deputed by Mahalanobis to Cambridge, he told the Professor about his offers and expressed his desire to work at the ISI.

In an ET interview by A Bera in 2003, CR Rao said: "...I had some interest in econometrics and was instrumental in founding the Indian Econometric Society and developing its activities. I served as president and chairman of the society for a number of years. I had also organized a series of seminars on the database of the Indian Economy, to assess gaps and deficiencies in government statistics and suggest methods of utilizing the data for policy purposes. My early research on estimation and linear models is a part of econometrics literature and also, perhaps, the score test..."

Controversy relating to National Accounts Statistics versus National Sample Survey estimates of household consumption expenditure has been addressed many times. It is interesting to note that Cross Entropy and ex-

tensions studied by CR Rao have been used in the case of Official Statistics as well. Reconciliation of household survey data and national accounts data using CE was successfully attempted by Robilliard and Robinson (Rev. Income and wealth, 49, 395-406, 2003) using the General Algebraic Modeling System (GAMS) software for Madagascar data. Reweighting of data from two sources to create a consistent time series using CE method discussed by Branson (Working Paper Series # 38, 2009, SALDRU and assessment of spatial distribution of crop areas by CE method by You and Wood (*Int. Jour. Appl. Earth Observations and Geo information*, 7, 310-323, 2005) to quote a few show a successful application of CE. The possibility of reconciliation of NSS Household Consumer Expenditure (HCE) data and National Accounts data on Private Final Consumption Expenditure (PFCE) in the Indian context using GAMS would perhaps be a good project.

Mathematics: Dr. Rao acknowledges his teacher at Andhra University Professor Vommi Ramaswamy for introducing him to the rigour of mathematical proofs, inculcating a spirit of enquiry and kindling a research interest in him. Rao was the first to introduce differential geometric concepts in statistics which gave rise to technical terms such as Fisher-Rao Metric, Rao Distance, Rao Measure and Cramér-Rao Functional. Quantum Physicists developed the Quantum Cramér-Rao Bound giving a more precise estimate of uncertainty than Heisenberg's Principle. His work on generalized inverse (g-inverse) of a matrix (singular or rectangular) resulted in several innovative results in linear models. One of his very early contributions on Orthogonal Arrays (OA) in Combinatorial Mathematics, already referred to in the previous paragraph, was published in the Proceedings of the Edinburgh Mathematical Society. This work though mathematical in nature found its extensive use in Japanese and American Industrial experimentation. Rao's work on Quadratic Entropy and his recent interest in Cross Entropy led to the construction of dissimilarity measures.

Course development, Teaching and Training of Statistics to students and officers: Together with Mahalanobis and Haldane, CR Rao devised the syllabi for B.Stat. and M.Stat. degree courses of ISI in 1960. He included a field visit for the students to the ISI campus in Giridih for first-hand experience in conducting crop cutting experiments and collecting data for a short socio economic survey. The syllabus also included a visit to the Central Statistical Organization (CSO) for training in Official Statistics with a grade in a test at the end of the training. During the initial years of the ISEC, officers from the participating countries used to be sponsored by the respective governments. Some had difficulty with English and some had school level mathematics only. While teaching a course on Sample Surveys, Dr. Rao made it a point not to use complicated notations or theorems. He devised simple techniques to explain the concepts. He would rather show a sum in a full form than use sigma notation. For their level, he believed that 'the best way of teaching sample surveys

is to choose some problem and let the students conduct a survey going through the various stages' involved in a sample survey. True to his belief, during a course on sample surveys for international officers and senior graduate students, he made them participate in conducting the 'Radio listeners' preference survey' in the city of Calcutta and acted as a project director in 1965. Senior students acted as 'supervisors', a concept created by Mahalanobis in NSS or 'crew leaders', a concept of Hansen.

Other interests: CR Rao was the Editor of Sankhya, Journal of Multivariate Analysis, for several decades and 40 plus Volumes of Handbook of Statistics. He acted as the President of all prestigious International Statistical Organisations as well as Founder of Indian Econometric Society and Indian Society for Medical Statistics. He was associated with the Quality Control Movement in India and organised Courses in Industrial Quality during the late forties at the Institute. Dr. Rao followed his teacher of Andhra University, Professor Vommi Ramaswami in his teaching style by calling the student to the board and making him work out the problems, guiding him only with essential steps. Students were thus always alert and had a mastery over the subject.

To create awareness of Statistics and to encourage those with an aptitude for numbers and numerical reasoning, to study Statistics, C.R. Rao suggested organizing Statistics Olympiad on lines similar to Mathematics Olympiad. Following his suggestion, a team of statisticians headed by T.J. Rao and S. Bendre organized the FIRST STATISTICS OLYMPIAD, for the first time in India and probably in the whole world, in June 2009 by administering tests to students at the high school/junior college level. For the first time in 2014, the same test was held in Sri Lanka as well, at the same time and same date and thus it became an international event and it continues to be so. Each year, the top students are felicitated at a function held on June 29, the birth date of Professor Mahalanobis which also happens to be the National Statistics Day of India. Rao started planning for the establishment of a Museum in Statistics, registered as Sankhya: The National Museum of Statistics, the first one of its kind. Dr APJ Abdul Kalam, former President of India laid the foundation stone for the museum on 30 March 2011 to be built on a 5 acre land donated by University of Hyderabad. Through this medium CR Rao wishes to demonstrate the applicability of Statistics in a variety of fields and spread numerical literacy. Some of the rare honours that C.R. Rao received include a National Award in his name instituted by the Government of India, Roads adjacent to University of Hyderabad and Andhra University named after him, a Special Postal Cover released in celebration of his 90th Birthday in 2010. Rao's hobbies include photography, playing badminton, long walks and writing humorous essays.

A Living Legend in Statistics, who is still active, Rao spent forty years of his prime life at the Indian Statistical Institute developing statistical activities in India, and

now living in the USA, Rao is in regular touch with the activities at CRRAO Advanced Institute of Mathematics Statistics and Computer Science (AIMSCS) named after him, guiding and advising the Institute as well as various National and International Statistical Organisations and University Departments of Statistics. On the occasion of his Award of ISP 2023 , the Statistical Community congratulates Prof C R Rao and wishes him a Very Happy and Healthy times ahead .

Dr. Calyampudi Radhakrishna Rao-The Centenarian legend of his centuries in statistics

by T. KRISHNA KUMAR, RE-
TIRED PROFESSOR AND HEAD, ECONOMIC ANALYSIS UNIT,
INDIAN STATISTICAL INSTITUTE. BANGALORE



The International Statistical Prize (ISP) 2023 for Dr. C.R. Rao is the highest honor to a person who adores as well as adorns statistics. Dr. C.R. Rao, a living centenarian legend of his twin centuries who not only created a history in statistics but prepared a vision for the future history. What I meant by the latter is that his contribution in 1945 on differential geometry continues to have its impact on the future course of Artificial Intelligence, data science, physics, etc. His students consider it a privilege to be Dr. Rao's students. Dr. C. R. Rao's contributions to statistics with applications to other sciences are well known and they are well documented in several articles written by Bradley Efron, et.al. (<https://academic.oup.com/jrssig/article/17/4/36/7038158>), George Andrews, et. al. (<https://www.jstor.org/stable/2346322>).

[//web.archive.org/web/20220613051917id_/https://www.ams.org/notices/202206/rnoti-p982.pdf](https://web.archive.org/web/20220613051917id_/https://www.ams.org/notices/202206/rnoti-p982.pdf)), Nandini Kannan (<http://dx.doi.org/10.1111/insr.12467>), B.L.S. Prakasa Rao, (<https://bhavana.org.in/c-r-rao-a-life-in-statistics/>) J.S. Rao, and T.J. Rao (the last in this IISA News Letter), and several others. I shall therefore confine myself to my personal observations about my recent interactions with Dr. Rao, and about my impressions of Dr. Rao as a teacher, an econometrician, and a role model for his students. I have known Dr. Rao since 1959 when I joined ISI as his student. We are extremely grateful to him for the excellent training in statistical theory and methods he had given us. Dr. Rao created a unique and world class statistical education infrastructure at the Research and Training School of I.S.I. That infrastructure included providing strong basic foundations in probability and statistics, covering theory and methods in the morning with practical numerical applications in the afternoon (employing the Facit calculating machines, with one machine for each student), bringing education to the latest developments- as reflected by the class notes matching with the recently published research papers by our own teachers. We were taught by teachers who are all quite famous in the field of statistics and economics, such as Dr. Rao, Abraham Mathai, Debabrata Basu, Raghuraj Bahadur, Sujit Kumar Mitra, Jogabrata Roy, Jayaram Sethuraman, K.R. Parthasarathy, K.R. Shah, Sarbadhikari, N.S. Iyengar, Ashok Rudra, and Ajit Kumar Biswas. Dr. Rao himself used to make the schedule of classes, and if some teacher did not show up, he used to find a substitute teacher, and if he could not find a substitute teacher, he himself used to walk into the class to teach. Occasionally he used to pick a student at random and ask him/her to go to the blackboard and start posing the problem for discussion. That meant everyone must be prepared to be called by Dr. Rao, and that itself introduced some fear and a practice of regular homework. On one occasion there was severe monsoon rain and expecting that many people like Dr. Rao and Dr. Mathai who used to come from the city would not be able to reach the Institute we did not go even from 205 B.T. Road to 203 B.T. Road. Dr. Rao did reach to take the class. He rewarded our classmate Bhanudutt Singh for attending the class and fined the rest of us. He derived these organizational and disciplinary skills from his father, a senior police official, and his mathematics professor Vomma Ramaswamy of Andhra University, where in 1940 Dr. Rao stood first in rank with record marks in B.A. (Hons) Mathematics. Incidentally, that record was surpassed 20 years later by B.L.S. Prakasa Rao, who immediately became a student of Dr. Rao. We were provided scholarship to study statistics, placing no financial burden on our parents. We were also given a book allowance to possess personal copies of classic books in probability and statistics such as Introduction to Probability Theory and Statistics by William Feller, Cramer's Mathematical Methods of Statistics, Dr. Rao's Book-Advanced Statistical

Methods in Biometric Research, Sampling Techniques by William G. Cochran, Experimental Designs by Cochran, and Cox. The practical sessions in the afternoon were to solve a set of problems (compiled as mimeographed bound notebook) prepared by Jogabrata Roy, R.G. Laha and Indra Mohan Chakravarti, which were extraordinarily good examples and were published much later as a book in the Wiley series on statistics.

About twelve years ago when I was writing an Advanced Econometrics textbook with two Chinese co-authors, I requested Dr. Rao to write the Foreword for it. He agreed to do it and wrote a very good foreword highlighting its importance as transitioning from small sample and parametric econometrics to the emerging big data situation requiring nonlinear and non-parametric modeling. I interacted with him (almost continuously since 2005) with respect to matters pertaining the CR Rao Advanced Institute for Mathematics, Statistics, and Computer Science (more on it later), of which I am a Founder Member. I had also served as a member of the program committee for the International Conference honoring him on his 90th birthday held at the CR Rao Advanced Institute on the University of Hyderabad campus. Dr. Rao did most of the organization work. The program committee members had to only execute what he had planned. The fact that the person in whose honor the conference was being organized was himself organizing the conference only suggests two things. First, his professional standards for excellence would not permit anyone else to mess it up by making it less ambitious than what he expects the conference to be. Second, it is the conference that is important to him and not in whose honor it is. At his 90th Birthday conference there was a very attentive person among the audience, often raising an interesting question to the speaker or the panel, and that was Dr. C.R. Rao! At age 98 he was working on editing a Handbook of Statistics with Dr. Arni Srinivasa Rao (They were co-editors). Arni told me that most of the work was being done by Dr. Rao, leaving very little work for him.

Three years ago, and just three months before his birth centenary, I noted that his birth centenary was being spoiled by Covid. I said to myself that such a great event needed a great celebration. It was a unique occasion for his students to pay their respects to him and honor him. With the cooperation of Dr. Rao and his daughter Dr. Teja Rao, I arranged a series of Zoom meetings in the first two weeks of September 2010 between Dr. Rao and his former students, colleagues, friends, and well-wishers. I and Dr. Rao's daughter, Teja Rao, created a Facebook Page on July 10, 2020, to celebrate his birth centenary. See the link: (<https://www.facebook.com/groups/1604465816396606>). Dr. Rao had two celebrations on his 100th birthday, a personal birthday at home in Buffalo, New York, with family and very few guests (due to the restrictions imposed by the Covid epidemic), and another virtual celebration arranged by me and Dr. Teja Rao with the help of Dr. Nagaraj Neerchal, Vice

Chancellor of Chinmaya Vishwa Vidyalaya, Kerala, India (on leave from University of Maryland, Baltimore Campus). The Zoom session on his birth centenary was attended by about 425-500 people from all over the world. Incidentally, his birth centenary coincided with the Platinum Jubilee of the Cramer-Rao Bound. Special features of that function were-Dr. Rao cutting a birthday cake and blowing hundred candles (with more than 400 students, friends, and admirers all over the world singing Happy Birthday song), releasing a Birth Centenary Souvenir Book by the ISI Retired Employees, Dr. Rao autographing a bust size photo of his with his 100th birthday date on it, a song on Cramer-Rao bound sung to the tune of "Take me home country road" (written by John Denver and sung by Simon and Garfunkel). This C-R bound version was originally written by Peter Kootsookos (see the Institute of Mathematical Statistics Link: Homeward Bound? Cramér–Rao Bound!). Kootsookos was searched on the Google by me and requested to sing it for Dr Rao to surprise him: <https://kootsoop.s3.amazonaws.com/Cramer-Rao-Bound-Song.mp4> Teja Rao had a professional singer sing that song much earlier and that recording was also played. And finally, his favorite Rabindra Sangeet was rendered by Dr. Sudeshna Basu (a former student of I.S.I, currently on the mathematics faculty of George Washington University and a very well-accomplished singer of Rabindra Sangeet). The participants in the Zoom celebration included K.R. Parthasarathy, J.N.K. Rao, Abraham Kagan, S.R.S. Varadhan, Jayaram Sethuraman, K.R. Shah, B.L.S. Prakasa Rao, Kanti Mardia, Krishna Athreya, J.S. Rao, T.J. Rao, Arni Srinivasa Rao, Sunil Rao, Bikas Sinha, Bimal Sinha, Bimal Roy, Rahul Mukherji, Marepalli Bhaskar Rao, Y.R.K. Sarma, Sati Mazumdar, Pallavi Chitturi, selected students from my batch at ISI and my contemporaries, and several others, too many to list here. Teja Rao, Dr. Rao's daughter, remarked: "The most beautiful aspect of the celebrations was connecting with so many people from my father's past on Zoom."

When I met Dr Rao at his daughter's residence five years ago on his 99th birthday I saw him engrossed looking at his PC screensaver with pictures of Professor P.C. Mahalanobis and Sir R.A. Fisher, his mentors. He was gazing at their pictures in admiration and with gratitude. Fisher gave him the mathematical foundations of statistics so that he could make further contributions exploiting information, Likelihood function, and orthogonal arrays. He and D.J. Finney were the only two statistics doctoral students of R.A. Fisher. In Professor Mahalanobis Dr. Rao found a teacher that would provide opportunities to his students to bring out their best. Mahalanobis gave Rao an opportunity to write a research paper in place of practical problems, and it is that opportunity which enabled Dr. Rao at age 23 to make all his major contributions for which he received very wide recognition and international acclaim. It was Professor Mahalanobis who gave C.R. Rao an opportunity to go to Cambridge Univer-

sity to work with Sir R.A. Fisher. When he was guiding his students Dr. Rao followed the same approach to guidance that he received from Mahalanobis and Fisher.

Dr. Rao and his Students:

That scene of Dr. Rao paying respects to his mentors prompts me to state that Dr. Rao not only contributed to the foundations of statistical science but also enabled to create statistical giants, as famous as him or even more famous. Varadhan, his student, won the Abel Prize in mathematics in 2007, and received the US Medal of science in 2010, only eight years after Dr. Rao. Dr. Rao often mentions that it gives him immense pleasure when his students get high recognitions. I shall just mention about a few of his students. The choice was difficult to make as there are several outstanding students of Dr. Rao. My choice is also limited by my knowledge! (and my knowledge of them). One of Dr. Rao's earliest students was Debabrata Basu. Basu did his Ph.D. under the supervision of Dr. Rao in 1953. He spent the year 1953 at University of California, Berkeley with Jerzy Neyman, and E.L. Lehman. Dr. Basu made significant contributions to foundations of statistics through Basu's Theorem, which forms an elegant part of the main core of statistical inference. His thought-provoking counter examples and his commentaries on the theory and practice of survey sampling from a Bayesian perspective stand out as major contributions to statistical science.

The ISI family of scholars very proudly recall the contributions made to probability theory by the so-called "Famous Four", V.S. Varadarajan, R. Ranga Rao, K.R. Parthasarathy, and S.R.S. Varadhan (<https://bhavana.org.in/reflections-on-a-long-innings/>). To quote V.S. Varadarajan: "This intervention by C. R. Rao gave a real boost to our solitary efforts and started us on a path from which we never looked back". What was that intervention? What was that solitary effort? Varadarajan came to ISI having been influenced by Professor R. Vaidyanathswamy (formerly of Madras University and was a Visiting Professor at I.S.I. then) and Dr. C. R. Rao. His research interest was in mathematical aspects of probability theory using the then modern topological methods in which Vaidyanathswamy was an expert. He was able to find among his immediate juniors three people R. Ranga Rao, K.R. Parthasarathy and S.R.S. Varadhan who were also interested in that line of work. As Professor Vaidyanathswamy left I.S.I. they had no one to help them in that line of research. I must however say that Dr. Rao and Mahalanobis tried unsuccessfully to get a famous mathematician and mathematical physicist, Professor S. Meenakshisundaram of Andhra University. He was at Princeton University's Institute for Advanced Studies in the late forties. I knew about it from him as he was a teacher both to me and to Dr. Rao (twenty years apart) at Andhra University. He was invited to I.S.I. with that intention in either in 1959 or 1960 when I was a student there. These "Famous Four" used to read the books and journal articles, conducted seminars among themselves

to reinforce each other's knowledge. In 1956 Dr. Rao attended a conference in Moscow and spent some time with Kolmogorov. On his return he brought an idea from Kolmogorov on the importance of information theory for the future developments in statistical theory. He also brought a paper by Kolmogorov and Prokhorov presented at a Berlin conference in 1954. Passing on these ideas to Varadarajan, Ranga Rao, Parthasarathy, and Varadhan is what stimulated the work by these "Famous Four". Dr. Rao chose Prokhorov as the external examiner for Varadarajan, and Kolmogorov as the external examiner for Varadhan. He chose Joseph L. Doob as the external examiner for K.R. Parthasarathy. Doob was very well-known for his work on probability with measure-theoretic approach. By then Doob had already supervised the doctoral work of Paul R. Halmos on measure theory and David Blackwell on statistical inference. Kolmogorov and Prokhorov were the best minds on mathematical foundations of probability. Dr. Rao picked the best mathematical minds in India and put them in touch with the world's best minds to create excellence. It is the same thing that Professor P.C. Mahalanobis had done by training R.C. Bose, S.N. Roy, S.S. Shrikhande, and C.R. Rao. I would like to say that these are foundations laid by Mahalanobis and Rao on establishing within India an Indian School of Statistics. This school's flags are kept flying high by the exemplary theoretical work done by some other students of Dr. Rao.

As an illustration of how Dr. Rao helped other ordinary students, I might mention my own experience. When I was working as a Research Scholar in econometrics at I.S.I. Kolkata (then Calcutta) in 1962 he asked me why I was still there at ISI. While I was startled by that question coming from him, he said that I was given the Research Scholarship as a springboard to grab opportunities of doing doctoral work in econometrics in USA. I told him I needed two letters of reference from people holding a doctorate and with work in econometrics, and that I could find only one such reference and I needed one more. He said he would write the letter of reference. Then I said: "Dr. Rao, no doubt you are a world-renowned statistician, but you are not an econometrician". To that he said: "What is your criterion for saying that someone is an econometrician? I replied by saying "I consider anyone who had published an article in *Econometrica* as definitely an econometrician". Dr. Rao said: "Go to the library and check 1947 Issue of *Econometrica*". I noted that there was a paper in that Volume by Dr. C.R. Rao on a very fundamental problem in econometrics posed by none other than the founder of the subject of Econometrics, Ragnar Frisch (who later became the first person to receive the Bank of Sweden Medal in Economics in honor of Alfred Nobel-also called the Nobel Prize in economics). I returned to Dr Rao and asked him to write the letter of reference. That is how I was able to obtain my Ph.D. from Iowa State University. In 2008 January while delivering the inaugural address at the Annual Conference of the Indian Econometric Society at I.I.T-Bombay Dr. Rao

recalled all this and remarked somewhat like this "Professor Krishna Kumar thinks that I am not an econometrician and yet I am now delivering the inaugural address for the Indian Econometric Society", and all the heads of the audience were turned towards me in an utter astonishment and disapproval! In that address he tried to emphasize the importance of his statistical contributions to econometrics by stressing the importance of prior and sample information to estimate economic structural equations.

CRR-AIMSCS:

Now I turn to the CR Rao Institute in Hyderabad. While presenting an Honorary doctorate to Dr. C.R. Rao in Hyderabad around the turn of the century the then Governor of Andhra Pradesh, Dr. C. Rangarajan, made a remark that there should be an advanced research institute in honor of Dr. C.R. Rao located in his home state and in the central part of India, Hyderabad. Dr. Rao liked the idea and took on the job himself. The then Vice Chancellor of Osmania University, Dr. D.C. Reddy granted land for establishing such an institute. But the land allotted had squatters and the Institute could not start for more than five years. When Dr. Rao mentioned this to me, I requested him to consider shifting it to the campus of University of Hyderabad. When Dr. Rao met him Dr. S.E. Hasnain, the V.C. of University of Hyderabad, had given the necessary unencumbered land for the new Institute but also provided a lot of encouragement to Dr Rao to give shape to his vision of an Advanced Research Institute in Mathematics, Statistics and Computer Science (AIMSCS). The potential donors and the granting agencies needed a Vision and Mission statement along with a budget. Dr. Rao asked me to help him prepare such a document and he provided the major vision for the Institute. He brought my attention to application of Cramer-Rao bound in physics, signal processing, and in quantum physics and so on. It is at that time that Dr. Rao brought my attention to the C-R Bound song by an electrical engineer Peter Kootsookos. I had to do some additional reading to comprehend and draft the Vision and Mission statements along with a long-term budget. The CRR-AIMSCS has a unique "Statistics Museum" designed by Dr. Tejasvini Rao (Dr. Rao's daughter). Dr. Rao's vision for that Institute still needs to take shape and his students may consider supporting that institute and take his vision forward.

IEEE Honorary Membership:

I came to know that the Signal Processing Society (SPS) of the Institution of Electrical and Electronic Engineers was planning to celebrate its Platinum Jubilee in this year (2023), three years after C-R bound celebrated its Platinum Jubilee. And yet they had not recognized the contribution of Dr. Rao to signal extraction formally through any honor. Dr. Raghuveer Rao, Director of Artificial Intelligence and Machine Learning at the Army Research Laboratory (US Army) and a Fellow of IEEE, pointed out to me that it was the best time to make Dr. Rao an Honorary Fellow of IEEE. At his suggestion

I had written to Professor Thomas Kailath of Stanford University, a well-known IEEE member and a recipient of Presidential Medal of Honor in Science, and K.V.S. Hari, Vice President of Signal Processing Society of IEEE, to honor Dr CR Rao with an Honorary Membership and an Honorary Fellowship of IEEE. Professor Kailath and Hari got the needed endorsements to Professor Kailath's proposal within a few hours through emails, and Dr. Rao was elected an Honorary Member of IEEE, which as I understand is (for a non-member of IEEE) on par with Founders Medal (for a member of IEEE). Given the significance of Cramer-Rao bound in signal processing history IEEE had also included an Interview with Dr. C.R. Rao in their Oral History Series. Here is the link for it: https://ethw.org/Oral-History:C.R._Rao

CR Rao's Contribution to Econometrics:

Both Dr. J.S. Rao and Dr. T.J. Rao mention about Dr. Rao's contributions to subjects other than mathematics and statistics as well. Dr. Rao's contributions to econometrics are so vital to the development of economic science that a Nobel Prize in economics should have been awarded to him long ago. Let me elaborate this point.

The origins of Indian econometrics can be traced to 1951, if not earlier, when Mahalanobis was elected a Fellow of the (International) Econometric Society and elected to its Executive Council. International Econometric Society held two joint sessions in India, one with the International Statistical Institute in New Delhi and the other with the Indian Economic Conference in Patna. A short session of the International Statistical Institute Conference was held at the Indian Statistical Institute in Calcutta from 16 to 18 December 1951. The Indian Statistical Institute acted as the host for all these activities. Both Mahalanobis and Dr Rao were instrumental in bringing that activity to India. In January 1960, the Indian Science Congress held its annual conference with the theme "The Impact of Society on Science" at Mumbai. Dr C R Rao chaired a special symposium on "Statistical Methods in Economics" at the Mathematics Division of Indian Science Congress. Pioneers of Indian econometrics attended this symposium and laid the foundation for the establishment of an organized programme devoted exclusively to econometrics. These Indian members of the Econometric Society organized themselves into The Indian Econometric Society (TIES) with Dr C R Rao as the President, although it was officially registered as a Society only in 1970. The First Indian Econometric Conference was held at the Indian Statistical Institute, Calcutta, in January 1960, when I was a student of econometrics. P C Mahalanobis delivered the inaugural address. Dr Rao presided over the Indian Econometric Society for 15 years from 1960–1975. During this period and beyond Dr. Rao has been instrumental in sensitizing TIES the importance of producing Indian Economic Data Base for econometric research. He organized, on behalf of TIES, a Conference on the Data Base of the Indian Economy in 1972.

Ragnar Frisch, the founder of econometrics had out-

lined the scope of econometrics just before the establishment of the econometric society in 1930. His preference then was to exploratory econometrics to discover empirical laws in economics. He advocated an axiomatic mathematical theory in a deterministic form that links a set of "n" endogenous variables to "m" exogenous variables through a set of "n" independent equations with constant coefficients in "n + m" variables to be explained by economic theory. These "n" equations were called autonomous or structural equations. As economic data are not generated either by a designed experiment or through a sample survey Frisch justified statistical modelling in economics by stating that there are measurement errors in variables which have unknown probability distributions. Assuming these structural equations are all linear one can use simple matrix algebra to rewrite each of the "n" endogenous variables as a linear function of all exogenous variables alone, called reduced form equations. In a simple two variable case with one exogenous variable, he posed the question: "under what assumptions on the distribution of exogenous variables and errors of the reduced form equations can one say that there exists a structural relation between the two endogenous variables? It is this question that was answered by Dr. Rao in his 1947 *Econometrica* article, and lead to an entire new branch of statistics on characterization of distributions. Incidentally, I heard through private correspondence from Olav Bjerkholt, a student of Ragnar Frisch and an econometric historian, that Dr. Rao's 1947 paper was forwarded to Ragnar Frisch, the founder editor of *Econometrica*, by Harold Hotelling, one of the founders of the Econometric Society. If this work was not ignored by econometricians, it could have generalized the problem to more variables, as it was in fact done for two endogenous variables and two exogenous variables with two independent structural equations only recently (Prakasa Rao and Kumar (2022)- https://www.researchgate.net/publication/351126030_On_Some_Characterizations_of_Probability_Distributions_with_Applications_in_Econometrics_A_Centennial_Tribute_to_CR_Rao

Non-recognition of this work of Dr. Rao by the econometrics profession is responsible for the profession totally abandoning exploratory modelling in econometrics with errors in variables approach preferred by Frisch.

The Cowles Foundation's (CF) econometric research took a different route than what was intended by Frisch by ignoring the errors of measurement and assuming that only equational errors exist. While Dr. Rao developed statistical inference in linear model, CF developed statistical inference using a system of linear equations. In so doing CF used only the method of maximum likelihood for estimation and for the asymptotic properties of the estimators. The small sample results such as Cramer-Rao inequality and Rao-Blackwellization for improving the estimators were totally ignored by econometricians. This was so until Thomas Rothenberg wrote his paper

in *Econometrica* in 1970 on identifiability in parametric models. In that paper he related the non-identification of a parameter to the information matrix being singular. This was followed by his 1973 treatise published by the Cowles Commission for Research in Economics as one of its Monographs- "Efficient Estimation With A Priori Information". Rothenberg says in the Preface to his 1973 Cowles Commission Monograph:

"This book presents an attempt at unifying certain aspects of econometric theory by embedding them in a more general statistical framework. The unifying feature is the use of a priori information and the basic tool is the traditional Cramer-Rao inequality. I believe that many confusing aspects of simultaneous equations problems can be cleared up by viewing that problem in a broader context. Certain results on identification and efficiency turn out to be elementary when viewed at a general level but are not at all elementary when studied in the particular. Furthermore, the limitations of our econometric theory are made clearer when seen in the general framework of traditional statistical theory". He further says in the same preface: "By generalizing and extending these earlier studies it has been possible to develop a unified theory of estimation which contains many of their results as special cases".

These conclusions of Rothenberg clearly show the extent of dependence of econometric methodology on the statistical inference methodology developed by Dr. Rao. The reason why Dr. Rao was not identified as a main contributor to major part of econometric methodology is

that all that methodology had already become a common pool of statistical methodology in statistics texts, mistakenly attributed to as "statistical commons" contributed by several scholars in statistics. But on a careful examination we can realize that most of it was contributed by just one person Dr. C.R. Rao! Dr. Rao was elected a Fellow of the Econometric Society in 1972. In addition, Rao's score test is very widely used in econometrics, as a preferred test among the holy trinity of three tests-Likelihood ratio test, Wald test, and Rao Score test. The Breusch-Pagan test used widely in model choice literature in econometrics is a variant of Rao's score test. For further clarification and other major published work highlighting importance of Dr. Rao's work in econometrics one may refer to a centennial tribute to Dr Rao by Kumar, Vinod, and Deman (2020)- <https://www.ias.ac.in/article/fulltext/pmsc/130/0045> . A special issue of *Journal of Quantitative Economics* was brought out in 2022 honoring Dr Rao's 102nd birthday. The lead article in that issue was by Heckman and Pinto demonstrating the use of Orthogonal array design of experiments, developed by Dr. Rao, to remove the participant bias in social experiments. <https://link.springer.com/article/10.1007/s40953-022-00320-z>

The best tribute that can be paid Dr. Rao on this occasion of celebrating the highest honor he received in the field of statistics is to help keep that flag flying high by continuing that legacy of Mahalanobis and Rao-excellence in statistics.

REMEMBERING PROFESSOR K R PARTHASARATHY (25 June 1936 – 14 June 2023)

by PROF. B. V. RAJARAMA BHAT, INDIAN STATISTICAL
INSTITUTE, BANGALORE.



Professor Kalyanapuram Rangachari Parthasarathy passed away on June 14, 2023. With this we have lost a legend of modern Indian mathematics. He was a top level researcher, an extraordinary expositor, and an excellent writer. He has been a role model for many budding mathematicians of India. Professor Parthasarathy was known as 'Partha' to his foreign collaborators and friends, but in India, he was popularly known as 'KRP'. So hereafter I abbreviate his name to KRP. KRP hailed from the southern state of Tamil Nadu in India. His first five years of education were in Thanjavur, and he studied from class 6 to 10 in P. S. High School in Mylapore, Chennai. Subsequently, he completed 2 years of intermediate schooling and a 3 year mathematics honours course at the famous Vivekananda College of Chennai. The well-known geometer S. Ramanujan was one of his classmates. In 1956, KRP wrote the entrance test of the Indian Statistical Institute (ISI), Kolkata, and got admitted. It was ISI's silver jubilee year. The institute was being nurtured and developed by P. C. Mahalanobis and C. R. Rao. Those were early days, but already the institute had a culture of basic research. Teachers at the institute were mostly active researchers at the frontier of statistics. In the words of KRP: "For the first time, we could listen to proofs of theorems proved by our own teachers." In the Indian Statistical Institute, during 1956-1965, he was a contemporary of V. S. Varadarajan, R. Ranga Rao and S. R. S. Varadhan. The economic situation of the country at that time was quite harsh and the infrastructure in terms of hostel facilities etc. were quite poor in the Institute, but nothing

could prevent this dedicated bunch of youngsters with an extraordinary zeal to learn mathematics from immersing themselves in their studies. They plunged into intensive seminars on the latest developments in mathematics and probability theory, and taught each other whatever topic took their fancy. Their hard work paid off, with all four of them ultimately making fundamental contributions to mathematics. They came to be known as the 'Famous Four' of the Indian Statistical Institute. One result from his student days at Kolkata that KRP was fond of quoting is V S Varadarajan's proof of Kolmogorov's consistency theorem using the Riesz representation theorem. Apart from subjects directly related to probability theory such as measure theory, ergodic theory etc., the famous four also worked on the representation theory of Lie groups and Lie algebras, culminating in the famous Parthasarathy, Ranga Rao and Varadarajan (PRV) Conjecture. As per Varadarajan, it should have been called PRVV conjecture, as the problem was initially formulated jointly with Varadhan. KRP's PhD supervisor was the eminent statistician C. R. Rao. He suggested that KRP study the then emerging field of information theory for his dissertation. KRP followed the advice and in 1961-62 wrote his PhD thesis titled "Some problems of ergodic theory and information theory". Thanks to the great vision of Prof. P. C. Mahalanobis, the Indian Statistical Institute routinely hosted top intellectuals and political leaders from all over the world. This gave students in the institute a great opportunity to interact with several eminent scientists of the day. Prof. A. N. Kolmogorov, the founder of modern probability theory, was one such visitor, and KRP developed a strong mathematical bond with him. In 1962-63, KRP visited Kolmogorov in the Steklov Mathematical Institute, Moscow. Landing there must have been a huge cultural shock for a pure vegetarian from a warm tropical country. Though the visit was for just one year, it had a lasting impression on KRP. He could attend seminars of great mathematical stalwarts like E. Dynkin and I. M. Gelfand, and could also learn more about the life and work of Kolmogorov. The admiration and the high regard KRP had for Kolmogorov can be seen in the obituary he wrote (See Obituary: Andrei Nikolaevich Kolmogorov, the Journal of Applied Probability, Vol. 25, No. 1, 445-450, March 1988). After returning from Moscow, KRP was in Kolkata for a couple of years working with S R S Varadhan and others. It is in this period that he married Shyama. In 1965, he got a job offer from the University of Sheffield, UK, and moved there. Subsequently, he shifted to the University of Manchester. Thanks to the efforts of the famous analyst M. H. Stone, a well-wisher of Indian mathematics, KRP returned to India to take up a professorship at the Bombay University. Later, he moved to IIT Delhi, and after a short stint there, he shifted to the newly

established ISI Delhi on an invitation by C R Rao in 1976, where he remained for the rest of his career. Out of the famous four of ISI, only KRP returned to India for good. Thanks to the influence of Varadarajan, Kolmogorov, and others, probability theory and measure theory on groups and more general spaces had by then become KRP's main topic of interest. His monograph on 'Probability Measure on Metric Spaces' became an indispensable source for anyone interested in this subject, and is now considered a classic in the field.



Back in India, KRP had at this time become one of the most prominent faces of Indian mathematics. In ISI Delhi, KRP mentored several students, hired new faculty members, and contributed immensely to building the Stat-Math Unit of ISI Delhi to great glory. In the 1970s, KRP began a collaboration with Robin L. Hudson on exploring probabilistic ideas in quantum theory. Within a decade, they had discovered a way to develop an integration theory of infinitesimals of operators appearing in second quantization. It was a major discovery. With this, the subject of Quantum Stochastic Calculus was born. The crowning glory of the field was a beautiful 'Quantum Ito formula' developed by Hudson and Parthasarathy that extended the famous Ito formula to a non-commutative setting (See: Robin L. Hudson, and K.R. Parthasarathy. "Quantum Ito's Formula and Stochastic Evolutions". *Comm. Math. Phys.* 93(3): 301–323 (1984)). By developing a rigorous quantum stochastic calculus analogous to classical stochastic calculus, Hudson and Parthasarathy opened up new avenues for research in Quantum Probability and it quickly became a front-line area of research. By then, Prof. Luigi Accardi had formed a group of like-minded researchers and had started conducting international conferences on quantum probability and related fields annually. This group was also regularly publishing conference proceedings to keep track of the developments and to disseminate new ideas. Research talks and articles on the Quantum Stochastic Calculus of Hudson and Parthasarathy became a major component of these conferences and conference proceedings. Thanks to the untiring efforts of Prof. Luigi Accardi, a formal association to encourage research in this area titled "Association for Quantum Probability and Infinite

Dimensional Analysis" was founded with KRP as its first president. Meanwhile, KRP's research collaboration with Robin Hudson had developed into close personal friendship, and gave rise to a strong research tie in quantum probability between UK and India that persists to this day thanks to Prof. Martin Lindsay and several others. Several classical probabilists were attracted by the rapid developments in quantum probability. Prof. P. A. Meyer wrote a book titled 'Quantum Probability for Probabilists'. One may say it was a golden era for the subject of quantum probability. The Delhi Centre of the Indian Statistical Institute became an international hub for quantum probability. Prof. Kalyan B. Sinha (KBS) returned from the US to India and joined hands with KRP and made this possible. In 1987, some of us M. Stat students at ISI wanting to learn more mathematics shifted from Kolkata to Delhi (the author, Indranil Biswas and Anilesh Mohari were part of this group). We could not have asked for a better place to be. Famous names such as KRP, KBS, R. Bhatia, and R. L. Karandikar became our teachers. At this point, I cannot resist relaying an anecdote about KRP as a teacher. In our first mid-term examination in KRP's probability theory course, we were expecting a question paper with difficult and interesting questions from KRP. We thoroughly prepared ourselves for difficult questions by solving exercises from whichever relevant books we could find in the library. To our complete surprise, the question paper was extremely straightforward and only contained questions asking us to state and prove routine theorems that KRP had already covered in the class. We were totally unprepared for this, having overlooked the standard proofs in favour of perfecting the techniques needed to attack tricky, esoteric questions. Consequently, most of us did not do very well. After the examination, some of us went to KRP and complained that it was a very bookish question paper and we didn't expect it. He just smiled and didn't say a thing. We came back disappointed. Keeping the disastrous mid-term in mind, we prepared ourselves for the final exam by memorizing every statement and proof that KRP had covered in class. To our utter surprise, the final examination comprised solely of difficult, involved problems which we had never seen before. Having neglected such exercises during our preparation, we were in a pickle. KRP relented, and allowed us the entire day of the examination to submit the answers. The examination had started at 9.30AM. One of my classmates, Pinaki Chattopadhyay, wrote that examination up to evening 5.30PM, and KRP ensured that Pinaki had lunch, tea, and snacks supplied to the examination free of cost by ISI! It is an experience I will never forget. After completing my M. Stat degree, I enrolled for a PhD under KRP's supervision. Finding a research problem was never an issue with KRP: every day, he would pose some new problems based on the discussion of that day. It was for me to choose a problem of my liking. KRP was a perfectionist and a strong disciplinarian, stating that one should prove at least one new lemma every day.

Consequently, it was sometimes difficult for students to keep up with him, but those who persisted benefitted immensely from his deep insights into mathematics and his approach to life. The list of other PhD students he supervised includes Michael Bingham, Inder K. Rana, Rajendra Bhatia, S. Ramasubramanian, and Arup Pal.



During my PhD days, KRP gave an extraordinary lecture series on Quantum Probability at ISI Delhi. This lecture series finally led to his book, 'An Introduction to Quantum Stochastic Calculus', a book that is familiar to every researcher in quantum probability. This book is very aptly dedicated to "Brahma (the creator), Vishnu (the protector) and Shiva (the annihilator)", a reference to the creation, conservation, and annihilation operators of quantum theory. The book is likely to remain as the primary source for anyone wanting to learn this subject for many decades to come. KRP's passion and enthusiasm for mathematics was unparalleled. During my PhD days, one of my classmates, Anilesh Mohari (a student of KBS), was asked to read and present a certain technical paper. KRP, as faculty member, was in the audience. He was not happy with some of Mohari's explanations, and in the middle of the presentation, walked up to the board and started explaining the material animatedly. Mohari was very upset by this take-over, and huffed out of the room. The rest of us in the audience simply sat agape, too shocked by what had transpired to know what to do. KRP, meanwhile, was too engrossed in the mathematics he was explaining to notice any of this. He continued his explanation for about half an hour. Only later did he realize that the original speaker is nowhere to be seen. It was not just the field he pioneered that KRP was entranced by. Indeed, he had a penchant to move from one research area to another every few years. Whenever he would become interested in a new field or problem, he would immerse himself completely in it, and inevitably

made a major contribution. In 1998, he was a member of the IMU Executive Committee for the International Congress of Mathematics (ICM) in Berlin, an event for which he had also been an invited speaker in 1994 (in Zurich). The Berlin congress highlighted the work of Peter Shor and others on quantum computers and quantum algorithms, a topic that caught KRP's attention. In a few years, he started exploring quantum coding and quantum information theory, and published several papers on the topic. In a way, it was a homecoming to information theory for KRP, who once again studied the topics that had captivated him during his PhD. His book on quantum information theory, "Coding theorems of classical and quantum information theory", remains a very useful beginner's guide to the subject. Age had no effect on KRP's mathematical spirit. After his retirement, he continued to work at ISI Delhi as an emeritus professor. I had the privilege of hosting him at ISI Bangalore on several occasions, where he continued to work on mathematics. KRP told me that in ISI Kolkata, it was common practice to think about mathematics while walking around the multiple ponds on campus, an activity fondly called 'pondering'. He continued the practice of thinking with his legs during his visits to the ISI Bangalore campus post-retirement, and greatly enjoyed walking around our campus while talking about mathematics and mathematicians. Towards the latter portion of his life, KRP became particularly interested in quantum Gaussian random variables. As the name suggests, these are quantum or non-commutative versions of classical Gaussian random variables. Here, we have states (or density matrices) inducing Gaussian distributions for position and momentum observables. The subject is old and well-established. Like in the classical multivariate Gaussian distribution, states of quantum Gaussian random variables are described by mean vectors and covariance matrices. Surprisingly, KRP (jointly with Dr. Tiju Cherian John, a young mathematician) found a brand new way to parametrize quantum Gaussian random variables through a generating function approach, transforming the picture completely. Many computations which had been difficult and tedious became much simpler with this new parametrization. With age, KRP had begun to face some eye problems related to glaucoma that impaired his vision and made reading increasingly difficult. He nevertheless continued to pursue active research in mathematics, and younger collaborators — Ritabrata Sengupta, Tiju Cherian John and Usha Devi A R — assisted him in reading and typesetting their joint work while also benefitting from interacting with KRP. The work often required very intricate computations, which KRP could elegantly visualize in his mind despite being unable to read what he himself had written in previous steps! KRP was a towering figure in quantum probability, and was internationally renowned and respected for his fundamental contributions to mathematics at large. Through the course of his illustrious career, this fame was also accompanied by some official recognition

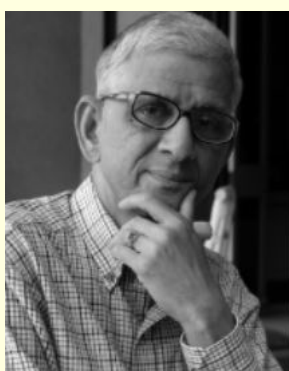
from various sources beyond the pure mathematics community. He was elected a fellow of all the three academies of science in India. He received the Shanti Swarup Bhatnagar prize for Science in 1977, and was conferred two honorary DSc degrees from across two continents: one from ISI, and the other from Nottingham Trent University. He was also honoured with The World Academy of Sciences (TWAS) Prize for Mathematics in 1996. Even after developing a reputation as a mathematical giant, it is no exaggeration to say that KRP lived like a 'rishi' with a very simple lifestyle completely dedicated to mathematics. In ISI Delhi, one could see him at his office from 9 AM to 5 PM, diligently working on mathematics, every single day without fail. I once asked him at what time of the day he found it best to do mathematics. He replied that he found the early morning, around 5.30 AM, the most productive time for mathematics, and was also his preferred time for writing books. This meant, of course, that he was working on mathematics even before coming to the office! He continued this habit even post-retirement: On his visits to Bangalore, he would unfailingly borrow a small table lamp from me to work before sunrise without disturbing Shyama. KRP was a great story teller, and always regaled students with anecdotes of himself and other mathematicians. During his time in Delhi, faculty and students alike used to enthusiastically gather in the lush green lawns in front of the canteen during the ritualistic tea time to join in conversation with KRP. His memory was phenomenal: Occasionally, he would recall Sanskrit verses he had learnt in his childhood. While talking about his time in Moscow, he would captivate his audience by perfectly recalling political speeches by Russian leaders that he had

heard during his stay. However, any conversation with KRP usually ended up turning into serious mathematical discussions, and one always left the conversation feeling like they had a deeper understanding of mathematics. True to his dedication to mathematics for its own sake, KRP was always contemptuous of formalities. One of the operator theory conferences in a local university began with a grand opening ceremony with garlanding of the vice chancellor and so on. Later, when his turn to lecture came, KRP remarked that: 'All operator theory conferences should begin with "Let H be a Hilbert space". Nothing more is needed.' Shyama was KRP's other half. She enabled his intensive research career by taking family responsibilities for all their married life of about sixty years. KRP is survived by Shyama, his sons Ramesh & Harish, as well as grand-children and other family members. Professor K. R. Parthasarathy is being mourned by thousands of students and researchers. Anybody who interacted with him would cherish the memory for life. True to his spirit, he will live on with us through his work, not only through the field he helped birth and the various corners of mathematics he contributed to, but also through the countless students who draw deep inspiration from his life and work.

PS: I had the privilege of interviewing KRP in 2015. A video recording of the interview can be found here: <https://www.youtube.com/watch?v=C7T9REQAuvc> and a written transcript can be found here: <https://bhavana.org.in/a-different-kind-of-mind/>.

©Prof. B. V. Rajarama Bhat, ISI Bangalore. July 2023.

Prof. K.B. Athreya (12 December 1939 – March 24, 2023)



It is with great sadness we announce to the IISA community the passing of Prof. Krishna B. Athreya. Prof. Athreya was a distinguished professor emeritus of Mathematics and Statistics at Iowa State University. He had a long and productive career, holding faculty positions at the University of Wisconsin, Madison; the Indian Institute of Science; Cornell University; and Iowa State University.

He passed away at his home in Ames, Iowa, on March 24, 2023, from complications of Multiple System Atrophy (MSA), a rare neurodegenerative disease.

During his career, Prof. Athreya made significant contributions to the fields of probability theory, branching processes, renewal processes, regenerative Markov chains, and measure theory. He authored several publications, including a definitive treatment of the topic of branching processes with Peter Ney.

Prof. Athreya was committed to making mathematics accessible to everyone. He wrote a comprehensive graduate-level textbook, Measure Theory and Probability, with Soumendra Lahiri to introduce the subject to a wider audience. Prof. Athreya also traveled to towns in India to give lectures on mathematics to high schoolers.

Prof. Athreya was a life member of IISA, being involved with the association since its inception. In his passing, IISA lost a great supporter and well-wisher. Prof. Athreya's legacy continues through his doctoral students who carry on his work. His impact on the field of mathematics is immeasurable, and his contributions will be remembered for years to come.

Report on IISA 2022 Conference

The International Indian Statistical Association (IISA) organized a conference on December 26-30, 2022, at the campus of the Indian Institute of Sciences (IISc), Bangalore, India. The conference program consisted of four plenary talks, including the Bahadur Memorial Lecture, eight special invited talks, four panel-discussion sessions, nearly two hundred fifty invited talks, over one hundred contributed talks, and a poster session with about twenty-five posters on diverse topics, including mathematical statistics, probability, applied statistics, biostatistics, machine learning and others. Prof. Soumendranath Lahiri delivered the Bahadur Lecture on high-dimensional central limit theorems. Three other plenary talks were given by Professors Kalyan Das on Precision Medicine, Hao Helen Zhang on High-dimensional Statistics, and Igor Pruenster on Random Partition Processes in Bayesian Nonparametrics. The four panel discussion sessions were about Statistics of Cricket, Diversity, Women in Data Science, and Modeling of Covid Data. Four special invited sessions covered the topics of Applied Machine Learning, Bayesian Nonparametrics, Multivariate Rank Testing and Stochastic Processes on Networks, and Biostatistics. During the invited sessions, speakers from many different fields talked about almost every area of modern statistics, probability, biostatistics, machine learning, genomics, and applications. Two student paper competitions and a student poster competition were conducted. Three winners from each category were awarded with certificates and cash prizes. Three short courses, respectively on Precision Medicine, Statistical Analysis using R, and Deep Learning, were offered to participants who registered for these courses. The instructors of these short courses were Drs. Bibhas Chakraborty, Ayush Patel and Heather Turner, and Abhinanda Sakar, respectively. In terms of participation, the conference was a huge success. More than four hundred participants attended the conference from India, the United States and many other countries. Most presentations were in the in-person mode. Only a few presentations were virtual. The main conference began on 26 th December after lunch and ended at lunch on 30 th December. An award ceremony took place during the banquet on 29 th December. Generous contributions from sponsors including Pfizer, Merck, Indian Statistical Institute, American Statistical Association, ICAST, R-studio, Springer and an anonymous donor institution, and funding from the US National Science Foundation, and the National Board of Higher Mathematics of India, allowed keep the registration fee relatively low, especially for participants from India, and providing travel support to many students and junior researchers. The conference offered excellent opportunities of socialization. IISc provided excellent facilities and human resources to make the conference successful. IISA gratefully acknowledges the tremendous effort of the local organizing committee to make the conference a great success.

–Subhashis Ghoshal
Chair of the Scientific Committee, IISA 2022

IISA Lifetime Achievement Award for 2021

It is our pleasure and honor to announce that Dr. Sati Mazumdar from University of Pittsburgh and Dr. J. V. Deshpande from Savitribai Phule Pune University have won the IISA Lifetime Achievement Award for 2021. Their dedicated service to our profession, our society and to the community at large made us proud. Congratulations Dr. Mazumdar and Dr. Deshpande! Please see their biographies below.



Dr. Mazumdar received her bachelor's and master's degrees in statistics from the University of Calcutta, India and her doctoral degree in 1967 in statistics from Cornell University, Ithaca, NY, USA. She joined as a faculty member in the Department of Biostatistics, and the Graduate School of Public Health, University of Pittsburgh. With over 40 years of professional expertise, Dr. Mazumdar retired as a Professor Emeritus of the University of Pittsburgh in 2013. She also held a secondary Professorship in University of Pittsburgh Medical School. During her long tenure, she was a core faculty in the masters and doctoral teaching programs and served as advisor of doctoral students, mentored postdoctoral fellows and junior faculty members in the departments of biostatistics and psychiatry.

Dr. Mazumdar has served in various professional committees and panels of the University of Pittsburgh and US Government Agencies. She served as a member of an Advisory Committee of FDA (1983-1987). Additionally, she regularly reviewed articles for several prestigious journals including JASA, SANKHYA and Archives of General Psychiatry. She was the program director of ENAR at the JSM in 2002. In 2007 Sati served on an expert panel organized by the Toxicology Excellence for Risk Assessment (TERA) of analyzing correlation of toxicological effects with the polycyclic aromatic compound (PAC) content of petroleum substances.



A M.Sc. in Statistics in 1962 and Ph.D. in Statistics in 1965, both from Savitribai Phule Pune University, Dr. Deshpande obtained a B.Sc. Hons. in Statistics in 1960 from Patna University. Professor J.V. Deshpande had worked as a teacher and as a researcher continuously since 1962. He started his meritorious teaching career in India in 1972, first at Punjab University, Chandigarh and then at University of Pune till his superannuation in 2002. Thereafter, he has been working at various Institutions in India and abroad. His research work spans the areas of Nonparametric Statistics, Survival Analysis and Reliability, Ranking and selection procedures and applications to portfolio analysis. He has guided ten students for the Ph.D. degree most of whom are still active statisticians.

Prof. Deshpande awarded Prof P.V. Sukhatme Lifetime Achievement Award by the Ministry of Statistics and Programme Implementation of the Govt of India in 2012. He was elected a Fellow of the Institute of Mathematical Statistics in 1995 and a member of the Council of the International Statistical Institute in 2004. Professor Deshpande has co-authored three text books in the area of Survival Analysis and Nonparametric Statistics.

IISA Lifetime Achievement Award for 2022

It is our pleasure and honor to announce that Dr. Dipak Dey from University of Connecticut has won the IISA Lifetime Achievement Award for 2022. Dr. Dey's dedicated service to our profession, our society, and to the community at large made us proud. Our heartiest congratulations to Dr. Dey! Please see his short biography below.



Dr. Dipak Dey's research portfolio encompasses diverse problems in statistical theory and methods focusing primarily on Bayesian decision theory and related developments in categorical and longitudinal data, clustering and classification, spatio-temporal data and survival data analysis. His research has been disseminated through diverse outlets including over 300 scholarly peer-reviewed articles, over 10 books or edited volumes, and more than 250 talks delivered at professional meetings and various academic departments across the world. His books continue to be standard references and pedagogical resources for practitioners from various disciplines. Substantive scientific areas that his research has embraced include applications of statistics in biology, chemistry, computer science, econometrics, and geosciences, medicine, and optics.

Dr. Dey's excellence in research has been recognized through the conferral of a vast array of awards and honors. These include his elected Fellowships of the American Statistical Association (ASA), the Institute of Mathematical Statistics (IMS), the American Association for the Advancement of Science (AAAS) and the International Society for Bayesian Analysis (ISBA), and an elected membership of the International Statistical Institute (ISI).

IISA Early Career Award in Statistics and Data Science (ECASDS)

In the IISA 2022 conference held in December 2022 at Bengaluru, India, we announced this year's IISA Early Career Award in Statistics and Data Science (ECASDS) awardees. We are pleased to recognize their contributions in the field of statistics and data science. Please join us in congratulating Dr. Mukherjee, Dr. Narisetty, and Dr. Mallick!

Theory & Probability

Dr. Gourab Mukherjee

Associate Professor of Data Sciences and Operations, University of Southern California



Methodology & Applications

Dr. Naveen Narisetty

Associate Professor, Department of Statistics, University of Illinois Urbana-Champaign



Practice

Dr. Himel Mallick

Associate Principal Scientist, Merck Research Laboratories



IISA Junior Service Award, 2023

IISA has introduced the IISA Junior Service Award from this year to recognize individuals for their exceptional contribution to IISA through dedicated service. We are happy to announce that the inaugural Junior Service Award has been given to Dr. Debashis Mondal for his outstanding service to the IISA.



Congratulations, Dr. Mondal!



Poster Session at the IISA 2023 Conference

Prof. S.R.S. Varadhan conferred Padma Vibhushan

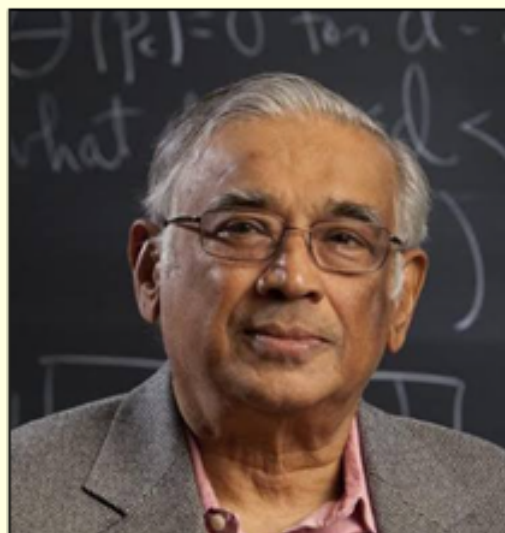
It is our pleasure and honor to announce that Prof. S. R. S. Varadhan has been conferred the Padma Vibhushan, the second-highest civilian award in India. A Professor at the Courant Institute of Mathematical Science, New York University, Prof. Varadhan is one of the world's most celebrated mathematicians of the 20th century. He is known for his fundamental contributions to the theory of diffusion processes and large deviations.

Prof. Varadhan was awarded the Abel Prize—the equivalent of the Nobel prize in mathematics—in 2007. He was the first Asian to win this prize. In 2010, Prof. Varadhan received the United States National Medal of Science. He gave the prestigious Wald lecture in probability in 2005, is a Fellow of the Royal Society and a member of the US National Academy of Sciences. Before his Padma Vibhushan, Prof. Varadhan was awarded Padma Bhushan by the Government of India in 2008.

Prof. Varadhan's connection to IISA goes back decades. He was a member of the IISA Board of trustees

from 2004 to 2007, and was a plenary speaker in the IISA 2011 conference held in Raleigh, NC, USA.

We congratulate Prof. Varadhan on his latest recognition, and are grateful for his contributions to mathematics, probability, and statistics research.



Prof. Kanti Mardia has been made OBE

It is our pleasure and honor to announce that Prof. Kanti Mardia has been made an Officer of the Order of the British Empire (OBE), in the 2023 New Year Honours. A Senior Research Professor at the University of Leeds, Prof. Mardia is one of the most distinguished Indian statisticians of the present day. He is known for his pioneering work on multivariate analysis, directional data, and statistical measures of shape. Prof. Mardia's book *Multivariate Analysis* (jointly written with J. T. Kent and J. M. Bibby) is a household name among statistics students.

Prof. Mardia is the founder of the RSS Mardia Prize, awarded by the Royal Statistical Society (RSS) for interdisciplinary research. Among his many honors, Prof. Mardia received the Guy Medal in Silver by the RSS, and the Wilks Memorial Award by the American Statistical Association. Prof. Mardia was awarded the IISA Lifetime Achievement Award in 2019.

We congratulate Prof. Mardia on this stellar honor, and are grateful for his contributions to statistics research and education.



Prof. Arup Bose wins Mahalanobis International Award

IISA is proud to announce that Prof. Arup Bose, Professor of Theoretical Statistics and Mathematics at ISI Kolkata, has won the prestigious Mahalanobis International Award. The Government of India sponsors the Mahalanobis International Award, which, managed by the International Statistical Institute, is presented every other year at the International Statistical Institute World Statistics Congress. The Mahalanobis Award recognises an individual for lifetime achievements in statistics in a developing country or region. Read the official announcement here: <https://bit.ly/46xuMa0>.

Heartiest congratulations to Prof. Arup Bose!



IISA 2023 Student Awards

IISA celebrates the Student winners in various categories at the recently concluded 2023 Conference in Colorado School of Mines, CO.

Student Paper - Application

Gaurab Hore	University of Maryland at Baltimore County
Elizabeth B Amona	Virginia Commonwealth University

Student Paper - Theory

Ritwik Sadhu	Cornell University
Dohyeong Ki	University of California, Berkeley

Poster Award

Sattwik Ghosal	Iowa State University
Meng Jia	Colorado School of Mines
Priyanjali Bukke	George Mason University
Indrila Ganguly	North Carolina State University
Maggie D Bailey	Colorado School of Mines



Student Paper Competition participants at IISA 2023 Conference

Appreciation letters for IISA 2023 Conference



Dr. Terri S. Hogue
Dean and Professor
Earth and Society Programs
Colorado School of Mines
Golden, Colorado 80401-1887
E-mail: thogue@mines.edu
[303-384-2588](tel:303-384-2588)

June 14, 2023

Dear IISA members,

On behalf of the Earth and Society Programs at the Colorado School of Mines, I extend my warmest congratulations on the successful completion of the 2023 International Indian Statistical Association (IISA) Conference. It gives me immense pleasure to acknowledge the remarkable efforts and achievements made during this momentous event, which was jointly organized by the International Indian Statistical Association and the Department of Applied Mathematics and Statistics (AMS).

Organizing a conference of such magnitude requires substantial effort and dedication, and the successful execution of IISA is a testament to the invaluable time and energy generously volunteered by numerous individuals. I would like to express my sincere gratitude to AMS for their unwavering support in making this conference a resounding success. In particular, I would like to extend a special mention to Soutir Bandyopadhyay, the lead of the local organizing committee, Gus Greivel, Interim Department Head of AMS, and Lisa Maddux, AMS Department Manager, for their exemplary commitment and contributions. I would also like to extend my appreciation to all the individuals associated with IISA, including the organizing committee members, session chairs, speakers, and presenters. Your expertise and dedication played a pivotal role in ensuring the smooth flow and academic excellence of the conference. Additionally, I would like to express my gratitude to the dedicated student volunteers who selflessly contributed their time and efforts to make this event a memorable one.

I take this opportunity to also provide a glimpse of the Colorado School of Mines and its milestone celebration, Mines@150. Founded in 1874, the Colorado School of Mines has a rich history of academic excellence and innovation in the fields of engineering, applied sciences, and mathematics. As we celebrate our 150th anniversary, we continue to strive for excellence in research, education, and community engagement. The successful organization of the IISA Conference at our esteemed institution reflects our commitment to fostering collaborative academic environments and promoting advancements in statistical sciences. Moreover, I am delighted to inform you that AMS has achieved remarkable success at the IISA Conference. The student paper and poster competitions witnessed outstanding contributions from our AMS students, showcasing their exceptional research abilities and dedication to their respective fields. Their achievements are a testament to the quality of education and mentorship provided by our esteemed faculty members.

In conclusion, I want to express my sincere congratulations once again to all the attendees of the 2023 IISA Conference. Your dedication, hard work, and contributions have made this conference a resounding success, fostering academic excellence and collaboration in the statistical sciences. I wish you all continued success in your future endeavors.

Sincerely,

Terri Hogue, PhD





June 6, 2023

Subhashis Ghoshal
President, International Indian Statistical Association
Goodnight Distinguished Professor of Statistics
North Carolina State University

Dear Subhashis:

I am writing to formally thank the International Indian Statistical Association (IISA) and all its members for holding your annual conference at the Colorado School of Mines (Mines). As the department of Applied Mathematics and Statistics at Mines continues to grow more prominent in the statistics community, we recognize and appreciate the opportunity to collaborate with the IISA to host a conference of this magnitude. Furthermore, the opportunity to expose our students to such a diverse and excellent collection of faculty and students from many of the finest universities in the world will have a lasting benefit to our emerging programs.

I would like to thank all of those involved in the organization of this event. In particular, I have observed the efforts of Soutir Bandyopadhyay and Lisa Maddux to lead the organization on behalf of Mines and the Department of Applied Mathematics and Statistics. I have also been impressed by the initiative and collegiality of the members of the IISA with whom I've had the pleasure of working. The efforts of the Local Organizing Committee, the International Organizing Committee, and the Scientific Programme Committee should also be commended, as all three were instrumental to the organization of this event. The event emphasized collaborative spirit, leading to insightful discussions and valuable networking opportunities, and was a joy to attend.

On a personal note, I have been a member of the Mines community for the best part of three decades and have been involved in the leadership Applied Mathematics and Statistics (and its predecessor Mathematical and Computer Sciences) for much of the last two decades. I have seen our statistics and data science programs evolve over the years, and I incredibly excited about the current trajectory of these programs at Mines and in the broader global setting. From my vantage point, this conference marks a major milestone for our department and our campus, and we are privileged to host such an outstanding array of attendees, presenters, and sessions. I would also like to acknowledge the students who presented their work in the Student Paper Sessions as well as Friday's Poster Session. They represent the future of the profession, and their contributions are already quite impressive.

To all the membership of the IISA and all the attendees, thank you so much for joining us in our quiet (but beautiful) little corner of the world!

Sincerely,

Gus Greivel
Interim Department Head & Teaching Professor of Applied Mathematics and Statistics
Newmont STEM Equity Faculty Fellow
Colorado School of Mines

Mail: 1301 19th Street, Golden, CO 80401
AMS Office: Chauvenet Hall 141 AMS Phone: 303-273-3880 Web: ams.mines.edu



Dr. Surya Tokdar becomes IMS Fellow

Congratulations to Dr. Surya Tokdar, Professor and interim chair of Statistical Science at Duke University, on being awarded the title of Fellow of the Institute of Mathematical Statistics (IMS).



Dr. Himel Mallick becomes ASA Fellow

Congratulations to Dr. Himel Mallick, our esteemed life member, on being awarded the title of ASA Fellow for the year 2023!



Dr. Abhi Datta wins Abdel El-Shaarawi Early Investigator's Award for 2023

Dr. Abhi Datta, Associate Professor in the Department of Biostatistics at Johns Hopkins Bloomberg School of Public Health was awarded the Abdel El-Shaarawi Early Investigator's Award for 2023 by the International Environmental Metrics Society (TIES). This is a major award in the spatial/environmental statistics community, given annually to a researcher within 12 years of completion of their PhD for their statistical contributions to Environmental Sciences. As the recipient of the award this year, Abhi will give the Plenary Talk at the TIES Conference in July,

2023, in Peterborough, Canada. Congratulations to Dr. Abhi Datta!



Dr. Sayantan Banerjee awarded SERB MATRICS grant

Dr. Sayantan Banerjee, Associate Professor at the Indian Institute of Management Indore, has been awarded the prestigious Mathematical Research Impact Centric Support (MATRICS) grant this year from the Science & Engineering Research Board (SERB), Department of Science & Technology, Govt. of India. This three-year grant award will fund his research into Bayesian clustering techniques.



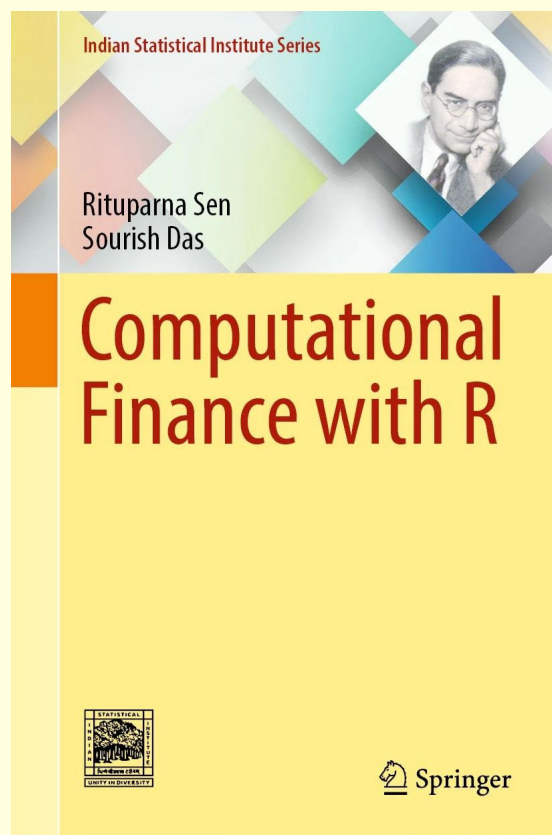
Prof. Siddhendu Biswas Travel Award

Caucus for Women in Statistics (CWS) is pleased to announce the Prof. Siddhendu Biswas Travel Award for 2023. Details can be found at <https://cwstat.org/2023-cws-annual-travel-award/>.

The award is for women Ph.D. students in developing countries to present their research at an international conference in India. The deadline for application is August 31, 2023. The inaugural award was presented last year at IISA 2022 conference in Bangalore.

New book on Computational Finance

Dr Rituparna Sen and Dr. Sourish Das have recently published a textbook titled "Computational Finance with R." The book was published in the ISI Book Series with Springer. The book will prepare the students to execute the quantitative and computational needs of the finance industry. The quantitative methods are explained in detail with examples of real financial problems including option pricing, risk management, and portfolio selection, among others. Codes are provided in R programming language to execute the methods. We hope students and young professional who aspires to work in finance will find this book useful.



Distinguished Professorship for Dr. Ravindra Khattree

IISA is glad to announce that our lifetime member Dr. Ravindra Khattree has been appointed as a Distinguished Professor of Applied Statistics at Oakland University.



Dr. Suprateek Kundu elected as member of ISI

IISA is glad to announce that Dr. Suprateek Kundu, Associate Professor at UT MD Anderson Cancer Center, Houston, has been elected as a member of the International Statistical Institute.



Dr. Ofer Harel becomes Interim Dean at UConn

Our life member, Dr. Ofer Harel, has been appointed as the Interim Dean of the College of Liberal Arts and Sciences and a professor in the Department of Statistics at the University of Connecticut.



IISA Sponsored conference hosted at UT Dallas

The Department of Mathematical Sciences at the University of Texas at Dallas (UTD) recently hosted a conference, *Advances in Statistical and Computational Methods for Analysis of Biomedical, Genetic, and Omics Data*, on March 17-19, 2023. IISA was one of the sponsors.



Celebrating 10 years of Prof. Dipak Dey

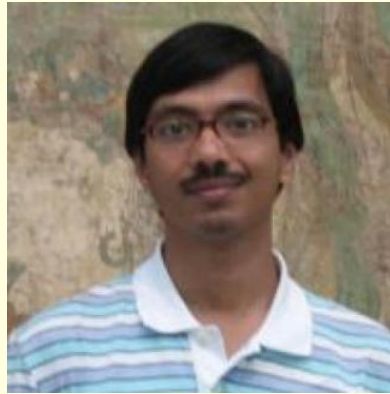
Department of Statistics at Virginia Tech is organizing a two-day conference on the theme "Pushing the Boundary of Data Science through Statistical Modeling and Inference" in honor of Prof. Dipak K Dey. The conference, held on July 13-14, 2023 at Virginia Tech, Blacksburg, VA, is a celebration of Prof. Dey's 70th birthday. The event brings together Dr. Dey's former students, collaborators, friends, and mentors to recognize his significant contributions to the field of Statistics. The conference program covers a broad range of topics, from cutting-edge statistical modeling and inference to innovative data science techniques in various applications. For more details, please visit <https://sites.google.com/view/dipakdeyconference/home?pli=1>.



Instituto de Ciência Exatas – ICEx, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil, is organizing "A New Era of Statistical Science: A Special Conference in Honor to Prof. Dipak Dey's 70th Anniversary" from August 16 to August 18, 2023. For more details, please visit <https://www.redeabe.org.br/a-new-era-of-statistical-science/>.

Treasurer's report

by ABHYUDYAY MANDAL, TREASURER, IISA



This report aims to provide an overview of IISA's financial activities. A financial summary of IISA for the year 2022 is given here.

	Beginning of year	End of year
Total assets (cash, savings and investment)	\$292,592	\$367,598
Total liabilities	\$7,214	\$17,060
Net assets or fund balances	\$285,378	\$350,538

IISA used the service of a tax professional to file taxes. In 2022, IISA experienced positive financial growth. Here is a summary:

- Total Revenue: The total revenue earned during 2022 amounted to \$99,988.
- Expenses: The organization incurred expenses amounting to \$34,828 during the year.

IISA at JSM 2023, Toronto

We are pleased to announce the upcoming International Indian Statistical Association (IISA) Mixer at the Joint Statistical Meeting (JSM), which will take place on Monday, August 7th, from 5:30 PM to 7:30 PM. This exciting event will be held at the Delta Hotels by Marriott Toronto, Canada in Room D - SOCO Ballroom B.

The IISA Mixer is an excellent opportunity for statisticians, data scientists, researchers, and professionals from various fields to come together and network with fellow

experts in the industry. It promises to be an evening filled with engaging conversations, knowledge sharing, and the chance to establish valuable connections within the statistical community.

Event: International Indian Statistical Association (IISA) Mixer Date: Monday, August 7th Time: 5:30 PM - 7:30 PM Venue: Delta Hotels by Marriott Toronto Room: D - SOCO Ballroom B

Follow us on LinkedIn!

Follow the official LinkedIn
account of IISA.

Get regular updates.



<https://www.linkedin.com/company/international-indian-statistical-association/>

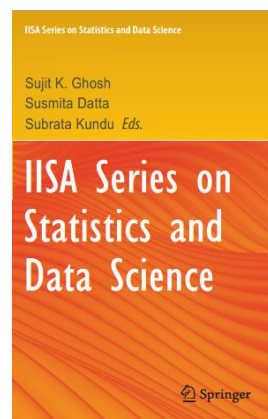
Springer collaborates with International Indian Statistical Association

IISA Series on Statistics and Data Science

Publish your next book in this series!

Series Editors

- **Dr. Sujit K. Ghosh**
Department of Statistics, NC State University, Raleigh, USA
- **Dr. Susmita Datta**
Department of Biostatistics, College of Public Health & Health Professions,
College of Medicine, University of Florida, Gainesville, USA
- **Dr. Subrata Kundu**
Department of Statistics, George Washington University, Washington D.C., USA



Aims and Scope

The book series is aimed at promoting the emerging research and case studies in the discipline of statistical science and cutting-edge computational data analytics by publishing books on theoretical foundations, computational techniques, methods, models and their applications. In addition to methodological research, the series will also include volumes on case studies that illustrate novel methods with applications to allied sciences including but not limited to biological, biomedical, epidemiological, engineering, finance, statistical learning and artificial intelligence. The books published within this series will be of interest not only to statisticians and researchers in academia but also to practitioners in industries and government institutions.

The series will encompass theoretical aspects of statistical methods, as well as innovative applications and their properties in the context of big data analytics, and data science, in general. The scope of the series will be broad based such that it can be used as a reference book of various topics of statistical instructions and advanced research monographs. A few volumes of this series will include articles presented by eminent researchers and practitioners at the annual conferences of the International Indian Statistical Association and will also include articles that provides comprehensive overview of some of the emerging and changing foci of statistical sciences and data analytics.

Forthcoming in this Series:

- **High Dimensional Data Science (2023)**
Ed. Snigdhanu Chatterjee, University of Minnesota, USA
- **Statistics in Clinical Development of Cancer Drugs: Recent Trends & Advances (2024)**
*Eds. Madan G Kundu, Biostatistics & Data Management (BDM), Daiichi Sankyo Inc, USA
Samiran Ghosh, Biostatistics School of Public Health, The University of Texas Health at Houston, USA*
- **Frontiers of Statistics and Data Science (2024)**
*Eds. Subhashis Ghosal, North Carolina State University, USA
Anindya Roy, University of Maryland, Baltimore County, USA*

Submit your proposal for a new monograph or contributed volume in this series

- Let your book benefit from being part of the largest STM eBook Collection
- Get a wider readership and increased longevity for your book
- Help you find your audience and your audience find you
- Get insights into the usage of your book

Contact Your Publishing Editor: Nupoor Singh: nupoor.singh@springer.com

Visit the series homepage on [springer.com](https://www.springer.com/series/16210) <https://www.springer.com/series/16210>

Aren't you a member of IISA yet?



Join Us!

Become a Member of our Exclusive Community

Are you ready to be a part of something extraordinary?

We are thrilled to announce that membership is now open for IISA! As a member, you'll have access to a wide range of benefits and opportunities. Join us and be a part of the extraordinary Statistics community!

Student membership is FREE!

Whether you are a professional looking for networking opportunities, an enthusiast passionate about Statistics, or someone seeking personal growth and development, our community welcomes you with open arms.

Don't miss out on this incredible chance to make a difference!

Visit our website at www.intindstat.org to learn more about our organization, the membership benefits, and how to join. Together, let's create a brighter future!

Join now and be part of something extraordinary!



Coming Soon in September 2023!

IISA Newsletter is getting updated

Check out our next issue