

## **“P.C. Mahalanobis : Mathematical Contributions to Statistics”**

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### **Abstract**

In this work, P.C. Mahalanobis's impact on Indian statistics is analysed. Famous physicist and statistician Mahalanobis is often credited with founding and shaping the Indian Statistical Institute. He has made significant contributions to the fields of statistical theory and methodology (ISI). The first section of the paper is a brief biography of Mahalanobis that covers the basics of his background, education, and career highlights. Statistical theory, technique, and applications are all highlighted as the article continues its examination of his contributions to the discipline. The Mahalanobis distance is a statistical metric that is commonly employed in multivariate analysis and pattern identification; its formulation was one of Mahalanobis's most significant achievements. By creating novel approaches to data gathering and analysis, he also made important strides in the field of sample survey methodology. The research shows that Mahalanobis had a major impact on Indian statistics and his work is still relevant today.

**Keywords:** Statistical Theory and Methodology, Renowned Statistician, Physicist, physicist

### **1. INTRODUCTION**

**Early Life :** Applied statistician and Indian scientist Prasanta Chandra Mahalanobis died on June 28, 1972. He was born on June 29, 1893. A statistical distance named after him—the Mahalanobis distance—is his lasting legacy. In India, he did some groundbreaking work in the field of anthropometry. He was instrumental in developing methods for conducting nation-wide sample surveys and established the Indian Statistical Institute.

He attended the Brahmo Boys School in Calcutta, from which he graduated in 1908. He then enrolled at Calcutta's Presidency College, where he was instructed by the likes of Jagadish Chandra Bose, Sarada Prasanna Das, and Prafulla Chandra Ray. When they were in college, Meghnad Saha was two years junior to Subhas Chandra Bose and two years junior to him, graduating from college in 1912 with a physics degree and honours. In 1913, he embarked for England and the University of London. Nonetheless, he failed to make his train, so he stayed at King's College in Cambridge with a buddy. His host's buddy, M. A. Candeth, highly recommended that he check out King's College Chapel, and he did just that. Besides excelling in his academics at King's, he also developed a passion for punting on the river and long-distance walks. During Srinivasa Ramanujan's tenure at Cambridge University, they became friends. After finishing his physics Tripos, Mahalanobis joined the Cavendish Laboratory to work with C. T. R. Wilson. While on a brief hiatus, he visited India, where he was acquainted to the Presidency College Principal and extended an invitation to teach physics there.

**Indian Statistical Institute:** The Statistical Laboratory at Mahalanobis's room at Presidency College, Calcutta, quickly grew as more and more of Mahalanobis's colleagues became interested in the field of statistics. On December 17, 1931, Pramatha Nath Banerji (Minto Professor of Economics), Nikhil Ranjan Sen (Khaira Professor of Applied Mathematics), and Sir R. N. Mukherji met. On 28 April 1932, the Indian Statistical Institute (ISI) was formally registered as a non-profit distributing learning organisation in India under the Societies Registration Act XXI of 1860, the result of a meeting held at the time. □ The first year's budget for the Institute was Rs. 238 and it was housed at the Physics Department of Presidency College. A number of his colleagues, such as S. S. Bose, J. M. Sengupta, R. C. Bose, S. N. Roy, K. R. Nair, R. R. Bahadur, Gopinath Kallianpur, D. B. Lahiri, and C. R. Rao, contributed significantly to its development. Pitamber Pant, a secretary to the Prime Minister Jawaharlal Nehru, was also a significant contributor to the institute. Pant was a student of statistics at the Institute and became quite invested in it during his time there.

Sankhya, modelled by Karl Pearson's Biometrika, was established in 1933. In 1938, the institute established a department devoted to education and training. Early employees departed the ISI for jobs in the United States and the Indian government. After been invited

by Mahalanobis, J. B. S. Haldane began working at the ISI in the capacity of Research Professor in August 1957 and remained there until February 1961. He left the ISI because he couldn't stand working under the leadership of Mahalanobis and disagreed with his views. He was particularly troubled by the director's absence and frequent trips, saying, "The... journeyings of our Director define a novel random vector." However, Haldane contributed to the ISI's expansion into biometrics. The institute received official recognition as a deemed university and national institute in 1959.

**Education:** Prasanta Chandra Mahalanobis attended both the Brahmo Boys' School and the University of Calcutta during his formative years. He entered Cambridge, a prestigious English university, on a full scholarship in 1913. In 1915, he graduated with a Bachelor of Arts in Mathematics, and in 1917, he graduated with another Bachelor of Arts in the Mathematical Tripos. The next year, in 1921, he completed his doctorate in physics at Cambridge. His dissertation covered ground in statistics and was titled "The Theory of Error and the Method of Least Squares." He also received India's second-highest civilian honour, the Padma Vibhushan, for his work.

## CONTRIBUTION TO MATHEMATICS

The following is a bulleted summary of some of Prasanta Chandra Mahalanobis' most important contributions to Indian statistics:

- The Mahalanobis distance was developed as a means of assessing the separation of two distributions that accounts for the interdependencies of their constituent variables.
- The Indian Statistical Institute (ISI) was established in Calcutta, and it quickly rose to prominence as a leading research centre for India's statistical community.
- The Mahalanobis sampling method, developed on the basis of stratified sampling and proportional allocation, is a popular approach to selecting sample members for use in statistical research.
- Improvements in areas such as statistical inference, design, and quality control that rely heavily on statistics.
- He was honoured with the Padma Vibhushan, India's second-highest civilian honour, and was elected as a Fellow of the Royal Society.
- His development of the Mahalanobis distance had a significant impact on multivariate analysis and pattern identification.
- His research and development of the Mahalanobis sampling technique have had a significant impact on survey sampling.
- His establishment of the Indian Statistical Institute (ISI) had a profound effect on the growth of statistics as a distinct academic field in India.

### ➤ **Mahalanobis distance**

Among descriptive statistics, the Mahalanobis distance gives a relative measure of the residual separation of two data points. P. C. Mahalanobis established this dimensionless quantity in 1936. By comparing an unidentified sample set to a labelled one, we may get a sense of how similar it is. It is not scale-dependent like the traditional Euclidean distance, and it also accounts for data set correlations. That is to say, it may be measured across multiple variables.

For a set of observations with mean and covariance matrix  $S$ , we have the following formula to calculate the Mahalanobis distance: For random vectors drawn from the same distribution with the covariance matrix  $S$ , the Mahalanobis distance (or "generalised squared inter point distance" for its squared value) can be defined as a dissimilarity measure: For the case where the covariance matrix is the identity matrix, the Mahalanobis distance is equivalent to the classical Euclidean distance. In the case of a diagonal covariance matrix, the resulting distance measure is known as a normalised Euclidean distance. Where  $s_i$  represents the sample-wide standard deviation of  $x_i$  and  $y_i$ .

### ➤ **Sample Surveys**

The use of large samples in surveys is the main focus of his most significant contributions. He proposed conducting test surveys beforehand and defended the value of random sampling.

The first surveys were conducted between 1937 and 1944, and they mainly focused on things like consumer spending, tea consumption, public opinion, crop acreage, and plant disease. The ISI has taken the lead in the original development of the technique of sample surveys, the most potent fact finding process available to the administration, as noted by Harold Hotelling and Sir R. A. Fisher, respectively.

He proposed a technique for estimating harvests in which statisticians would go out to fields and take samples by cutting crops in a 4-foot diameter circle. P. V. Sukhatme and V. G. Panse, who had previously worked on crop surveys with the Indian Council of Agricultural Research and the Indian Agricultural Statistics Research Institute, respectively, argued that a survey system should use the preexisting administrative infrastructure. Due to their heated disagreements, Mahalanobis and the agricultural research community never worked together again.

#### ➤ **Linguistic**

While working at the Indian Statistical Institute, Mahalanobis also established a research programme in quantitative linguistics and language planning at the institute's Linguistic Research Unit. Together with Djordje Kostic, Rhea Das, and Alakananda Mitter, he contributed to the field of language correction through their work in Speech Pathology.

### **HONOURS**

- Fellow of the Indian Academy of Sciences (FASc, 1935)
- Fellow of the Indian National Science Academy (FNA, 1935)
- Officer of the Order of the British Empire (Civil Division), 1942 New Year Honours list
- Weldon Memorial Prize from the University of Oxford (1944)
- Fellow of the Royal Society, London (1945)
- President of Indian Science Congress (1950)
- Fellow of the Econometric Society, US (1951)
- Fellow of the Pakistan Statistical Association (1952)
- Honorary Fellow of the Royal Statistical Society, UK (1954)
- Sir Deviprasad Sarvadikari Gold Medal (1957)
- Foreign member of the Academy of Sciences of the USSR (1958)
- Honorary Fellow of King's College, Cambridge (1959)
- Fellow of the American Statistical Association (1961)
- Durgaprasad Khaitan Gold Medal (1961)
- Desikottam by Visva Bharati University (1961)
- Padma Vibhushan (1968)
- Srinivasa Ramanujan Gold Medal (1968)

The government of India decided in 2006 to celebrate his birthday, 29 June, as "National Statistical Day".

On the occasion of his 125th birth anniversary on 29 June 2018, Indian Vice-President M Venkaiah Naidu released a commemorative coin at a programme at ISI, Kolkata.

### **LATER LIFE**

Later in life, Mahalanobis served on the planning commission and made significant contributions to India's five-year plans, beginning with the second one after the country gained independence. His second five-year plan centred on a two-sector model of industrialization. The Mahalanobis model, a modification of Wassily Leontief's Input-output model, was used in India's Second Five Year Plan, which aimed to rapidly industrialise the country, and he, along with his colleagues at the institute where he worked, was instrumental in laying the groundwork for the country's modern statistical system. He recommended that Daniel Thorner take on a study to evaluate India's deindustrialization and fix several flaws in the census's earlier approach. Mahalanobis was a pivotal figure in the movement that won the 1950s for the introduction of the first digital computers in India.

As a result of his lifelong passion for the arts, Mahalanobis worked as Rabindranath Tagore's secretary at Visva-Bharati University and later wrote about Tagore in the Journal of the Oriental Society of Australia. The Government of India recognised his contributions to

research and service to the country by awarding him the Padma Vibhushan, the country's second-highest civilian honour.

On June 28, 1972, one day before his 79th birthday, Mahalanobis passed away. He continued to perform research and carry out his duties as secretary and director of the Indian Statistical Institute and honorary statistical advisor to the Cabinet of the Government of India, all the while being 102 years old.

## CONCLUSION

So, to sum up, Prasanta Chandra Mahalanobis did a lot for Indian statistics. Forever changing the face of statistics in India and beyond, Mahalanobis is best known for developing the Mahalanobis distance and Mahalanobis sampling method and establishing the Indian Statistical Institute. His legacy lives on in the many sectors, including machine learning, biostatistics, and economics, that have benefited from his contributions to the subject. Many credit Mahalanobis with helping to establish statistics as a distinct field of study in India, and his work has inspired generations of statisticians since.

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