

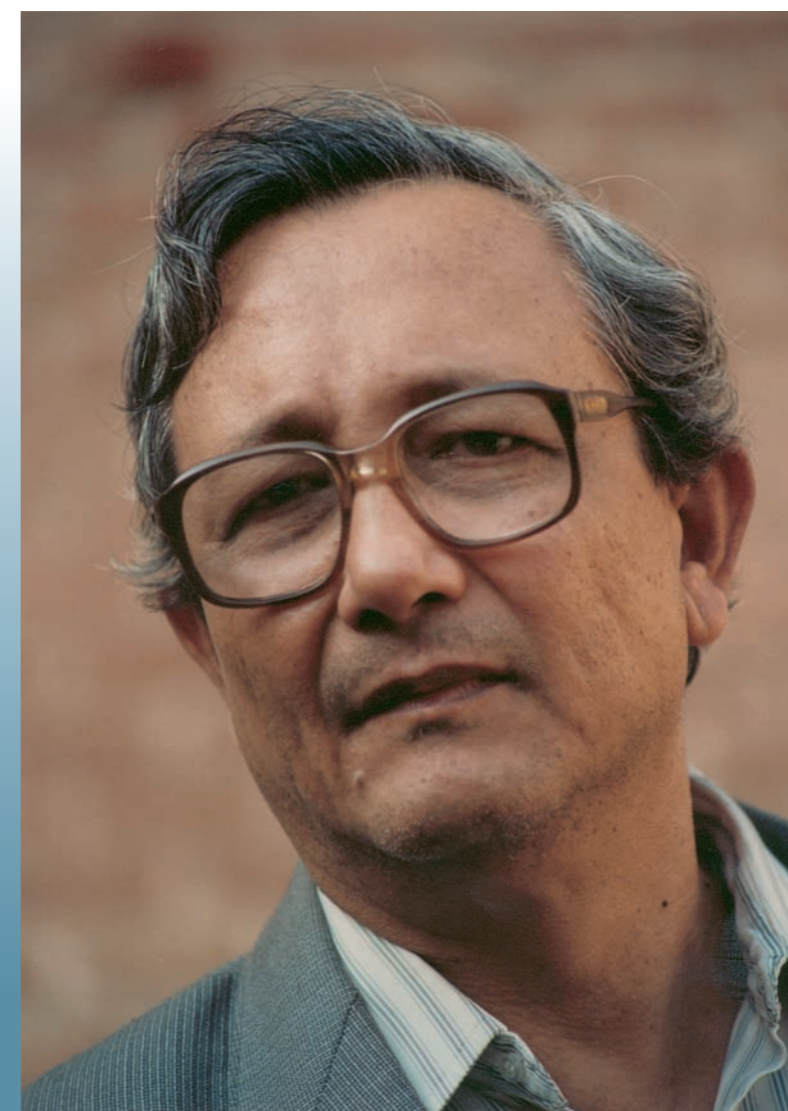


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A conversation with Sujit Kumar Mitra in 1993 and some comments on his research publications

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University of Tampere
Department of Mathematics, Statistics and Philosophy
Report A 372 December 2006

A conversation with Sujit Kumar Mitra in 1993 and some comments on his research publications

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Photo on the front cover (Simo Puntanen):

Sujit Kumar Mitra, New Delhi, December 1992.

Photo on the back cover (Simo Puntanen):

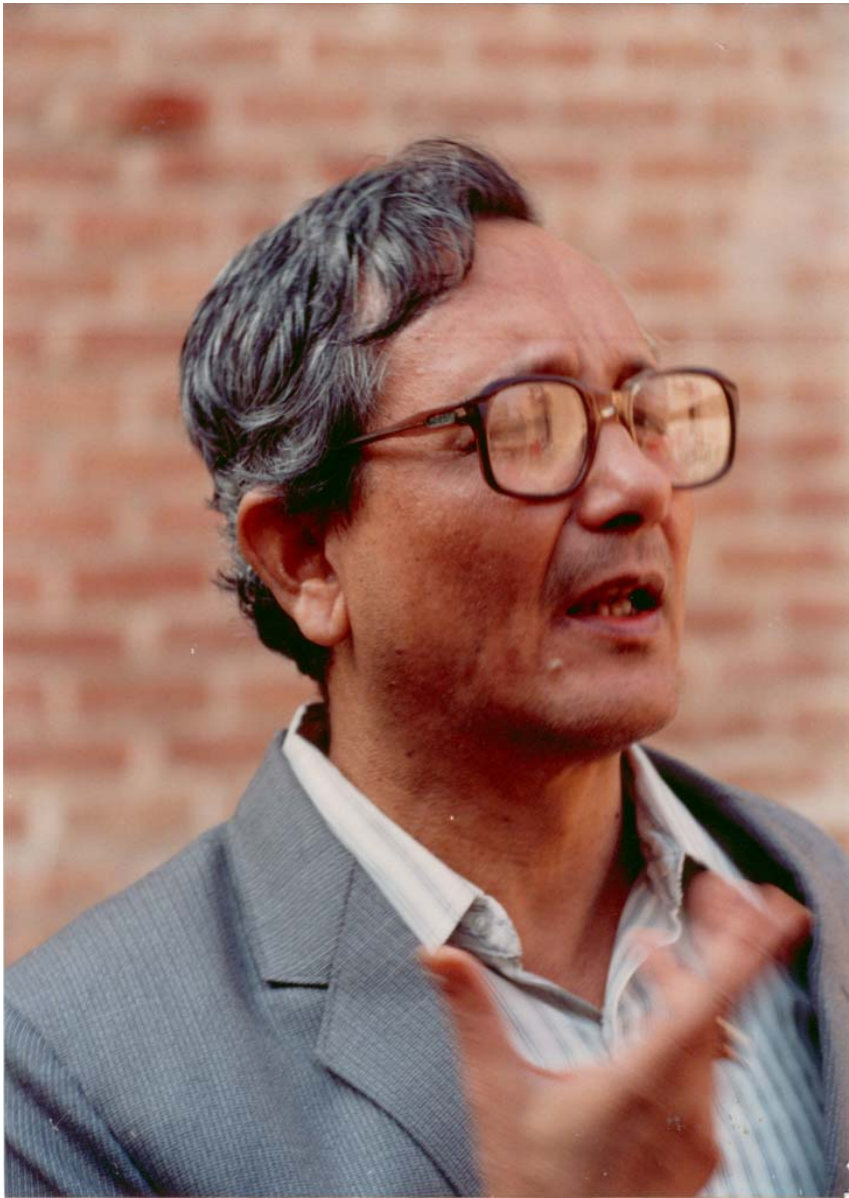
Sunset in the Hooghly River, Calcutta, December 1994.

This Report A 372 is a preliminary edition of “A conversation with Sujit Kumar Mitra in 1993 and some comments on his research publications”.

Tampereen Yliopistopaino Oy
December 2006

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Simo Puntanen

Figure 1: Sujit Kumar Mitra, New Delhi, December 1992.

Sujit Kumar Mitra (1932–2004)

Sujit Kumar Mitra was born on 23 January 1932 in Calcutta¹, India. He earned his B.Sc. degree in Statistics from Presidency College, Calcutta, in 1949, and his M.Sc. degree in Statistics, from Calcutta University, in 1951. He spent two years, August 1954–August 1956, in the Department of Statistics at the University of North Carolina at Chapel Hill, completing his Ph.D. thesis entitled “Contributions to the statistical analysis of categorical data” under the guidance of Samarendra Nath Roy (1906–1964), in 1956. Sujit Kumar Mitra passed away at his home in New Delhi on 18 March 2004. He was survived by his wife, Sheila, whom he married in 1958, three daughters, Utsa, Ipshita and Anindita, and a son, Kaustav, and their families.

At the Indian Statistical Institute (ISI) in Calcutta, Dr. Mitra was a Lecturer from 1956–1958, Reader from 1959–1963, and Professor from 1963–1971. He was also Professor of Statistics at ISI, New Delhi, 1974–1991, and Distinguished Scientist there, 1991–1992. He retired in 1992 and continued as Professor Emeritus.

Professor Mitra held several visiting professorships in the United States and Japan: Indiana University, Bloomington, June 1971–August 1974 (also June–August 1977 and May–November 1980), Keio University, Japan, September 1974, Purdue University, West Lafayette, January–May 1981, and University of Texas at Dallas, January–May 1984.

Professor Mitra’s main interests were statistical methodology, multivariate analysis, design of experiments, and matrix algebra, particularly concerning the concept of a generalized inverse of matrix. His classic book with Calyampudi Radhakrishna Rao, *Generalized Inverse of Matrices and Its Applications* (Wiley, 1971), presented “a general unified treatment of the concept of inversability of singular, and in general rectangular, matrices over the complex field” (Plemmons, 1975), and has been used with enthusiasm by mathematicians and statisticians all over the world; a Japanese translation was published in 1973. Very appropriately, Sujit Kumar Mitra was called a “Master of the Row Space and the Column Space” by Bapat and Hartwig (1994).

Among Professor Mitra’s Ph.D. students were C.G. Bhattacharya, Pochiraju Bhimasankaram, Dibyen Majumdar, and Betty Jeanne Moore (later Betty Jeanne Moore Thorne), C. Ramanujacharyulu, N.N. Singh, and M.T. Subramanya. Professor Mitra published about 100 research papers and several books. He served on various editorial boards and administrative committees, and organized influential international conferences and workshops. He was associated with many journals, in particular *Sankhyā: The Indian Journal of Statistics*, *Linear Algebra and its Appli-*

¹In 2001, the government of West Bengal changed the official name of the city from Calcutta to Kolkata; we use, however, the old name throughout this report.

cations, and the *Journal of the Indian Society of Agricultural Statistics*, and edited several special volumes. He earned many awards and honours; we may mention the Calcutta University Gold Medal and Prize for meritorious performance in the M.Sc. degree examination, which well predicts Sujit Kumar Mitra's serious attitude towards an academic career. He was a Fellow of the Indian National Science Academy, the Indian Academy of Sciences, the International Statistical Institute and the Institute of Mathematical Statistics. He was elected President of the Statistics Section of the Indian Science Congress in 1988.

An extensive biography of Sujit Kumar Mitra was provided by Nitis Mukhopadhyay in "A conversation with Sujit Kumar Mitra" [*Statistical Science*, 12 (1997), 61–75]; that conversation took place in Storrs, Connecticut, USA, in 1995. Other appreciative comments of Professor Mitra's life appeared in the articles by Bapat and Hartwig (1994), Bhimasankaram (1991), Ghosh (1991), and Rao (1991), and in the obituaries by Bhimasankaram (2004), Dey (2004), and Mukhopadhyay (2004).

A conversation with Sujit Kumar Mitra, February 1993

We now present a conversation that took place at the Indian Statistical Institute, New Delhi, in early February 1993, while Simo Puntanen and George Styán were visiting the Institute.



Simo Puntanen

Figure 2: George P. H. Styán and Sujit Kumar Mitra in the middle of matrices, New Delhi, February 1993.

Early years, Orissa, 1932–1945 (age 1–13)

What I recall about your early years is that you were born in Orissa, or Orissa Province. Is that right?

“My parents lived in Orissa, but I was born in Calcutta, in a part of central Calcutta. My school education took place exclusively in Jajpur town in Orissa Province. I completed school at what was considered to be a very young age. I was twelve, passing the matriculation exam in 1944.”

This is compared to sixteen in the present...

“Sixteen–seventeen.”

You were four years ahead of your peers.

“And then no college would take me...”

... because you were too young.

“Too young. So for one year I stayed at home in Orissa and then entered college in the second year.”

Which college was this?

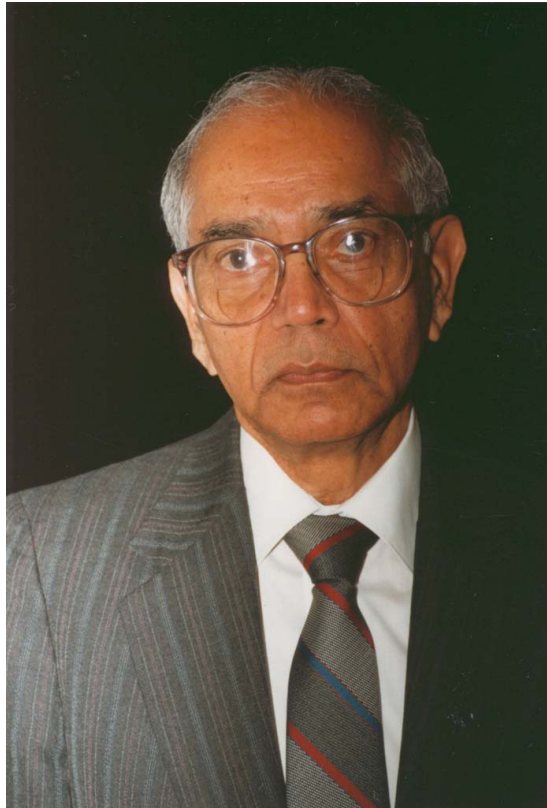
“This was St. Paul’s College in Calcutta. Must be something to do with St. Paul’s Cathedral in Calcutta. It was a Christian school. And that was what corresponds to the freshman and what is the next...”

... sophomore. And then you were thirteen years old. You were born in 1932, so this is 1945, directly at the end of the war. Why was it so that you were four years ahead of the others? Was it simply that easy for you?

“It goes like this. Firstly, when I was young my health was troubled. My parents saw that I will not be able to undergo the strains of going to school every day. So at the end, they let me study only at home, and only important subjects. They gave me a tutor, who taught me the important subjects: mathematics, English, geography, and parts of language.”

Did your parents allow you to become interested in music? I remember that Professor C. R. Rao² said that his parents did not allow him to become interested in music because that would take his attention to not so serious matters.

²Calyampudi Radhakrishna Rao (b. 1920). Received an M.A. degree in mathematics from Andhra University in 1940, an M.A. degree in statistics from Calcutta University in 1943, a Ph.D. from Cambridge in 1948 (under the guidance of Professor R. A. Fisher), and an Sc.D. in the same University in 1965. C. R. Rao had the post of Professor and Head of the Division of Theoretical Research and Training in the ISI in 1949–1963, Director of the Research and Training School 1963–1972, Director and Secretary of the ISI 1972–1976, after which he worked as Jawaharlal Nehru Professor in the ISI. After moving to the United States in 1979, he has worked at the University of Pittsburgh and at Pennsylvania State University. Up to date he has received 30 Honorary Doctoral degrees from universities in 17 countries (including one from the University of Tampere).



Simo Puntanen

Figure 3: C. Radhakrishna Rao, Istanbul, August 1997.

“Actually, my parents, particularly my father, were extremely fond of music. So he employed a music teacher to teach me music. He used to come to our home – I do not know, maybe once or twice every week, and teach me classical music.”

Piano?

“No, we used to have a kind of portable instrument, you just put it on a desk. And this went on for quite a few years. Unfortunately, I say unfortunately, because in spite of my liking music, we had a visitor from Calcutta, who came from the city, and he once told me that this is ridiculous, because no boy will learn music in this country. This is something that only girls do. I was eight years old at that time but I was highly offended by his remark. I told my parents that from tomorrow onwards I will not do any music since only girls in Calcutta are taught music. That was the end of my music career.”

Very interesting. Were you able to play well at that time?

“Actually once, in a school function, I played a couple of pieces. And it was so liked by the audience that they announced a special award for my music. I got a silver medal created specially for my performance. It was presented to me a few months later.”

You must make sure to include this in your CV. I have not seen this mentioned. [Laughs] And you never did anything more with music after that time?

“No, except that my wife, Sheila, she is extremely fond of music and dancing. You may know one of my daughters, who is presently at Columbia University in New York City, has learnt a classical form of Indian dancing for the last must be at least 14–15 years while she was in Delhi. In addition to mathematics which she was studying, she spent quite a long time in learning a classical form of dancing. When my wife wanted this to happen, I let it happen. I let it happen, in spite of the fact that I talked like Dr. Rao’s parents, saying that if there are two interests simultaneously, then at least one of them is likely to suffer. So I thought that it may not be very good in the long run because if my daughter is seriously interested in mathematics the time practising and learning dancing was naturally time taken away from learning mathematics.”

And what is she studying now?

“She is studying computer science at Columbia University. She is also thinking of starting a dance school in Stanford.”

Interesting. So maybe the two careers can be accommodated simultaneously.

“Let us see. I do not have an example or counterexample.”

St. Paul’s College & Presidency College in Calcutta, 1945–1951 (age 13–19)

Let us now return to the year 1945, when you were at St. Paul’s College in Calcutta, three or four years ahead of your peers at college. How long did you stay there?

“Two years. It corresponds to freshman and sophomore years.”

This is the Junior College in the American sense.

“After that I had to appear in an exam conducted by the university to qualify for entry to a college.”

The usual final two years of the Master’s degree programme in North America. And where did you spend those two years?



Figure 4: Neuchâtel, Switzerland, August 1989: Sheila Mitra (partially hidden), Erkki Liski, Sujit Kumar Mitra, Friedrich Pukelsheim, George P. H. Styan, Tarmo Pukkila, Jerzy K. Baksalary.



Figure 5: Neuchâtel, August 1989: Erkki Liski, Sheila Mitra, Sujit Kumar Mitra, Jerzy K. Baksalary.

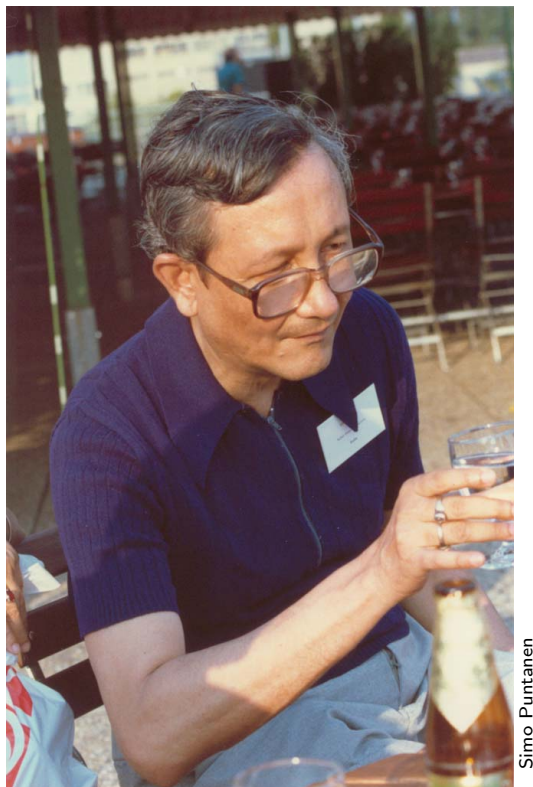


Figure 6: Neuchâtel, August 1989: Sujit Kumar Mitra.

“At the Presidency College, in Calcutta. And that time, if I remember correctly, it was the only college which was offering a programme in statistics.”

Was Professor P. C. Mahalanobis teaching there then?

“No, Mahalanobis³ was not teaching then. In fact my entry to the subject at Presidency College is something on which I should devote some time. Because after my two years of studies at St. Paul’s College and the exams, I went back to my parents in Orissa and was spending the summer months there preparing myself for admission to Presidency College. At that time I didn’t have the faintest idea that I would end up in statistics. But my uncle – even though he is a cousin of my father, he is only two or three years

³Prasanth Chandra Mahalanobis (1893–1972), founder of the Indian Statistical Institute (ISI). Mahalanobis studied physics at the University of Calcutta, and physics and mathematics at Cambridge University, where he also became interested in statistics. The ISI began as a small room in Presidency College in 1931, but now includes many buildings on several acres of land in Calcutta, as well as in the major cities of New Delhi, Bangalore and Hyderabad.

senior to me – he wrote to me that I should try for admission to Presidency College with statistics as a major subject. In my Intermediate Science exam I had scored higher marks in chemistry than in mathematics. In fact, I had applied to Presidency College for admission with chemistry as my major subject. And I was told that I was found suitable for admission to that programme. Because Presidency College is an exclusive college in Calcutta with only students who are above a certain level, it is considered to be quite an honour for somebody to be granted admission.”

So this is like Oxford and Cambridge in England or Yale and Harvard in the United States.

“Professor Mahalanobis was at that time the Principal of the Presidency College and the Professor of Physics, not teaching statistics. It was 1947 when I was admitted and in 1949 I qualified with a Bachelor’s degree in statistics.”

With first class?

“No, actually that is very interesting. I got a second class degree, because of my performance in what they called practical statistics. We had some theory papers and some practical papers. Practical papers mean that they give you some numerical data and you analyse that, and somehow with that I was not very comfortable. In theory I did get a first class grade, but because of my poor performance in the practical exam my overall grade had gone down. And incidentally I had a classmate who had got a uniformly bright record all through. You may well know him, his name is Laha. R. G. Laha⁴.”

Yes, R. G. Laha. Working in quadratic forms?

“He works actually in characteristic functions.”

Characteristic functions, yes. Worked with Eugene Lukacs⁵. They wrote a book together?

“Yes. R. G. Laha is an extremely good scholar. He received a Bachelor’s degree in statistics in 1949, graduating first in rank; and a Master’s degree in statistics in 1951, with a first class.”

You had some kind of top rank in second class?

“No, actually I was compensated in my later performance because both R. G. Laha and I joined the University in 1949.”

⁴Radha Govind Laha (1930–1999), Ph.D. at the Calcutta University in 1957, Professor at the Catholic University of America in Washington, D.C., 1962–1972, and Bowling Green State University in Ohio, 1972–1996.

⁵Eugene Lukacs (1906–1987) received his primary and secondary education and studied mathematics at the University of Vienna. In 1955, he joined the Catholic University of America where he organized the Statistical Laboratory in 1959 and became its first and only director.

Which University?

“Calcutta University. And after two years of hard work I succeeded in beating R. G. Laha. [Laughs.] In fact the story is very interesting. Laha and I actually were very close friends, and after our examination we took a train together to my home town Jajpur, in Orissa. And strange as it may seem, even though Laha was that time at least 21–22, he had never seen a train before.”

Where was he born?

“He was born in the southern part of central Calcutta. All the time he was confined there. He never had an opportunity to go out. – No, I must correct that statement. He did have an opportunity to go out, to travel on a train when we were studying together for the M.Sc. exam. Some of my classmates went on an educational tour. That must have been the first time that Laha was on a train. And the second time was when Laha and I went to my home in Jajpur after our exam.”

Laha was a year or two older than you?

“He was born in 1930.”

So going back still further, how did you become aware of your interest and capabilities in the mathematical sciences? Did you become aware of your talents very young?

“No, in school I was reasonably good in mathematics, I was in the top 4 or 5. My real mathematics education started when I was in the university. You know Professor D. Basu⁶—he is actually related to me. He’s related to me in two ways. Firstly, he is a cousin, first cousin of my mother, through D. Basu’s father’s side. That means, D. Basu’s father and my grandmother were brother and sister. And after spending 2–3 years in various places, D. Basu actually got admission into the Institute as a research scholar in statistics. But he had only a mathematical background and so he had learned most of his statistics by himself. In the evenings, when the college day was over, he would start teaching statistics to me because he thought that the best way to learn statistics was to teach it.”

So you both learned statistics at the same time.

⁶Debabrata Basu (1924–2001) was born in Dacca, Bengal, now Dhaka, Bangladesh. Master’s degree in Mathematics at the Dacca University in 1946. Joined the ISI, Calcutta, in 1950. [Citing Basu (1992, p. 15): Professor C. R. Rao was then head of the Research and Training School (RTS). Most of the technical staff of the RTS could then be accommodated in a single large room that was partitioned into a number of small cubicles. One of the end cubicles, overlooking the inside lawn of the Presidency College, used to be Professor Rao’s office. It was a small room filled almost end to end with an oversized table.] Ph.D. from the Indian Statistical Institute, Calcutta, 1953, advisor C. R. Rao. After teaching at the Indian Statistical Institute Dr. Basu moved to the United States and taught statistics at Florida State University, Tallahassee, from 1975 to 1990, when he was made an emeritus professor.

“We both learned statistics at the same time. But essentially I was his student and he was my teacher.”

How old was he, you were about the same age?

“He was born in 1924. So he was 8 years older. Actually, I must say that before that, I had never seen anybody with such a sharp intellect. When you talk to him and when he is teaching you, you can feel that he is different from others. Because his way of teaching and his way of interpreting are not quite the same as what I find in textbooks. He had his own way of interpreting things.”

Very crisp and very clear and an excellent lecturer.

“I think one should see his 1992 article in the *Glimpses* book [Basu, 1992]. Take one particular theorem, the Cramér–Rao inequality. When D. Basu teaches, he says that these are the premises and these are the conclusions. Now you play with the premises at some point. And see to what extent the conclusions remain the same, or what is the interpretation. So later in my own teaching I tried to copy both D. Basu and C.R. Rao, who incidentally was also my teacher in statistics at that time. As you know C.R. Rao is the Rao in the Cramér–Rao Inequality.”



Figure 7: Tampere, August 1990: Sujit Kumar Mitra giving a talk with the assistance of Friedrich Pukelsheim. C. Radhakrishna Rao listening near the door. [International Workshop on Linear Models, Experimental Designs, and Related Matrix Theory (1st International Workshop on Matrices and Statistics, IWMS-1).]



Figure 8: Tampere, August 1990: Jerzy K. Baksalary, Tadeusz Caliński, Sujit Kumar Mitra.



Figure 9: Tampere, August 1990: Jerzy K. Baksalary giving a talk; in the audience Shanti S. Gupta, J. N. Srivastava, Song-Gui Wang, Götz Trenkler, Stanisław Gnot, Jürgen Kleffe, Roman Zmysłony, Jan Hauke, Tõnu Kollo, Augustyn Markiewicz, and Sujit Kumar Mitra in the back row (partially hidden).

ISI, Calcutta, 1952–1954 (age 20–22)

You then continued on for two or three years and completed your Master's degree at Calcutta University in late 1951. And then you went to Chapel Hill in 1954. There was a two years' gap?

“A two years' gap which I spent at the Indian Statistical Institute.”

Was the Institute at that time located in the Presidency College? Or had it already moved to Barrackpore Trunk Road?

“When I joined the Institute, it was still located in the Presidency College.”

There was one room or two rooms?

“Two rooms.”

And very few employees?

“Very few employees.”

P. C. Mahalanobis, the Professor as he was called, and Dr. Rao, and Dr. Basu, and who else?

“R. G. Laha, J. Roy⁷, I. M. Chakravarti⁸, and then A. K. Gayen⁹.”

Yes, I know that name.

“A. K. Gayen actually worked at University College London, where he completed his Ph.D. degree. We had also A. C. Das, who later on left the Institute and joined the State Statistical Bureau in Calcutta.”

So there were two rooms in Presidency College and about what year did they move to Barrackpore Trunk Road?

“I think, I joined the Institute in 1953 January, and then perhaps some time in 1953 the Institute shifted to Barrackpore Trunk Road.”

And this was because Mahalanobis already owned the house called Amrapali and he owned some land there?

“Actually Amrapali was his personal property but he was able to acquire the neighbouring land for the Institute, and get some money from the government for building what eventually turned out to be a seven-storied building, the main building.”

⁷According to Sinha (2005), Jogabrata Roy (1930–2005) was the architect of statistical computing at the Indian Statistical Institute. Master's and D.Phil. Degree in Statistics from Calcutta University, Professor J. Roy spent sometime at UNC-Chapel Hill, working with S. N. Roy on some aspects of Multivariate Testing. His D.Phil. dissertation was titled “On Some Problems of Multivariate Analysis” and he worked under the guidance of Professor C. R. Rao. The degree was awarded in 1956.

⁸Indra M. Chakravarti (1928–2002). Ph.D. from Calcutta University in 1958. He was a visiting Professor at the University of North Carolina at Chapel Hill in 1959–1960 and a research fellow there during 1961–1962. He became an Assistant Professor there in 1964 and a full Professor there in 1968.

⁹Anil Kumar Gayen (1919–1978). See the obituary by Sujit Kumar Mitra (1979).

Ph.D. in Chapel Hill, North Carolina, 1954–1956 (age 22–24)

So how did it happen that you decided to go to North Carolina? I guess that sometimes some people are “sent” to do a Ph.D. Was there somebody who sent you there or was it just on your own?

“I had applied to several places. In particular I had applied to the University of California at Berkeley. But in those days not many people used to go abroad. So Berkeley did send me the forms but by sea mail, and when they reached me I noticed that the last day of application was already over, so naturally I couldn’t apply to Berkeley. For a similar reason, perhaps, I could not apply to Princeton. I had written to Professor S. S. Wilks, at Princeton, but it turned out that everything went favourably for North Carolina.”

And Professor S. N. Roy¹⁰ was already there?

“Yes, he was already there.”

Did you know him from before?

“I knew his name but I had not known him on a personal level. But I had read some of his papers. During my stay at ISI, when it was located at Presidency College, S. N. Roy visited at least once. I attended the lectures he was giving at that time, particularly those connected with the union-intersection principle and simultaneous confidence interval estimation. S. N. Roy wrote a key paper with R. C. Bose¹¹ published in the *Annals* [Roy and Bose, 1953]. He also gave lectures on testing composite hypotheses.”

So when you arrived at Chapel Hill, Professor Roy was the chief contact. Were there other people there from India at that time? There are several Indian statisticians who completed their Ph.D. degrees in Chapel Hill. Did you know any of them already?

“No. I went as a student, and of course I could not have gone unless they gave me financial assistance. So Professor Roy was able to give me money from his Air Force Grant. R. C. Bose and S. N. Roy were the two Indian statisticians on the faculty of the department. But as students we had

¹⁰Samarendra Nath Roy (1906–1964). Earned his M.Sc. degree at the University of Calcutta in 1931, joined the ISI in 1934. Professor at the University of North Carolina, Chapel Hill, 1950–1964. Centennial memorial issue of the *Journal of Statistical Planning and Inference*, in press (expected December 2006).

¹¹Raj Chandra Bose (1901–1987). Worked in the ISI 1932–1938, at the University of Calcutta, 1938–1949. Submitted his published papers on multivariate analysis and the design of experiments and was awarded a D.Litt. degree in 1947. Professor at The University of North Carolina at Chapel Hill, 1949–1971, and at Colorado State University, Fort Collins, 1971–1980.

at that time for example Shanti Gupta¹². Then there were two students from Pakistan. One was Moinuddin Siddiqui¹³”

Was this your first trip abroad?

“It was my first trip abroad.”

I remember that you once mentioned that it was a long trip.

“Yes. In fact the admission letter from North Carolina reached me quite late. Professor Roy told me that among the students that were selected for admission I was not on the first list, I was on the second list, so that when somebody dropped out, they were able to offer that money to me. When I got that letter, I started making the bookings; most people those days would travel by boat to the USA.”

From Calcutta to New York?

“From Bombay to Southampton and from Southampton to New York.”

So you took a train from Calcutta to Bombay?

“No, because I could not get the letter in time I had some difficulties in getting my passport issued by the government. When everything was finalised, I checked with the American Embassy and the only passage that they could offer me was on a ship which was actually a cargo ship, not a passenger ship, carrying jute and I don’t know what else from Calcutta, allowing 12 people from Calcutta including me. Most of them were students like me who went to the USA for studying at different places.”

When you left Calcutta, the ship must have gone round the southern part of India?

“It went round the southern part of India and then the Arabian Sea, Colombo, Suez Canal, Alexandria in Egypt, and Lebanon.”

To Tripoli?

“A place close to Tripoli. I think that was called Meena¹⁴.”

The name of your secretary, Mrs. Meena Ramachandran. And did it stop in Southampton?

¹²Shanti Swarup Gupta (1925–2002), M.A. degree in Mathematics from Delhi University in 1949, Ph.D. at Chapel Hill, under the guidance of Professor R. C. Bose, in 1956. Worked in the Bell Telephone Laboratories in Allentown, Pennsylvania, 1956–1961, Professor at Purdue University, 1962–2002.

¹³Mohammed Moinuddin Siddiqui (b. 1928). Ph.D. University of North Carolina, 1957. Joined the Department of Statistics, Colorado State University, Fort Collins, 1964; now Professor Emeritus there.

¹⁴According to the Tripoli Internet Database website <http://tripoli-city.org/mina.html>: “At present, Tripoli, Lebanon, is really made up of two towns – the city proper with its ancient and modern quarters, and the harbour – ‘El-Mina’ – three kilometers away, where there was apparently at one time a Phoenician town of which nothing now remains. El-Mina is also known as the ‘City of Waves and Horizons’.”

“No, it went through Gibraltar and then across the Atlantic. It was a total of 32 days on board.”

So what did you do for 32 days? You were writing a paper, counting jute bags?

“No, I would just lie down on the deck, and what shall I say? Just doing nothing I think.”

And did you know anybody on the ship?

“I did not know anybody on the ship before, but because most of the passengers were of my age, we soon became friends, and we used to play games together.”

And are you still in contact with any of the fellow passengers or have they all gone their separate ways?

“I was in contact with one of them for quite some time but I don’t quite remember his name. I used to write letters to him. After a year or so, a letter suddenly came back to me.”

It bounced back, could not be delivered. So he had left his hometown, I suppose?

“No. Actually he had left but he had left for heaven. That gave me a shock, because he had indicated that he had received unpleasant news from home. It was not quite clear to me what this unpleasant news was. But later on I learned that the girl who he wanted to marry had married somebody else. This must have moved him sufficiently to have taken to justice to such extent.”

So what was the exact date when you left Calcutta on the boat for 32 days?

“I think that was the 10th of August, no, just a minute, the 10th of July in 1954.”

You completed all the requirements for the Ph.D. degree within two years?

“Yes, actually I completed most of the requirements in one year. Since I had already taken most of the courses in Calcutta, Professor Rao and Professor Bose were able to convince the Committee that the requirements in Calcutta were not that different from what they would expect at Chapel Hill.”

And then you wrote your thesis with Professor S. N. Roy, in multivariate analysis. Did you feel homesick in Chapel Hill?

“I felt terribly homesick. In fact, there is an interesting episode in that. Because Professor Mahalanobis, as I was told, was very much against Indian students, particularly in statistics, going abroad for a Ph.D. programme. So when I went to Chapel Hill and I was homesick, I thought

for a while that, well, I have to make a decision, because when I go back to India after the degree, Professor Mahalanobis may refuse to take me.

I do not know if it was my homesickness which was responsible for even thinking that I may come back without the degree. So I wrote to Mahalanobis asking whether he would take me from the States back to the Institute, without a degree. I proposed that instead of the Ph.D., Mahalanobis would arrange some practical training for me in statistical quality control in the USA. And indeed something was arranged. But in the middle of these arrangements, I got two letters, one was from D. Basu and the other from C. R. Rao. Both of them told me that I was silly and that I must first complete my Ph.D. degree and then come to ISI. As it turned out I had sufficient control over my homesickness to decide that, no, I came for the Ph.D. degree in statistics and I must have it first. And then if necessary, to go to statistical quality control.”

Was Professor Mahalanobis still suggesting that you might want to come home without the degree?

“No, actually the interesting point is that after that, I do not know if I wrote to Mahalanobis but in any event I wrote that to Professor Rao, that I have changed my mind, and that I will stay in Chapel Hill for a year or so, two years. I don’t think I wrote to Mahalanobis on that subject any more.”

Professor P. C. Mahalanobis in New York City, 1956 (age 24)

You then wrote to Professor C. R. Rao. He was already the head of the Research and Training School?

“Yes. And something interesting happened. When I completed my degree and I was almost on my way back to India, it was in May–June 1956, I got a long-distance phonecall from New York City and the caller was surprisingly Professor Mahalanobis. I was expecting that I would face a really bad time with Mahalanobis, but it was entirely different. He was very nice on the phone and he said that he was glad that I am planning to return to India and to the ISI and will not be staying on permanently in the USA, as many others from India had done. And would I consider spending some time with him in New York? Before he would leave he had something important to discuss with me. I told Professor Mahalanobis that when I come to New York I have to stay in a hotel and I do not think that my budget could afford 15 days stay in a New York hotel. He said that he can arrange to pay for that. I said please allow me a few days for preparing papers out of my thesis for publication. Most of them were already almost ready, and so in a couple of weeks time I would be free from serious academic work and I could go to New York.



Figure 10: At the Mitra home in New Delhi, December 1990: Subhash Kochar, Sujit Kumar Mitra.



Figure 11: P. Bhimasankaram and Sujit Kumar Mitra, New Delhi, December 1990.



Figure 12: New Delhi, December 1990: Kirti R. Shah and Sujit Kumar Mitra chatting with two daughters of Chinubhai Ghelabhai Khatri.

I stayed in the Hotel Martinique¹⁵. In those days the Hotel Martinique had a special rate for students which was 50 percent of the normal rate. I could stay in the same room for just two dollars a day!”

Wow!

“So that’s how I spent 15 days in New York.”

Was Professor Mahalanobis in the same hotel?

“No. He used to stay in some friend’s house.”

You were saying that Mahalanobis was not very happy when Indian students went abroad and did not then return to India. Was he then happy when you met in New York?

“In New York he did not mention the subject at all. He was happy that I was going back to the ISI.”

Did you go back to India by boat?

“Yes, from New York to Southampton on the Queen Mary¹⁶. Then in London I spent about a week. Then I travelled by (boat and) train to

¹⁵The Hotel Martinique is now the Raddison Martinique on Broadway (49 West 32nd Street) offering rooms from US\$179.

¹⁶The RMS Queen Mary was a Cunard Line (then Cunard White Star Line) ocean liner that sailed the North Atlantic Ocean from 1936 to 1967. She made her maiden voyage from Southampton to New York, May 27–June 1, 1936, and then on December 9, 1967, she arrived in Long Beach, California, and is now permanently moored there as a tourist attraction.

Naples, by various Roman roads sightseeing, and then I reached Bombay from Naples in 14 days by ship.”

So that was not so bad?

“The ship was a small passenger ship.”

The ship again went through the Suez Canal?

“Again the same route as westbound two years earlier. And from Bombay I took a train to Calcutta.”

Going back to North Carolina, how would you describe the academic atmosphere in Chapel Hill. Was it very different from ISI?

“North Carolina at that time had almost all the top statisticians, like Harold Hotelling¹⁷, R. C. Bose, S. N. Roy, and Wassily Hoeffding¹⁸. At ISI, the only comparable figure to these scholars was perhaps C. R. Rao. Apart from C. R. Rao, the rest of us were just students who had learnt statistics.”

And Mahalanobis, of course?

“Mahalanobis did not come to work with us. He was busy with administration and the central statistical bureau.”

I guess that Chapel Hill with the arrival of Hotelling from Columbia University then became the top institution in statistics in the United States.

“I think Columbia and Chapel Hill were perhaps comparable institutions at that time.”

Of your fellow students, was Sudhish Ghurye with you at Chapel Hill?

“No.”

Ghurye had left by that time?

“He had left by that time. He completed his thesis with Herbert Robbins in 1952.

By the way, I forgot to mention one important name, Ram Gnanadesikan¹⁹. He was actually for a short time at ISI, as a student. So I knew Ram Gnanadesikan before he left the Institute for Chapel Hill. He also worked with S. N. Roy.”

¹⁷Harold Hotelling (1895–1973). Ph.D. from Princeton University in 1924, Professor at Columbia University 1931–1946, and the University of North Carolina at Chapel Hill 1946–1973.

¹⁸Wassily Hoeffding (1914–1991), born in Mustamäki, Finland (now Gorkovskoye, Russia); worked at Chapel Hill 1946–1979, then Professor Emeritus there: 1979–1991.

¹⁹Ramanathan Gnanadesikan (b. 1932). B.Sc. and M.A. degrees in 1952 and 1953 from the University of Madras, Ph.D. at Chapel Hill in 1957, industrial career at Procter & Gamble, Bell Laboratories and Bellcore, Professor at Rutgers University from 1991–1998.

He is a little bit older than you?

“He is about my age and he joined Chapel Hill a year earlier and he completed his Ph.D. degree a year later. I did my thesis like speed post, at great speed. Almost in one year my thesis was ready, but I could not submit it because of other necessary requirements.”

And Somesh Das Gupta²⁰ had not yet arrived. – Did you have your topic ready when you arrived at Chapel Hill?

“It was not ready. What happened was that I had published two–three papers, one in *Sankhyā* (1954), one in the *Calcutta Statistical Association Bulletin* (1954) with J. Roy, and one was then under consideration for the *Journal of the American Statistical Association* (published in 1957). So my thesis is quite different from these areas.”

Getting married, 1956–1958 (age 24–26)

So you then returned to India on the Queen Mary across the Atlantic, and on another ship from Naples to Bombay.

You rejoined the ISI, and two years later you married. By the way, had you already met Mrs. Mitra before you left for Chapel Hill?

“Actually, as I might have told you earlier, my wife and I we have a common link, again to Professor D. Basu.”

Yes, in fact you mentioned earlier that you were related to D. Basu by two ways. I think you only said one of those two ways.

“Yes, the other way was my wife, who was related to Dr. Basu. My mother-in-law and Dr. Basu’s mother were sisters. She was a first cousin of Dr. Basu. And Dr. Basu was responsible to a large extent in getting our marriage arranged.”

He introduced the two of you?

“Yes. In fact, I had met her because of our common relative. When I came back from Chapel Hill, I found my wife already working at the ISI in a specific unit which was operating under the guidance of Mrs. Mahalanobis. And my wife was very good in painting and those sorts of things. So I saw her there when she was painting some flower vases, which were sold at quite fancy prices outside.”

Were you in correspondence with her when you were in North Carolina?

“No.”

You only met her after you went back?

²⁰Somesh Das Gupta (1935–2006), completed his Ph.D. degree at Chapel Hill in 1963 under the guidance of S. N. Roy.



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Figure 13: Neuchâtel, August 1989: Sheila Mitra.

“As I told you I’d already met her earlier also, but at that time there was no romantic link or anything like that, just met her casually. And I also met her when I came back from Chapel Hill and she was still unmarried.”

And you were also still unmarried. So then the romance blossomed.

“No, to be quite true, our marriage was again very much an arranged marriage. As I told you, Dr. Basu liked both of us. He liked me, and he liked my wife also. He talked to the girl’s father (now my father-in-law), and persuaded him to consider me for a possible son-in-law. And he also persuaded my father too. I remember once my marriage was about to get fixed with some other girl and then D. Basu came to our home and was very much irritated because things were not working in the way he wanted. So told my father: ‘Give me just one more day! Do not close the deal.’ And then I think that evening, I don’t remember what happened but I heard that this possibility no longer existed.”

Were you given any choice in the matter or was it all decided by other people?

“No, I had definitely a choice and so did my wife. We could have said no and that would have been respected in both families.”

But you obviously said yes.

“I said yes because, my wife is quite attractive, as you might have noticed.”

Yes, certainly!

“And when I had met her in various places I had developed some liking for her, but not started an approach, that was unthinkable in those days.”

All marriages those days were arranged?

“Most of the marriages. So when my mother asked me what I thought of this I used the reply what all boys used to give when consulted on this question: Please do whatever you like and I will entirely agree.”

[Laughs]

“And my wife also, I was told by my sister-in-law and others, that when consulted with a similar question by her parents, she said that she wanted somebody from the teaching position. That was the type of life that she wanted. And my sister-in-law said that she wanted somebody teaching statistics. That means again that she had no obligation to this.”

What day did you get married?

“28 May 1958. – As for the family life and Professor Mahalanobis, I may tell you an interesting episode. As is well known, the Professor was a rather

demanding²¹ leader with a great ability to get things done. So, when I was in the ISI after returning from Chapel Hill and getting married, I remember him proposing that I should meet him in the office also on Sundays. I was thinking of this request very carefully and decided to say no, I'm sorry but I cannot do that. This was somewhat unheard behavior since usually people did not talk like that to the Professor. But I felt that since I already had a family to take care of, I really don't do the right thing if I devote all seven weekdays to the Institute – it might be very harmful for the family if I cannot be with them enough. So I dared to say no to the Professor, and he respected my opinion.”

Back at ISI, Calcutta, 1956–1971, Classic Book 1971 (age 24–39)

Let's go back to your return from Chapel Hill in August 1956. Then you stayed at ISI Calcutta until...?

“1971, when I went to Bloomington, where I worked with Madan Puri²².”

By this time you had four children.

“Four children, and also I had a book, which had just appeared, with C.R. Rao on generalized inverses [*Generalized Inverse of Matrices and Its Applications*, Wiley, 1971.]”

There were also some other books on generalized inverses by other people that year. A peak year of books on generalized inverses! Can you tell us something about writing that book. I think it must have been quite an interesting period.

“I have always have had an interest in matrices. Matrices fascinated me even in my student days. I must say this primarily because of the lectures that Professor C.R. Rao gave us on linear models, distribution theory, etc., which used matrices heavily, and I could see what a powerful tool matrices can be. In fact, in my thesis, one of the strong points was matrices. For example, in the proofs of the limiting distribution of the goodness-of-fit chi-squared test, essentially the strong point was the use of matrices, which apparently considerably simplified the original approach by Harald Cramér²³.”

²¹As an example we may cite Draper (1990): “R. C. Bose had told Mahalanobis that he knew little statistics; soon Bose was given *Biometrika* for 1900–1932, a typewritten list of 50 papers and R. A. Fisher's *Statistical Methods for Research Workers* [Oliver and Boyd, Edinburgh, 1925; 14th edition, 1970], and was told to master the 50 papers and the book! Bose and Roy also had to master one new topic per year and to lecture on it to the rest of the staff.”

²²Madan Lal Puri (b. 1929), Ph.D. in the University of California, Berkeley, 1962. Professor of Statistics, Indiana University, Bloomington, 1968–.

²³Harald Cramér (1893–1985) was a Swedish mathematician and statistician, who specialised in mathematical statistics. Cramér also made some outstanding statistical



Figure 14: New Delhi, December 1992: Sujit Kumar Mitra, C. Radhakrishna Rao.



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Figure 15: S. K. Jain, Sujit Kumar Mitra, and C. Radhakrishna Rao in New Delhi, December 1992.



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Figure 16: Sujit Kumar Mitra, New Delhi, December 1992.

Whom did you learn matrix theory from, or was there a book to learn from?

“Mostly from C.R. Rao. And then later on I gave my students a set of lecture notes on matrices which used to be sold at two rupees per copy. The set comprised 70 pages and it was a series of exercises, meant for statistics students. This meant learning matrix theory by solving a series of exercises. Students were invited to solve them one by one, and I promised that by the time they were done they would have learned statistics.”

Did these lecture notes then become a part of the Rao–Mitra book?

“No, they consisted mainly of elementary things.”

So the material was never subsequently published?

“No.”

Do you still have a copy?

“No.”

When was the decision made that you will start writing that book with Professor Rao?

“Actually, Professor Rao had written a paper on generalized inverses already in 1955, in *Sankhyā* [Rao, 1955]. But then in 1967, when Professor Rao wrote a paper on the calculus of generalized inverses, and by this time he had already collected some material available in the literature on the subject, and he asked me to review a paper for *Sankhyā* or just to get my comments so that he can revise his paper if necessary [Rao, 1967].

In 1967 we had a summer school at ISI, with a lot of students participating. Often new areas of statistics and mathematics were exposed to the students during these six weeks of summer. In those days the ISI used to regularly have a summer school and I was in fact once the programme director of such a summer school.

As a member of the summer school, I was able to get the best of C.R. Rao’s papers and manuscripts. So I taught a course in the summer school and then by the time I had completed the course, I myself had some new results. In fact my first two papers on generalized inverses, which appeared in 1968, were essentially papers that appeared in their first form in of these summer schools.

Professor C.R. Rao had at that time already decided to write a book on generalized inverses all by himself. It was also announced as a forthcoming publication of the Statistical Publishing Society in Calcutta. He must have seen my new results and in a few days he invited me to be a co-author. That is how the book started.

contributions to the distribution of primes and twin primes. Ph.D. from the University of Stockholm in 1917 for his thesis “On a class of Dirichlet series”.

At that time there was a very small and active group at the ISI, including me, C.R. Rao, and P. Bhimasankaram²⁴, who was a student in the M.Sc. programme. Professor C.G. Khatri²⁵ was visiting Calcutta for a year on leave from the Gujarat University in Ahmedabad. I still remember the type of questions I used to raise. Questions were raised and then we started working on them. For example, I asked this question:

If there is a nonsingular square matrix, then there is a one-to-one correspondence between the matrix and its inverse. Is there a one-to-one correspondence between a singular matrix and the class of its generalized inverses? For example, is it possible for two different matrices to have the same class of generalized inverses.

In fact you must have seen similar problems that are involved in quite a large number of papers which are subsequently published. For example, in a paper on parallel sums with Patrick Odell in 1986 [Mitra and Odell, 1986], we attacked such problems.

This area reminds me that recently Yongge Tian²⁶ has found a slight flaw in a theorem of mine. The theorem is essentially correct, provided that one puts the restriction that a particular matrix is a nonnull matrix to start with. If it is nonnull, then all things are correct.

Actually the null matrices appear to me very interesting matrices. Firstly, a square null matrix is always a singular matrix. But a square nonnull matrix can be a singular or a nonsingular matrix. That means that the null matrix has some peculiarities which are not possessed by nonnull singular matrices. So I call the null matrix the Prince of singular matrices. Some of the mistakes I made were quite interesting but I was quite happy about those mistakes. I was quite happy that somebody could point out that there is a flaw and with that correction, in my opinion, the result may become even more interesting than it was earlier. So I am planning to write a paper entitled ‘My Encounters with the Null Matrix²⁷.’

²⁴Pochiraju Bhimasankaram (b. 1945), Diploma in Computer Science in the ISI, Calcutta, 1968, Ph.D. under the guidance of Professor Sujit Kumar Mitra in 1972 in the ISI, Calcutta. Visiting Professor in the University of Dar es Salaam, Tanzania, 1973–1977; since then a professor in the ISI (Calcutta and later Hyderabad).

²⁵Chinubhai Ghelabhai Khatri (1931–1989). Master’s degree from the Dept. of Statistics at the University of Bombay, 1956; Ph.D. from University of Baroda, 1960. Professor and Head of the Dept. of Statistics, Gujarat University, Ahmedabad, 1960–1989.

²⁶Yongge Tian (b. 1959), Ph.D., Queen’s University, Department Mathematics and Statistics, Kingston Ontario, Canada, 2003. Assistant Professor and Supervisor for Doctors, School of Economics, Shanghai University of Finance and Economics, Shanghai, China, 2005–.

²⁷See Mitra (2000) in the references. As an example of Professor Mitra’s sense of humor we may quote here the last sentence of his manuscript (1993) of the corresponding paper: “I conclude this essay panic-stricken wondering if the null matrix is lurking somewhere in the dark only to jump out on any of my other theorems.”

Going back to 1971, were you then surprised that there were simultaneously other books on general inverses coming out?

“Actually we were in correspondence with Pringle and Rayner²⁸ in South Africa. Often they wrote in asking for copies of our papers.”

Rayner was certainly very active in the 1960s when he was working on quadratic forms. I guess he was frustrated when he could not find copies of various journals from India in South Africa.

“There is an interesting Preface in their book [Pringle and Rayner, 1971] They found that some results had been proved earlier, maybe just a few months earlier in India by these three people: Mitra, Khatri, and C.R. Rao.”

Was it ever supposed that C. G. Khatri might join the Rao–Mitra team for the generalized inverse book?

“No. Actually Professor Rao had always wanted to write the book all by himself. As it was already announced as a forthcoming publication. He made the offer to me after Khatri had returned to Ahmedabad.”

Didn't Khatri's book on matrix theory in Gujarati also appear in 1971? And what about Ben-Israel and Greville²⁹, were you surprised when their book [Ben-Israel and Greville, 1974] appeared?

“No, I was not surprised. In fact, when Professor Rao came back from the United States, I think in 1968, he brought some lecture notes prepared by Adi Ben-Israel which eventually led to that book.”

Then you continued to do research on generalized inverses. In the 1970s you published many papers on generalized inverses.

“Actually what happened was that in the last days of working on the book, we were really searching the literature, literally hunting for applications, good applications. Many papers were available which in my opinion contained trivial applications, and quite a lot of the mistrust that other people had on the subject actually initiated from such papers. At that time C. R. Rao gave a talk at Carnegie–Mellon University in Pittsburgh and perhaps then R. J. Duffin³⁰ gave him a copy of his paper with William N. Anderson, Jr. When C. R. Rao came back to India, he asked me to read it to see if it can be included in our book.”

This is the Anderson–Duffin 1969 paper on the parallel sum?

²⁸Robert Macdonald Pringle (b. 1944) and Arthur Asquith Rayner (1917–1994).

²⁹Adi Ben-Israel (b. 1933) and Thomas Nall Eden Greville (1910–1998).

³⁰Richard James Duffin (b. 1909), Ph.D. in the University of Illinois at Urbana–Champaign 1935; Professor, Department of Mathematics, Carnegie–Mellon University, Pittsburgh.

“Yes. When I read it I was extremely fascinated and of course, consistent with the theme of the book, I accepted the task of replacing the Moore–Penrose inverse by the $\{1\}$ -inverse³¹. And that immediately brought out the question of invariance, because the expression

$$\mathbf{M} = \mathbf{A}(\mathbf{A} + \mathbf{B})^- \mathbf{B}$$

would be very much dependent on the invariance with respect to the choice of the generalized inverse. I said, let me restrict my attention only to those cases when the matrix \mathbf{M} is invariant. As soon as I had done that I found that I had a very interesting concept of parallel summability. And for the resulting parallel sum I found most of the properties that Anderson and Duffin had proved for the parallel sum of nonnegative definite matrices.

So when I went to Bloomington, I got in touch with Professor Duffin in Pittsburgh. I used to send my papers to him and he used to comment on them. Perhaps a few months later I got a letter from George Trapp saying that he was very much fascinated by the treatment of parallel sum given in our book and he would very much like to study with me the hybrid sum and to see whether the hybrid sum would enjoy a similar approach. That resulted in a paper we published in *Linear Algebra and its Applications* in 1975.”

Did George Trapp come to Indiana?

“He spent a few days in Bloomington.”

What about William N. Anderson, Jr.? Did you meet him?

“I never happened to meet him but we corresponded with each other. From his work it appeared to me that he was an extremely intelligent and capable person. I used to get from Professor Duffin most of the preprints of the papers related to parallel sum and shorted matrices. A generalization which he proposed appeared in a paper by Duffin and Tom Morley in 1978, where the idea was to give a framework, under which the parallel sum, hybrid sum, cascade sum, shorted matrices, etc., could all be put under a uniform framework. And when I started working on this, I used my standard treatment to see to what extent the Moore–Penrose inverse could be replaced by a $\{1\}$ -inverse. Most of the time I succeeded. So my work after 1971 was to a large extent inspired by the work of Duffin and his colleagues.”

By the way, Professor Mahalanobis, who actually died one year after the book came out, in 1972, how did he comment on your book?

“Actually, I do not know. We dedicated the book to Professor Mahalanobis. Mahalanobis had a very broad outlook on scientific research³².

³¹A $\{1\}$ -inverse \mathbf{G}^- satisfies the first Moore–Penrose equation $\mathbf{G}\mathbf{G}^-\mathbf{G} = \mathbf{G}$.

³²We may cite Ghosh (2001): “In his work as an applied statistician, Mahalanobis was very innovative, often introducing new concepts or methodologies or systemizations. . . .



Simo Puntanen

Figure 18: Sujit Kumar Mitra and Simo Puntanen in New Delhi, December 1992.

let us go back to 1971. You stayed three years in the United States and then, did you come to Delhi immediately or did you go first to Calcutta?

“Actually I wanted to come back to Delhi. Because firstly, my three-year stay in the United States had already somewhat separated me and my family from Calcutta. My children had to go to school and they would face the same problems in Calcutta as in Delhi. And secondly, C. R. Rao had moved to Delhi by that time. So by all accounts, Delhi was a better place for me.”

You did not hesitate to come?

“No, as I told you, I wanted to shift to the ISI. In fact something interesting happened. The position that I had in Bloomington was really meant to be a permanent position in the department there. The department was looking for a permanent person. I went to the United States in 1971 with a one-year leave from the Institute, but I had told Professor Rao, who was the Director of the Research and Training School of the ISI, that if I go, I will go for two years, because one year’s stay is not financially viable in a six-person family. I tentatively agreed that I would stay for two years and then would return to the Institute. The department was keen on hiring a really top statistician, and their searching was on. Then they told me to continue for a third year because nobody was yet found suitable for this position.”

So you asked Professor Rao?

“No, I did not ask. When the Chairman asked me for the third year, I said that this time you have to take the initiative. Because I had already told Professor Rao in advance that I am going for two years and he had tentatively agreed. So the second year was just a routine extension of the first year. But this time it would not be a routine extension. Then he wrote to Professor Rao and he agreed and then I stayed a third year.”

In the early 1980s you went again to the United States?

“In 1980 I went to Bloomington for six months, and in 1981 to Purdue. Then in 1984 I went to Texas. By that time I already had Parkinson’s disease. I was facing real difficulties and I knew for sure that this will be my last visit for a substantial period to the United States. At least all by myself.”

You had a sister in Texas?

“I had, she has now moved.”

And she cooked for you? Made six weeks of meals in advance?

“She put them in bags in the freezer. Actually there is an interesting anecdote. My sister put the bags in the freezer, but after the bags were frozen I was unable to see what was inside. She did not label them and it sometimes happened that I picked two which I thought to be different but turned out to be the same.”

Did she cook in Indian style?

“Mostly in Indian style. In fact, I had learnt cooking myself in my 1980 visit to Bloomington.”

So in 1984 was your last visit to the United States? That is almost 10 years ago. But you certainly came to the Matrix Workshop in Tampere, Finland, in 1990.

“And Neuchâtel in 1989.”

I think you were in Poland at some time?

“That was earlier. I was in Poland 1978: in Wrocław and I think in Poznań.”

And all during the 1980s your research was in matrix theory.

“Yes, except one area which I was trapped in by the persuasion of P. K. Pathak, who is at the University of New Mexico, Albuquerque. Actually P. K. Pathak came to India for six months under some international exchange program. He drew my attention to a certain class of problems which come from a broad area of integration of surveys.”

But your first love these days is matrix theory and generalized inverses.

“I have plenty of problems in my bank, which can keep me busy spending interesting time with generalized inverses.”

Well, I hope that when we come back in November³³, we will still find problems in that bank and we can work together.

“Actually, you should learn the technique of developing these problems. The main thing I question, for example, I proved the properties of parallel sum and shorted operator and immediately I asked the questions: Well, are these the only examples, or are there other matrices with a similar property. So if you ask these questions you are not in lack of problems to work with.”

So that still leads to the cascade sum, hybrid sum. . .

“I have still not proved it but I hope to be able to prove it, and at a sufficiently high level of generality.”

Can you mention any particular papers that have given you an exceptional amount of pleasure to write and complete?

“I do not think I can say one most, but I can say two or three which are about the same level. Perhaps that based on unified theory of partial orders, \mathcal{G} -based order. That is one paper I enjoyed writing. Then the paper on minus partial order and the shorted matrix, that I also enjoyed writing. And more recently, a very short note, which was motivated essentially by a remark made by Michael P. Drazin³⁴ on my paper on the sharp order. And I really enjoyed writing my Presidential Address to the Indian Science Congress in 1988 [Mitra, 1988]. That covered the work done with P. K. Pathak and K. Krishnamoorthy on integration surveys.”

Two very different areas, sample surveys on the one hand and \mathcal{G} -based partial orders on the other hand.

“Actually, I do not claim myself to be an expert in sample surveys. I simply became attracted by that particular problem.”

So that is a problem which has an immediate application. Whereas the matrix theory does not have such an immediate applications. Well, I hope in the next few months you enjoy working on shorted matrices³⁵ and I look forward to hearing from you.

“We should be in contact.”

Absolutely.

³³In November 1993, Simo Puntanen came to New Delhi to work with Professor Mitra on shorted matrices.

³⁴Michael P. Drazin (b. TBC), Ph.D., Cambridge University 1953; Professor Emeritus of Mathematics, Purdue University, West Lafayette, Indiana.

³⁵This led to the paper by Mitra, Puntanen and Styan (1995).



Simo Puntanen

Figure 19: New Year's Eve, 31 December 1992, at the Mitra home: Soile Puntanen, Sheila Mitra, Sujit Kumar Mitra.

Publications by Sujit Kumar Mitra

We present several tables based on the publications by Sujit Kumar Mitra. In Table 2 we begin with a list of 7 books by Sujit Kumar Mitra and then in Table papers continue with an annotated list of 102 publications in research journals and collections (conference proceedings, Festschriften, and other edited books). We also include references to reviews of his publications in *Mathematical Reviews* (MR) and *Zentralblatt MATH* (Zbl); for signed reviews the reviewer's name is given in parentheses. For reviews in *Mathematical Reviews*, the new style review number (seven digits) is given; the old-style number is given (when available) in parentheses. The 102 publications in research journals and collections in Table 3 are listed chronologically, and by journal/collection within year, and may be classified as follows:

88 papers in 24 peer-refereed research journals,

14 papers in 14 research collections (conference proceedings, Festschriften, and other edited books).

In Tables 6 and 7 we list the 24 research journals and the 14 research collections (conference proceedings, Festschriften, and other edited books) in which Sujit Kumar Mitra published. In Table 5 we identify 38 coauthors.

Associated with a bibliography by a particular author (with several coauthors), we follow Baksalary and Styan (2005) and Puntanen and Styan (2006) by defining an “authorship matrix” $\mathbf{A} = \{a_{ij}\}$, where $a_{ij} = 1$ if bibliographic entry number i is written with coauthor number j and $a_{ij} = 0$ otherwise. The authorship matrix \mathbf{A} for Sujit Kumar Mitra based on Tables 2 and 3 is 109×38 . The diagonal entries of the 38×38 matrix $\mathbf{A}'\mathbf{A}$ represent the numbers of bibliographic entries written with each of the 38 coauthors and these numbers are presented in Table 4.

We note that for the 38×38 matrix $\mathbf{A}'\mathbf{A}$, there are 16 coauthors for whom the off-diagonal elements are all zero and so whose joint publications are with Sujit Kumar Mitra alone. These 16 coauthors are at the end of the Table 4. We define the matrix \mathbf{B} to be the 22×22 reduced $\mathbf{A}'\mathbf{A}$ matrix, with “reduced” here meaning that the rows and columns of $\mathbf{A}'\mathbf{A}$ for these 16 coauthors have been removed. We arrange the rows and columns in \mathbf{B} so that it is block-diagonal:

$$\mathbf{B} = \begin{pmatrix} \mathbf{B}_A & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{B}_B & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{B}_C & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{B}_D & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{B}_E & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{B}_F & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{0} & \mathbf{B}_G \end{pmatrix},$$

with

$$\mathbf{B}_A = \begin{pmatrix} 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 3 & 1 & 2 & 2 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 2 & 0 & 2 & 1 & 0 & 0 & 0 \\ 1 & 2 & 1 & 1 & 2 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \end{pmatrix}, \quad \mathbf{B}_B = \begin{pmatrix} 5 & 0 & 0 & 1 \\ 0 & 2 & 1 & 2 \\ 0 & 1 & 1 & 1 \\ 1 & 2 & 1 & 12 \end{pmatrix},$$

$$\mathbf{B}_C = \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix}, \quad \mathbf{B}_D = \begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}, \quad \mathbf{B}_E = \begin{pmatrix} 4 & 1 \\ 1 & 5 \end{pmatrix},$$

$$\mathbf{B}_F = \begin{pmatrix} 2 & 1 \\ 1 & 1 \end{pmatrix}, \quad \mathbf{B}_G = \begin{pmatrix} 2 & 2 \\ 2 & 3 \end{pmatrix}.$$

The 22×22 block-diagonal matrix \mathbf{B} has rank 14 and nullity 6. The rows (and columns) of \mathbf{B}_A correspond to the coauthors (in alphabetical order) in Group A: Das Gupta, Ghosh, Mukhopadhyay, Parthasarathy, Prakasa Rao, Rao PSSNVP, Rao SB, and Sarma, while those of \mathbf{B}_B correspond to

Group B: Bhimasankaram, Matthai, Ramamurthy, and Rao CR, those of \mathbf{B}_C correspond to Group C: Diamond and Roy SN, those of \mathbf{B}_D correspond to Group D: Jain and Werner, those of \mathbf{B}_E correspond to Group E: Khatri and Puri, those of \mathbf{B}_F correspond to Group F: Puntanen and Styan, those of \mathbf{B}_G correspond to Group G: Babat and Hartwig.

The 8×8 matrix \mathbf{B}_A has rank 3 and nonzero eigenvalues (to 4 decimal places) 8.3074, 3.2901, and 0.4025, while the 4×4 matrix \mathbf{B}_B is nonsingular with eigenvalues 12.6297, 4.8924, 2.1002, and 0.3776. The 2×2 matrices \mathbf{B}_C and \mathbf{B}_F are both nonsingular and have the same eigenvalues 2.6180 and 0.3820. The 2×2 matrix \mathbf{B}_D has rank 1 with the single nonzero eigenvalue 2, while the 2×2 matrix \mathbf{B}_E is nonsingular with eigenvalues 5.6180 and 3.3820. The 2×2 matrix \mathbf{B}_G is nonsingular with eigenvalues 0.4384 and 4.5616.

The nonzero entries within the 7 block matrices $\mathbf{B}_A, \dots, \mathbf{B}_G$ are illustrated graphically in Figure 20.

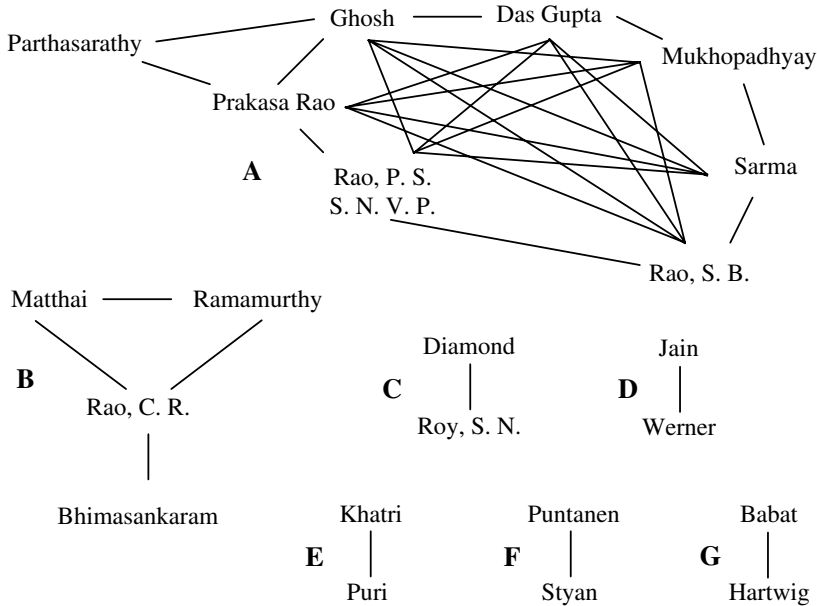


Figure 20: 22 coauthors of Sujit Kumar Mitra in 7 groups

Table 1: Articles about Sujit Kumar Mitra

[T1-1] R. B. Bapat, Hartwig, Robert E. (1994). A master of the row space and the column space: the mathematical work of Sujit Kumar Mitra. *Linear Algebra and its Applications*, 211, 5–14.

[T1-2] P. Bhimasankaram (1991). Professor Sujit Kumar Mitra – my mentor. In *Professor Sujit Kumar Mitra: Felicitation Souvenir, December 1991*,

- Indian Statistical Institute, Division of Theoretical Statistics and Mathematics, Calcutta, pp. 3–4.
- [T1-3] P. Bhimasankaram (2004). Sujit Kumar Mitra (1932–2004). *Current Science*, 87, 395.
- [T1-4] Aloke Dey (2004). Obituary [of Sujit Kumar Mitra]. *Sankhyā: The Indian Journal of Statistics*, 66, 211–212.
- [T1-5] Indian Statistical Institute (1991). *Professor Sujit Kumar Mitra: Felicitation Souvenir, December 1991*, Division of Theoretical Statistics and Mathematics, Indian Statistical Institute, Calcutta, 4 pp.
- [T1-6] J. K. Ghosh (1991). Introducing Professor Sujit Kumar Mitra. In *Professor Sujit Kumar Mitra: Felicitation Souvenir, December 1991*, Indian Statistical Institute, Division of Theoretical Statistics and Mathematics, Calcutta, page 2.
- [T1-7] Nitish Mukhopadhyay (1997). A conversation with Sujit Kumar Mitra. *Statistical Science*, 12, 61–75.
- [T1-8] Nitish Mukhopadhyay (2004). Obituary: Sujit Kumar Mitra. *The IMS Bulletin*, 33, 10.
- [T1-9] C. Radhakrishna Rao (1991). Sujit Kumar Mitra. In *Professor Sujit Kumar Mitra: Felicitation Souvenir, December 1991*, Indian Statistical Institute, Division of Theoretical Statistics and Mathematics, Calcutta, page 1.



Simo Puntanen

Figure 21: At the Mitra residence, New Delhi, November 1993: Sujit Kumar Mitra, Simo Puntanen, Sheila Mitra, TBC.

Table 2: Annotated complete list of books by Sujit Kumar Mitra

- [T2-1] C. Radhakrishna Rao, Sujit Kumar Mitra, Abraham Matthai, eds. (1966). *Formulae and Tables for Statistical Work*. Statistical Publishing Society, Calcutta, India, xii + 234 pp.
- [T2-2] C. Radhakrishna Rao, Sujit Kumar Mitra (1971). *Generalized Inverse of Matrices and Its Applications*. Wiley, New York, xiv + 240 pp., ISBN 0-471-70821-6. [MR0338013 (49 #2780), R. J. Plemmons; Zbl 0236.15004. Translated into Japanese by M. Sibuya & K. Tanabe, pub. Tosho, Tokyo, 1973.]
- [T2-3] C. Radhakrishna Rao, Sujit Kumar Mitra, Abraham Matthai, K. G. Ramamurthy, eds. (1975). *Formulae and Tables for Statistical Work*, Second edition. Statistical Publishing Society, Calcutta, xii + 256 pp.
- [T2-4] J. K. Ghosh, S. K. Mitra, K. R. Parthasarathy, eds. (1992). *Glimpses of India's Statistical Heritage*. Wiley Eastern, New Delhi, ix + 293 pp., ISBN 0-470-22086-4, 81-224-0423-5.
- [T2-5] J. K. Ghosh, S. K. Mitra, K. R. Parthasarathy, B. L. S. Prakasa Rao, eds. (1993). *Statistics and Probability: A Raghu Raj Bahadur Festschrift*. Wiley Eastern, New Delhi, xii + 564 pp., ISBN 81-224-0541-X.
- [T2-6] Ravi Bapat, Sujit Kumar Mitra, Robert Hartwig, eds. (1994). Special Issue of *Linear Algebra and its Applications* on Generalized Inverses: Papers from the Workshop on g -inverses held at the Indian Statistical Institute-Delhi Centre, December 11-16, 1992, vol. 211, pp. i-v and 1-113.
- [T2-7] *Selected Papers of C. R. Rao*, five-volume set: S. Das Gupta, J. K. Ghosh, S. K. Mitra, A. C. Mukhopadhyay, P. S. S. N. V. P. Rao & Y. R. Sarma (Editorial Board),
 Volume 1: Wiley Eastern, New Delhi, 1994, xii + 506 pp., ISBN 0-470-22091-0 (MR 95a:01028) [original version: Indian Statistical Institute, Calcutta, 1989 (MR 91h:01100)];
 Volume 2: Wiley Eastern, New Delhi, 1994, xii + 504 pp., ISBN 0-470-22092-9 [MR1279382 (95a:01029)];
 S. Das Gupta, J. K. Ghosh, S. K. Mitra, A. C. Mukhopadhyay, B. L. S. Prakasa Rao, P. S. S. N. V. P. Rao, S. B. Rao & Y. R. Sarma (Editorial Board),
 Volume 3: Indian Statistical Institute, Calcutta & New Age International, New Delhi, 1995, x + 437 pp., ISBN 0-470-22093-7, 81-224-0774-9;
 Volume 4: New Age International, New Delhi, 1999, ix + 393 pp., ISBN 0-470-22094-5, 81-224-1213-0;
 Volume 5: New Age International, New Delhi, 2001, x + 485 pp., ISBN 0-470-22095-3, 81-224-1285-8.

Table 3: Annotated complete list of research papers by Sujit Kumar Mitra

- [T3-1] Sujit Kumar Mitra, J. Roy (1954). A method of selection for improvement. *Calcutta Statistical Association Bulletin*, 5, 82–86.
- [T3-2] Sujit Kumar Mitra (1954). A note on minimum variance in unbiased estimation. *Sankhyā: The Indian Journal of Statistics*, 14, 53–60. [MR0065100 (16,383d), D. G. Chapman; Zbl 0056.38106.]
- [T3-3] S. K. Mitra, S. N. Roy (1956). An introduction to some non-parametric generalizations of analysis of variance and multivariate analysis. *Biometrika*, 43, 361–376.
- [T3-4] Sujit Kumar Mitra (1957). Tables for tolerance limits for a normal population based on sample mean and range or mean range. *Journal of the American Statistical Association*, 52, 88–94. [MR0085669 (19,74b); Zbl 0085.35602.]
- [T3-5] Jogabrata Roy, Sujit Kumar Mitra (1957). Unbiased minimum variance estimation in a class of discrete distributions. *Sankhyā: The Indian Journal of Statistics*, 18, 371–378. [MR0092320 (19,1096g), E. L. Lehmann; Zbl 0084.14901.]
- [T3-6] Sujit Kumar Mitra (1958). On the limiting power function of the frequency chi-square test. *The Annals of Mathematical Statistics*, 29, 1221–1233. [MR0102880 (21 #1666), W. Hoeffding; Zbl 0093.15601.]
- [T3-7] Sujit Kumar Mitra (1959). Some remarks on the missing plot analysis. *Sankhyā: The Indian Journal of Statistics*, 21, 337–344. [MR0124955 (23 #A2262), C. J. Maloney.]
- [T3-8] Sujit Kumar Mitra, E. L. Diamond, S. N. Roy (1960). Asymptotic power and asymptotic independence in the statistical analysis of categorical data. *Bulletin of the International Statistical Institute*, 37 (3), 309–329.
- [T3-9] Sujit Kumar Mitra (1960). On the F -test in the intrablock analysis of a balanced incomplete block design. *Sankhyā: The Indian Journal of Statistics*, 22, 279–284. [MR0132646 (24 #A2485), R. L. Anderson.]
- [T3-10] Nani Gopal Das, Sujit Kumar Mitra (1964). Effect on non-normality on plans for sampling inspection by variables. *Sankhyā: The Indian Journal of Statistics, Series A*, 26, 169–176. [MR0184381 (32 #1854).]
- [T3-11] Sujit Kumar Mitra (1968). On a generalised inverse of a matrix and applications. *Sankhyā: The Indian Journal of Statistics, Series A*, 30, 107–114. [MR0229346 (37 #4920), C. G. Khatri.]
- [T3-12] Sujit K. Mitra, C. Radhakrishna Rao (1968). Some results in estimation and tests of linear hypotheses under the Gauss–Markoff model. *Sankhyā: The Indian Journal of Statistics, Series A*, 30, 281–290. [MR0240926 (39 #2271).]
- [T3-13] Sujit K. Mitra, C. Radhakrishna Rao (1968). Simultaneous reduction of a pair of quadratic forms. *Sankhyā: The Indian Journal of Statistics, Series A*, 30, 313–322. [Reprinted in [T2-7, vol. 3, pp. 162–171]; MR0241444 (39 #2784), P. Fortunati.]

- [T3-14] Sujit Kumar Mitra (1968). A new class of g -inverse of square matrices. *Sankhyā: The Indian Journal of Statistics, Series A*, 30, 323–330. [MR0242853 (39 #4180), C. G. Khatri.]
- [T3-15] Sujit Kumar Mitra, M. T. Subrahmanya (1968). A robust property of the OC of binomial and Poisson sampling inspection plans. *Sankhyā: The Indian Journal of Statistics, Series B*, 30, 335–342. [MR0253468 (40 #6682).]
- [T3-16] Sujit Kumar Mitra, C. Radhakrishna Rao (1969). Conditions for optimality and validity of simple least squares theory. *The Annals of Mathematical Statistics*, 40, 1617–1624. [Reprinted in [T2-7, vol. 3, pp. 177–184]; MR0256517 (41 #1173), M. J. Karson.]
- [T3-17] Sujit Kumar Mitra (1969). Goodness of fit of a compound multinomial distribution. *Bulletin of the International Statistical Institute*, 43 (2), 160–162.
- [T3-18] C. G. Khatri, Sujit Kumar Mitra (1969). Some identities and approximations concerning positive and negative multinomial distributions. In *Multivariate Analysis-II: Proceedings of the Second International Symposium on Multivariate Analysis held at Wright State University, Dayton, Ohio, June 17–22, 1968* (Paruchuri R. Krishnaiah, ed.), Academic Press, New York, pp. 241–260. [MR0251828 (40 #5055), E. Lukacs.]
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- [T3-20] P. Bhimasankaram, Sujit Kumar Mitra (1969). On a theorem of Rao on g -inverses of matrices. *Sankhyā: The Indian Journal of Statistics, Series A*, 31, 365–368. [Zbl 0262.15005.]
- [T3-21] Sujit Kumar Mitra, Brij Mohan Mahajan (1970). On gammaization of the variance ratio. In *Essays in Probability and Statistics: Samarendra Nath Roy Memorial Volume* (R. C. Bose, I. M. Chakravarti, P. C. Mahalanobis, C. R. Rao, K. J. C. Smith, eds.), University of North Carolina Monograph Series in Probability and Statistics 3, University of North Carolina Press, Chapel Hill (and Statistical Publishing Society, Calcutta, 1969), pp. 479–488. [MR0264798 (41 #9389); Zbl 0267.62007.]
- [T3-22] Sujit Kumar Mitra (1970). Goodness of fit of a compound multinomial distribution and allied problem. In *Random Counts in Scientific Work (Expanded from the Proceedings of the Biometric Society Symposium, Dallas, Texas, December 1968), Volume 2: Random Counts in Biomedical and Social Sciences* (Ganapati P. Patil, ed.), Pennsylvania State University Press, University Park, pp. 221–235.
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- [T3-24] Sujit Kumar Mitra (1970). Analogues of multivariate beta (Dirichlet) distributions. *Sankhyā: The Indian Journal of Statistics, Series A*, 32, 189–192. [MR0293758 (45 #2833); Zbl 0225.62069.]

- [T3-25] Sujit Kumar Mitra, P. Bhimasankaram (1970). Some results on idempotent matrices and a matrix equation connected with the distribution of quadratic forms. *Sankhyā: The Indian Journal of Statistics, Series A*, 32, 353–356. [MR0292856 (45 #1938); Zbl 0232.62025.]
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- [T3-28] Sujit Kumar Mitra, P. Bhimasankaram (1971). A characterisation of Moore–Penrose inverse and related results. *Sankhyā: The Indian Journal of Statistics, Series A*, 33, 411–416. [MR0313264 (47 #1819), C. G. Cullen; Zbl 0237.15004.]
- [T3-29] C. Radhakrishna Rao, Sujit Kumar Mitra (1971). Further contributions to the theory of generalized inverse of matrices and its applications. *Sankhyā: The Indian Journal of Statistics, Series A*, 33, 289–300. [MR0321249 (47 #9782), A. K. Gupta; Zbl 0236.15005. Corrigenda: *Sankhyā: The Indian Journal of Statistics, Series A*, 34, 477 (1972). MR0332815 (48 #11140), A. Hedayat; Zbl 0261.62051.]
- [T3-30] Sujit Kumar Mitra (1971). Right and left-handedness of plant organs: is it determined by a Bernoulli process? *Sankhyā: The Indian Journal of Statistics, Series B*, 33, 291–292. [Discussion of “Statistical analysis of bilateral symmetry in plant organs” by T. Anthony Davis & C. Ramanujacharyulu, *Sankhyā: The Indian Journal of Statistics, Series B*, 33, 259–290 (1971).]
- [T3-31] Sujit Kumar Mitra (1972). Simultaneous diagonalization of two or more hermitian forms. In *Proceedings of the 15th Midwest Symposium on Circuit Theory (University of Missouri, Rolla, May 4–5, 1972): Volume 2*, Dept. of Electrical Engineering, Extension Division, University of Missouri, Rolla, pp. XII: 3.1–3.10.
- [T3-32] C. Radhakrishna Rao, Sujit Kumar Mitra (1972). Generalized inverse of a matrix and its applications. In *Proceedings of the Sixth Berkeley Symposium on Mathematical Statistics and Probability (held at the Statistical Laboratory, University of California on June 21–July 18, 1970, June 16–21, 1971), Volume I: Theory of Statistics* (Lucien M. Le Cam, Jerzy Neyman, Elizabeth L. Scott, eds.), University California Press, Berkeley, pp. 601–620. [Reprinted in [T2-7, vol. 3, pp. 314–332]; MR0403093 (53 #6906), E. J. Williams; Zbl 0232.15002.]
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- [T3-35] Sujit Kumar Mitra (1973). Statistical proofs of some propositions on nonnegative definite matrices. *Bulletin of the International Statistical Institute*, 45 (2), 206–211. [MR0378240 (51 #14409), D. G. Kabe.]
- [T3-36] N. K. Bose, Sujit Kumar Mitra (1973). Applications of theory of simultaneous diagonalization of several hermitian forms. *International Journal of Electronics*, 35, 721–735.
- [T3-37] Sujit Kumar Mitra, Madan Lal Puri (1973). On parallel sum and difference of matrices. *Journal of Mathematical Analysis and Applications*, 44, 92–97. [MR0325642 (48 #3989), N. K. Bose; Zbl 0271.15008.]
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- [T3-42] Sujit Kumar Mitra (1974). On a definition of the chisquare distribution. *Gujarat Statistical Review*, 1, 33–36. [MR0415833 (54 #3910), D. N. Shanbhag; Zbl 0335.62012.]
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- [T3-44] N. K. Bose, Sujit Kumar Mitra (1974). Results in a matrix factorization problem. In *Proceedings of the Seventh IEEE International Symposium on Circuits and Systems: Sir Francis Drake Hotel, San Francisco, April 22–25, 1974*, IEEE, New York, pp. 91–94.
- [T3-45] Sujit Kumar Mitra, George E. Trapp (1975). On hybrid addition of matrices. *Linear Algebra and its Applications*, 10, 19–35. [MR0357439 (50
- [T3-46] Sujit Kumar Mitra, C. Radhakrishna Rao (1975). Extensions of a duality theorem concerning g -inverses of matrices. *Sankhyā: The Indian Journal of Statistics, Series A*, 37, 439–445. [Reprinted in [T2-7,

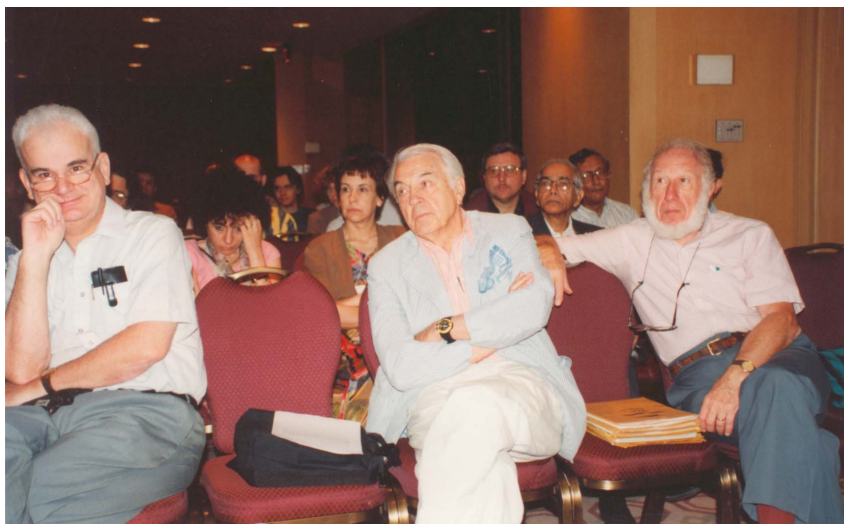
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- [T3-49] Sujit Kumar Mitra (1976). Nonexistence of uniformly minimum variance unbiased estimators: some examples. *Gujarat Statistical Review*, 3 (2), 27–30. [MR0431483 (55 #4481), R. Ponnappalli; Zbl 0341.62028.]
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- [T3-52] Sujit Kumar Mitra (1977). The matrix equation $AXB + CXD = E$. *SIAM Journal on Applied Mathematics*, 32 (4), 823–825. [MR0432676 (55 #5662), Frank W. Owens; Zbl 0392.15005.]
- [T3-53] N. K. Bose, Sujit K. Mitra (1978). Generalized inverse of polynomial matrices. *IEEE Transactions on Automatic Control*, 23 (3), 491–493. [MR0506328 (58 #22099); Zbl 0377.15002.]
- [T3-54] S. K. Mitra (1979). Obituary: Anil Kumar Gayen, 1919–1978. *International Statistical Review*, 47, 95.
- [T3-55] C. G. Khatri, S. K. Mitra, M. L. Puri (1979). Matrices G satisfying simultaneous equations $A^*MAG = A^*M$ and $G^*NGA = G^*N$. *Journal of the Indian Statistical Association*, 17 (Professor Huzurbazar felicitation volume), 103–108. [MR0606397.]
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- [T3-57] Dibyen Majumdar, Sujit Kumar Mitra (1979). Least squares under quadratic constraints. In *Optimizing Methods in Statistics: Proceedings of an International Conference held at the Indian Institute of Technology, Bombay, December 20–22, 1977* (Jagdish S. Rustagi, ed.), Academic Press, New York, pp. 321–333. [MR0541567 (80f:65015), N. N. Abdelmalek; Zbl 0475.15002.]
- [T3-58] Sujit Kumar Mitra (1980). Generalized inverse of matrices and applications to linear models. In *Handbook of Statistics, Volume 1: Analysis of Variance* (Paruchuri R. Krishnaiah, ed.), Elsevier/North-Holland, New York, pp. 471–512. [Zbl 0465.62055.]

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- [T3-97] S. K. Jain, S. K. Mitra, H. J. Werner (1996). Extensions of \mathcal{G} -based matrix partial orders. *SIAM Journal on Matrix Analysis and Applications*, 17, 834–850. [MR1410704 (97g:15017), Jacques Dubois.]
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Simo Puntanen

Figure 22: Montréal, Canada, July 1995: George P. H. Styan, Geoffrey S. Watson, C. Radhakrishna Rao (2nd row), Sujit Kumar Mitra (3rd row), Ingram Olkin.

Table 4: Authorship submatrices and their eigenvalues

| coauthor | eigen- values | block | Das Gupta | Ghosh | Mukhopadhyay | Parthasarathy | Prakasa Rao | Rao, PSSNVP | Rao, SB | Sarma | Bhimasankaram | Matthai | Ramamurthy | Rao, CR | Diamond | Roy, SN | Jain | Werner |
|----------------|------------------|-------|--------------|-------|--------------|---------------|-------------|-------------|---------|-------|---------------|---------|------------|---------|---------|---------|------|--------|
| Das Gupta | 0 | A | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | | | | | | | | |
| Ghosh | 8.3074 | A | 1 | 3 | 1 | 2 | 2 | 1 | 1 | 1 | | | | | | | | |
| Mukhopadhyay | 0 | A | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | | | | | | | | |
| Parthasarathy | 0.4025 | A | 0 | 2 | 0 | 2 | 1 | 0 | 0 | 0 | | | | | | | | |
| Prakasa Rao | 3.2901 | A | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | | | | | | | | |
| Rao, PSSNVP | 0 | A | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | | | | | | | | |
| Rao, SB | 0 | A | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | | | | | | | | |
| Sarma | 0 | A | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | | | | | | | | |
| Bhimasankaram | 4.8924 | B | | | | | | | | | 5 | 0 | 0 | 1 | | | | |
| Matthai | 2.1002 | B | | | | | | | | | 0 | 2 | 1 | 2 | | | | |
| Ramamurthy | 0.3776 | B | | | | | | | | | 0 | 1 | 1 | 1 | | | | |
| Rao, CR | 12.6297 | B | | | | | | | | | 1 | 2 | 1 | 12 | | | | |
| Diamond | 0.3820 | C | | | | | | | | | | | | | 1 | 1 | | |
| Roy, SN | 2.618 | C | | | | | | | | | | | | | 1 | 2 | | |
| Jain | 2 | D | | | | | | | | | | | | | | | 1 | 1 |
| Werner | 0 | D | | | | | | | | | | | | | | | 1 | 1 |
| Khatri | 3.382 | E | | | | | | | | | | | | | | | | |
| Puri | 5.618 | E | | | | | | | | | | | | | | | | |
| Puntanen | 2.618 | F | | | | | | | | | | | | | | | | |
| Styan | 0.3820 | F | | | | | | | | | | | | | | | | |
| Bapat | 0.4384 | G | | | | | | | | | | | | | | | | |
| Hartwig | 4.5616 | G | | | | | | | | | | | | | | | | |
| Baksalary | 1 | H | | | | | | | | | | | | | | | | |
| Bose | 3 | H | | | | | | | | | | | | | | | | |
| Das | 1 | H | | | | | | | | | | | | | | | | |
| Krafft | 1 | H | | | | | | | | | | | | | | | | |
| Krishnamoorthy | 2 | H | | | | | | | | | | | | | | | | |
| Mahajan | 1 | H | | | | | | | | | | | | | | | | |
| Majumdar | 1 | H | | | | | | | | | | | | | | | | |
| Mathew | 2 | H | | | | | | | | | | | | | | | | |
| Moore [Thorne] | 1 | H | | | | | | | | | | | | | | | | |
| Odell | 2 | H | | | | | | | | | | | | | | | | |
| Pathak | 1 | H | | | | | | | | | | | | | | | | |
| Prasad | 2 | H | | | | | | | | | | | | | | | | |
| Roy, J | 3 | H | | | | | | | | | | | | | | | | |
| Shah | 2 | H | | | | | | | | | | | | | | | | |
| Subrahmanya | 1 | H | | | | | | | | | | | | | | | | |
| Trapp | 1 | H | | | | | | | | | | | | | | | | |

| Khatri | Puri | Puntanen | Styan | Bapat | Hartwig | Baksalary | Bose | Das | Krafft | Krishnamoorthy | Mahajan | Majumdar | Mathew | Moore [Thorne] | Odell | Pathak | Prasad | Roy, J | Shah | Subrahmanya | Trapp | coauthor |
|--------|------|----------|-------|-------|---------|-----------|------|-----|--------|----------------|---------|----------|--------|----------------|-------|--------|--------|--------|------|-------------|-------|----------------|
| | | | | | | | | | | | | | | | | | | | | | | Das Gupta |
| | | | | | | | | | | | | | | | | | | | | | | Ghosh |
| | | | | | | | | | | | | | | | | | | | | | | Mukhopadhyay |
| | | | | | | | | | | | | | | | | | | | | | | Parthasarathy |
| | | | | | | | | | | | | | | | | | | | | | | Prakasa Rao |
| | | | | | | | | | | | | | | | | | | | | | | Rao, PSSNVP |
| | | | | | | | | | | | | | | | | | | | | | | Rao, SB |
| | | | | | | | | | | | | | | | | | | | | | | Sarma |
| | | | | | | | | | | | | | | | | | | | | | | Bhimasankaram |
| | | | | | | | | | | | | | | | | | | | | | | Matthai |
| | | | | | | | | | | | | | | | | | | | | | | Ramamurthy |
| | | | | | | | | | | | | | | | | | | | | | | Rao, CR |
| | | | | | | | | | | | | | | | | | | | | | | Diamond |
| | | | | | | | | | | | | | | | | | | | | | | Roy, SN |
| | | | | | | | | | | | | | | | | | | | | | | Jain |
| | | | | | | | | | | | | | | | | | | | | | | Werner |
| 4 | 1 | | | | | | | | | | | | | | | | | | | | | Khatri |
| 1 | 5 | | | | | | | | | | | | | | | | | | | | | Puri |
| | | 2 | 1 | | | | | | | | | | | | | | | | | | | Puntanen |
| | | 1 | 1 | | | | | | | | | | | | | | | | | | | Styan |
| | | | | 2 | 2 | | | | | | | | | | | | | | | | | Bapat |
| | | | | 2 | 3 | | | | | | | | | | | | | | | | | Hartwig |
| | | | | | | 1 | | | | | | | | | | | | | | | | Baksalary |
| | | | | | | | 3 | | | | | | | | | | | | | | | Bose |
| | | | | | | | | 1 | | | | | | | | | | | | | | Das |
| | | | | | | | | | 1 | | | | | | | | | | | | | Krafft |
| | | | | | | | | | | 2 | | | | | | | | | | | | Krishnamoorthy |
| | | | | | | | | | | | 1 | | | | | | | | | | | Mahajan |
| | | | | | | | | | | | | 1 | | | | | | | | | | Majumdar |
| | | | | | | | | | | | | | 2 | | | | | | | | | Mathew |
| | | | | | | | | | | | | | | 1 | | | | | | | | Moore [Thorne] |
| | | | | | | | | | | | | | | | 2 | | | | | | | Odell |
| | | | | | | | | | | | | | | | | 1 | | | | | | Pathak |
| | | | | | | | | | | | | | | | | | 2 | | | | | Prasad |
| | | | | | | | | | | | | | | | | | | 3 | | | | Roy, J |
| | | | | | | | | | | | | | | | | | | | 2 | | | Shah |
| | | | | | | | | | | | | | | | | | | | | 1 | | Subrahmanya |
| | | | | | | | | | | | | | | | | | | | | | 1 | Trapp |

**Table 5: The 38 coauthors with whom
Sujit Kumar Mitra published**

| | |
|-----------------------------------|----|
| Jerzy K. Baksalary | 1 |
| Ravi Bapat | 2 |
| P. Bhimasankaram | 5 |
| N. K. Bose | 3 |
| Nani Gopal Das | 1 |
| Somesh Das Gupta | 1 |
| E. L. Diamond | 1 |
| J. K. Ghosh | 3 |
| Robert E. Hartwig | 3 |
| S. K. Jain | 1 |
| C. G. Khatri | 4 |
| Olaf Krafft | 1 |
| K. Krishnamoorthy | 2 |
| Brij Mohan Mahajan | 1 |
| Dibyen Majumdar | 2 |
| Thomas Mathew | 1 |
| Abraham Matthai | 2 |
| Betty Jeanne Moore Thorne | 2 |
| A. C. Mukhopadhyay | 1 |
| Patrick L. Odell | 1 |
| K. R. Parthasarathy | 2 |
| P. K. Pathak | 2 |
| B. L. S. Prakasa Rao | 1 |
| K. Manjunatha Prasad | 3 |
| Simo Puntanen | 2 |
| Madan Lal Puri | 5 |
| K. G. Ramamurthy | 1 |
| Calyampudi Radhakrishna Rao | 12 |
| P. S. S. N. V. P. Rao | 1 |
| S. B. Rao | 1 |
| Jogabrata Roy | 2 |
| Samarendra Nath Roy | 2 |
| Y. R. Sarma | 1 |
| Kirti R. Shah | 1 |
| George P. H. Styan | 1 |
| M. T. Subrahmanyam | 1 |
| George E. Trapp | 1 |
| H. J. Werner | 1 |

Table 6: The 24 research journals in which Sujit Kumar Mitra published

| | |
|---|----|
| <i>The Annals of Mathematical Statistics</i> | 2 |
| <i>The Annals of Statistics</i> | 1 |
| <i>Bulletin of the International Statistical Institute</i> | 4 |
| <i>Calcutta Statistical Association Bulletin</i> | 2 |
| <i>Circuits Systems and Signal Processing</i> | 1 |
| <i>Gujarat Statistical Review</i> | 5 |
| <i>IEEE Transactions on Automatic Control</i> | 1 |
| <i>IEEE Transactions on Circuits and Systems</i> | 2 |
| <i>The IMS Bulletin</i> | 1 |
| <i>International Journal of Electronics</i> | 1 |
| <i>International Statistical Review</i> | 1 |
| <i>Journal of Mathematical Analysis and Applications</i> | 1 |
| <i>Journal of the American Statistical Association</i> | 1 |
| <i>Journal of the Indian Society of Agricultural Statistics</i> | 1 |
| <i>Journal of the Indian Statistical Association</i> | 2 |
| <i>Linear Algebra and its Applications</i> | 17 |
| <i>Linear and Multilinear Algebra</i> | 1 |
| <i>Proceedings of the Cambridge Philosophical Society</i> | 1 |
| <i>Sankhyā: The Indian Journal of Statistics</i> | 5 |
| <i>Sankhyā: The Indian Journal of Statistics Series A</i> | 18 |
| <i>Sankhyā: The Indian Journal of Statistics Series B</i> | 5 |
| <i>Scandinavian Journal of Statistics</i> | 1 |
| <i>SIAM Journal on Applied Mathematics</i> | 4 |
| <i>SIAM Journal on Matrix Analysis and Applications</i> | 1 |

Table 7: The 14 edited books (collections) in which Sujit Kumar Mitra published

- [T7-1] *Essays in Probability and Statistics: A Volume in Honor of Professor Junjiro Ogawa* (Sadao Ikeda, Takesi Hayakawa, Hiroshi Hudimoto, Masashi Okamoto, Minoru Siotani & Sumiyasu Yamamoto, eds.), Shinko Tsusho, Tokyo, xix + 716 pp., 1976, ISBN 0-80781109-2.
- [T7-2] *Essays in Probability and Statistics: Samarendra Nath Roy Memorial Volume* (R. C. Bose, I. M. Chakravarti, P. C. Mahalanobis, C. R. Rao, K. J. C. Smith, eds.), The University of North Carolina Monograph Series in Probability and Statistics 3, The University of North Carolina Press, Chapel Hill, xviii + 750 pp., 1970, ISBN 0-8078-1109-2. [Indian edition: Statistical Publishing Society, Calcutta, 1969.]
- [T7-3] *Handbook of Statistics, Volume 1: Analysis of Variance* (Paruchuri R. Krishnaiah, ed.), Elsevier/North-Holland, New York, xvii + 1002 pp., 1980, ISBN 0-444-85335-9.

- [T7-4] *Mathematical Statistics and Probability Theory: Proceedings of the Sixth International Conference on Mathematical Statistics: Wisła, Poland, 1978* (W. Klonecki, A. Kozek & J. Rosiński, eds.), Lecture Notes in Statistics 2, Springer-Verlag, New York, xxii + 373 pp., 1980, ISBN 0-387-90493-X.
- [T7-5] *Multivariate Analysis-II: Proceedings of the Second International Symposium on Multivariate Analysis held at Wright State University, Dayton, Ohio, June 17-22, 1968* (Paruchuri R. Krishnaiah, ed.), Academic Press, New York, x + 696 pp., 1969, ISBN 0-12-426652-5.
- [T7-6] *New Trends in Probability and Statistics: Volume 3, Multivariate Statistics and Matrices in Statistics, Proceedings of the Fifth Tartu Conference, Tartu-Pühajärve, Estonia, 23-28 May 1994* (E.-M. Tiit, T. Kollo & H. Niemi, eds.), New Trends in Probability and Statistics 3, VSP International Science Publishers, Zeist (Utrecht), The Netherlands & TEV Ltd., Vilnius, Lithuania, x, 342 pp., 1995, ISBN 90-6764-195-2 (VSP), 9986-546-03-6 (TEV).
- [T7-7] *Optimizing Methods in Statistics: Proceedings of an International Conference held at the Indian Institute of Technology, Bombay, December 20-22, 1977* (Jagdish S. Rustagi, ed.), Academic Press, New York, xx + 556 pp., 1979, ISBN 0-12-604580-1.
- [T7-8] *Proceedings of the 15th Midwest Symposium on Circuit Theory (University of Missouri, Rolla, May 4-5, 1972): Volume 2*, Dept. of Electrical Engineering, Extension Division, University of Missouri, Rolla, 2 vols., 1971, OCLC 4544955.
- [T7-9] *Proceedings of the Seventh IEEE International Symposium on Circuits and Systems: Sir Francis Drake Hotel, San Francisco, April 22-25, 1974*, IEEE, New York, TBC
- [T7-10] *Proceedings of the Sixth Berkeley Symposium on Mathematical Statistics and Probability (held at the Statistical Laboratory, University of California on June 21-July 18, 1970 & June 16-21, 1971), Volume I: Theory of Statistics* (Lucien M. Le Cam, Jerzy Neyman, Elizabeth L. Scott, eds.), University California Press, Berkeley, 6 vols., 1972, ISBN 0-520-01964-4.
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- [T7-14] *Statistics and Probability: Essays in Honor of C. R. Rao* (G. Kallianpur, P. R. Krishnaiah, J. K. Ghosh, eds.), Elsevier/North-Holland, New York, 1982 xi + 722 pp., ISBN 0-444-86130-0.

Table 8: Doctoral students supervised by Sujit Kumar Mitra

- C. G. Bhattacharya: Thesis title, institution, and date not available, but “worked entirely on his own on the common mean estimation problem” [R-22, p. 70]; see “Yates type estimators of a common mean”, *Annals of the Institute of Statistical Mathematics*, 30 (1978), 407–414. [MR538315 (80i:62065)]
- Pochiraju Bhimasankaram: Ph.D. awarded by the Indian Statistical Institute, Calcutta, 1972, for the thesis “Some Contributions to the Theory, Application and Computation of Generalized Inverses of Matrices”. See also “A characterization of subclasses of generalized inverses of specified rank”, *Sankhyā: The Indian Journal of Statistics, Series A*, 36 (1974), 214–218. [MR0384825 (52 #5697)]
- Dibyen Majumdar: “Statistical Analysis of Nonestimable Functionals”, Indian Statistical Institute, New Delhi, 111 pp., 1981.
- Betty Jeanne Moore Thorne: “On Gauss-Markov Estimation in a General Linear Model”, Ph.D., Indiana University, Bloomington, x + 82 pp., 1974. [OCLC 6974404]
- Chilakamarri Ramanujacharyulu: Ph.D. awarded by the Indian Statistical Institute, Calcutta, 1968, for the thesis “Solutions of Some Balanced, Doubly Balanced and Partially Balanced Statistical Designs”. “Ramanuj[a]charyulu . . . worked on construction of designs: my 2nd student”, [R-22, p. 70].
- N. N. Singh: Thesis title, institution, and date not available, but “N. N. Singh . . . worked on genetics. Actually [he] already had enough results which he obtained entirely by himself. My role was to guide him to consolidate all these results and properly present in a thesis form”, [R-22, p. 70].
- M. T. Subrahmanya: Thesis title, institution, and date not available, but “thesis on ‘acceptance sampling plans’: my first student”, [R-22, p. 70].; see “EQL and related measures of Poisson double sampling plans (n_1, n_2, c_1, c_2)”, Technical Publication Series 3, Institute of Statistical, Social, and Economic Research, University of Ghana, Legon, 114 pp., 1968.

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Figure 23: Montréal, Canada, July 1995: participants of the Fourth International Workshop on Matrix Methods for Statistics (IWMS-4).

and Kimmo Vehkalahti for their help. Much of the biographical information in the footnotes has been culled from *Wikipedia: The Free Encyclopedia*. This research was supported in part by the Natural Sciences and Engineering Research Council of Canada.

The abbreviation TBC in this report indicates “to be checked”. We look forward to receiving answers to the various questions we have raised, especially concerning the individuals who completed their Ph.D. degrees under the guidance of Sujit Kumar Mitra.

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