INDIAN STATISTICAL INSTITUTE

HISTORY AND ACTIVITIES
1931—1957

MARCH 1958

THE STATISTICAL LABORATORY
AND
THE INDIAN STATISTICAL INSTITUTE
1931–1957

Early Beginnings

The beginnings of the Indian Statistical Institute were modest enough : a solitary computer working part-time and a total current expenditure of even less than Rs. 250 —that was all when it started in April 1932. In December 1957, the Institute had on its roll 1864 regular workers who were backed by an annual budget allocation of Rs. 73,00,000. Impressive as these figures are, they convey little idea of the nature of the work that is being carried on by the Institute, its wide range, its complex character and the specialization at high scientific levels that is necessary for carrying out investigations that have an intimate bearing on the life of the nation.

A long period of preparatory activity, going back to the early years of the first world war, preceded the formal inauguration of the Institute. This period was marked by a series of random events which, appropriately enough, played an important role in the foundation of the Institute. Prasanta Chandra Mahalanobis was back in India in 1915 on a short holiday after he had been awarded a senior scholarship of King's College, Cambridge, for research in physics. Just before his departure from Cambridge, his tutor, W. H. Macaulay, had quite casually drawn his attention to the *Biometrika* and Karl Pearson's *Biometric Tables*, copies of which he brought with him to India and which he studied with keen interest while waiting to return to Cambridge for his physical researches. But he did not return to Cambridge. Accepting the post of a professor of physics in the Presidency College, Calcutta, he decided to stay back in India and to carry on his statistical studies alongside of his work as a teacher of physics.

In 1917 the University of Calcutta appointed a committee with Brajendra Nath Seal (then University Professor of Philosophy) as chairman to enquire into the examination system of the University. Seal was a scholar with a wide range of interests and was conversant with recent developments in biometry. He asked Mahalanobis to help in the work of the committee by using statistical methods for the analysis of the examination data. This led to Mahalanobis's starting work on statistical problems. Before the enquiry was completed, Seal accepted the post of the Vice-Chancellor of the University of Mysore and left Calcutta. Clearly visualizing future needs, he however asked his young disciple to take up seriously the study of statistics.

For some time Mahalanobis carried on his statistical studies in his own home with the help of part-time computers engaged by him. A chance meeting with N. Annandale (then Director of the Zoological and Anthropological Survey of India) at an excursion at the Nagpur Session of the Indian Science Congress in 1920 led to Mahalanobis's first systematic work on a statistical study of the anthropometric measurements which had been taken

by Annandale on Anglo-Indians (of mixed British and Indian parentage) in Calcutta. Mahalanobis's first paper was thus on "the Statistical Analysis of Anglo-Indian Stature" which was published in the *Records of the Indian Museum* in 1922.

In accordance with the usual practice the above paper had been referred to Sir Gilbert Walker (then Director General of Observatories) for opinion which led to Sir Gilbert asking Mahalanobis to undertake a statistical study of some meteorological problems. This resulted in two memoirs on upper air variates being published in 1923. Statistical deviations from the average were for the first time explicitly separated from experimental errors of observation. This led, by purely statistical methods, to the location at the height of about 4 kilometers above sea level of the region of highest control for changes in meteorological conditions on the surface of the earth (a result which was rediscovered several years later by F. Bauer in Germany from physical considerations).

The meteorological studies led to Mahalanobis being appointed Meteorologist, Calcutta, in which post he worked for more than 3 years from 1922 to 1926 in addition to his duties as professor of physics in the Presidency College. In 1922 a disastrous flood had occurred in North Bengal. An expert committee of engineers appointed by Government were about to recommend the construction of expensive retarding basins to hold up the flood water when the question was referred to Mahalanobis for examination. A statistical study of rainfall and floods extending over a period of about 50 years showed that the proposed retarding basins would be of no value in controlling floods in North Bengal. Entirely different remedies were recommended, many of which were implemented and proved effective.

A little later, after a severe flood in the Brahmini river in 1926, the question of flood control in Orissa was referred to Mahalanobis, and resulted in a laborious study of the areal and time distribution of rainfall in relation to floods in Orissa rivers. An expert committee of engineers were of opinion that a catastrophic rise had occurred in the river-bed of the Brahmini, and the committee recommended increasing the height of river embankments by several feet. The statistical study covering a period of about 60 years showed that no change had occurred in the river-bed, and indicated that the construction of dams for holding up of excessive flood water in the upper reaches of the rivers was likely to be of value in this region. Apart from such suggestions for really effective flood control these extensive investigations into rainfall and floods in Orissa and West Bengal also supplied in later years some of the basic calculations for two great river valley schemes, namely, the Damodar Valley and the Hirakud Projects.

In 1924 Mahalanobis had the occasion to study the probable error of results of agricultural experiments in which six varieties of paddy had been sown in a systematic manner in ten replicated blocks. In the resulting paper the variation in soil heterogeneity was sought to be eliminated by fitting non-linear graduating curves (a method which was used independently by J. Neyman several years later). In complete ignorance of the work on the design of experiments done a little earlier by R. A. Fisher, Mahalanobis suggested in this paper that each strip or plot should be divided into a number of sub-plots with a view to securing replicated observations. The paper placed him in touch with R. A. Fisher; and Mahalanobis immediately began to study seriously Fisherian methods of field experiments. During a visit to England in 1926, he met Fisher and close personal relations were established.

Some further work was also done on physical anthropology in the early days. Mahalanobis selected "Analysis of Race Mixture in Bengal" as the subject of his Presidential Address to the Anthropological Section of the Indian Science Congress in 1925 in which he used for the first time an early and crude form of the generalized distance (D^2-statistic) for purposes of classification.

Since 1920 or 1921 Mahalanobis had employed one or two part-time computers at his own expense to assist him in the statistical studies. Small *ad hoc* grants which were sanctioned by Government between 1924 and 1930 for studies on rainfall and floods enabled one or two whole-time computers being employed from time to time. One of these, Sudhir Kumar Banerjee, who joined in 1925, later became chief computer. Among other early workers were Jaladhar Sarma who is still in the Institute, Nistaran Chakravarti who till recently had been the Director of the West Bengal Statistical Bureau, and Sarojendra Nath Das Majumder who is now a lawyer and helps the Institute in its legal work.

Grant from the I.C.A.R. : 1931

After his return from Europe in 1927 Mahalanobis gathered around him several part-time assistants and a group of young research workers to form the nucleus of the Statistical Laboratory which was located in the Presidency College, Calcutta. Mahalanobis's own room in the physics laboratory of the Presidency College was partitioned. On one side the statistical workers were kept busy. In an adjoining room, Subhendu Sekhar Bose was engaged on research in physics.

The Report of the Royal Commission on Indian Agriculture had been published by this time. It brought the Imperial (now Indian) Council of Agricultural Research into existence. R. A. Fisher's work at Rothamsted had by that time revolutionized the technique of agricultural experiments. The Indian authorities were anxious to introduce statistical methods on Fisherian lines. Mahalanobis had as early as 1924-25 published a paper on the probable error of field experiments in agriculture. In July 1931, the I.C.A.R. sanctioned an annual grant of Rs. 2,500 for statistical studies relating to agricultural research for three years. The Laboratory was already in possession of Rs. 25,000 worth of books, journals, calculating machines and other equipments which had been bought by Mahalanobis with his own money.

Meanwhile Subhendu Sekhar Bose's infectious good nature had broken down the partition in the room at Presidency College which we have mentioned above. Another student of physics became a statistician. In September 1931, Bose became the Senior Assistant at the Statistical Laboratory, Calcutta. It was then that the Laboratory began to develop at an accelerating rate. S. S. Bose had a flair for friendship and through him the Institute soon created a wide circle of friends and sympathisers. His death in November 1938 was an irreparable loss.

The Laboratory at this time consisted of a small group of young workers with S. S. Bose at the head. Sudhir Banerjee was the chief computer; from the very beginning he used to look after business and financial management which he continued to do with great ability until his death in 1952. Jitendra Mohan Sen Gupta joined in 1932 and after a few years took charge of the whole of the computing section; later he specialized in sample surveys. There were also a number of young men who had taken their master's degree and who used to do a good deal of computational work while learning statistics. Among them

may be mentioned Rabindra Nath Sen, Prabhat Ranjan Roy, J. R. Guha Thakurta, Anil Nag, Sailen Sen, K. C. Basak, and Sadasiv Sen Gupta who all joined before 1933. Although they have left the Institute, most of them are working as statisticians or economists. Khagendra Nath Chakravarti became associated with the Laboratory from this time and later served as Joint Secretary of the Institute for 10 years until retirement. Hari Charan Ghosh also established contact with the Institute about this time and has been maintaining it in various ways since then.

The annual grant from the Imperial Council of Agricultural Research opened new fields of work. Six or seven years earlier, some work had been done on the margin of error of agricultural field experiments. The ICAR grant was originally intended to be used for theoretical research on the same subject. A large number of enquiries about applied problems of many kinds, however, soon began to be received from all over India, and the scope and nature of the work changed rapidly.

From the very beginning Mahalanobis and his associates used the Fisherian method of field experiments in India. Through their efforts a latin square design was first used in India in 1931, factorial designs in 1932, split-plot arrangements in 1933, confounded designs in 1935, and quasi-factorial experiments in 1937.

For nearly 10 years the Statistical Laboratory in Calcutta functioned as a focal centre for attending to enquiries about the application of statistical methods to agricultural investigations. These covered a wide range of subjects such as field trials, plant physiology, bacteriological surveys, entomology, vernalization, effect of borer pests on sugar cane, animal nutrition, forest research, soil deterioration, etc. In the course of replying to these enquiries a series of "Statistical Notes for Agricultural Workers" were prepared out of which more than 25 were published in the *Indian Journal of Agricultural Research* between 1932 and 1940.

One of these enquiries came from an officer engaged in agricultural research who asked whether he could come for a short course of training in the Statistical Laboratory. He was told that he would be welcome. This marked the beginning of the training section which was started on an entirely individual basis in July 1932. The section steadily expanded, the trainees including officers interested in the application of statistics for purposes other than agricultural research. Within a short time from 12 to 15 officers in Government Departments or scientific institutions were coming every year for short courses of training in statistics. Gradually, younger scholars who had taken their master's degree also began to join.

Indian Statistical Institute : 17 December 1931

The year 1931 marks another milestone in the progress of statistical organization in India. Early that year the workers in the Laboratory started discussing the question of founding a statistical society. Mahalanobis sought the advice of K. B. Madhava who at that time was working as professor of mathematical economics and statistics in Mysore (a post which had been created in 1924 by Brajendra Nath Seal, then Vice-Chancellor of the University). Madhava immediately pointed out the need of keeping the door open for training and examinations in statistics. A preliminary circular was issued in June 1931 which received encouraging support from all over India. On 14 December 1931, a notice was issued over the signatures of Pramatha Nath Banerjee (Minto Professor

of Economics), Nikhil Ranjan Sen (Khaira Professor of Applied Mathematics), and P. C. Mahalanobis (Professor of Physics) convening a meeting to be held on the 17th December to consider the steps to be taken towards the establishment of an association for the advancement of statistics in India.

At this meeting, held on 17 December 1931, it was unanimously resolved that the Indian Statistical Institute be established, and Sir R. N. Mukherjee (who presided over the meeting) was requested to accept the office of the first President of the Institute. P. C. Mahalanobis was appointed Honorary Secretary, and two committees were formed—one for drawing up the constitution of the Institute and the other for preparing a scheme for a statistical journal. At the same time, V. G. Kale, K. B. Madhava and C. N. Vakil were requested to organize local centres at Poona, Mysore and Bombay respectively. The Institute was registered on the 28th April 1932 as a non-profit scientific society under the Societies Registration Act No. XXI of 1860. The total expenditure in the first year was Rs. 238 out of which Rs. 50 was the registration fee.

The membership of the Institute is open to all persons interested in statistics, irrespective of sex, caste, creed, class or nationality. A Council, consisting partly of the representatives of the provincial branches and partly of councillors elected annually by the members of the Institute, is responsible for the management of the Institute. In October 1951 a Governing Body was established to look after the work of the Research and Training School of the Institute.

Office-bearers of the Institute

The first President, Sir R. N. Mookerjee held office till his death in 1936. He took a keen interest in the work of the Institute and used to preside over all its meetings. His support gave the Institute a definite status in the eyes of the public. He was followed by a number of leading businessmen and industrialists as President : Sir Edward Benthall (1936–38), Sir James Reid-Kay (1939-40), Sir Badridas Goenka (1941-42), and Mr. N. R. Sarker (1942-44). Since 1945 Shri Chintamon D. Deshmukh has been holding the office of the President and helping in the development of the Institute in every possible way.

Vice-Presidents and Presidents of local branches have included many prominent scientists, industrialists and public men from different parts of India.

The office of the Treasurer was held by Sir Harisankar Paul for a short time and then for several years by Mr. K. C. Mahindra. Dr. Satya Churn Law became the Treasurer in 1936 and has been functioning in this capacity since then.

P. C. Mahalanobis has been working as Secretary from the beginning with S. N. Bose holding charge during Mahalanobis's absence in 1946 and 1947.

As regards the work of the Joint Secretary, H. C. Sinha (1931-32 to 1939-40) and K. N. Chakravarti (1941-42 to 1951-52) rendered valuable services in this office for many years; R. C. Bose, K. R. Nair and H. C. Ghosh held this post for 3 or 4 years each ; S. C. Sen and N. C. Chakravarti are looking after the administrative work in this capacity since 1950-51 and 1952-53 respectively.

Sir Dhirendra Nath Mitra was elected Chairman of the Institute in 1955 when this new post was created by a change of rules.

Early Developments

In 1933, *Sankhyā : The Indian Journal of Statistics* was started and letters of appreciation were received from statisticians from different parts of the world. The review in the *Journal of the Royal Statistical Society* (1934) was particularly encouraging. In 1934 H. C. Sinha made an extensive tour of Europe which served to establish personal contacts with a large number of statisticians and statistical institutions abroad. He was particularly successful in securing a large number of publications on an exchange basis. Contributions to *Sankhyā* also began to be received through his efforts; and he rendered invaluable services in making the work of the Institute known abroad.

Harish Chandra Sinha, whose early training was in mathematics but who had taken his doctor's degree in economics, had started advanced studies and research in economic statistics as early as 1926 or 1927. He took a leading part in the foundation of the Indian Statistical Institute in 1931-32, and took up the work of the Institute with great vigour as its Joint Honorary Secretary. With the help of Amulya Ratan Sinha and others, he made a series of studies on Indian prices in relation to other economic factors.

In 1933, Raj Chandra Bose started work on a part-time basis with the help of a research fellowship of the Institute, and began working on the exact distribution of the generalized distance, that is, the measure of divergence between two populations as an aid to classification which had been introduced by Mahalanobis in 1925 and had been developed in later papers. In 1935, Samarendra Nath Roy joined the staff and started working on the same problem of classification and discrimination in terms of variances and covariances leading to his important contributions in multivariate analysis.

With the expansion of its activities other workers were attracted to the Institute. K. Raghavan Nair joined the Institute in 1936 and K. Kishen joined a little later. Both of them carried on researches on theoretical and applied problems and also participated in the teaching programme. The Institute was very fortunate in having succeeded in attracting a devoted group of workers not only in purely scientific or intellectual pursuits but also in the humbler sphere of computation, field investigation, and routine and administrative duties. Jitendranath Talukdar joined in 1935 and became in time the chief of the computing section and later the officer in charge of the Giridih Branch. Subodh Das Gupta started work in 1935 and later took over charge of the construction of buildings and of the Estate Office. Herambo Ghosal, Gayanath Adak, Sambhu Haldar and Naresh Mukherjee had joined by 1936 and in time undertook work of much responsibility; it was a great loss when Ghosal died in 1952 and Adak in 1953.

In the early years about 10 or 12 meetings used to be organized in Calcutta every year at which lectures were given or discussions were arranged on both theoretical and applied problems of statistics. These meetings served to stimulate interest in statistics and also gave an opportunity to the younger workers to present reports on selected topics and sometimes on their own researches.

Attending to statistical enquiries of various kinds was an important part of the work of the Institute for a long time. During the first 8 or 9 years, that is up to about 1942, the total number of enquiries handled every year was more than 130 on an average. These enquiries covered a wide range of statistical topics and came from all over India. From about 1943, with the growth of local centres of statistical work in different parts of

the country, the number of such enquiries gradually decreased. In the early years this part of the work was, however, of great educational value.

The Institute was doing promotional work in other directions. A note on the need of organization of statistical studies was submitted to the Government of Bengal in 1933. Another note emphasising the need of introducing statistical quality control (SQC) in India was submitted to the Government of India in 1934. In 1935 a committee was set up to report on professional examination in statistics, and on the basis of the recommendations made by this committee, the Institute started annual examinations in statistics in 1938. A committee was also set up to report on official statistical publications which made valuable recommendations in 1937.

The work in the Laboratory in these early days was rather informal. From 1928 the workers started going to a hill-station (usually to Giridih) during the summer and the autumn vacations where a kind of vacation camp used to be set up for statistical work. The workers lived together and worked intensively on statistical subjects. This was the formative period in the laboratory when a great deal of fruitful work was done by co-operative team work. The vacation camps continued to be organized till about 1944 or 1945.

Grant from the Government of India : 1935

Sir James Grigg (then Finance Minister) visited the Laboratory in 1934, and it was due to his sympathetic interest that the Institute got its first research and training grant of Rs. 5,000 per year from the Government of India in 1935. This was of great help and enabled a small whole-time staff being appointed in the Institute.

In 1934, the visit of A. L. Bowley and D. H. Robertson gave a stimulus to the organization of economic and statistical surveys. The Government of Bengal set up a Board of Economic Enquiry with the work of which the Statistical Laboratory became closely associated. A sample survey of rural indebtedness was undertaken in 1934-35. In 1935-36 the Institute conducted on behalf of a private firm an interesting sample survey of consumer preference which gave the workers valuable experience and confidence in a new type of work. An extensive survey of the handloom industry (covering about 8,000 weaving and 2,000 other rural families) was conducted in 1936-37. Nihar Chandra Chakravarti, as the Secretary of the Board of Economic Enquiry, began to work in close contact with the Institute from this time and a few years later began working in the Institute on a part-time basis in connection with large scale sample surveys; still more recently he has been helping in the administrative work of the Institute as its Joint Secretary.

Indian Statistical Conference : 1938

Developments in other directions were also taking place. For many years statistical workers had been contributing papers to the Indian Science Congress, and they were gradually pressing for a statistical section of their own. The request, however, did not receive sympathetic consideration at first. In 1937 it was, therefore, decided to organize independently an Indian Statistical Conference. R. A. Fisher was invited to come to India to act as the President of the first session in 1938.

In January 1938, the first Indian Statistical Conference was organized in Calcutta with R. A. Fisher as President immediately after the Jubilee Session of the Indian

Science Congress. During the next five years similar conferences were organized by the Indian Statistical Institute at the same place and usually at the same time as the annual session of the Indian Science Congress. The Statistical Conferences had immediate promotional value. The Science Congress authorities agreed to start a separate section for mathematics and statistics from 1942 with Mahalanobis as the Sectional President. A separate section for statistics was started in 1945 with K. B. Madhava as the Sectional President. In 1945 Mahalanobis was elected General Secretary of the Indian Science Congress Association ; and in 1950 when he was elected the General President, he selected "Why Statistics" as the subject of his Presidential Address. In this way statistics gradually won recognition in India and in this process the Institute had played an important part.

Sample Survey of the Jute Crop : 1937

In his report to the ICAR Sir John Russel, who visited the Institute in 1936, had strongly recommended extending the facilities for statistical training in the Institute, and had also supported the proposal made by Mahalanobis for using the sample survey for improving crop estimates. The newly established Indian Central Jute Committee initiated an exploratory sample survey of the jute crop in 1937 under the technical guidance of Mahalanobis. After the field enquiry was over, serious administrative difficulties arose about completing the statistical analysis of the material. Owing to sharp differences of opinion, there was also a danger of sampling being abandoned altogether.

At this stage Fisher's strong support was of great help. In a memorandum submitted to Government in 1938, Fisher wrote :—

"In sociology and in the economic aspects of agriculture, the most obvious line of progress now suggested is the development of the sampling method. This method is capable, at very trifling expense, of ascertaining, with more than the necessary precision, such facts as the actual yield in a district, or province, of any chosen agricultural crop. Details of the technique required for Indian conditions must be worked out thoroughly for a mere imitation of the English procedure might easily encounter special obstacles.

"An adequate sampling technique is equally feasible and equally necessary in economic and sociological enquiries. This should, I believe, be developed at the Statistical Institute which already has several such studies to its credit. The immediate danger here is the undertaking of such surveys by persons having little acquaintance with modern statistical methods, or with the economic planning of such enquiries. Gross incompetence here is not at all out of the question."

The organization of statistical studies was also under consideration by Government at that time. In this matter also Fisher gave strong support to the Institute in his memorandum to the Government of India :—

"In regard to the future of statistical studies in India, at present it would seem that everything depends on the future of the Statistical Institute. This holds a key position, for the reason that India is rich in men capable of making a good showing on the basis of a university education, but poorly off in respect of those having a thorough technical grasp of what can in practice be done. Consequently, the mere creation of posts for statisticians followed by filling them with applicants possessing abundantly plausible credentials, would merely perpetuate an imitative adherence to the obsolete methods of the older text

books, and would stand in the way of real advances. There are, on the contrary, many young Indians capable of responding to the dual discipline of sound mathematical training, followed by practical, responsibly conducted research, in which sound judgment can be acquired, and the real meaning of the mathematical studies brought to the surface.

"I should regard the Institute as the training ground for candidates for future appointments. For this purpose it should in the meanwhile be freely used as a centre where special problems can be studied, especially in agriculture, public health, and sampling surveys for economic and sociological purposes. Its most difficult duty is to show that such studies can be carried out both objectively and with scientific precision; that is to say, with a precision which is itself demonstrable, and is not a matter of opinion.

"..... The value of such temporary training to those who experience it cannot be over-estimated. In a research atmosphere they should become familiar with the most effective means of coping with common difficulties, and with the ordinary fallacies and misapprehensions which bring ill-planned projects to an enviable and costly failure. They become aware of the strict tests by which statistical conclusions can be scrutinized, and come to regard conclusions which cannot pass such tests as intellectually impertinent."

Increasing Activities

The year 1938 was in many ways a turning point in the history of the Institute. As already mentioned, up to 1931 the number of workers was only about 2 or 3. The number had slowly increased from about 8 in 1931-32 to 26 in 1937-38. By this time younger workers were coming from all over India for advanced studies and research. Even more significant was the decision of the Indian Central Jute Committee and the Government of Bengal to proceed with the sample survey of the jute crop which had started on a very small scale in 1937. From 1938 the scale of the exploratory work was increased from year to year which led to rapid developments in the Institute. The statistical staff increased in strength from 51 in 1938-39 to about 140 in 1941-42, the last year of the five-year jute survey project. The total budget of the Institute, which was less than Rs. 4,000 in 1932-33, increased to nearly one hundred and fifty thousand rupees in 1941-42.

Since 1937 the sample survey of agricultural crops and a little later, large scale economic and social surveys of all kinds became the most important field of activity of the Institute. A survey of family budgets was conducted in 1938-39 and extensive work on crop-cutting experiments (to estimate the yield per acre) was started in 1939 which is being still continued. Jitendra Mohan Sen Gupta ("Shankar"), who has been associated with the agricultural crop surveys from the very beginning and has been responsible for many of the technical advances in this field, is continuing actively his research activities.

Some of the most valuable workers of the Institute joined at about this time, such as, Satyabrata Sen (1938), S. Raja Rao (1938), Mohanlal Ganguli (1939), Nimai Ghosh (1940), Pranay Kumar Chatterjee (1940), and Anikendra Mahalanobis (1940); some had gone to work outside the Institute from time to time but all have come back and are now working here. Another group of workers had shared heavy responsibilities for many years but are now working in other places; among them may be mentioned Dhirendra Mohan Ganguly (1935), Atindranath Bose (1938), Mrs. Chameli Bose (1939), B. N. Ghosh (1939), P. K. Bose (1939), Anil Bhattacharyya (1940) and N. T. Mathew (1940). Among others who had worked

in the Institute for shorter periods at this time were P. V. Sukhatme (1936), G. M. Panchang (1937), K. S. Banerjee (1937), V. G. Pendharkar (1938-39), Tarini Prasad Ghosh (1938), B. N. Datar (1940) and K. C. Cheriyan, all of them are working in statistical or associated fields.

On the computational and administrative sides, Rajen Ray, Shamsundar Bose, Haribhajan Chaudhury, Susanta Guha, Sarat Mitra, Prabhat Sinha, Dhiren Sarkar, Purna Ghosh and Sukumar Hazra had joined the Institute by about 1940 or 1941 and are now a part of the inner core of old workers.

Jibananda Saha joined as a computer in 1937 but gradually took charge of the library and has attracted some able associates like Biswajit Ray, Sarat Chandra Banerjee and Braja Kishore Sinha who is in charge of the photographic section.

Research and Training

Fisher's visit in 1937-38 had other important consequences. Research in the construction and analysis of balanced incomplete block designs was at that time in its early stage. Personal contact with Fisher led R. C. Bose to take up the subject from the point of view of advanced theory. With the application of the theory of Galois fields R. C. Bose obtained all the known solutions previously given by Fisher and Yates together with a number of new solutions. This opened up a great deal of work on the design of experiments under the leadership of R. C. Bose in which a number of young workers like K. Raghavan Nair, K. Kishen and others participated. Since then the design of experiments has continued to be an important field of research in the Institute.

Harold Hotelling came to India as the Visiting Professor in 1939-40 and established personal contacts between Institute workers and statisticians in the USA. Hotelling gave strong support to the Institute and in a memorandum submitted to the Government of India discussed the problems of (1) training, (2) research, (3) advisory work, and (4) statistical projects; and stated that "the Statistical Laboratory had distinguished itself in all the four types of activities."

Training School : 1939

During the seven years from 1932 to 1939 more than 150 officers had come to Calcutta on deputation from all over India for short courses of training in statistical methods. The demand for advanced training from other qualified persons had also steadily increased; and, in spite of limited resources, the Institute started an organized course of instruction from July 1939. Since then these training classes have gradually developed into a professional school the chief aim of which is to offer facilities for professional training to persons who have already taken their master's degree in mathematics, statistics or economics. During the twenty years, 1932–1951, about 1500 persons had received training in one way or another in the Indian Statistical Institute.

Through the efforts of the workers of the Institute a post-graduate department of statistics was established in the Calcutta University in 1941 in which full courses began to be given leading to the master's degree in statistics. The first batch of students passed the examination for the Master's Degree in 1943 with C. R. Rao at the head of the list. For about 5 years the University department of statistics used to be located in the Indian Statistical Institute and the entire teaching work was done by a joint staff who worked

in both the University and the Institute. Purnendu Kumar Bose, Harikinkar Nandi, Manindra Nath Ghosh, and other old workers of the Institute are at present in charge of the University department. Undergraduate classes leading to the honours B.Sc. degree in statistics was opened in 1944 in the Presidency College, Calcutta. Teaching in these classes in the early years used to be done by persons who were either whole-time or part-time workers of the Institute. Anil Bhattacharyya and some other members of the college statistical staff are also old workers of the Institute.

Professional Examinations in Statistics

Another activity of the Institute is worth mentioning. A Committee was set up by the Council in 1935 to consider the question of initiating professional examinations in statistics. This Committee was fortunate in securing the advice of many experienced men from outside India such as A. C. Aitken (UK), A. L. Bowley (UK), R. A. Fisher (UK), Corrado Gini (Italy), J. O. Irwin (UK), Karl Pearson (UK), E. S. Pearson (UK), John Wishart (UK) and Friedrich Zahn (Germany). On the recommendation of this Committee a scheme of external examinations was started in 1938 for the award of Certificates for Computers, Certificates for Field Investigators, and Diplomas for Statisticians. The examinations are being held at present simultaneously in Calcutta, Delhi, Bombay, Poona, Bangalore, Giridih, etc.

Operating Centres at Baranagore and Giridih : 1942

Owing to the change in the war situation at the end of 1941 a new phase began in the history of the Institute. The work so far was being done in the Presidency College, Calcutta. Early in 1942 the Institute was advised to go out of Calcutta. One portion of the laboratory was hurriedly moved to Mahalanobis's own house at 87 (now 204) Barrackpore Trunk Road. The library, original papers and records, a large section of the laboratory, the Institute's training classes, and the post-graduate department of the University were shifted to Giridih, a subdivisional town in Bihar about 200 miles from Calcutta. In this way, operating branches came to be established at Baranagore and at Giridih.

After the completion in 1941-42 of the five-year project of the sample survey of the jute crop, the Government of Bengal at first decided to discontinue the sample survey and then, reversing their decision, asked Mahalanobis to conduct the survey on behalf of Government. The Institute took over the whole project including the field branch from 1942-43 with an immediate increase in its scale of operations. After the Bengal famine of 1943 the sample survey was extended to cover the paddy crop from the winter season of 1943, and a little later to cover the winter crops in Bengal.

The controversy between advocates of sample counts and of complete counts, however, continued from year to year; and in 1945-46, a complete enumeration of all crops was attempted in Bengal in addition to the sample survey with a view to comparing the relative accuracy and efficiency of the two methods. Although the results were conclusively in favour of the sample survey (as tested by commercial estimates of the production of jute made about one year after the crop season), the sample survey of crops was ordered to be discontinued by the Government of Bengal 3 or 4 times but the decision was reversed

on each occasion mainly due to the powerful support of Mr. H. S. Suhrawardy in his capacity as Minister of Civil Supplies and later as Chief Minister. Without his help the battle would have been lost for the time being. However, the sample survey was ultimately accepted as the basis for official estimates in West Bengal in 1948, nearly 12 years after the first pilot survey was started in 1937. From 1951-52, the West Bengal crop survey was taken over by the State Bureau of Statistics which had been started in January 1945 by P. C. Mahalanobis as Statistical Adviser and which itself is staffed by a large number of old workers of the Institute.

Sample Surveys and other Projects from 1943

The Government of Bihar requested the Institute to organize a sample survey of agricultural crops in Bihar and surveys were rapidly conducted in 1943-44 and 1944-45 with encouraging results. Sinheswar Prasad Sinha, a Bihar official, showed great organizing ability in setting up the field branch; and N. T. Mathew, a young worker of the Institute, established a large statistical office at Giridih which looked after the processing of the data and analysis of results with great efficiency. The project was discontinued in 1945 owing to the prevailing view in the Government of India at the time that the sample survey was of no use and that a complete enumeration was indispensable.

From 1942 the volume of work increased rapidly, and the total number of workers in the Institute increased from about 240 in 1942-43 to over 900 in 1945-46 and 1946-47. The total budget increased from Rs. 2.50 lakhs in 1942-43 to nearly Rs. 13.5 lakhs in 1945-46 and 1946-47. In the partition of India about two-thirds of the old province of Bengal went to Pakistan, and there was a considerable reduction in the scale of operations of the crop survey.

Developments, however, were occurring in other directions. In 1939-40 and 1940-41 work had started on family budget enquiries and surveys of public opinion. An important project on population data began in 1945. The tabulation programme of the 1941 Census of India had been severely curtailed as a measure of war economy. Fortunately, at the direction of M. W. M. Yeatts, Census Commissioner, a 2% sample of the individual census slips had been preserved, and the Institute was asked by Government to reconstruct the age and occupational tables on the basis of the 2% Y-sample. This involved the transferring of information (originally recorded in a large number of different languages) to about 7 millions of punched cards and then tabulating the results. As some sample slips had been drawn in a wrong way and same sample slips were missing it became necessary to use various special methods for estimation. Great credit is due to Debabrata Lahiri, a mathematician, who had joined the Institute as a war refugee from Burma, for completing this work satisfactorily in 1950. Since then, Lahiri has specialized in the design of sample surveys and has made important contributions to sampling technique.

A survey of economic and social conditions in Bengal was conducted at the request of the Government of Bengal in 1944 to assess the effects of the severe famine which had occurred in 1943, and supplied information of great significance which was published in a special report.

Between 1944 and 1948 several new projects were also started on economic aspects of road development, rural indebtedness in Bengal, economic and social conditions of agricultural labour in Bengal, family budgets of middle class households, sample census of

traffic across the Howrah bridge, a survey of displaced persons in Delhi etc. At the request of the Government of Burma, the Institute also helped in organizing a sample survey of economic conditions in Rangoon in 1948-49.

A list of reports on sample surveys conducted by the Institute is given in Appendix A, and a list of surveys in Appendix C. The Institute's success in large scale sample surveys was due entirely to the close co-operation of a very large group of workers. In the Laboratory, R. C. Bose and S. N. Roy were always ready to help not only with mathematical but also with numerical calculations. On the applied side, Jitendra Mohan Sen Gupta soon became the undisputed leader. Debabrata Lahiri specialized in the theory of the design of sample surveys and made important contributions to the subject. In the field branch, Nihar Chandra Chakravarti (a Government official whose part-time services have been made available to the Institute for more than 15 years) showed exceptional powers of organization and great resourcefulness in overcoming difficulties. He was ably assisted by Dhirendra Mohan Ganguli (who worked in the Institute for nearly 8 years until 1949) and Pranay Kumar Chatterjee.

Postwar Difficulties

The Institute passed through a period of uncertainty and of stress and strain from the end of 1945 to 1950. The volume of work had increased very rapidly with the initiation of the Bihar crop survey which had started as a five-year scheme in 1943. The number of workers had increased from 240 in 1942-43 to 993 in 1944-45 and the budget from Rs. 2,49,884 to Rs. 12,11,328 which meant more than a four-fold increase in two years. The Bihar scheme was, however, suddenly terminated in the second year as the view taken by Government was that sample surveys of crops were not adequate. This called for all round reduction of work.

Economic and political conditions in the country were getting worse and difficulties within the Institute were also increasing. At the end of 1945 a number of workers resigned from the Institute and there was a short strike of one group of workers in 1949. Since 1946 Professor Mahalanobis became increasingly busy with work outside India. Two young workers, C. R. Rao and Ramkrishna Mukherjee, left in 1946 to accept research posts in the University of Cambridge. R. C. Bose and S. N. Roy left the Institute to accept posts in the USA in 1949 and 1950 respectively.

The question of stabilization of the Institute had been taken up by the Government of India in 1937 but war broke out before any decision was reached and there was not much progress during the war. Government made some definite proposals in 1945 which, however, were not considered entirely suitable by the Institute. There was serious difference of opinion on two basic issues. The Institute was opposed to the separation of research and training from large scale project work and also to excessive Government control in its day to day administration.

At a critical period in its history Shri Chintamon Deshmukh agreed to become the President of the Institute in 1945. He had been taking active interest in the work of the Institute since 1939 and was also serving as a member of the Council for several years. Since 1945 he has been quietly helping the Institute in solving its many difficulties.

It was also most fortunate for the Institute that Professor S. N. Bose undertook the heavy responsibility of looking after the administrative work of the Institute during

Mahalanobis's absence abroad in 1946 and 1947. It was a critical period to tide over which would have been difficult without S. N. Bose's unsparing services.

Contacts outside India

In spite of its many difficulties the Institute never lost its initiative. The practice of inviting foreign scientists was revived with the second visit of R. A. Fisher in 1945 which gave a fresh stimulus to research. In discussions with Government, Fisher supported the Institute's stand on the use of sample surveys in agriculture and the need of integration of research, training and project work.

It was due to the efforts of the Institute that Walter A. Shewhart (father of Statistical Quality Control) came to India in 1947-48. A successful conference on SQC was arranged in Calcutta under the joint auspices of the Institute and the Indian Standards Institution. Shewhart's visit created great interest in SQC among both engineers and industrialists and led to the establishment of the Indian Society of Quality Control in 1948.

H. Wold of Uppsala who came to the Institute as a visiting professor in 1949-50 held discussions and organised a co-operative research project work on the analysis of time series. In 1950-51, Abraham Wald of the Columbia University came as visiting professor but met with a tragic death in an air-crash on the 10th December 1950.

In the meantime, the work of the Institute was steadily gaining recognition outside India : the award of the Weldon medal of the Oxford University to Mahalanobis in 1944 and his election as a Fellow of the Royal Society in 1945 were, in a sense, laurels won by the Institute. In 1946 he was appointed a member of the Statistical Commission of the United Nations. Since then he has been regularly going abroad, usually twice a year, to attend various international scientific and statistical conferences. He served as the Chairman of the United Nations Sub-Commission on Statistical Sampling from 1947 to 1951; and was elected Chairman of the U.N. Statistical Commission in 1954. The Institute now maintains through him close contact with many of the statistical deve lopments at the international level.

The scientific papers of R. C. Bose, S. N. Roy, C. R. Rao and others were winning recognition abroad. R. C. Bose was invited to go to the Columbia University as a visiting professor in 1947 and S. N. Roy in 1948 as a recognition of their distinguished contributions to mathematical statistics. They both returned to India, but Bose left the Institute in 1949 and S. N. Roy in 1950 to take up posts of professors in the U.S.A. This was no doubt a serious loss; yet the Institute is proud of having sent out its representatives to the other side of the globe.

International Statistical Education Centre : 1950

The Indian Statistical Institute actively collaborated with the International Statistical Institute in establishing the International Statistical Education Centre in Calcutta under the sponsorship of the UNESCO in 1950. Professor K. B. Madhava worked hard in organizing the work in the beginning and gave shape to the ISEC in its initial stage. The Government of India have been giving substantial financial support since 1952 and have been also awarding a large number of scholarships under the Colombo Plan. The Research and Training School of the Institute under the leadership of C. R. Rao and A. Mathai are

in effective charge of the teaching programme. The Permanent Office of the International Statistical Institute at the Hague is responsible in a general way for the admission of students and also helps in securing teachers from outside India. The United Nations and the Specialized Agencies (FAO, ILO, WHO, etc.), have been providing some teachers from time to time.

At first there used to be two academic sessions of about five months each which, however, was not convenient and from 1954 the period of study was increased to about 9 or 10 months (July to April). The eleventh session started in July 1957. It is gratifying to note that between 1950 and 1957 as many as 294 students have come to the ISEC from 17 countries, namely, Afghanistan, Burma, Cambodia, Ceylon, India, Indonesia, Iran, Iraq, Japan, Malaya, Nepal, Pakistan, Philippines, Singapore, Syria, Thailand and Vietnam; some special students also came from Egypt.

International Statistical Conferences in India : 1951

The Institute acted as the host society for the 27th Session of the International Statistical Institute and the International Statistical Conferences which opened in New Delhi on the 5th December 1951. The Conference held a session in Calcutta from 16 to 18 December, the Institute's own building providing the venue.

Closer connexion with Government

Conditions were becoming more favourable for the advancement of statistics in India. Just before the general election of 1946 Shri Jawaharlal Nehru visited Calcutta and stayed for a few days in Mahalanobis's house in which the Institute was located at that time and thus came to know the work of the Institute intimately. He made arrangements for a young scientist, Pitambar Pant, to come to the Institute early in 1946 to assist Mahalanobis as his scientific secretary. Some time later, Pant went to the U.S.A. On his return to India in 1948 he joined the Central Service in New Delhi and since then has been closely associated with the Institute.

In 1949 Mahalanobis began to work in New Delhi as Honorary Statistical Adviser to the Cabinet, Government of India, and as Chairman of the Committee of Central Statisticians. N. T. Mathew went from Calcutta to set up a small office of the Institute and also to organize a Central Statistical Unit in New Delhi. Pant and Mathew, with the help of the Institute, prepared a valuable report on the organization of statistics at the centre and in the states. Also, for nearly two years the Institute staff with the help of Pitambar Pant looked after the work of the Central Statistical Unit until the Central Statistical Organization (CSO) was established in February 1951. Since then the CSO and the Institute have been working in close collaboration.

The National Income Committee : 1949

The Government of India set up the National Income Committee in 1949-50 with Professor P. C. Mahalanobis as Chairman and Professors D. R. Gadgil and V. K. R. V. Rao as members. Mani Mohan Mukherjee, an old worker of the Institute, who had gone abroad for advanced studies, came back to India in 1949 and started work on national income in the Institute Office in New Delhi. A little later he took charge of the National Income Unit in the Ministry of Finance which also has been working in close association with the Institute.

The National Sample Survey : 1950

On the project side the sample survey of crops in Bengal, which had been started by the Institute in 1937, was handed over as a going concern to the Government of West Bengal in 1951. However, a year earlier the Institute had been called upon by the Government of India to take up an even bigger project. Shri Chintamon Deshmukh had come to New Delhi at the end of 1949 as Financial Adviser to Government. Prime Minister Nehru, after a discussion with Shri Deshmukh and Professor Mahalanobis, desired that a continuing sample survey should be started covering the whole country. The National Income Committee, which had been established by this time, also recommended that gaps in national statistics be filled through sampling.

In 1950 the National Sample Survey was established to collect comprehensive information relating to social, economic and demographic characteristics on a countrywide basis in the form of about two "rounds" of survey every year covering both rural and urban areas. This is reputed to be the biggest sample survey of its kind in the world today.

The Institute was asked by Government to take charge of the design of the survey and the processing and analysis of data. The heavy task of organizing fell on J. M. Sen Gupta, Debabrata Lahiri and Ramkrishna Mookerjee. In the first round the Gokhale Institute of Politics and Economics of Poona actively collaborated in the work. In 1951 Satyabrata Sen came back from the United Nations to take charge of the section. In January 1956 the work of the NSS was reorganized in two divisions, one for the operational work under Mohanlal Ganguli and Ajit Das Gupta; and the other for pilot studies and methodological researches under J. M. Sen Gupta, D. B. Lahiri and Nimai Ghosh with S. B. Sen acting as consultant. Since May 1957, the NSS is functioning under a committee consisting of N. C. Chakravarti, J. M. Sengupta, D. B. Lahiri, Nimai Ghosh, Mohanlal Ganguli, Ajit Das Gupta and S. Raja Rao (Secretary).

Twelve rounds of the NSS have so far been conducted as a result of which extensive information has been made available on the economic conditions of the whole country. The NSS collected much useful information for the Taxation Enquiry Commission, the Press Commission, and the Ministries of Rehabilitation, Labour and Commerce of the Government of India; it has undertaken special studies on unemployment for the Planning Commission, and an extensive survey of agricultural holdings in the eighth round. A number of reports have been completed on household consumption, demographic conditions, unemployment in urban and rural areas, couple fertility, manufacturing industries, small scale transport operations etc.; and also a technical paper on the sample design by D. B. Lahiri; and a valuable study of Faridabad (a new refugee town near Delhi) by Pitambar Pant.

Research and Training School : 1952

After discussions extending over several years with the Department (and later, the Ministry) of Education basic changes were made in the rules of the Institute in 1949 to convert it primarily into a research and training institution but owing to certain technical difficulties, the rules were not brought into operation. Mainly through the efforts of the President of the Institute, Shri Chintamon Deshmukh, further changes were made in the rules to enable a separate Governing Body being established, as had been desired by the Education Ministry, to look after the work of the Research and Training School and at the same time the more comprehensive scope of activities of the Institute was retained under

the control of its Council which was made responsible for the general co-ordination of the work of the Institute as a whole.

The Research and Training School was stabilized with an initial recurring grant of Rs. 4.5 lakhs from the Government of India from 1949-50. The administrative sponsorship was transferred from the Ministry of Education to the Ministry of Finance in 1950, and a Governing Body consisting of members elected by the Council of the Institute and a number of representatives of the Government of India, the Reserve Bank of India, the Federation of Indian Chambers of Commerce, Associated Chambers of Commerce, Inter-University Board, the National Institute of Sciences and the Indian Economic Association, was formed in 1952 to look after its affairs.

The departure of R. C. Bose and S. N. Roy for USA naturally left the Research and Training School in a somewhat weak position. At this stage C. R. Rao, who had resumed his work in the Institute on his return to India in 1948 took charge of the School from 1950 and through wise leadership soon placed it on a sound foundation. He gradually gathered round him a group of young statisticians among whom may be mentioned Tarapada Chaudhuri, G. Kallianpur, A. Mathai, Debabrata Basu, Des Raj, Jogabrata Roy, I. M. Chakravarti, Sujit Mitra, R. G. Laha and others who now form the core of the research and training personnel on what may be called the theoretical side of statistics. D. B. Lahiri and J. M. Sen Gupta have been working mostly on research and training in sample surveys and statisticians engaged in applied work also carry on researches in their own special subjects.

In the Research and Training School there is emphasis on theoretical studies based on the foundation of probability and the logic of statistical inference but attention is also given to research in applied statistics and the application of statistical methods in various fields. A brief note on the main lines of research is given later ; and a list of papers by the workers of the Institute is given in Appendix D.

The teaching programme of the School is being continually developed in the light of experience and to suit changing needs. The training of officers deputed by Central and Provincial (now State) Governments had started in 1932. In the earlier years training was given more or less on an individual basis; but as the demand gradually increased the Institute started giving organized courses of instruction from July 1939. At first the duration of the course was one year. Although admissions were restricted to advanced students who had already taken their master's degree, usually in mathematics or statistics, it was found that one year was not adequate for professional training. The period of study was increased to two years from July 1948. In 1954 a new scheme of three-year training was introduced with possibility of exemption of one year for those who have already taken the master's degree in statistics. The teaching programme is arranged jointly by the Institute and the CSO and all trainees work for a good part of the time in the CSO and other Government statistical offices. A special feature is that candidates, who are selected jointly by the Institute and the CSO with the help of special tests, are not required to pay any fees but are awarded scholarships varying from Rs. 75 to Rs. 200 per month or even more depending on merit and experience.

The Institute has been providing for a long time organized training for computers and in-service training at various levels. Evening courses of lectures were started,

in 1950 for candidates intending to appear at the Computers Certificate Examination and in 1955 for candidates for the Diploma for Statisticians, in the Institute Office in Calcutta city for groups of selected trainees. The Institute has also continued to offer facilities for training to officers on deputation from Government offices more or less on an individual basis. Between 1932 and 1957 more than about two thousand persons have received training in the Institute in one form or other (exclusive of in-service or apprenticeship training).

The different courses imparted at present in the School are as follows: 1. Advanced studies 2. Three-year Statistician's course, in collaboration with the Central Statistical Organisation (CSO) 3. Short-term Statistician's courses, (Junior and Senior) 4. Officer's Training course, jointly with the CSO 5. Individual Officers on deputation 6. Computer's Training courses, (Junior and Senior) 7. Training at the International Statistical Education Centre (ISEC) 8. Short-duration Intensive courses on special subjects, the subjects in which courses have been given in the past being (a) Design of experiments, (b) Operational research, (c) Industrial statistics and (d) Psychometric methods of personnel selection.

Workshop and Electronic Computers : 1953

An associated non-profit institution for the development of calculating machines and scientific instruments had been established in 1943 with the approval of the Council of the Institute and a small workshop was started which did some useful work in repairing calculating machines during the war but which became somewhat inactive after the war when imported machines again became available. In 1950, Samarendra Kumar Mitra, who had gone abroad with a UNESCO Fellowship to study electronic computers, returned to India and joined the Institute. The small workshop was reorganized and was gradually expanded to undertake the repair and maintenance of desk calculating machines and other equipment. An electronic laboratory was started a little later where a small electronic analogue computer with some novel features was designed and constructed in 1953. An order was placed for a digital computer HEC-2M in London in 1954. In the meantime arrangements were made for the Institute to receive, through the United Nations, technical aid and equipment for electronic computers. Mahalanobis and Mitra went to USSR in the summer of 1954 for personal discussions in this connexion; a number of Soviet experts, D. Y. Panov, B. A. Ditkin and others came to the Institute in the same year; and S. K. Mitra and D. S. Kamat went to the USSR for further technical discussions in 1955. It was finally decided that USSR would send through UNTAA a large electronic computer URAL and machine tools, instruments and equipment for a laboratory and workshop for the repair, maintenance and development of electronic computers and precision instruments and accessories. A good deal of Soviet equipment was received in 1956 and the workshop was expanded and reorganized.

The Hollerith Electronic Computer, HEC-2M, was received in February, 1956. The Machine was installed in an air-conditioned room and has been in operation from the end of March, 1956. The Research and Training School of the Institute has many problems to be solved on the machine. Requests have been received and certain assignments have been accepted from several scientific institutions in India for assistance in solving computational problems. Efforts are also being made to use this machine for certain classes

of data-processing work of the National Sample Survey. A number of new workers have joined this section and its activities are increasing in different directions. The maintenance of punched machines of Russian Origin and development of new punched card machines are notable lines of expansions. Schemes are also being got ready for the utilization of the Soviet machine tools and equipment in a suitable way.

Statistical Quality Control : 1953

As early as 1935, the Institute had recommended that the Government should take appropriate measures to initiate Statistical Quality Control methods in Indian industries. Dr. Walter A. Shewhart (the originator of Statistical Quality Control) came to India at the invitation of the Institute in 1947-48, toured the country, held conferences and stimulated interest among industrialists. The first all-India Conference on SQC was held in Calcutta in January 1948 with Dr. Shewhart as Chairman. In 1952-53 a team of SQC experts sponsored by the United Nations Technical Assistance Administration visited India and conducted intensive training courses in SQC methods in different parts of India. The Institute functioned as the host society and in collaboration with the Central Statistical Organization made arrangements for these courses.

In 1953 an Advisory Committee for SQC was set up with Shri C. D. Deshmukh as Chairman and Pitambar Pant as Secretary. Gradually three whole-time SQC Units were established in Bombay, Bangalore and Calcutta. Dr. W. A. Shewhart visited India for the second time in 1954-55; and the second SQC conference was held in Calcutta in January 1955 which gave an impetus to the movement. Since 1954 a number of experts such as Mr. T. Hanada and Dr. G. Taguchi from Japan, Mr. D. J. Desmond from the UK, Mr. A. L. Raich from the USA have come to help in this work. Professor G. A. Barnard of the UK came for a short visit in 1956 and Professor E. R. Ott of the USA in 1957, and participated in technical conferences of SQC workers in India. Work in this sector is making slow but steady progress.

National Planning : 1954

In 1940, Jawaharlal Nehru asked Mahalanobis to prepare a statistical commentary on the reports of the National Planning Committee, which had been set up by the Indian National Congress a little earlier with Nehru as its Chairman. Pandit Nehru visited the Institute in 1946 since when he has been taking a keen interest in its work. He asked Mahalanobis to work as Honorary Statistical Adviser to the Cabinet, Government of India in 1949. Since then the Institute has become more and more closely associated with the work of the Central Statistical Organization (CSO), the Planning Commission and other Government agencies in New Delhi. In accordance with a decision of the Government of India of 1952 the Institute is functioning as the focal centre for professional training and research and as a National Statistical and Computational Laboratory in India.

In 1953-54 an Operational Research Unit (ORU) was established in the Institute to undertake, on a small scale, technical work relating to planning. In September 1954 the Institute was asked by the Planning Commission to undertake jointly with the Central Statistical Organization (Cabinet Secretariat) to study the possibility of solving the problem of unemployment in 10 years and at the same time to increase national income at a reasonably rapid rate.

On the 3rd November 1954, Prime Minister Nehru inaugurated in the Indian Statistical Institute studies relating to planning for national development. The Economic Division of the Planning Commission and the Department of Economic Affairs (Ministry of Finance) started to collaborate actively with the Institute and the CSO in this matter from December 1954. On the basis of such four-agency co-operative studies, P. C. Mahalanobis prepared the Draft Plan-frame of 17 March 1955 which was accepted as the basis for the formulation of the Second Five Year Plan.

In September 1955 it was decided by Government that the technical and statistical work on the Second Plan in the Institute should continue and greater attention should be paid to perspective planning and more especially to statistical work in this connexion. It was further agreed that in order to facilitate this work the operational research unit (ORU) in the Institute should continue on an expanded scale in close collaboration with the Central Statistical Organization, the Ministry of Finance and the Planning Commission. In accordance with the above decisions by Government, the staff for work on planning was expanded and an economic wing was set up in the Institute in the last quarter of the financial year 1955-56.

Studies undertaken by ORU and Economic Wing of the Institute during 1956 and 1957, related to methodological aspects of annual and long range planning, growth models, construction and utilization of input-output tables, production capacity, projection of population, expenditure elasticity, transport problems, taxation and financing of the plan, and a few other topics of similar type. Some of these studies were conducted under directions of eminent visiting experts. The collaboration with the Planning Commission, Central Statistical Organization (CSO) and the Economic Wing of the Ministry of Finance was continued and a section of Institute workers worked directly for the Technical Man-power Division of the Planning Commission to produce a number of interesting studies on technical man-power. Assistance was given to Professor Kaldor when he, working on behalf of the Institute, formulated his recommendations on direct taxation which partly formed the basis of recent taxation proposals. The forms used for collecting information on the projects included in the plan were devised in collaboration with the CSO.

The current work programme of the group at Calcutta includes studies on economic growth and planning, inter-industry relations studies and estimation and assessment of basic economic aggregates. Apart from this, work is proceeding on a ten-year decision model and a study of long range planning in USSR, East Germany and other socialist countries. Recently, the group has taken up the responsibility of a course on Planning in the Research and Training School.

A series of working papers on Planning are being prepared in the Institute; a list is given in Appendix B. Apart from this a number of technical notes have been prepared and some technical notes and working papers are under preparation.

Visiting Scientists

Many distinguished foreign scientists have come out to India to work and lecture in the Institute as visiting professors. The first to come was Professor (now Sir) Ronald A. Fisher, who paid his maiden visit in 1938, repeating it in 1945, 1951, 1954 and on the occasion of the Silver Jubilee in 1956. Other visitors have followed and except for an un-

avoidable break during the second world war, a stream of distinguished foreign scientists, statisticians as well as specialists in other fields of science, have responded to the invitation of the Institute to come here and work as research workers and guest lecturers. In recent years many of the visiting scientists have actively participated in the studies and discussions on planning for national development.

The Institute has thus become a real international centre of research as well as a forum for scholars and scientists from all over the world to work and hold discussions. Mention may be made of a few amongst these distinguished visitors who came to work in the Institute for an extended period of several weeks or months, such as, H. Hotelling (USA, 1939-40), W. A. Shewhart (USA, 1947-48, 1954-55), Herman O. Wold (Sweden, 1948-49), Abraham Wald, (USA, 1950), William Hurwitz (USA, 1951), J. B. S. Haldane (UK, 1951, 1954, 1956), Frank Yates (UK, 1951, 1953-54, 1956), Arthur Linder (Switzerland, 1951, 1956), M. Masuyama (Japan, 1951, 1952, 1953-54), T. Kitagawa (Japan, 1953, 1956), H. Theil (Netherlands, 1952-53), J. Durbin (UK, 1953-54), Charles Bettelheim (France, 1953-54, 1954-55, 1955-56), Q. M. Hussain (Pakistan, 1954, 1955, 1956), Richard Goodwin (UK, 1954-55), Ragnar Frisch (Norway, 1954-55), D. D. Degtyar, I. Y. Pisarev, D. Y. Panov, V. A. Ditkin, M. I. Rubinstein, P. M. Moskvin (USSR, 1954-55), M. Zia-ud-din (Pakistan, 1955, 1956), Oskar Lange (Poland, 1955, 1956), Norbert Wiener (USA, 1955-56), J. Tinbergen (Netherlands, 1956), J. K. Galbraith (USA, 1956), The Rt. Hon'ble John Strachey, M.P. (UK, 1956), Nicholas Kaldor (UK, 1956), Paul Baran (USA, 1956), G. A. Barnard (UK, 1956), Sir Robert Hall (UK, 1956), Morris Hansen (USA, 1956), J. S. Neyman, S. S. Wilks, Russel L. Ackoff, (USA 1956-57) Leon H. Keyserling, Samuel Alexander (1957) A. F. Zelinovsky (Deputy Chairman, Gosplan) and A. I. Polosukhin N. N. Bogolyubov, A. I. Ezhov (USSR, 1956-57). Wang Szu Hua, Hwang Chien. To, Tai Shinkuang (1956-57).

New Research Units

Biometric Unit : This unit for research in biometry was started in April 1954 under the leadership of Dr. M. Masuyama of Japan. Dr. B. C. Das joined in 1955 and is now in charge of the unit and is assisted by Shri Subodh Roy and others. Professor J. B. S. Haldane and Mrs. Haldane (Dr. Helen Spurway) who worked in this unit for several months in 1954 and 1956, have joined as members of the staff with effect from July 1957.

Psychometric Unit : Some work on group tests had been done in the Statistical Laboratory and the Institute in the early days. A separate unit for psychometric research and service was established under the leadership of Dr. Ed. Harper, Jr., and is mainly concerned with selection tests. Dr. Shibkumar Mitra and Dr. Rhea Das joined in 1955 and are assisted by a number of other professional workers.

Anthropometric Unit : A good deal of anthropometric studies had been carried out in the Statistical Laboratory and the Institute in the early days by Mahalanobis and a little later by C. R. Rao but there was no provision for systematic work. In 1955-56 an Anthropometric Unit was started with two anthropologists who had been trained by Professor D. N. Majumdar of the Lucknow University. This unit is engaged in the standardization and collection of measurements.

Operational Research Group : In view of the usefulness of Operational Research in India and the need for trained personnel, the Institute organized in February 1957 a seminar and a training course under the guidance of Dr. Russel Ackoff, Case Institute of Technology, USA. Following this, an Operational Research Group was formed in April 1957 with the objective of developing and promoting Operational Research techniques. This group consists of two trained technicians and a number of part-time workers drawn from different fields.

Demographic Section : Demographic studies are also proceeding in different directions. Two of the senior statisticians in the National Sample Survey, D. B. Lahiri and Ajit Das Gupta have made important contributions on different aspects of demography. A separate section for demographic researches have also been organized under the charge of a younger worker, S. Janardan Poti.

Kalyanashree : A new unit called *Kalyanashree* was started in Calcutta on 28 February 1956 to study the economics of small scale household industries and handicrafts. The Institute has provided accommodation, some equipment and staff for the statistical and economic studies. The industrial work in the unit is organized on an entirely self-supporting basis, current expenses being met from sales of production.

Industrial Management Research Unit for Planning : The Council of the Institute approved in March 1956 a scheme for the setting up of another special unit with headquarters at Bangalore to study the problems of industrial management in both the public and private sectors. Three experienced engineers of senior standing, Shri R. Natarajan, Dr. Bhola D. Panth and Shri D. P. Basu are in charge of this unit.

Twenty-fifth Anniversary : December 1956

The Institute completed 25 years of its existence in December 1956 and celebrated the twenty-fifth anniversary in a befitting manner. Many distinguished statisticians and scientists including 46 guests from abroad participated in the anniversary celebrations.

Sri Chintaman D. Deshmukh, President of the Institute, inaugurated the celebrations at a meeting held on December 17th in the Mango-grove, and also presided over the Anniversary Meeting on December 22nd. Both the meetings were attended by the workers and a large number of guests.

The Prime Minister Sri Jawahar Lal Nehru sent the following message on this occasion :

"The Indian Statistical Institute has gained a reputation for itself not only in India but in every country where statistics are studied. It has grown in recent years and has performed important functions in connection with our planning work. Indeed, it is an essential part now of our planning organisation. On the occasion of its Silver Jubilee, I send it all my good wishes."

The most important feature of the celebrations was a programme of about 60 lectures and seminars by leading statisticians and economists from different parts of India and abroad, spread over nearly three weeks. There was also a crowded programme of entertainments, such as a musical soiree, staging of Bengali play, folk plays and cinema shows.

HISTORY AND ACTIVITIES

The Problem of Accommodation : The Institute's Buildings

The need for increased accommodation made itself acutely felt with the rapid expansion of the Institute's activities. A large part of the Institute had been located in Professor Mahalanobis's house at 204 Barrackpore Trunk Road since 1942. An adjoining plot of land of about 3 acres at 203 Barrackpore Trunk Road was acquired in 1950 and a building constructed thereon in 1951 which was dedicated by Professor R. A. Fisher in the same year. In 1954 the Institute purchased a plot of 1.5 acres of land to the west of the Institute premises. In the same year the Government of India placed at the disposal of the Institute a larger plot of about 9 acres with some buildings at 202 Barrackpore Trunk Road immediately to the north of the main Institute building. An operating branch had been in existence at Giridih (in Bihar, about 200 miles from Calcutta) since October 1941; and a 35 acre plot of land (partly agricultural) was acquired there in 1952. Since 1937 the Institute has also been using rented accommodation in Calcutta, Baranagar and Giridih. A number of rooms in the Presidency College, which the Institute had been occupying from the beginning, were vacated at the end of 1953 and a new city office was opened at 9B Esplanade East, Calcutta.

The main offices of the Institute are at present located on the Institute's own land at 203 Barrackpore Trunk Road in a seven-storeyed building covering 62,400 sq. ft. of floor space. In addition about 30,000 sq.ft. of floor space is occupied by the Institute at 202 Barrackpore Trunk Road, acquired by the Government of India for the Institute's work. The Institute also uses about 50,000 sq. ft. of space in other premises in Baranagar and Calcutta alone. In Giridih the Institute acquired about 35 acres of land for location of an experimental farm.

Branches

From the very beginning the Institute adopted the policy of opening society-type branches in different parts of India. The earliest branches to be organized were at Mysore, Poona and Bombay which were all active from the very beginning. New branches were established at Banaras in 1936-37, at Madras and Lahore in 1937-38, at Lucknow in 1939-40 and at Delhi in 1942. The chief work of these branches is to organize lectures and discussions on statistical subjects. Activities have fluctuated a great deal depending largely on the time and energy of the local members, especially of the local secretary. In recent years, the Bombay branch has extended its activity by giving special courses of instructions in statistical quality control and by undertaking socio-economic surveys of various kinds. The Branches of the Institute are serving a useful purpose in promoting interest in statistics in different parts of India.

Government Assistance

The Indian Statistical Institute started receiving grants from the Government of India in 1936. It is practically since then that the question of the stabilization of the Institute has been under the consideration of the Central Government. Many different approaches have been explored for this purpose during the last twenty years. From time

to time there were proposals from Government to take over the Institute, or to convert the Institute into a primarily educational and research institution. After several years of negotiations new rules were framed in 1950, at the desire of the Ministry of Education, in which the teaching activities were made the main function of the Institute under the control of a Governing Body with Government representatives. The new rules could not, however, be brought into effect owing to certain technical difficulties; and in 1951 the provision for the Governing Body was incorporated in the constitution in the form of regulations and the Council retained its status as the general co-ordinating agency.

In 1952 the Cabinet of the Government of India decided that the Institute should function as a focal centre for advanced studies and research in statistics in India; and since then extensive programmes of professional training have been developed jointly by the Institute and the Central Statistical Organization. In 1953 there was a proposal that the Institute should be converted into a University under a Central Act, but it was felt that there would be difficulties in preserving the operational and society-type activities within the framework of a University. Since 1954 the Institute has been increasingly participating in studies relating to planning for national development. It was agreed that the Institute should retain its autonomous status but would be recognized by the Government of India as an institution of national importance in some suitable way, for example, by an Act of the Parliament.

Conclusion

The activities of the Institute are diverse : developments are still taking place in many directions; but there is a unity in its purpose. The Institute has been endeavouring for twenty-five years to promote national development through the patient collection and analysis of statistical and technical information and their utilization for formulating policy and administrative decisions in a scientific manner.

Whatever success the Institute has achieved has been due to the intellectual integrity, the sense of responsibility, the spirit of team-work, and the initiative of the workers of the Institute on the one hand and, on the other, the help it has received from its friends and sympathisers.

In administrative and organizational matters, the Institute has always encouraged initiative and endeavoured to reduce costs by improving efficiency and to utilize the savings made in this way for offering incentives to workers, for promoting the welfare of workers, and for making investments in books, equipment, land and buildings. The future success of the Institute depends entirely on the devotion and the spirit of co-operation which its workers can continue to bring to the work of the Institute.

RESEARCH PAPERS AND REPORTS

The results of extensive work by the Statistical Laboratory and the Indian Statistical Institute on theoretical and applied statistics upto December 1957 are embodied in over 550 research papers, 65 reports based on large scale sample surveys and 85 working papers on economic planning. A brief survey of some of the important contributions in different fields of statistics is given below.

Applied Research

The Institute has a record of applied research of an extremely wide range. In the earlier years painstaking studies were made of meteorological problems and especially of rainfall and floods in Bengal, Bihar and Orissa. Statistical methods led to many effective remedial measures against floods and were also used to investigate the economic value of irrigation projects. Some of the basic calculations for the Hirakud and the Damodar Valley Projects were made in the Institute.

Another field of early work was the analysis of anthropometric measurements of the many castes and tribes of India as well as of Anglo-Indians (of mixed Indian and British parentage). These studies led to the formulation of the D^2-statistic (the Distance Function) and opened a rich field for research in multivariate analysis. The analysis of race-mixture in Bengal revealed some association between the hierarchy of social status and resemblance in physical appearance as well as the influence of geographical contiguity. The analysis of measurements in Uttar Pradesh led to a number of problems and also gave some indications for future lines of investigation. Fresh data collected in Bengal in 1945 were recently analysed to throw some light on the racial composition of the Bengalees. Some new statistical tools were introduced in this study.

Considerable work was done in the early days on intelligence and educational tests. The earliest group tests in the medium of the Bengali language were constructed and used in the Institute. Studies were made of the correlation between intelligence or aptitude tests and success in School Leaving Certificate and other examinations. Certain studies were made on the Intelligence Quotient (IQ) and on standardization of tests. Statistical methods were also used in the analysis of psychological measurements, for example, the method of non-linear regression and analysis of variance was used for the study of the differential limen in the discrimination of weight. Since 1954 a special unit has been established in which systematic work is being done on selection tests and the application of statistical methods in psychology.

Statistical methods have been also used for the study of births and deaths, public health and medical statistics, blood pressure and nutrition experiments. Recently a separate Biometric Unit has been established which is proceeding with a variety of investigations.

A great deal of work was done for the application of statistical methods to agricultural research. The topics covered a wide range and included field trials, plant physiology, bacterial counts, entomology and control of pests, animal nutrition, forestry, experiments on grasslands, vernalization, estimating the yield of bark of cinchona plants etc. The

Institute was also responsible for the introduction and promotion of the Fisherian designs and analysis of variance on a large scale in India. Experiments designed to examine, new methods of cultivation, use of manures and growth of fish in Paddy fields are now being conducted on the Institute farm at Giridih.

Much work has also been done from the very beginning on various economic and demographic problems. Some of the earlier studies related to banking, fluctuations in prices, the relation between supply and price of agricultural crops like wheat and jute, the rupee-sterling exchange rate, index of business activity in India or the problem of over-population. There were also factual studies based on field investigations relating to rural indebtedness, economic conditions of handloom weavers in Bengal, and family budgets of working classes.

With the inauguration of studies relating to planning for national development in 1954 a new phase began in econometric work. The aim was first to develop a consistent conceptual frame for a planned economy under the prevailing social and political conditions in India and to develop necessary analytic tools for solving problems of planning. Secondly, attention was given to a systematic analysis of factual information for the estimation of technological parameters and ratios required for purposes of planning. The series of Working Papers on Planning represent this latest phase of work.

A general idea has been given above of the main lines of applied papers. There were also many publications dealing with miscellaneous problems. Finally, a number of statistical and mathematical tables were constructed in the Institute and published in the form of papers.

Sample Surveys

Some early sample surveys were carried out in 1935 and 1936. Systematic work on agricultural crops began in 1937 which culminated in a survey of the jute crop covering the whole province of (pre-partition) Bengal in 1941. This demonstrated the possibility of using large scale sample surveys to collect information on crops, quickly and economically, with sufficient accuracy for most practical purposes. Two notable contributions were made to the technique, namely, the concepts of 'pilot surveys' and 'interpenetrating subsamples'. The pilot surveys constitute an early example of sequential decision functions developed in recent years by the late Abraham Wald, providing as it does a sequential method of progressively improving the design of the survey utilizing the previous information on cost and variance functions. The interpenetrating net work of samples, used in the proper way, makes it possible to estimate non-sampling errors which seem to be inevitable in large scale sample surveys and usually are of a greater order of magnitude than sampling errors. The first full length treatment of these concepts is contained in the memoir on large scale sample surveys by P. C. Mahalanobis which appeared in 1944.

Besides agricultural surveys, several ad hoc surveys on socio-economic factors relating to indebtedness, unemployment, destitution, standard of living, consumption patterns etc., were conducted between 1937 and 1949. The Institute also undertook in 1941 a comprehensive survey to ascertain public preference in radio broadcasting. A list of large scale surveys (175 in number) conducted upto December 1956 is given in Appendix C.

One important achievement may also be mentioned. The preparation of many basic tables had been abandoned after the Population Census of 1941 and most of the original census slips were destroyed with the exception of a two percent sample (called the Y-sample which was preserved by the Census Commissioner, Mr. M. W. M. Yeatts. The Institute constructed a series of census tables on the basis of the Y-sample.

By 1950 when the Planning Commission was established it was realised that serious gaps existed in the information necessary for the preparation of the plan or the assessment of its progress. The Institute at this stage took a bold step in undertaking the responsibility of organising a multi-purpose National Sample Survey on an all-India basis. Designed as a continuing type of survey, information is collected, with the help of a whole-time field organisation spread all over the country which works under Government control, to provide periodic estimates of social and economic factors affecting the national economy. The information collected in the first twelve rounds upto November 1957 covered production, consumption, land utilization, manufacturing industries, unemployment and demographic data of many kinds.

Advanced Probability

A detailed study is made of the weak topology of the space of all regular signed measures defined on a general topological space. These measures are considered as elements of the dual of the Banach space of all bounded continuous functions defined on the topological space. Results are then obtained which go beyond the classical results of Levy and others, for example it is shown that the space of regular measures which are—smooth, is metrizable when and only when the basic space is metrizable, and is then topologically complete when and only when the basic space is topologically complete. A definitive form is given to the investigations of Alexandroff, Prohorov and others concerning convergence and compactness of sets of measures. Structure theorems are obtained, which show that under general conditions, these spaces of measures determine the basic space to within a homeomorphism. Methods are also developed which (a) obtain the classical results of Gelfand, Kolmogoroff, Hewitt and others on function spaces and function rings and (b) give explicit descriptions of the each compactification and Q-extension of an arbitary completely regular Hansdorff space.

The result that two linear functions of a set of independent random variables can be independent of one another only if each of the components that are present in both functions are normal was proved under certain assumptions. Various similar characterizations of the univariate and multivariate normal distributions, others stable distributions, Gamma distribution etc., were given in terms of near or complete independence of various sample statistics.

It was proved that a statistic U can be independent of a complete sufficient statistic T if and only if U is information less (i.e., has a distribution free of the unknown parameters). A large number of results useful in distribution theory and tests of hypotheses are immediate consequences of the above result.

Estimation

The theory of unbiased minimum variance estimation has been extensively studied starting with the investigations on the least attainable variance. The lower limit to the asymptotic variance of a consistent estimate derived by Fisher (that is, the reciprocal of information) is shown to hold good for the exact variance of an unbiased estimate. This was further generalised to obtain sharper inequalities to the minimum variance. Later the existence of a uniformly minimum variance estimate was examined and its applicability to a very limited class of distributions has been demonstrated.

An important result which is referred to in statistical literature as Rao-Blackwell theorem which came out of these studies, namely, that a minimum variance estimate is an explicit function of the sufficient statistic, found application in a variety of problems and, in particular, in the general theory of decision functions when the loss function is convex.

The results on large sample estimation obtained by the Institute workers have led to a clarification of the methods of estimation by maximum likelihood and minimum chi-square. Firstly the rigorous conditions under which a consistent estimate has Fisher's lower bound to asymptotic variance have been worked out. Secondly it was shown in the multinomial case that with probability tending to unity the supremum of the likelihood infimum of chi-square) is attained at the unique consistent root of the maximum likelihood (of the minimum chi-square) equation.

Large Sample Theory

Large sample tests of hypothesis, utilising efficient scores of the parameters and their variance covariance matrix, were developed. These tests, though asymptotically equivalent to Wald's test (involving maximum likelihood estimates and their estimated variance covariance matrix) or the Likelihood Ratio, distinguish themselves from the rest in that they include the large class of frequency chi-square tests as particular cases. Frequency chi-square tests, for composite hypothesis, which use the different of minimum chi-squares (as in least square theory), were developed and rigorous demonstrations were given for the limiting chi-square distribution of the suggested test criterion. Asymptotic power functions of the frequency chi-square tests were obtained. The goodness of fit chi-square is shown to be stochastically smaller when deviations from simple sampling occurred, which led to a plausible explanation of the predominance of small chi-square values in Blood group surveys.

Design of Experiments

Researches in design and analysis of experiments started in the Statistical Laboratory as early as 1938. The theory of Galois fields was used to construct a large number of new balanced incomplete block designs in addition to those already enumerated by Fisher and Yates. Further work led to a compact representation of all practically useful balanced incomplete block designs.

A new class of designs called partially balanced incomplete block designs, which includes as special cases the balanced and quasi-factorial designs, was introduced and the problem of construction and analysis was studied in detail. Another important class of

designs called intra and inter group balanced designs was developed. A general method of approach for recovering the intra and interblock information from the results of a general incomplete block design and the necessary tests of significance have been given.

Studies relating to factorial experiments started with a new representation of main effects and interactions using the properties of an s-sided hyper-graeco-latin square. This was exploited to get confounded arrangements. Euler's conjecture regarding completely orthogonalised latin squares when s is a prime or prime power was proved. The principle of generalised interaction first enunciated by Barnard for $s = 2$, was proved to hold good also in the general case when s is a prime or prime power. With the help of finite geometries a complete enumeration was made of confounded designs when s is a prime or prime power.

Balanced confounded designs were defined and constructed for a large number of useful asymmetrical factorial experiments. A new class of arrangements known as orthogonal arrays is introduced and used in the construction of factorial designs with the maximum number of factors for given block size and fractionally replicated designs with or without confounding.

By employing an integral representation of the treatment combinations in a factorial experiment and also of the contrasts for main effects and interactions, a method was developed by which all possible confounded designs could be simply obtained by mechanical tabulation with punched card equipment. The analysis of factorial designs requiring the computation of main effects and interactions is also made available through mechanical tabulation.

Multivariate Analysis

The problem of discrimination between statistical populations on the basis of multiple measurements on individuals first came up in connection with anthropometric studies. A measure of divergence between two populations in respect of the mean values of multiple characteristics was introduced and its properties studied in a number of papers. This measure has come to be known as Mahalanobis' D^2 or Distance Function. Since its use was first demonstrated in the classification of 25 castes and tribes of the United Provinces in 1946 the method has been applied in a variety of other fields with some success both in India and abroad.

In the application of D^2 one assumption is made that the groups under consideration possibly differ in the mean values but not in the variances and covariances. To test this hypothesis, test criteria depending on the roots of a determinantal equation were introduced. In a series of papers, distributions were obtained of individual roots and also of their symmetric functions in the null and non-null hypotheses for the general case of p variates.

A further problem which arises in the use of D^2 and allied applications is the choice of characters, their number and nature. The question to be asked is whether some assigned characters show any discrimination between the groups independently of a basic panel of characters already selected. It is to be recognized that these assigned characters may be important by themselves for purposes of discrimination but, in conjunction with a basic panel, may not contribute any additional distance. This is important if a stable classification of a given number of groups is to be obtained. There must be a limit beyond which the

rest of the characters do not contribute to the distance function. This had been stated in an axiomatic manner by Mahalanobis : an empirical test has been made available for this purpose.

Following Fisher's work on the discriminant function, methods of classification when more than two groups are involved have been developed. General problems of classification and selection have been considered in a number of papers. The concept of size and shape factors was extended to construct new functions of observed characteristics, which are found to be useful in problems of classification.

To facilitate the use of the test criterion of the likelihood-ratio in many problems of multivariate analysis, a powerful approximation requiring the use of available statistical tables only, was obtained. Techniques appropriate for the treatment of multiply classified data with unequal numbers in cells and for missing observations in multivariate analysis of variance have been developed recently.

Appendix A

LIST OF REPORTS ON LARGE SCALE SAMPLE SURVEYS

1. Study of consumer preference in Calcutta. By P. C. Mahalanobis. (Report submitted to D. J. Keymar and Co., in 1935).

2. Preliminary Report of the survey of Handloom Weaving Industry in Bengal Conducted under the Technical Guidance of P. C. Mahalanobis. By N. C. Chakravarti. (*Government of Bengal*, 1937).

3. Statistical Report on the Experimental Crop Census, 1937. By P. C. Mahalanobis. (*Indian Central Jute Committee*, 1938).

4. First Report on the Crop census of 1938. By P. C. Mahalanobis. (*Indian Central Jute Committee*, 1939).

5. General Report on the enquiry into the prevalence of drinking tea among Middle Class Indian families in Calcutta, 1939. By P. C. Mahalanobis. (*Tea Market Expansion Board*).

6. Progress Report of the jute census scheme for 1939. By P. C. Mahalanobis. (*Indian Central Jute Committee*).

7. Report on the sample census of jute in 1938. By P. C. Mahalanobis. (*Indian Central Jute Committee*).

8. Statistical Note on crop-cutting experiments on paddy in Mymensingh. By P. C. Mahalanobis. (Submitted to the Government of Bengal. May 1940).

9. Statistical Report on crop-cutting experiments on Jute 1940. By P. C. Mahalanobis. (*Indian Central Jute Committee*).

10. Preliminary Reports on the sample census of the area under Jute. By P. C. Mahalanobis. (*Indian Central Jute Committee*, August 1940).

11. Report on the sample census of the area under jute in Bengal in 1940. By P. C. Mahalanobis. (*Indian Central Jute Committee*, November 1940).

12. A Note on the expenditure on tea among working-class families in Howrah and Kankinara. By P. C. Mahalanobis. (Submitted to the Tea Market Expansion Board, October 1940).

13. Report on the enquiry into prevalance of drinking tea in Nagpur. By P. C. Mahalanobis. (Submitted to the Tea Market Expansion Board, March 1941).

14. Preliminary Statistical Report on the Regional Survey of Borer Pests of Sugarcane. By P. C. Mahalanobis. (Submitted to the Imperial Council of Agricultural Research, June 1941).

15. A Statistical Report on the Rupee Census. By P. C. Mahalanobis. (Published in the Report on Currency and Finance, 1940-41, by Reserve Bank of India, June 1941, 49-55).

16. Statistical Report on crop-cutting experiments on jute in Bengal, 1940. By P. C. Mahalanobis. (*Indian Central Jute Committee*, June 1941).

17. Reports on programme preference and broadcast reaction, Calcutta. By P. C. Mahalanobis. (Submitted to the Government of India, July 1941).

18. Report on the sampling technique for forecasting the block yield of Cinchona Plants : Experiments Series B. By P. C. Mahalanobis. (Submitted to the Government of Bengal, October 1941).

19. General Report on the sample census of the area under jute in Bengal, 1941. By P. C. Mahalanobis. (*Indian Central Jute Committee*, 1941).

20. Family Budget enquiries of Labourers, Jagaddal. By P. C. Mahalanobis. (*Board of Economic Enquiry, Bengal*, January 1942).

21. Report on the precision of family budget enquiry at Jagaddal, August 1942. By P. C. Mahalanobis. (*Bengal Board of Economic Enquiry*).

22. Preliminary Report on Burdwan-Hooghly-Howrah crop-cutting survey. By P. C. Mahalanobis. (Submitted to the Government of Bengal, 1942).

23. Preliminary Report on the sample census of the area under jute in Bengal, 1942. By P. C. Mahalanobis. (Submitted to the Government of Bengal).

24. Preliminary Report on the sample census of the area under aus Paddy in Bengal, 1942. By P. C. Mahalanobis. (Submitted to the Government of Bengal).

25. Preliminary Report on the crop-cutting experiment on Jute 1941. By P. C. Mahalanobis. (Submitted to the Government of Bengal).

26. Report on the survey of Borer Pests on Sugarcane, Parts 1–9. By P. C. Mahalanobis. (Submitted to Imperial Council of Agricultural Research).

27. Preliminary Report on the sample census of the area under aman paddy in Bengal, 1943. By P. C. Mahalanobis. (Submitted to the Government of Bengal).

28. Final Report on the sample census of the area under jute and aus paddy in Bengal, 1943. By P. C. Mahalanobis. (Submitted to the Government of Bengal).

29. Report on the Bihar Crop Survey : Rabi Season 1943-44. By P. C. Mahalanobis. *Sankhyā*, 7(1), 1945, 29–106.

30. Traffic census on New Howrah Bridge. By P. C. Mahalanobis. (Report submitted to the Government of India, November 1946).

31. Anthropometric survey of the United Provinces, 1941. By P. C. Mahalanobis, D. N. Mazumdar and C. R. Rao. (Published in *Sankhyā*, 9, 90).

32. Report on the Survey of Refugee Population in West Bengal, 1948. By N. C. Chakravartti (submitted to the Government of India, 1949).

33. Age tables based on the Y-sample. By P. C. Mahalanobis. (Submitted to the Government of India, 1950).

34. Means of livelihood and industries tables based on the Y-sample. By P. C. Mahalanobis. (Submitted to the Government of India, 1950-51).

35. Survey of Rural Indebtedness. By P. C. Mahalanobis. (Report submitted to the Government of West Bengal, April 1950).

36. Survey of Economic Condition of Agricultural Labour. By P. C. Mahalanobis. (Report submitted to the Government of West Bengal, December 1950).

37. The National Sample Survey. General Report No. 1 on the First Round, October 1950–March 1951. By P. C. Mahalanobis. (*Government of India*, published in December 1952).

38. Report of a sample survey of refugee households settled in rehabilitation colonies in West Bengal, December 1951. By S. B. Sen. (Submitted to the Fact-Finding Committee in February 1953).

39. THE NATIONAL SAMPLE SURVEY. REPORT NO. 2. TABLES WITH NOTES ON THE SECOND ROUND, APRIL–JUNE 1951. (Submitted to the Government of India in August 1953 and published in December 1953).

40. THE NATIONAL SAMPLE SURVEY. REPORT NO. 3. TABLES WITH NOTES ON THE THIRD ROUND, AUGUST–NOVEMBER, 1951. (Submitted to the Government of India in August 1953 and published in March 1954).

41. NATIONAL SAMPLE SURVEY. REPORT NO. 4. SURVEY OF PERSONS IN THE 'LIVE-REGISTER' OF DELHI EMPLOYMENT EXCHANGE, SEPTEMBER 1953. By Pitambar Pant. (Submitted to the Government of India in December 1953 and published in March 1954).

42. SAMPLE SURVEY OF DISPLACED PERSONS IN THE URBAN AREAS OF BOMBAY STATE, JULY–SEPTEMBER 1953. By S. B. Sen (Submitted to the Ministry of Rehabilitation in February 1954).

43. THE NATIONAL SAMPLE SURVEY. REPORT NO. 5. TECHNICAL PAPER ON SOME ASPECTS OF THE DEVELOPMENT OF THE SAMPLE DESIGN. By D. B. Lahiri. (Submitted to the Government of India. Published in March 1954).

44. THE NATIONAL SAMPLE SURVEY. REPORT NO. 6. SURVEY OF FARIDABAD TOWNSHIP, MARCH–APRIL 1954. By P. Pant with a foreword by P. C. Mah alanobis. (Submitted to the Government of India. Published in December 1954).

45. THE NATIONAL SAMPLE SURVEY. REPORT NO. 7. COUPLE FERTILITY. By A. Dasgupta, R. K. Som, M. Majumdar and S. N. Mitra. With a foreword by P. C. Mahalanobis. (Submitted to the Government of India. Published in December 1955).

46. THE NATIONAL SAMPLE SURVEY. REPORT NO. 8. REPORT ON PRELIMINARY SURVEY OF URBAN UNEMPLOYMENT, SEPTEMBER 1953. With a foreword by P. C. Mahalanobis. (Submitted to the Government of India. Published in March 1956).

47. THE NATIONAL SAMPLE SURVEY. REPORT NO. 9. LAND HOLDING. (Provisional report submitted to the Government of India).

48. THE NATIONAL SAMPLE SURVEY. REPORT NO. 10. REPORT ON SAMPLE SURVEY OF MANUFACTURING INDUSTRIES, 1949 AND 1950. (Provisional report submitted to the Government of India).

49. THE NATIONAL SAMPLE SURVEY. REPORT NO. 11. CALCUTTA EMPLOYMENT SURVEY. (Provisional report submitted to the Government of India).

50. THE NATIONAL SAMPLE SURVEY. REPORT NO. 12. REPORT ON SAMPLE SURVEY OF MANUFACTURING INDUSTRIES, 1952. (Provisional report submitted to the Government of India).

51. THE NATIONAL SAMPLE SURVEY. REPORT NO. 13. TABLES WITH NOTES ON THE FOURTH ROUND, APRIL–SEPTEMBER 1952. VOLS. 1 & 2. (Provisional report submitted to the Government of India).

52. THE NATIONAL SAMPLE SURVEY. REPORT NO. 14. SOME CHARACTERISTICS OF THE ECONOMICALLY ACTIVE POPULATION. (Provisional report submitted to the Government of India).

53. THE NATIONAL SAMPLE SURVEY. REPORT NO. 15. REPORT ON SAMPLE SURVEY OF EMPLOYMENT AND UNEMPLOYMENT, MAY–NOVEMBER 1955. (Provisional report submitted to the Government of India).

54. THE NATIONAL SAMPLE SURVEY. REPORT NO. 16. A TECHNICAL NOTE ON AGE GROUPING. (Provisional report submitted to the Government of India).

55. THE NATIONAL SAMPLE SURVEY. REPORT NO. 17. REPORT ON SMALL SCALE TRANSPORT OPERATION, SEVENTH ROUND, OCTOBER 1953–MARCH 1954. (Provisional report submitted to the Government of India).

56. The National Sample Survey. Report No. 18. Bombay refugee survey. (Provisional report submitted to the Government of India).

57. The National Sample Survey. Report No. 19. Pattern Consumer Expenditure Second to Seventh Round, April 1951–March 1954. (Provisional Report submitted to the Government of India).

58. The National Sample Survey. Report No. 20. Report on Small Scale Manufacturing (Household Enterprise), October 1953–March 1954. (Provisional Report submitted to the Government of India).

59. The National Sample Survey. Report No. 21. Report on Small Manufacturing Establishments, Ninth Round, May–November 1955. (Provisional Report submitted to the Government of India).

60. The National Sample Survey. Report No. 22. Notes on Investigators Time Records, Eighth Round, July 1954–April 1955. (Provisional Report submitted to the Government of India).

61. The National Sample Survey. Report No. 23. Report on Sample Surveys of Manufacturing Industries 1952. April 1957 (Provisional Report submitted to the Government of India).

62. The National Sample Survey. Report No. 24. Some Basic Information about Sample Villages, Ninth Round, May–November 1955. (Provisional Report submitted to the Government of India).

63. The National Sample Survey. Report No. 25. Tables with Notes on the Land Utilization Survey and Crop-Cutting Experiments, Ninth Round, December 1955–May 1956. (Provisional Report submitted to the Government of India).

64. The National Sample Survey. Report No. 26. Report on Sample Survey of Manufacturing Industries 1953, May 1957. (Provisional Report submitted to the Government of India).

65. The National Sample Survey. Report No. 27. Village Statistics, Third Round, August–November 1951. (Provisional Report submitted to the Government of India).

Appendix B

WORKING PAPERS

(*a*) *Economic Planning*

1. MAHALANOBIS, P. C. : **Note on studies relating to planning for national development** now being conducted at the Indian Statistical Institute in collaboration with the Central Statistical Organisation. (9 November 1954)

2. BETTELHEIM, CH. : **Scheme of a model of reasoning for the elaboration of the 2nd** F.Y.P. of India. (9 November 1954)

3. FRISCH, RAGNAR : **Planning for economic development in India: A memorandum on** the broad macro-economic aspects of the problem. (26 November 1954)

4. ROY, J., CHAKRAVARTY, I. M. and LAHA, R. G. : A study of concentration curves as description of consumption pattern. (26 November 1954)

5. FRISCH, RAGNAR : **A short memorandum on a technique for elaborating the new F.Y.P.** for India. (11 December 1954)

6. BETTELHEIM, CH.: **Notes on the economic policy.** (15 December 1954)

7. DUTTA, UMA: **A preliminary study of inter-industry relations in India.** (16 December 1954)

8. ROY, J. and LAHA, R. G. : Preliminary estimates of relative increase in consumer demand in rural and urban India. (18 December 1954)

9. DAS GUPTA, AJIT and MAJUMDAR, M. : India 1951-2001 population projections. (23 December 1954)

10. BETTELHEIM, CH. : Investment allocation and increase in national income. (24 December 1954)

11. FRISCH, RAGNAR : General remarks on the programming matrix. (25 December 1954)

12. RUDRA, A. : Balance relations involved in the Bettelheim model. (29 December 1954)

13. FRISCH, RAGNAR : A basic instrument in the planning work—the technical description sheet. (29 December 1954)

14. ——— : Investment, consumption and employment under a balanced expansion. (16 January 1955)

15. ——— : The programming chart with a preliminary draft of a nomenclature of production sectors. (20 January 1955)

16. BETTELHEIM, CH. : Observations on the social conditions necessary for a rapid and planned economic development. (21 January 1955)

17. CHOWDHURY, T. and GOODWIN, R. M. : Transactions matrices for the Indian Union 1950-51. (21 January 1955)

18. OSTROVITIANOV, K. V. : Scientific principles of planning the national economy of the USSR. (22 January 1955)

19. BHATTACHARYA, SITANGSHU : A note on the concentration of production and labour in some selected industries and its consequences. (22 January 1955)

20. FRISCH, RAGNAR : The methodology of planning in an under-developed country. (23 January 1955)

21. RAO, V. K. R. V. : Second Plan: Aims and philosophy. (27 January 1955)

22. FRISCH, RAGNAR : A sequence of calculations for determining an optimal plan-frame by means of linear programming. (4 February 1955)

23. ——— : Some preliminary results on experimental plan-frame no. 1. (15 February 1955)

24. SEN GUPTA, PRASUN : The concepts of employment in India and their measurement. (16 February 1955)

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Appendix C

LIST OF SAMPLE SURVEYS CONDUCTED UP TO DECEMBER 1957

Sample surveys of the area under different crops

1. *Area under jute in Bengal, 1935.* Field work : under control of H.P.V. Townend, I.C.S., Development Commissioner, in consultation with Indian Statistical Institute ; Coverage : 20 districts (practically the whole jute growing area of about 40,000 sq. miles) ; Sample-unit : Square shape 40 acre ; Number of sample units : 2,100.

2. *Experimental sample-census of area under jute in Bengal, 1937.* A pilot survey to explore possibilities of sampling. Both complete enumeration and sample survey methods were used for comparison. Field work : under Director of Agriculture, Bengal; Coverage : 124 sq. miles ; Sample-unit : Three different units—(a) square shape 5 acre, Number of sample-units : 1,488, (b) plots as indicated on settlement maps, Number of units : 14,159, (c) mouzas (small villages); Number of units : 20.

3. *Area under jute in Bengal, 1938.* Field work : Indian Statistical Institute ; Coverage : 414 sq. miles ; Sample-unit : Different sizes at different densities—(a) 16 acre, Number of sample-units : 328, (b) 4 acre, Number of sample-units : 1,221, (c) 1 acre, Number of sample-units : 6,339—Total : 7,888 sample-units. Also complete enumeration over 400 sq. miles for comparison.

4. *Area under jute in Bengal, 1939.* Field work : Indian Statistical Institute ; Coverage : 2,563 sq. miles ; Sample-unit : 5 different sizes at 12 different densities—(a) 36 acre, Number of units : 344, (b) 16 acre, Number of units : 475, (c) 9 acre; Number of units : 1,432, (d) 4 acre, Number of units : 2,208, (e) 1 acre, Number of units : 7,652. Total : 12,111 sample-units. Also complete enumeration over 700 sq. miles for comparison.

5. *Area under jute in Bengal, 1940.* Field work : Indian Statistical Institute: Coverage : 20,533 sq. miles; Sample-unit : 4 acre; Number of units : 32,996. A small number of four other sample-units were used for the study of cost and variance functions. Survey conducted in the form of two independent and interpenetrating sub-samples.

6. *Area under jute in Bengal, 1941.* Field work : Indian Statistical Institute; Coverage : 59,199 sq. miles ; Sample-unit : Different sizes at different densities—(a) 1 acre, Number of units : 10,690, (b) 2 acre, Number of units : 9,018, (c) 2.5 acre, Number of units: 7,314, (d) 3 acre, Number of units : 14,168, (e) 4 acre, Number of units : 12,458, (f) 6 acre, Number of units : 2,414, (g) 9 acre, Number of units : 660, (h) other sizes, Number of units : 650. Total number of sample-units : 57,362. Survey was arranged in the form of two sub-samples.

7. *Area under jute and Aus paddy in Bengal, 1942.* Field work : Indian Statistical Institute ; Coverage : 47,713 sq. miles ; Sample-units : Different sizes ranging from 1 to 16 acre. Total number of sample-units : 54,031. Survey arranged in two independent half samples.

8. *Area under jute and Aus paddy in Bengal, 1943.* Field work : Indian Statistical Institute ; Coverage : 59,199 sq. miles ; Sample-unit : 2.25 acre ; Number of sample-units : 59,352. Survey arranged in the form of 2 independent interpenetrating sub-samples.

9. *Area under Aman paddy in Bengal, 1943.* Field work : Indian Statistical Institute; Coverage : 59,199 sq. miles; Sample-unit : 2.25 acre; Number of sample-units : 62,431. Survey arranged in the form of 2 independent interpenetrating sub-samples.

10. *Area under cereals in Bihar, Rabi (Winter) season, 1944.* Field work : Bihar Government assisted by Indian Statistical Institute ; Coverage : 8,075 sq. miles ; Sample-unit : 4 acre ; Number of sample-units : 14,352.

11. *Area under jute and Aus paddy in Bengal, 1944.* Field work : Indian Statistical Institute ; Coverage : 59,199 sq. miles ; Sample-unit : 2.25 acre ; Number of sample-units : 60,534. Survey was arranged in two independent and interpenetrating sub-samples.

12. *Area under Aman paddy in Bengal, 1944.* Field work : Indian Statistical Institute; Coverage : 59,199 sq. miles; Sample-unit : 2.25 acre; Number of sample-units : 1,00,608. Arrangement of survey as in No. 11.

13. *Area under paddy in Bihar, Bhadoi (Autumn) season, 1944.* Field work : Bihar Government; Coverage : 67,536 sq. miles; Sample-unit : 4 acre; Number of sample-units : 44,196.

14. *Area under Aghani paddy in Bihar, 1945.* Field work : Bihar Government; Coverage : 67,536 sq. miles; Sample-unit : 4 acre; Number of sample units : 64,260. Survey arranged in the form of overlapping sub-samples (with duplicated sample-units) for judging accuracy of field work.

15. *Area under cereals in Bihar, Rabi (Winter) season, 1945.* Field work : Bihar Government; Coverage : 67,536 sq. miles; Sample unit : 4 acre. Number of sample-units : 67,800. Survey arranged in two independent and interpenetrating networks with a third survey of some sample-units of these two networks.

16. *Area under jute and Aus paddy in Bengal, 1945.* Field work : Indian Statistical Institute; Coverage : 59,199 sq. miles; Sample-unit : 2.25 acre; Number of sample-units : 1,06,127. Plan slightly different from No. 11.

17. *Area under Aman paddy in Bengal, 1945.* Field work : Indian Statistical Institute; Coverage : 59,199 sq. miles; Sample-unit : 2.25 acre; Number of sample-units : 92,119. Plan similar to No. 16.

18. *Area under jute and Aus paddy in Bengal, 1946.* Field work : Indian Statistical Institute; Coverage : 59,199 sq. miles; Sample-unit : 2.25 acre; Number of sample-units : 87,410. Plan similar to No. 16.

19. *Area under Aman paddy in Bengal, 1946.* Field work : Indian Statistical Institute; Coverage : 59,199 sq. miles; Sample-unit : 2.25 acre; Number of sample-units : 84,313. Plan same as in No. 16.

20. *Area under jute and Aus paddy in Bengal, 1947.* Field work : Indian Statistical Institute; Coverage : 59,199 sq. miles; Sample-unit : 2.25 acre; Number of sample-units : 99,000. Plan similar to No. 16.

21. *Area under Aman paddy in West Bengal, 1947.* Field work : Indian Statistical Institute; Coverage : 29,000 sq. miles; Sample-unit : 2.25 acre; Number of sample-units : 43,000. Plan similar to No. 16.

22. *Area under jute and Aus paddy, pulses, oilseeds, potato and other winter crops in West Bengal, 1948-49.* Field work : Indian Statistical Institute; Coverage : 25,000 sq. miles; Sample-unit : 2.25 acre; Number of sample-units : 49,816. Plan similar to No. 16 with slight variation in details.

23. *Area under jute and Aus paddy in West Bengal, 1949-50.* Field work : Indian Statistical Institute; Coverage : 30,000 sq. miles; Sample-unit : 2,25 acre and 6.25 acre; Number of sample-units : 16,143. Plan similar to No. 16 with modifications in details.

24. *Area under Aman paddy in West Bengal, 1949-50.* Field work: Indian Statistical Institute; Coverage : 30,000 sq. miles; Sample-unit : 2.25 acre and 6.25 acre. Number of sample-units : 19,031. Plan similar to No. 16 with modifications in details.

25. *Area under wheat, barley, pulses, sugarcane potato, mustard and linseed in West Bengal, 1949-50.* Field work : Indian Statistical Institute; Coverage : 30,000 sq. miles; Sample-unit : 2.25 acre and 6.25 acre; Number of sample-units : 22,749. Plan similar to No. 16 with modifications in details.

26. *Area under jute and Aus paddy in West Bengal, 1950-51.* Field work : Indian Statistical Institute ; Coverage : 30,000 sq. miles : Sample-unit : Exclusive cluster of 30 serial plots in a Union (administrative unit); Number of sample-units : 4,800. Plan based on two-stage sampling; in the first stage 600 unions were chosen from 17 strata and in the second stage 4,800 clusters of 30 plots were chosen from the Unions at the rate of 8 clusters per Union. Unions chosen from each stratum were divided into two interpenetrating random samples.

27. *Area under jute and Aus paddy in West Bengal, 1951.* Field work : Indian Statistical Institute ; Coverage : Entire state of West Bengal (except for the hill-tracts and Sunderban forests)—area, 30,000 sq. miles ; Sample unit : Cluster of 30 serial plots ; Design : stratified, two-stage ; Number of strata : 17 ; Number of sample unions : 599 ; Number of sample clusters : 4,557 ; Objective : To try out a new sample design for estimation of area under crops in West Bengal.

28. *Area under Aman paddy in West Bengal, 1951-52.* Field work, coverage, sample unit, design and objective same as for the jute and *aus* survey (1951) ; Number of strata : 17 : Number of sample unions : 600 ; Number of sample clusters : 4,644.

29. *Area under jute and Aus paddy in West Bengal. 1952.* Field work : Indian Statistical Institute ; Coverage : 30,000 sq. miles of West Bengal; Sample unit : plot within clusters: Design : stratified three stage ; Number of unions : 596: Number of clusters of plots (50 to 100 plots each) : 6,845 ; Objective : To try modifications in the design and get reasonably dependable estimate for the state as a whole.

30. *Area under Aman paddy in West Bengal, 1952-53.* Field work, coverage, sample unit, design and objective same as for the jute and *aus* survey (1952) ; Number of unions : 532 ; Numbers of clusters of (50 to 100) plots : 5,246.

31. *Area under jute and Aus in West Bengal, 1953.* Field work : Indian Statistical Institute ; Coverage : 30,000 sq. miles of West Bengal ; Sample unit : Cluster of plots ; Design : Stratified, two-stage ; Number of unions : 600 ; Number of clusters : 6,000.

32. *Area under Aman paddy in West Bengal, 1953-54.* Field work, coverage, sample unit and design same as in Jute-*Aus* survey (1953)—Number of unions : 599 ; Number of clusters : 5,909.

33. *Area under jute and Aus paddy in West Bengal, 1954.* Field work, coverage, design, sample unit and number of sampling units same as in Jute-*Aus* survey of 1953.

34. *Area under Aman paddy in West Bengal, 1954-55.* Field work, coverage, design, sample unit and number of sampling unit same as in *Aman* survey of 1953-54.

35. *Special harvest survey in West Bengal, 1955-56.* Field-work : Indian Statistical Institute ; Coverage : 14 villages, one in each of the districts of West Bengal ; Design : complete enumeration of all the plots in the selected villages ; Objective : To collect basic data for use in designing crop surveys.

36. *Sample survey for pre-harvest estimates of crop-acreage : Rabi season, 1955-56.* Field work : Village revenue officials and patwaris of the selected villages ; Coverage : Bihar, Bombay, Hyderabad, Madhya Bharat, Madhya Pradesh, Rajasthan, Uttar Pradesh and Vindhya Pradesh ; Sample unit : Plot ; Design : Stratified, two-stage : Number of sample villages : 22,500 ; Objective : To obtain the pre-harvest estimates of areas under major crops of *rabi* reason.

37. *Sample survey for pre-harvest estimates of crop-acreage : Kharif season, 1955-56.* Field work same as in the *rabi* survey (1955-56) ; Coverage : Besides the states which partook in the *rabi* survey, the states of Assam, Madras, Mysore and Saurastra also participated. Sample unit and design same as in rabi survey ; Number of sample villages : 30,000 ; Objective : To obtain the pre-harvest estimates of areas under major crops of *Kharif* season.

Sampling for estimates of yield per acre (crop cutting experiments)[1]

38. *Aman rice in Burdwan-Hooghly-Howrah flushing and irrigation area* (*B.H.H.F.I.*). Field work : Bengal Government ; Coverage : 1,057 sq. miles in 3 districts ; Sample-cut : $5.2' \times 5.2'$; Number of sample-cuts : 48,000 (approx.).

39. *Aman rice in Mymensingh, 1939-40.* Field work : Bengal Government ; Coverage : 837 sq. miles ; Sample-cut : $5.2' \times 5.2'$; Number of sample-cuts : 16,000 (approx.).

40. *Aman rice in B.H.H.F.I. area.* Specifications same as in No. 38. Number of sample-cuts : 26,000 (approx.).

41. *Jute in Bengal, 1939-40.* Field work : Indian Statistical Institute ; Coverage : 804 sq. miles ; Sample-cut : 23 types of different size and shape ; Number of sample-cuts : 492.

42. *Jute in Bengal, 1940-41.* Field work : Indian Statistical Institute ; Coverage : 800 sq. miles ; Sample-cut : (a) $4' \times 4'$, (b) $16' \times 16'$, (c) $(1'+3'+12')^2$ multiple cut with 7 sub-cuts ; Number of sample-cuts : 528 ; Samples were located in 5 stages. Accurate time records were kept for enumeration studies.

43. *Sugarcane in United Provinces, 1940-41.* Field work : U.P. Government ; Coverage : 2,500 sq. miles ; Sample-cut : (a) $6' \times 6'$, (b) $12' \times 12'$, (c) $18' \times 18'$, (d) $27' \times 27'$, (e) $45' \times 45'$, (f) $(6'+12'+27')^2$ multiple cut, (g) $(6'+12'+9')^2$ multiple cut ; Number of sample-cuts : 2,650. The survey was of an exploratory nature divided into 3 schemes.

44. *Wheat in United Provinces, 1940-41.* Field work : U.P. Government ; Coverage : 2,500 sq. miles ; Sample-cut : (a) $3' \times 3'$, (b) $(3'+6'+12')^2$ multiple cuts with 9 sub-cuts ; Number of sample-cuts : 1,624.

45. *Aman rice in B.H.H.F.I. area, 1940-41.* Field work : Bengal Government; Coverage : 1,057 sq. miles (same area as in No. 38); Sample-cut : (a) $5.2' \times 5.2'$, (b) $12' \times 12'$, (c) $21' \times 21'$, (d) $33' \times 33'$, (e) $(5.2'+7.2'+20.8')^2$ multiple cut; Number of sample-cuts : 16,000 (approx.).

46. *Jute in Bengal, 1941.* Field work : Indian Statistical Institute ; Coverage : 40 Police Stations in 8 districts; Sample-cuts : (a) $3' \times 3'$, (b) $5' \times 5'$, (c) $7' \times 7'$, (d) $8' \times 8'$, (e) $10' \times 10'$, (f) $12' \times 12'$, (g) $15' \times 15'$, (h) $(3'+5'+7')^2$ multiple cut with 7 sub-cuts ; Number of cuts : 2,019. Exploratory survey to study technique.

47. *Aman rice in B.H.H.F.I. area, 1941-42.* Field work : Bengal Government; Coverage : same as in No. 38; Sample-cut : (a) $5.2' \times 5.2'$, (b) $7' \times 7'$, (c) $12' \times 12'$, (d) $16' \times 16'$, (e) $21' \times 21'$, (f) $33' \times 33'$, (g) $(5.2'+7.0'+20.8')^2$ multiple cut with 7 sub-cuts ; Number of sample-cuts : 15,200.

48. *Sugarcane in United Provinces, 1941-42.* Field work : U.P. Government ; Coverage : 3,500 sq. miles ; Sample-cut : (a) $6' \times 6'$, (b) $12' \times 12'$, (c) $18' \times 18'$, (d) $27' \times 27'$, (e) $39' \times 39'$, (f) $45' \times 45'$, (g) $(6'+12'+7')^2$ multiple cuts ; Number of sample-cuts : 23,000 (approx.). The survey was divided into 5 schemes to study different problems of technique.

49. *Wheat in United Provinces, 1941-42.* Field work : U.P. Government ; Coverage : 2,800 sq. miles ; Sample-cut (extensive scheme) : $6' \times 6'$; Number of sample-cuts : 1,780 ; Sample-cut (intensive scheme) : $(3'+6'+9')^2$ multiple cut ; Number of sample-cuts : 173.

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[1] It is believed that Sir John Hubback attempted for the first time to conduct crop cutting experiments in accordance with the principles of random sampling between 1923 and 1925 in Bihar, India. He worked on the rice crop using triangular cuts of size 1/3200 acre demarcated by a rigid frame. The same method was used by C. D. Deshmukh on the rice crop in the Central Provinces in 1928, 1929 and 1930. Hubback gave a general account of his work in a paper on "Sampling for Rice Yield in Bihar and Orissa" published by the Government of India in 1927, which was later reprinted in Sankhyā (Vol. 7, Pt. 3, pp. 281-294). Hubback's work influenced the work of R. A. Fisher at Rothamsted.

*50. *Jute in Bengal, 1942.* Field work : Indian Statistical Institute ; Coverage : 32,236 sq. miles ; Sample-cut (extensive survey) : (a) $12' \times 12'$, (b) $7' \times 7'$; Number of sample-cuts : (a) 1,127, (b) 1,321 ; Sample-cut (intensive survey) : (a) $8' \times 8'$, (b) $3' \times 3'$, (c) $7' \times 7'$, (d) $12' \times 12'$, (e) $15' \times 15'$. Total number of sample-cuts : 8,984.

*51. *Aus Paddy in Bengal, 1942-43.* Field work : Indian Statistical Institute ; Coverage : 50,288 sq. miles ; Sample-cut : $4' \times 4'$; Number of sample-cuts : 2,794. Decision to include crop-cutting experiments was taken very late in the season when most of the *Aus* crop had already been harvested.

52. *Aman paddy in B.H.H.F.I. area, 1942-43.* Field work : Indian Statistical Institute ; Coverage : 1,057 sq. miles (same area as in No. 38) ; Sample-cut : (a) $5.2' \times 5.2'$, (b) $7' \times 7'$, (c) $12' \times 12'$, (d) $16' \times 16'$, (e) $21' \times 21'$, (f) $33' \times 33'$, (g) $(5.2' + 7.0' + 20.8')^2$ multiple cut ; Number of sample-cuts : 15,000 (approx.).

*53. *Jute in Bengal, 1943-44.* Field work : Indian Statistical Institute ; Coverage : 47,123 sq. miles ; Sample-cut (extensive survey) : $8' \times 8'$; Sample-cut (intensive survey) : (a) $4' \times 4'$, (b) $8' \times 8'$, (c) $6' \times 6'$, (d) $12' \times 12'$, (e) $16' \times 16'$; Number of sample cuts : 8,100. Different schemes were used to study ground variances at different stages.

*54. *Aus paddy in Bengal, 1943-44.* Field work : Indian Statistical Institute ; Coverage : 43,684 sq. miles ; Sample-cut : $4' \times 4'$; Number of sample-cuts : 3,500.

*55. *Aman paddy in Bengal, 1943-44.* Field work : Indian Statistical Institute ; Coverage : 59,199 sq. miles ; Sample-cuts : (a) $6' \times 6'$, (b) $12' \times 12'$; Number of sample-cuts : (a) 4,248, (b) 4,249.

*56. *Wheat and gram in Bihar, 1943-44.* Field work : Bihar Government ; Coverage : 8,075 sq. miles ; Sample-cut : $25' \times 25'$ square divided into two triangles of equal area ; Number of sample-cuts : 1,800 (approx.).

*57. *Jute in Bengal, 1944-45.* Field work : Indian Statistical Institute ; Coverage : 59,199 sq. miles ; Sample-cut : (a) $5.2' \times 5.2'/2$, (b) $10' \times 10'$; Number of sample-cuts : 2,000.

58. *Aus paddy in Bengal, 1944-45.* Specifications same as in No. 57. Number of sample-cuts : 39,024.

59. *Bhadoi paddy in Bihar, 1944-45.* Field work : Bihar Government ; Coverage : 67,536 sq. miles; Sample-cut : (a) $8' \times 8'$, (b) 12.5 sq. ft. triangle ; Number of sample-cuts : 2,277.

*60. *Aman paddy in Bengal, 1944-45.* Specifications same as in No. 57 with slight modification; Number of sample-cuts : 11,037.

*61. *Aghani paddy in Bihar, 1944-45.* Field work : Bihar Government ; Coverage : 67,536 sq. miles; Sample-cut (extensive survey) : (a) $10' \times 10'$, (b) $5' \times 5'/2$; Number of sample-cuts : (a) 3,120, (b) 2,250; Sample-cut (intensive survey) : multiple cuts of (a) $(6' + 2' + 2' + 2')^2$, (b) $4'(9' + 7' + 9' + 11')$, (c) $7'(5' + 4' + 5.2' + 6.3')$, (d) $(5' + 8')^2$: Number of sample-cuts : 6,204.

62. *Wheat, gram and musur in Bihar, 1944-45.* Field work : Bihar Government; Coverage : 67,536 sq. miles; Sample-cut (extensive scheme) : $8' \times 8'$; Number of sample-cuts : 3,100; Sample-cut (intensive scheme) : (a) set of 3 independent cuts of (i) $6.25' \times 5'$, (ii) $6.25' \times 8'$, (iii) $6.25' \times 10'$ in a plot; (b) set of 3 concentric circular cuts with radii (i) 2', (ii) 3', (iii) 4' and another multiple cut $6.25'$ $(2' + 6')$ inside a plot; (c) set of 3 cuts of (i) $8' \times 5'$ (ii) $8' \times 9'$, (iii) $8' \times 16'$ taken at a random point in a field ; Number of sample-cuts : (a) 2,063, (b) 222, (c) 1,807.

*63. *Jute in Bengal, 1945-46.* Field work : Indian Statistical Institute ; Coverage : 59,199 sq. miles ; Sample-cut : set of 3 concentric circles of radii (i) 2', (ii) 4', (iii) 5'-7½" ; Number of sample-cuts (sets) : 1,254.

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*Joint area and yield survey.

64. *Aus paddy in Bengal, 1945-46.* Field work : Indian Statistical Institute; Coverage : 59,199 sq. miles ; Sample-cut : Set of 3 concentric circles of radii (i) 2′, (ii) 4′, (iii) 5′-7½″ ; Number of sample-cuts (sets) : 2,129.

*65. *Aman paddy in Bengal, 1945-46.* Specifications similar to No. 64 ; Number of sample-cuts (sets) : 2,569.

*66. *Jute in Bengal, 1946-47.* Specifications similar to No. 64 ; Number of sample-cuts (sets) : 893.

*67. *Aus paddy in Bengal, 1946-47.* Specifications same as in No. 64 ; Number of sample-cuts (sets) : 1,630.

*68. *Aman paddy in Bengal, 1946-47.* Specifications same as in No. 64 ; Number of sample-cuts (sets) : 2,746.

69. *Jute in Bengal, 1947-48.* Specifications same as in 64 ; Number of sample-cuts (sets) : 1,150.

70. *Aus paddy in Bengal, 1947-48.* Specifications same as in No. 64 ; Number of sample-cuts (sets) : 2,192.*

71. *Aman paddy in West Bengal, 1947-48.* Coverage : 29,000 sq. miles ; Other specifications similar to No. 64 ; Number of sample-cuts (sets) : 3,089.

72. *Jute and Aus paddy in West Bengal, 1949-50.* Field work : Indian Statistical Institute ; Coverage : 30,000 sq. miles ; Other : Specifications same as in No. 64 ; Number of sample-cuts (sets) : 3,396.

73. *Aman paddy in West Bengal, 1949-50.* Specifications same as in No. 64 ; Number of sample-cuts (sets) : 6,392.

74. *Wheat, barley, pulses, sugarcane, potato, mustard and linseed in West Bengal. 1949-50.* Specifications as in No. 64 with the following exceptions—for potato, sugarcane and ahrar 15″×15″; Number of sample-cuts : 4,219.

75. *Jute in West Bengal, 1950-51.* Coverage : 30,000 sq. miles. Specifications same as in No. 64 : Number of sample-cuts : 365.

76. *Aus paddy in West Bengal, 1950-51.* Coverage : 30,000 sq. miles. Specifications same as in No. 64 ; Number of sample-cuts : 247.

77. *Aman paddy in West Bengal, 1950-51.* Coverage : 30,000 sq. miles. Specifications same as in No. 64 ; Number of sample-cuts : 1,285.

† 78. *Wheat and barley, West Bengal, 1951-52.* Field work : Indian Statistical Institute ; Coverage : 30 sq. miles ; Sample-cuts : same as in No. 64 also two concentric circles of radii 1′ and 1′-10″ ; Number of sample-cuts : 1,152.

† 79. *Jute and Aus in West Bengal, 1951-52.* Field work : Indian Statistical Institute; Coverage : Entire state of West Bengal (except for the hill-tracts and Sunderban forests)—area of 30,000 sq. miles ; Sample-unit : circular cuts of radii, 2′, 4′, and 5′-8″; Design : Stratified four-stage design. A 20% sub-sample of unions selected for the Jute-*Aus* area survey (1951-52) was chosen at random : Number of strata : 17 ; Number of sample cuts : 365 (jute) and 247 (*aus*) ; Objective : To try out a new sampling design for purposes of estimating the yield of crops in West Bengal. Jute retting work was carried out in 291 cuts belonging to different strata for purposes of estimating the ratio of weight of dry jute fibre to weight of freshly harvested jute plants.

80. *Aman paddy in West Bengal, 1951-52.* Field work, coverage, sample-unit and design : same as in Jute-*Aus* survey ; Number of cuts : 1.285 ; Objective : To estimate the yield of *aman* paddy in West Bengal.

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* Joint area and yield survey.

† Pilot studies for improvement of the design of sample surveys.

81. *Jute and Aus in West Bengal, 1952-53.* Field work, coverage, sample-unit and design : same as in Jute-*Aus* survey of 1951-52; Number of unions : 125; Number of clusters of 50 to 100 plots : 921.

82. *Aman in West Bengal, 1952-53.* Field work, coverage, sample-unit and design : same as in Jute-*Aus* survey ; Number of unions : 118 ; Number of clusters of 50 to 100 plots : 1,149.

83. *Jute and Aus in West Bengal, 1953-54.* Field work, coverage, sample-unit and design : same as in Jute-*Aus* yield survey of 1952-53.

84. *Aman in West Bengal, 1953-54.* Field work, coverage, sample-unit and design : same as in Jute-*Aus* yield survey ; Number of circular cuts of radius 5′-7½″ : 225.

85. *Jute and Aus in West Bengal, 1954-55.* Field work, coverage, sample-unit and design : same as in Jute-*Aus* yield survey of 1953-54 ; Number of sample plots : 748 cuts (in 748 fields) for Jute, 832 cuts (in 832 fields) for *Aus.*

86. *Aman in West Bengal, 1954-55.* Field work, coverage, sample-unit and design : same as in Jute-*Aus* yield survey ; Number of sample plots : 2176 cuts in 2176 fields.

Miscellaneous agricultural surveys

87. *Yield of Cinchona bark, 1949.* Multiple survey or 'double sampling' method was used to develop a technique for estimating yield of bark from measurements of characters on living plants.

88. *Damage caused to sugarcane by borer pests, 1940-41.* Field work : Imperial Council of Agricultural Research ; Coverage : nine principal sugarcane growing regions of India; Plan : from each region 11 localities, from each locality 2 villages, and from each village 5 sugarcane fields were successively selected at random. Each field was divided into 3 portions and from each such portion 3 shoots were selected at random, examined and extent of damage was recorded. Data relating to density of crop were also collected.

89. *Forecasting the yield of cinchona bark (Madras plantations), 1950-51.* Three-phase sampling to estimate three factors separately in three successive phases was adopted with sub-sampling in the second and third phases.

†90. *Special experiments on Jute, August 1953.* Coverage : three centres in West Dinajpur and 24 Parganas in West Bengal: Objective to study very small cuts of 1′ radius compensated for border bias and (a) prediction of dry fibre from auxiliary characters, (b) retting experiment for the extraction of dry fibre for jute plants.

†91. *Experiments on land utilisation surveys in cadastrally unsurveyed areas—Giridih, Birbhum August 1956-February 1957.* Objective : To study the possibilities of the 'line sampling' in land utilisation surveys without the use of (plot-wise) cadastral survey maps.

†92. *Special experiment for a study of the distribution of harvestable fields on different days of the crop season, August-October, 1956.* Coverage : three centres in West Bengal.

†93. Special area and yield estimation surveys in Birbhum with three different investigating units moving on foot, on bicycles and in motor car.

†94. Cost and precision in sampling for acreage under crops with varying types of sampling units, Birbhum, March–May 1957; Giridih, July–October, 1957; Birbhum, Burdwan and Murshidabad, August–October, 1957.

†95. Sampling with line units in cadastrally unsurveyed areas with the help of magnetic compass and "degree" maps (survey of India) Birbhum and Giridih, January 1957; Hazaribagh, March 1957.

Socio-economic surveys

96. *Rural indebtedness in Bengal, 1933-34.* Field work : Government of Bengal ; Coverage : 20 districts of Bengal ; Sample-unit : Family; Number of sample-units : 7,000 (approx.).

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† Pilot studies for improvement of the design of sample surveys.

97. *Study of consumer preference in Calcutta, 1935.* A study was undertaken of preference for three non-alcoholic drinks served both hot and cold to several groups of individuals. The work was organised in collaboration with Dr. Girindra Sekhar Bose, Head of the Dept. of Psychology, Calcutta University. Financed partly by a private firm.

98. *Sample Survey of consumer preferences in Calcutta, 1935.* Field work : Indian Statistical Institute ; Coverage : Selected localities of Calcutta ; Sample-unit : Family; Number of sample-units : 1,000 (approx.). The survey financed partly by a private firm was designed to collect general information about economic status of the family and purchases of consumer goods including proprietory and advertised goods.

99. *Handloom weaving industry in Bengal, 1936.* Field work : Board of Economic Enquiry, Bengal ; Coverage : 500 villages from 8 selected districts and 5 principal centres ; Sample-unit : Family ; Number of sample-units : 5,372.

100. *Prevalence of drinking tea among middle class families in Calcutta, 1939.* Field work : Indian Statistical Institute ; Coverage : 7 wards of Calcutta Corporation ; Sample unit : Family ; Number of sample-units : 1,187. Questionnaire was designed to ascertain dietetic habits in relation to economic factors.

101. *Prevalence of drinking tea among middle class families in Nagpur, 1940.* Field work : Indian Tea Market Expansion Board ; Coverage : Nagpur city ; Sample-unit : Family ; Number of sample-units : 1,573.

102. *Economic condition of industrial labour, 1941.* Field work : Indian Statistical Institute ; Coverage : Jagaddal, Budge-Budge and Asansol (industrial towns of Bengal) ; Sample-unit : Family ; Number of sample-units : 2,499.

103. *Radio programme preference, 1941.* Field work : Indian Statistical Institute ; Coverage : Predominantly middle class residential areas in Calcutta ; Sample-unit : (a) family, (b) individual radio licence holder ; Number of sample-units : (a) 1,503, (b) 803.

104. *Family budget of labourers, Jagaddal, 1942.* Field work : Indian Statistical Institute ; Coverage : Jagaddal ; Sample-unit : Family; Number of sample-units : 740.

105. *Family budget of textile labourers, Nagpur, 1942.* Field work : Central Provinces Government ; Coverage : Labour area, Nagpur ; Sample-unit : Family ; Number of sample-units : 1,044.

106. *After-effects of Bengal famine, 1943.* Field work : Indian Statistical Institute ; Coverage : 60,000 sq. miles in 41 sub-districts ; Sample-unit : Family ; Number of sample-units : 15,769.

107. *Family budget of labourers, Jagaddal, 1945.* Field work : Indian Statistical Institute ; Coverage : Jagaddal ; Sample-unit : Family ; Number of sample-units : 755.

108. *Diet survey, Calcutta, 1945.* Field work : Indian Statistical Institute ; Coverage : 23 wards of Calcutta Corporation ; Sample-unit : Family ; Number of sample-units : 1,700.

109. *Family budgets of middle class Government employees, 1945-46.* Field work : Indian Statistical Institute and Bengal Government ; Coverage : 4 district towns ; Sample-unit : Family ; Number of sample-units : 1,200.

110. *Family budgets of labour employed by Calcutta Corporation, 1945.* Field work : Indian Statistical Institute ; Sample-unit : Family ; Number of sample-units : 402.

111. *Economics and statistics of road development, 1945-46.* Field work : Indian Statistical Institute. Enquiry divided into two complementary parts—(a) traffic census, (b) economic survey of catchment areas of 7 centres. 1,75,000 vehicles were enumerated. In economic survey three types of schedules were used : (a) village, (b) market, (c) family. Number of schedules collected : (a) 603, (b) 81, (c) 3,738.

112. *Incidence of tea drinking in a number of areas in North and West Bengal, 1946.* Field work : Indian Tea Market Expansion Board ; Sample-unit : Family ; Number of sample-units : 2,520.

113. *Rural indebtedness and economic condition of agricultural labour in Bengal, 1946-47.* Survey conducted in two stages (a) and (b). Field work : Indian Statistical Institute ; Coverage : 59,199 sq. miles ; Sample-unit : Family ; Number of sample-units : (a) 80,710, (b) 16,000.

114. *Sample survey of family budgets and social conditions of working class families, Jagaddal, 1948-49.* Field work : Indian Statistical Institute ; Coverage : Jagaddal ; Sample-unit : Family ; Number of sample-units : 850 (work suspended after completion of field work).

115. *Rangoon sample survey, 1948-50.* Indian Statistical Institute acted as consultants in this economic survey of Rangoon city by the Government of Burma.

†116. *Enquiry into the economic condition of the population Calcutta, 1949-50.* Field work : Indian Statistical Institute ; Coverage : 28 sq. miles (Calcutta Corporation) ; Sampling unit : Municipal holding ; Number of sampling units : 6,000 ; Objective : To bring out the distribution of resident families and possibilities of stratification for planning the main survey. Work was suspended after completion of the field work.

117. *A Survey of newspaper reading habits in Calcutta, May-June 1951.* Field work : Indian Statistical Institute ; Coverage : 28 sq. miles (Calcutta Corporation) ; Sample-unit : Family ; Number of sample-units : 14,000.

†118. *Family budget enquiry at Giridih, June 1952.* Field work : Indian Statistical Institute; Coverage : 11 villages near Giridih; Sample-unit : household ; Number of sample-units : 60 ; Objective : To collect information on quantities of daily consumption of major food items to test whether the length of the reference period (day, week, month) had any effect on the ultimate estimate.

†119. *Refugee survey in West Bengal, December 1952.* Coverage : three typical regions of West Bengal—Midnapore, 24 Parganas and Nadia ; Design : two stage design where first stage units were camps selected with probability proportional to the number of families and second stage units where families selected with equal probability ; Objective : To ascertain the condition of the refugee families residing in Government rehabilitation camps.

120. *Survey of refugee families at Bombay, August-November 1953.* Conducted at the request of the Ministry of Rehabilitation ; Coverage : Government refugee colonies as well as other places in Bombay ; Sample-unit : household ; Number of sample-units : 3,000; Design : the units were drawn in two sub-samples ; Objective : To ascertain the socio-economic condition of refugee families residing in the state of Bombay.

†121. *Urban unemployment survey, September 1953.* Coverage : all towns having population 50,000 and above except the four big cities of Calcutta, Bombay, Madras and Delhi ; Sample-unit : household; Number of sample-units : 4,446; Design : stratified three stage where the first stage units, towns were selected with probability proportional to population with replacement, the second stage units, blocks were selected with probability proportional to number of households and third stage units, households were selected systematically with a random start; Objective : To find out the various types of problems arising in urban unemployment surveys.

122. *Survey of persons in the live-register of Delhi Employment Exchange, September 1953.* Sample-unit : registrant; Number of sample-units : 800; Design : stratified simple random sampling; Objective : To collect relevant data for a study of employment position during the period of survey by household enquiry.

123. *Calcutta employment survey, September-November 1953.* Coverage : municipal area of Calcutta city; Sample-unit : household; Design : stratified two stage; Objective : To collect details about employment characteristics.

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† Pilot studies for improvement of the design of sample surveys.

124. *Survey of saver's preference in Delhi State, August 1954.* Sample-unit : applicant for National Saving Certificate; Number of sample-units : 496; Design : stratified systematic; Objective : To study the preferences of purchasers of National Saving Certificates in Delhi State.

†125. *Employment and unemployment survey : Baranagar pilot enquiry, December 1954.* Coverage : Baranagar in the immediate vicinity of Indian Statistical Institute's headquarters; Objective : To collect basic information for the preparation of an efficient sampling design for a detailed All-India Survey of Employment and Unemployment.

126. *Chittaranjan enquiry, January-March 1955.* Sample-unit : household; Number of sample-units : 780; Design : stratified simple random sampling without replacement; the sample was divided into six independent interpenetrating sub-samples; Objective : To study the characteristics of the economic development in the newly developed industrial towns.

127. *Indian Statistical Institute Workers' Household Survey, December 1955–January 1956.* Conducted by Indian Statistical Institute Club at the request of the Planning Section of the Institute; Sample-unit : household; Number of sample-units: 821 ; Objective : To study the living conditions of Indian Statistical Institute workers' households and their consumer preferences.

†128. *Survey of housing conditions in Calcutta, February 1956.* Coverage : 14 blocks of Calcutta; Sample-unit: household; Objective: To collect information on housing conditions and consumer expenditure on some selected items with particular reference to their source of supply. This survey was conducted to give field training to the second year trainees of Research and Training School and the trainees of the International Statistical Education Centre.

†129. *Pilot Agricultural Labour Enquiry, April 1956.* Field work : Indian Statistical Institute in West Bengal and NSS Directorate in the rest of India: Coverage : 24 selected villages all over India: Objective: To test out schedules to be used in the Agricultural Labour Enquiry to be conducted during the eleventh and twelfth rounds of NSS.

†130. *Occupation survey in West Bengal.* Field work : Indian Statistical Institute; Coverage : 30 villages in Hooghly district in West Bengal; Objective : To have an idea of the nature and variety of occupation in the rural areas, the extent of self-employment in such occupational activities and testing the efficiency of the probability of selection proportional to non-agricultural population.

†131. *Studies on the variability (regional and overtime) in the rate of consumption for certain selected items with varying lengths of refrence periods, October-November 1956.* A small experiment was carried out at Giridih and at Sainthia (Bengal).

†132. *Studies on the cost of enumeration for different blocks,* i.e., *item groups in a consumption schedule, September 1956-November 1957.* A small experiment was carried out at Calcutta and at Sainthia (Bengal).

†133. *Public preferences and opinions on certain topics of general interest, October-November 1956.* Number of households surveyed : 400; Objective : To study the effect of the choice of a particular informant on the final estimates.

134. *Survey of Faridabad Township, March-April 1954.* Field work : NSS Directorate ; Coverage : Faridabad town in Gurgaon district of the Punjab ; Sampling unit : household; Design : stratified random sampling; Number of sample-units : 500; Objective : To collect information on (a) population of Faridabad (separately in households registered for rehabilitation in the township and households not so registered), (b) sources of livelihood of the population, (c) nature and extent of unemployment and (d) level of living of the population.

†135. Change in the pattern of living between April-September 1952 and January-March 1957. 410 sample households in Calcutta, which were interviewed in an earlier survey (April-September 1952), were revisited and a short schedule on the consumption of food and clothing was collected in February 1957.

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† Pilot studies for improvement of the design of sample survey.

Multipurpose National Sample Survey

136. *First round, October 1950–March 1951.* Field work : Government of India in collaboration with (a) Indian Statistical Institute and (b) Gokhale Institute of Politics and Economics; Coverage : Union of India (rural only) excluding Jammu and Kashmir; Sampling unit : household for socio-economic and cluster of five plots for land utilisation survey; Design : stratified two stage; Number of strata : 256; Number of sample villages ; 1,833; Number of sample households : 25,494; Number of clusters : 36,660; Objective ; Socioeconomic surveys and land utilisation survey.

137. *Second round, April-June 1951.* Field work : Government of India in collaboration with the Indian Statistical Institute; Coverage : rural India excluding some parts of Assam and Bombay, Jammu and Kashmir, Andaman and Nicobar Islands; Sample-unit : household; Design : same as in first round; Number of strata : 240; Number of sample villages : 1,160; Number of sample households : 10,947; Objective : Socio-economic surveys; village statistics were also collected.

138. *Third round, August-November 1951.* Field work and sample unit : same as in second round; Coverage : entire geographical area of India excluding Jammu and Kashmir, Andaman and Nicobar islands and some parts of Assam; Sample-unit : household; Design: same as in second round for rural and stratified three-stage design for urban; Number of strata : 254 (rural) and 7 (urban); Number of sample villages : 920; Number of towns and cities : 53; Number of blocks : 490; Number of households : 10,214 (rural), 3,378 (urban); Objective : Socio-economic survey.

139. *Fourth round, April-September 1952.* Field work, coverage, sample-unit : same as in third round; Design : stratified three-stage design (rural), for socio-economic and land utilisation surveys and same as in third round for urban; Sample-unit for land utilisation survey : cluster of 5 plots; Number of strata : 240 (rural), 7 (urban); Number of sample tehsils : 480 (rural), number of towns and cities : 53; Number of sample villages : 960; Number of sample blocks : 406; Number of sample households : 25,722 (rural), 11,713 (urban); Number of clusters : 7,680; Objective : Same as in third round; land utilisation survey was also conducted.

140. *Fifth round, December 1952–March 1953.* Field work, coverage, sample-units and design are same as in fourth round; number of first and second stage sample units: same as in fourth round; Number of sample households : 12,878 (rural), 59,42 (urban); Number of clusters : 7,680 for land utilisation; Objective : Same as in fourth round except that village statistics data were collected in this round on weekly wholesale and retail prices on selected weekdays in the villages and on manufacturing establishments owned by non-household entities excluding government agencies.

141. *Sixth round, May-September 1953.* Field work, coverage, sample-units and design same as in fifth round, except that the scheme of stratification was changed for the urban survey; Number of sample tehsils : 480; Number of sample towns and cities : 57 ; Number of sample villages : 960; Number of sample blocks : 444; Number of households : 18,300 (rural), 5,134 (urban); Number of clusters : 7,680. Objective : socio-economic and land utilisation survey; data were collected in this round relating to village statistics as well as opinion of newspaper readers in regard to the newspapers read.

142. *Seventh round, October 1953–March 1954.* Field work, coverage, sample units and design same as in sixth round; Number of sample tehsils: 480; Number of sample towns and cities : 57; Number of sample villages : 960; Number of sample blocks : 444; Number of sample households : 28,817 (rural), 12,144 (urban); Number of clusters : 7,680; Objective : socio-economic and land utilisation surveys; opinion on changes in outturn of rice in villages from 1952-53 to 1953-54 were also collected.

143. *Eighth round, July 1954–March 1955.* Field work : NSS Directorate in collaboration with the Indian Statistical Institute. All the States participated in the field work for land holding survey; Coverage : Indian Union excluding Andaman and Nicobar islands; Sampling units : same as in seventh round; Design : stratified two stage for rural and urban; Number of strata : 356 (rural), 8 (urban); Number of sample villages : 1,424

(central) and 2,992 (states); Number of sample blocks : 468; Number of sample households : 54,163 (rural, central sample), 79,187 (rural, states) and 15,711 (urban); Number of clusters: 11,392 (central): Objective : socio-economic and land utilisation surveys with special emphasis on land-holdings .

144. *Ninth round, May-September 1955.* Field work : NSS Directorate in collaboration with the Indian Statistical Institute and the States of Bombay, Uttar Pradesh and Travancore-Cochin; Coverage : same as in eighth round; Design : same as in eighth round except that the scheme of stratification was different; Sampling units : same as in eighth round; Number of strata : 266 (rural), 94 (urban) ; Number of sample villages : 1,624 (central); 308 (states); Number of sample blocks : 2,108 (central), 512 (states) ; Number of sample households : 25,364 (central, rural), 47,897 (central, urban) : Number of clusters : 6,496 (central). Objective : socio-economic and land utilisation surveys with special emphasis on the employment and unemployment situation.

145. *Tenth round, December 1955–May 1956.* Field work, coverage, sample-unit and design for urban and rural socio-economic survey same as in ninth round, design for crop survey, stratified two-stage for land-utilisation, and stratified three-stage for yield survey; Sample units : Cluster of plots (for land utilisation), circular cuts of radius 2′-3″ and 4′ (for yield survey); Number of strata : 266 (rural, socio-economic survey), 308 (land utilisation survey) and 96 (urban) ; Number of sample villages : 1,624 (central sample, socio-economic survey), 448 (state sample, socio-economic survey), 3,260 (central sample, crop survey), 1,000 (state sample, crop survey) ; Number of sample blocks : 1,328 (central sample), 364 (state sample) ; Number of households : 20,158 (central sample, rural), 19,913 (central sample, urban) ; Objective : socio-economic and crop surveys. The land utilisation survey was carried out in the socio-economic survey sample villages (central) also.

146. *Eleventh round, August 1956–January 1957.* Field work, coverage and sample units : same as in tenth round; Design : same as in the tenth round except that the principle of allocation of sample units to the strata for crop survey was different and scheme of stratification for socio-economic survey in rural areas was also changed; Number of strata : 72 (rural, socio-economic survey), 94 (urban), 128 (crop survey); Number of sample villages : 1,848 (central sample, socio-economic survey), 6,96 (states sample, socio-economic survey), 6,336 (central sample, crop sruvey), 1,872 (state sample, crop survey); Number of sample blocks : 584 (central sample, urban), 188 (state sample, urban); Number of sample households per village : 18; Number of sample households per block : 18.

147. *Twelfth Round; March–August 1957.* Field work : NSS Directorate in collaboration with the Indian Statistical Institute and the states of Bihar, U.P., Bombay, Mysore and Kerala. Coverage, Objective, Design and sample size for the round were the same as for the eleventh round.

148. *Thirteenth round, September 1957-May 1958.* Field Work : NSS Directorate in collaboration with the Indian Statistical Institute and the states U.P., Bihar, Kerala, Bombay*. The duration increased to eight months against 6th month in the 11th round. Coverage : The survey will be carried out in the whole of the rural and urban India excluding the Andaman and Nicobar islands and North-East Frontier Agency, Naga Hills United Mikir and North Cachar Hills in Assam. Objective : Socio-economic survey and crop-area and yield survey. Special stress given on the collection of food statistics. Design and Sampling Unit : The design and the sampling unit broadly the same as in the previous two rounds. For socio-economic surveys the villages and blocks selected are the same as those selected in 11th and 12th rounds and for one set of village even the households are the same as selected previously. For the other set of villages and the blocks the design is made self-weighting. For land utilisation surveys, systematic sampling of clusters replaced the previous selection with probability proportional to area with replacement. No. of sample villages : (1) Central Sample (a) *Scheme I—2072, (b) Scheme II & III—3390; (2) States Sample (a) Scheme I—1196, (b) Scheme II & III—1646. No. of sample blocks: (1) Central sample—1224, (2) States sample—580.

*Scheme I—Socio-economic Survey

*Scheme II & III—Crop-area and yield survey.

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* After the survey started the following states have agreed to participate in the survey : Andhra, Madhya Pradesh, Punjab, Orissa, Assam and Mysore.

The contral sample size for Jammu and Kashmir was also increased.

Sample Surveys of Manufacturing Industries (NSS)

(Coverage : Factories registered under Factories Act 1948)§

149. *Sample survey of manufacturing industries, 1950.* Pilot survey with reference period : 1949 and 1950. Field work : Government of India; Analysis of data : Indian Statistical Institute; Sample-unit : Factory employing 20 or more persons and using power; Number of sample-units : 1,800; Design : from a total of 17,000 factories, a stratified random sample of 1,800 factories was drawn; Objective : the survey was designed to collect data regarding the contribution to the national income from manufacturing industries.

150. *S.S.M.I., First round, September 1952–July 1953.* Reference year : 1951. Field work : NSS Directorate; Coverage : 28,206 in India excluding Jammu and Kashmir; Sample-unit : factory; Number of strata : 1,073; Number of sampling units : 2,988; Design : stratified, simple random sampling without replacement. Objective : same as in the 1949-50 survey.

151. *S.S.M.I., Second round, June 1953–May 1954.* Reference periods : (a) 1952 and (b) April 1952—March 1953. Field work, sampling unit, design and objective same as in the first round; Coverage : 29,175 factories of India excluding Jammu and Kashmir; Number of strata : 1,096; Number of sampling units : 3,143.

152. *S.S.M.I., Third round, April 1954–March 1955.* Reference year : 1953. Field work, sampling unit, design and objective same as in the second round ; Coverage : 29,931 factories of India including Jammu and Kashmir ; Number of strata : 1,279; Number of sampling units : 3,536.

153. *S.S.M.I., Fourth round, September 1955–November 1956.* Reference year : 1954. Field work, sampling unit, design and objective same as in the third round ; Coverage : 32,757 factories in India including Jammu and Kashmir; Number of strata : 1,410 ; Number of sampling units : 3,788.

154. *S.S.M.I., Fifth round, June 1956.* Reference year : 1955. Field work, sampling unit, design and objective same as in the fourth round except that all factories employing more than 250 workers were completely enumerated ; Coverage : 32,756 factories in India including Jammu and Kashmir; Number of strata : 1,109; Number of sampling units : 4,058.

155. *S.S.M.I., Sixth round, September 1957.* Reference year 1956 : Commencement of field work : September 1957. Objectives, scope and design : Some as in previous rounds. For the first time all the factories having scheduled industry undertakings have been completely enumerated. Coverage : (Approx.) 35,000 factories in India including Jammu & Kashmir. Sampling units : 6010, four sub-samples per stratum instead of two as in previous surveys introduced for the first round. Strata : 624.

156. *Census of Coal Mining undertakings :* Commencement of field work : September 1957. Objectives, scope and design : Same as in S.S.M.I. surveys. Coverage : All coal mines registered as undertakings under the Schedule A to the Industries (Development & Regulation) Act, 1951. Samples selected : 370.

Demographic surveys

157. *All India Population Statistics, 1941.* Mechanical tabulation contained in 1941 census slips preserved on a two-percent basis was completed. Construction of age-tables, occupation tables, means of livelihood and industries tables and studies on fertility data and sampling methods in population census were undertaken. Total number of tabulated cards : 5,341 millions.

158. *Survey of refugee population in West Bengal 1948.* Field Work : Indian Statistical Institute. Coverage : 29,000 sq. miles; Sample-unit : family; Number of sample-units : 17,436.

§ 2m(i) factories employing 10 or more workers on any working day during the year and using power; and 2m(ii) factories employing 20 or more workers on any workng day during the year but not using power.

159. *Survey of refugee population in Delhi, September–October 1947.* A rough estimate of refugee population was submitted to the Government of India after a pilot survey. A scheme for a detailed sample survey was also submitted.

†160. *Calcutta health survey, 1952–1953.* A pilot survey was conducted in ward No. 23 in South Calcutta to collect basic information regarding the incidence of disease, types of treatment availed of, the cost of medical consultation and medicine, during a period of twelve months.

161. *Pilot health survey—West Bengal 1955.* This survey was conducted chiefly for the purpose of trying out suitable methods of collecting morbidity and medical care statistics. The validity of morbidity statistics collected by medical and non-medical investigators were assessed by a special survey based on a comparison of the diagnostic results entered in the hospital register with the results obtained by household canvass of the patients. Other points regarding validity are also discussed in the report of this survey which has been submitted for publication in *Sankhyā*.

162. *Survey on attitude towards family planning, 1956.* A pilot investigation in the city of Calcutta and 2 adjoining villages was conducted to study the correlation between the attitudes of married women towards family limitation, level of income, occupation, educational status etc.

163. *Pilot survey on Social mobility and differential fertility—West Bengal 1956.* This survey was conducted for the purpose of assessing social mobility and its demographic consequences. Also differential fertility with respect to a number of socio-economic factors has been studied.

164. *An enquiry into prevalence of contraception and its demographic consequences—Calcutta City 1956–1957.* This survey was conducted to assess the prevailing contraceptive practices among different socio-economic groups of Calcutta city populations and their relation to certain cultural aspects of the couples surveyed. Both male and female partners of 1000 couples in reproductive ages have been investigated separately by male and female investigators respectively.

Miscellaneous surveys

165. *Blood pressure survey 1936.* Statistical study of blood pressure of 2,800 persons in relation to their age, height, weight, marital status, etc.

166. *Anthropometric survey in United Provinces, 1941.* Field work : Under supervision of Dr. D. N. Mazumdar of Lucknow University. Study on 14 anthropometric characters of 24 castes. Number of persons measured : 2,997.

167. *Anthropometric survey in Bengal, 1944.* Field work : Indian Statistical Institute. Study of important anthropometric characters and blood groups of 3,000 individuals.

168. *Rupee census, 1940-41.* A survey to devise methods for estimating the amount of rupee coins of various dates in circulation in India.

169. *Average life of rupee notes, 1940-41.* A study to devise methods for estimating average life of rupee notes.

170. *Traffic survey on Howrah bridge, 1946.* Field work : Indian Statistical Institute ; Coverage : Howrah bridge and its road approaches to and from Calcutta. Planned to study movement of wheeled and pedestrian traffic and to ascertain origin and destination of vehicles without interrupting movement.

171. *Enumeration of postal traffic, 1946.* Survey was conducted to estimate total volume of unregistered articles passing through post offices in Calcutta areas for 3 months. 300 sample mail bags were counted. Three-way sampling procedure with respect to (a) days of count, (b) post offices and (c) mail bags, was used.

172. *Enumeration of postal traffic, 1947.* Survey was conducted to study effects of better supervision in enumeration of postal articles. It was conducted in 4 batches of 100 post offices selected at random.

† Pilot studies for the improvement of the design of sample surveys.

173. *Spot check of patwari records, 1950.* Records relating to areas under different crops as maintained by the patwaris (village revenue officials) were checked by plot to plot enquiry with a view to testing the accuracy of the records. Investigations were carried out during March-April 1950 in the States of (i) Uttar Pradesh, (ii) Vindhya Pradesh, (iii) Punjab (I) and (iv) PEPSU.

174. *Blood group survey, 1950-51.* Blood group data of 12,819 of Indian army personnel (collected during the second world war) were analysed with a view to finding out whether and what relationships exist between blood groups and caste, religion or area of origin.

175. *Spot check of patwari records, 1951.* Investigations with the same object as in No. 165 were carried out during March-April 1951 in the States of (i) Bihar, (ii) Uttar Pradesh, (iii) Punjab (I), (iv) Madhya Pradesh and (v) PEPSU.

176. *An opinion survey on the efficacy of antimalarial drugs, October 1952.* Type of enquiry : mail survey; Coverage : all registered medical practitioners in India; Sample-unit : medical practitioner; Design : stratified simple random sampling using the list of registered medical practitioners published by the Government of India; Objective : assessment of preferences in the use of antimalarial drugs; a sub-sample of the non-respondents residing in greater Calcutta was surveyed by the interview method.

†177. *Pilot survey of agricultural holdings, 1952-53.* This survey was conducted to collect basic data in various parts of the country for assessing the variability and cost of the survey, and deciding on a suitable sampling design for conducting a countrywide survey of agricultural holdings.

178. *A study on the standardisation of ready-made garments, 1953.* This survey was conducted at the request of the Directorate General of Postal Services—for advice in designing garments for their inferior staff. Measurements for garments were taken on 130 workers of the Indian Statistical Institute and 3,000 individuals of the postal staff.

179. *Survey of bullock utilisation at Giridih from 1953.* Field work : Indian Statistical Institute; Objective : to study the nature and extent of utilisation of bullock labour in the rural areas near Giridih and the seasonal pattern of 'idle bullock-hours'.

†180. *Pilot survey of cow-dung production and utilisation, February 1956.* This survey was conducted at the request of the Ministry of Food and Agriculture of the Government of India to explore the possibilities of conducting a large scale survey for estimating the quantity of cow-dung production in the country and its utilisation for manurial purposes. This survey was carried out in three villages of 24 Parganas; Sample-unit : household.

†181. *Pilot survey of cattle census, 1956.* This survey was conducted in two villages to study the responses to the different questions regarding number and utilisation of cattle.

182. *Sample verification of All-India livestock census, May-June 1956.* Field work : NSS Directorate in collaboration with Indian Statistical Institute; Coverage : Indian Union excluding Andaman and Nicobar islands; Sample-unit : household ; Design : same as in 7th and 10th rounds of NSS; Number of sample villages : 2,104 (1,624 of 10th round, NSS and 480 of 7th round, NSS); Number of sample blocks : 340 (of 10th round, NSS); Number of households : 42,080 (rural), 6,800 (urban); Objective : to verify information collected on livestock numbers in the Eighth All-India Livestock Census.

†183. *Survey to study response error, 1956.* Field work : Indian Statistical Institute; Coverage : two villages in West Bengal, one in Hooghly district and the other in 24 Parganas district; Objective to have an idea of the response error so that means might be devised to control it.

†184. Accuracy in the listing of households using different enumeration procedures. Birbhum, March–May 1957; Giridih, July–October 1957, November–December 1957.

†185. Enquiry on the sale of patent medicines (Allopathic) in different localities of Calcutta, April–June 1957.

† *Pilot studies for the improvement of the design of the sample survey.*

Appendix D

LIST OF PAPERS PUBLISHED AND REPORTS SUBMITTED BY THE WORKERS OF THE INDIAN STATISTICAL INSTITUTE, CALCUTTA

1922

22.01 MAHALANOBIS, P. C. : Statistical Analysis of Anglo-Indian Stature. *Rec. Ind. Museum*, 23, 1. 1

1923

23.01 MAHALANOBIS, P. C. : On the seat of activity in the upper air. *Memoirs Ind. Met. Dept.*, 24, 1, 2

23.02 ——— : On errors of observation and upper air relationship. *Memoirs Ind. Met. Dept.*, 24, 10. 3

23.03 ——— : Correlation of upper air variables. *Nature.* 4

23.04 ——— : On the significant character of local variations in the proportion of dextral and sinistral shells in samples of Bul. Dextro-Sinister from the salt range, Punjab. *Rec. Ind. Museum*, 25. 5

1924

24.01 SINHA, H. C. : Seasonal fluctuations in the Indian Bank Rate and the remedy. With a plate. *Banker's Magazine.* 6

1925

25.01 MAHALANOBIS, P. C. : Analysis of race-mixture in Bengal. Presidential address, Anthropological Section, Indian Science Congress. *Jour. Asiat. Soc. Bengal*, 23(3), 301. 7

25.02 ——— : Probable error of field experiments in agriculture. *Agri. Jour. Ind.*, 20, 96. 8

1926

26.01 MAHALANOBIS, P. C. : A note on seasonal variations in the incidence of diarrhoea, dysentery and appendicitis in Calcutta. *Cal. Med. Jour.* 9

1927

27.01 MAHALANOBIS, P. C. : Report on rainfall and floods in North Bengal during the period 1870–1922. In 2 volumes with 29 tables and 28 maps (submitted to the Government of Bengal). 10

1928

28.01 MAHALANOBIS, P. C. : A statistical study of the Chinese head. *Man in India*, 8, 107. 11

28.02 ——— : On the need for standardization in measurements on the living. *Biometrika*, 20, 1. 12

28.03 SINHA, H. C. : Indian purchases of British cotton goods. *Capital.* 13

1929

29.01–29.04 SINHA, H. C. : Marketing of jute in Bengal, Parts I–IV. *Capital.* 14

1930

30.01 MAHALANOBIS, P. C.: Tests and measures of divergence. *Jour. Asiat. Soc. Bengal*, 26, 541. 15

30.02 ———: A statistical study of Swedish anthropometric data. *Biometrika*, 22, 94. 16

30.03–30.04 SINHA, H. C.: Financial notes, Parts I and II. *Modern Review*. 17

30.05 ———: British trade with India. *Capital*. 18

30.06 ———: Cooperation in Bengal. *Visva-Bharati Quarterly*. 19

1931

31.01 MAHALANOBIS, P. C.: Statistical analysis of Anglo-Indian head length. *Rec. Ind. Museum*, 23, 97. 20

31.02 ———: A statistical study of the level of the rivers of Orissa and the rainfall in the catchment areas during the period 1868–1928 (submitted to the Government of Bihar and Orissa). 21

31.03 ——— assisted by CHAKRAVARTI, N.: A statistical report on river floods in Orissa during the period 1868–1928. In 20 chapters with 47 tables and 27 maps. (submitted to the Government of Bihar and Orissa). 22

1932

32.01 MAHALANOBIS, P. C.: A note on the comparison of means based on small samples. *Ind. Jour. Agri. Sc.*, 2, 28. 23

32.02 ———: A statistical note on certain rice breeding experiments in the Central Province. *Ind. Jour. Agri. Sc.*, 2, 157. 24

32.03 ———: Auxiliary tables for Fisher's Z-test for use in the analysis of variance. *Ind. Jour. Agri. Sc.*, 2, 679. 25

32.04 ———: Rice and potato experiments at Sriniketan. *Ind. Jour. Agri. Sc.*, 2, 694. 26

32.05 ——— and BOSE, S. S.: On the variation of the percentage infection of Wilt disease in the cotton plant in Surat. *Ind. Jour. Agri. Sc.*, 2, 704. 27

32.06–32.08 SINHA, H. C. and GUHA THAKURTHA, J. R.: Indian imports (1929–31), Parts I, II and III. *Capital*. 28

32.09 SINHA, H. C.: Variance of Imperial Bank advances. *Ind. Jour. Econ. (Conference Number)*. 29

1933

33.01 GUHA THAKURTHA, J. R.: A short list of Indian official trade returns (1931). *Sankhyā*, 1, 106. 30

33.02 MAHALANOBIS, P. C.: Studies in educational tests, No. 1. The reliability of a group test of intelligence in Bengali. With five figures. *Sankhyā*, 1, 25. 31

33.03 ———: A revision of Risley's anthropometric data relating to the tribes and castes of Bengal. *Sankhyā*, 1, 76. 32

33.04 ———: Tables for the application of L-tests. *Sankhyā*, 1, 109. 33

33.05 ———: Effects of fertilizers on the variability of the yield and rate of shedding of buds and flowers and bolls in cotton plant in Surat. *Ind. Jour. Agri. Sc.*, 3, 131. 34

33.06 ———: A note on field technique. (*Government of Bombay, Department of Agriculture*). 35

33.07 ———: On the use of method of paired differences in estimating the significance of field trials. *Ind. Jour. Agri. Sc.*, 3, 349. 36

33.08 ———: The randomization of plots in field trials. *Ind. Jour. Agri. Sc.*, 3, 549. 37

33.09 ———: The use of random sampling numbers in agricultural experiments. *Ind. Jour. Agri. Sc.*, 3, 1108. 38

33.10 MAHALANOBIS, P. C. and BOSE S. S. : Effect of the time of application of fertilizers on the yield and the rate of shedding of buds, flowers and bolls in the cotton plant in Surat. *Ind. Jour. Agri. Sc.*, 3, 139. 39

33.11 ——— : and BOSE, S. S. : Effect of different doses of Nitrogen on the rate of shedding of buds, flowers and bolls in the cotton plant in Surat. *Ind. Jour. Agri. Sc.*, 3, 147. 40

33.12 ——— : Certain varietal studies on the cotton plant. *Ind. Jour. Agri. Sci.*, 3, 339. 41

33.13 ——— : Analysis of manurial experiments on wheat conducted in Sakrand, Sind. *Ind. Jour. Agri. Sci.*, 3, 345. 42

33.14 ——— : Analysis of varietal tests with wheat conducted at Sakrand, Sind, 1931-32. *Ind. Jour. Agri. Sci.*, 3, 544. 43

33.15 SEN, S. N. and SINHA, H. C. : Indian prices during the depression. With seven figures. *Sankhyā*, 1, 5. 44

33.16 SINHA, H. C. : Gold exports. *Capital.* 45

1934

34.01 BOSE, R. C. : On the application of hyperspace geometry to the theory of multiple correlation. *Sankhyā*, 1, 338. 46

34.02 BOSE, S. S. : Tables for testing the significance of linear regression in the case of time-series and other single-valued samples. *Sankhyā*, 1, 277. 47

34.03 ——— : A note on the mathematical expectation of the variance of the regression coefficient. *Sankhyā*, 1, 432. 48

34.04 CHAKRAVARTI, K. N. : Age-distribution in secondary schools in the United Provinces. *Sankhyā* 1, 343. 49

34.05 DAS, K. N. and MAHALANOBIS, P. C. assisted by NAG, A. C. : A preliminary note on the rates of maternal deaths and still-births in Calcutta. With ten figures. *Sankhyā*, 1, 215. 50

34.06 GUHA THAKURTHA, J. R. : A note on cotton prices in India in relation to the supply factor With two figures. *Sankhyā*, 1, 186. 51

34.07 ——— : A short list of current Indian official statistical publications relating to agriculture : *Sankhyā*, 1, 329. 52

34.08 ——— : A short list of Indian official publications relating to price statistics. *Sankhyā*, 1, 440. 53

34.09 MAHALANOBIS, P. C. : Studies in educational tests, No. 2. The age variation of scores in a group test of intelligence in Bengali. With eight figures. *Sankhyā*, 1, 231. 54

34.10 ——— : A revision of Risley's anthropometric data relating to the Chittagong hill tribes. *Sankhyā*, 1, 267. 55

34.11 ——— : Rotation experiments with cotton, groundnut and juar in Berar, 1923-31. *Ind. Jour. Agri. Sc.*, 4, 361. 56

34.12 ——— : Studies in educational tests, No. 4. A preliminary study of the intelligence quotient of Bengali School children. With ten figures. *Sankhyā*, 1, 407. 57

34.13 ——— : and BOSE, S. S. : A statistical note on the effect of pests on the yield of sugarcane and the quality of cane juice. *Sankhyā*, 1, 399. 58

34.14 ——— with the cooperation of BOSE, S. S., RAY, P. R. and BANERJEE, S. K. : Tables for random samples from a normal population. *Sankhyā*, 1, 289. 59

34.15 ——— and CHAKRAVARTI, K. N. : Studies in educational tests, No. 3. Analysis of marks in the school-leaving certificate examination in the United Provinces, India. 1919. With ten figures. *Sankhyā*, 1, 245. 60

34.16 SEN, S. N. : An estimate of the rural indebtedness of Bengal. *Sankhyā*, 1, 335. 61

34.17 SINHA, A. R. The statistical law of demand for wheat in the United Provinces. With two figures. *Sankhyā*, 1, 166. 62

34.18 ——— and SINHA H. C. and GUHA THAKURTHA, J. R. : Studies in Agricultural prices in India—No. 1. Indian cultivator's response to prices. With four figures. *Sankhyā*, 1, 155. 63

34.19 SINHA, H. C. : Indian agricultural statistics. *Jour. Roy. Stat. Soc.*, 97, 155. 64

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35.01 Bose, R. C. : On the exact distribution and moment coefficients of the D^2-statistic. *Science and Culture*, 1, 205. 65

35.02 ——— and Roy, S. N. : On the evaluation the probability integral of the D^2-statistic. *Science and Culture*, 1, 436. 66

35.03 Bose, S. S. : On the distribution of the ratio of two samples drawn at random from two uncorrelated population of type III. *Science and Culture*, 1, 365. 67

35.04 ——— : On the distribution of the ratio of variances of two samples drawn from a given normal bivariate correlated population. *Sankhyā*, 2, 65. 68

35.05 ——— and Mahalanobis, P. C. : On estimating individual yields in the case of mixed-up yields of two or more plots in agricultural field experiments. *Science and Culture*, 1, 205. 69

35.06 Harrison, C. J., Bose, S. S. and Mahalanobis, P. C. : The effect of manurial dressings, weather conditions and manufacturing processes on the quality of tea at Tocklai experimental station, Assam. *Sankhyā*, 2, 33. 70

35.07 Mahalanobis, P. C. : Study of consumer preference in Calcutta. (submitted to D. J. Keymer & Co.) 71

35.08 Sinha, A. R. : Elasticity of demand for wheat in India. *Sankhyā*, 2, 55. 72

35.09 Sinha, H. C. : Is India over-populated ? *Modern Review*. 73

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36.01 Banerjee, K. C., Bose, S. S. and Mahalanobis, P. C.: Studies in tiller variations, *Ind. Jour. Agri. Sc.*, 6, 1122. 74

36.02 Banerjee, S. K.: The one-tenth percent level of the ratio of variances. *Sankhyā*, 2, 425. 75

36.03 Bose, R. C.: A note on the distribution of differences in mean values of two samples drawn from two multivariate normally distributed populations and the definition of the D^2-statistics. *Sankhyā*, 2, 379. 76

36.04 Bose, S. P.: Marketing of rice at Bolpur. *Sankhyā*, 2, 105. 77

36.05 Bose, S. S., Sengupta, S. C. and Mahalanobis, P. C.: Statistical analysis of a manurial experiment on Napier grass by the method of covariance. *Agri. Livestock in India*, 183. 78

36.06 ———, Ganguly, P. M. and Mahalanobis, P. C.: Frequency distribution of plot yields and optimum size of plots in a uniformity trial with rice in Assam. *Ind. Jour. Agri. Sci.*, 6, 1107. 79

36.07 ———, Chakravarti, S. C. and Mahalanobis, P. C.: The effect of different methods of harvest on the estimated error of field experiments. *Agri. Livestock in India*, 814. 80

36.08 ———, Chakravarti, S. C. and Mahalanobis, P. C.: A complex experiment on rice at the Chinsurah farm, Bengal, 1933-34. *Ind. Jour. Agri. Sci.*, 6, 34. 81

36.09 Kulkarni, R. K., Bose, S. S. and Mahalanobis, P. C. : On the influence of shape and size of plots on the effective precision of field experiments with juar. *Ind. Jour. Agri. Sc.*, 6, 460. 82

36.10 Mahalanobis, P. C. : A new theory of ancient Indian chronology, *Sankhyā*, 2, 309. 83

36.11 ——— Note on cotton prices in relation to quality and yields. *Sankhyā*, 2, 135. 84

36.12 ——— : Editorial note on the margin of error in the calculation of the cost of cultivation and profit. *Sankhyā*, 2, 121. 85

36.13 ——— : Karl Pearson, 1857–1936. *Sankhyā*, 2, 362. 86

36.14 ——— :. A note on the statistical and biometric writings of Karl Pearson (with selected references). *Sankhyā*, 2, 411. 87

36.15 ——— assisted by Roy, S. : School marks and intelligent test scores. *Sankhyā*, 2, 397. 88

36.16 MAHALANOBIS, P. C. : On the generalised distance in statistics. *Proc. Nat. Inst. Sciences*, 2, 49. 89

36.17 SAKSENA, S. P. Cost of living index for industrial labour at Cawnpur, 1914–1935. *Sankhyā*, 2, 429. 90

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37.01 BOSE, R. C. : On the distribution of the means of a certain Bessel function population. *Science and Culture*, 3, 335. 91

37.02 ——— and ROY, S. N. : On the distribution of Fisher's taxonomic coefficient and 'Studentized' D^2-statistics. *Science and Culture*, 3 335. 92

37.03 BOSE, S. P. : Survey of rural indebtedness in South-west Birbhum, Bengal in 1933-34. *Sankhyā*, 3, 143. 93

37.04 BOSE, S. S. and MENON, T. V. G. : A statistical study of the deterioration of yields of the permanent manurials, Pusa. *Ind. Jour. Agri. Sc.*, 7, 205. 94

37.05 CHAKRAVARTI, N. C. : Preliminary report of the survey of handloom weaving industry in Bengal. (submitted to the Government of Bengal). 95

37.06 MAHALANOBIS P. C. : On the accuracy of profile measurements with a photographic profiloscope. *Sankhyā*, 3, 65. 96

37.07 ——— The need of a sample survey of the growth of population in India, *Sankhyā*, 3, 58. 97

37.08 MAHALANOBIS, P. C. : Statistical note on the Hooghly-Howrah flushing and irrigation scheme. (submitted to the Government of Bengal, Irrigation Department). 98

37.09 ———, BOSE, R. C. and ROY, S. N. : Normalization of variates and the use of rectangular co-ordinates in the theory of sampling distributions *Sankhyā*, 3, 1. 99

37.10 MENON, T. V. G. and BOSE, S. S. : A statistical study of the yield of the permanent manurials, Pusa. *Ind. Jour. Agri. Sc.*, 7, 193. 100

37.11 NAIR, K. R. : A note on the exact distribution of λ_n. *Sankhyā*, 3, 171. 101

37.12 ——— : A note on the distribution of the mean of Fisher's '*t*'. *Current Science*, 6, 290. 102

37.13 SINHA, H. C. : Should the rupee be devalued ? *Ind. Jour. Econ.* 103

37.14 SINHA, H. C. and SINHA, J. C. : The ratio question. *Sankhyā*, 3, 125. 104

1938

38.01 ACHARYA, D. P. and MAHALANOBIS, P. C. : A note on the correlation between results in the college and university examinations. *Sankhyā*, 3,239. 105

38.02 BOSE, R. C. : On the distribution of the means of samples drawn from a Bessel function population. *Sankhyā*, 3, 262. 106

38.03 ——— : On the application of the properties of Galois fields to the problem of construction of hyper-graeco-latin squares. *Sankhyā*, 3, 323. 107

38.04 ——— and ROY, S. N. : The Distribution of studentized D^2-statistics. *Sankhyā*, 4, 19. 108

38.05 BOSE, S. S. : On a Bessel function population. *Sankhyā*, 3, 253. 109

38.06 ——— : Relative efficiencies of regression coefficients estimated by the method of finite differences. *Sankhyā*, 3, 339. 110

38.07 ——— and MAHALANOBIS, P. C. : On the exact test of association between the occurrence of thunderstorms and an abnormal ionisation. *Sankhyā*, 3, 249. 111

38.08 ——— : On estimating individual yields in the case of mixed-up yields of two or more plots in field experiment. *Sankhyā*, 4, 103. 112

38.09 DATTA, B. N. and MAHALANOBIS P. C. : A note on the foot and stature correlation of certain Bengali castes and tribes. *Sankhyā*, 3, 245. 113

38.10 DATTA, H. K. and SINHA, H. : Indian foreign trade (1933–37) : Its relation to exchange rate. *Sankhyā*, 3, 405. 114

38.11 MAHALANOBIS, P. C. : A note on the influence of lunar phase on the rainfall in the month of July in Calcutta, 1878–1924. *Sankhyā*, 3, 233. 115

38.12 ——— : A review of the application of the statistical theory to agricultural field experiments in India. (Proceedings of the Second Meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry, Lahore, 6th December 1937, Government of India). 116

38.13 ——— : A note on grid sampling. *Science and Culture*, 4, 30(. 117

38.14 ——— : Statistical report on the experimental crop census, 1937 (Indian Central Jute Committee, 1938). 118

38.15 NAIR, K. R. The distribution of Krishna Iyer's 'Mean of Fisher's t^2'. *Current Science*, 7, 21. 119

38.16 ——— : On Tippett's 'Random Sampling Numbers'. *Sankhyā*, 4, 65. 120

38.17 ——— : On a method of getting confounded arrangements in the general symmetrical type of experiment. *Sankhyā*, 4, 121. 121

38.18 ROY, S. N. : A geometrical note on the use of rectangular co-ordinates in the theory of sampling distributions connected with a multivariate normal population. *Sankhyā*, 3, 273. 122

38.19 SINHA, A. R. : A study of the Indian official jute forecast. *Sankhyā*, 3, 413. 123

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39.01 BOSE, R. C. : On the construction of balanced incomplete block designs. *Annals of Eugenics*, 9, 358. 124

39.02 ——— and KISHEN, K. : The generalized interaction in s^n factorial design where s is a prime or a power of a prime. *Science and Culture*, 4, 473. 125

39.03 ——— : On partially balanced Youden's squares. *Science and Culture*, 4, 473. 126

39.04 BOSE, R. C. and NAIR, K. R. : On completely orthogonalised sets of latin squares. *Science and Culture*, 4, 666. 127

39.05 ——— : Partially balanced incomplete block designs. *Sankhyā*, 4, 337. 128

39.06 BOSE, S. S., KHANNA, K. L. and MAHALANOBIS, P. C. : A note on the optimum share and size of plots for sugarcane experiments in Bihar. *Ind. Jour. Agri. Sci.*, 9, 807. 129

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