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THE UNIVERSITY TEACHING OF SOCIAL SCIENCES: STATISTICS

TEACHING IN THE SOCIAL SCIENCES

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STATISTICS

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*The University Teaching
of Social Sciences*

STATISTICS

A survey prepared and edited
on behalf of the International Statistical Institute,
The Hague

by
P. C. MAHALANOBIS

with the help of the Indian Statistical Institute
and on the basis
of national reports contributed by:

Guido O. Liserro (Argentina); **M. H. Belz, A. L. Blakers,**
H. M. Finucan, R. S. G. Rutherford, G. S. Watson (Australia);
Lourival Camara (Brazil); **Nathan Keyfitz, J. A. Sawyer** (Canada);
E. Morice (France); **Oskar Anderson** (Federal Republic of Germany);
P. B. Patnaik (India); **B. Gil** (Israel); **Nora Federici, Fernando Pedroni** (Italy);
Ryokichi Minobe (Japan); **S. H. Khamis** (Lebanon and Iraq);
Anna Maria Flores (Mexico); **D. van Dantzig** (Netherlands);
Q. M. Hussain, Zia-Ud-Din (Pakistan); **Bokdan Szulc** (Poland);
José Ros Jimeno (Spain); **H. Wold, A. Rand** (Sweden); **T. Koslov, V. Novikov,**
V. Ovsienko (U.S.S.R.); **J. Durbin** (U.K.); **William G. Cochran** (U.S.A.);
with contributions from **Hildegarde Kneeland** for Ceylon, Egypt,
Israel, Pakistan, Syria and Yugoslavia.

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P R E F A C E

DURING the period 1951-53, Unesco carried out an international survey on the university teaching of the main disciplines in the social sciences. This resulted in the publication of a series of reports dealing with the teaching of sociology, social psychology and cultural anthropology; law; political science; international relations and economics.

In December 1954, the General Conference of Unesco at its eighth session invited the Secretariat to include surveys on criminology, statistics, demography and the administrative sciences.

The present report on the teaching of statistics is the second to appear in the new group, the first dealing with the teaching of criminology. Professor G. Goudswaard, former director of the International Statistical Institute in The Hague, assumed responsibility for the present survey. A first outline, based on a limited number of national reports, was submitted to the twenty-ninth session of the International Statistical Conference, meeting in Rio de Janeiro in June 1955, which recommended the further collection of data and the extension of the survey to more countries. It also entrusted Professor P. C. Mahalanobis, director of the Indian Statistical Institute, Calcutta, with the task of preparing a general conspectus based on the results of the inquiry being conducted in 25 countries.

For their continuing effort and pioneering spirit in making this project possible, Unesco wishes to thank Professor Goudswaard, who initiated the survey; Professor Mahalanobis, who completed it and wrote the general report, and the national rapporteurs and national institutions who contributed the reports on the various countries considered: Guido O. Lissero, professor of mathematical statistics and deputy director, Institute of Statistics of the National University of Litoral, Rosario (Argentina); M. H. Belz, professor of statistics, University of Melbourne, A. L. Blakers, professor of mathematics, University of Western Australia, H. M. Finucan, University of Queensland, R. S. G. Rutherford, University of New South Wales, G. S. Watson, Australian National University (Australia); Lourival Camara, direc-

tor, National School of Statistics, Rio de Janeiro (Brazil); Nathan Keyfitz, senior research statistician, Dominion Bureau of Statistics, J. A. Sawyer, Dominion Bureau of Statistics (Canada); Hildegard Kneeland, former consultant, Office of Statistical Standards, U.S. Bureau of the Budget (Ceylon); Hildegard Kneeland (Egypt); E. Morice, director, Ecole d'Application de l'Institut National de la Statistique et des Etudes Economiques (France); Oskar Anderson, professor of statistics, University of Munich (Federal Republic of Germany); P. B. Patnaik, Indian Statistical Institute (India); B. Gil, director, Social and Demographic Department, Central Bureau of Statistics, Jerusalem, Hildegard Kneeland (Israel); Nora Federici, professor of statistics, University of Rome, Fernando Pedroni, University of Rome (Italy); Ryokichi Minobe, chief, Statistical Standards Division, Administrative Management Agency (Japan); S. H. Khamis, associate professor of mathematics and head, Department of Mathematics, American University of Beirut (Lebanon and Iraq); Anna Maria Flores, chief, Department of Sampling, Dirección General de Estadística, Mexico (Mexico); D. van Dantzig, professor in the theory of collective phenomena, University of Amsterdam, and director of the Statistical Department, Mathematical Centre, Amsterdam (Netherlands); Q. M. Hussain, professor of statistics and head of the Statistics Department, University of Dacca, Hildegard Kneeland, M. Zia-Ud-Din, professor of statistics and director, Institute of Statistics, Panjab University, Lahore (Pakistan); Bokdan Sculc, University of Warsaw (Poland); José Ros Jimeno, University of Madrid (Spain); H. Wold, professor of statistics and director, Institute of Statistics, University of Uppsala, A. Rand, Institute of Statistics, University of Uppsala (Sweden); Hildegard Kneeland (Syria); T. Koslov, V. Novikov and V. Ovsienko, professors at the Institute of Economics and Statistics, Moscow (Union of Soviet Socialist Republics); J. Durbin, reader in statistics, University of London, Royal Statistical Society (United Kingdom); William G. Cochran, professor of biostatistics, Johns Hopkins University, Baltimore (United States of America); Hildegard Kneeland (Yugoslavia).

The Secretariat also wishes to express its sincere thanks to the International Statistical Institute and the Indian Statistical Institute, who sponsored the inquiry and helped in carrying it out successfully.

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FOREWORD

In 1954, the International Statistical Institute accepted an invitation from Unesco to undertake a survey on the teaching of statistics in six specified countries—France, India, Mexico, Sweden, the United Kingdom and the United States of America, and in other countries in which the teaching of statistics is well developed, as well as in countries urgently needing improvement of such teaching. Subsequently Unesco requested that Poland, U.S.S.R. and Yugoslavia be covered also by the inquiry.

On behalf of the Statistical Education Committee of the International Statistical Institute, requests were accordingly made to several leading statisticians to prepare reports in respect of their own countries. These reports were considered at a meeting of the committee during the twenty-ninth session of the Institute at Rio de Janeiro in 1955. Miss Hildegard Kneeland, who visited several centres of teaching during 1953–54 on behalf of the International Statistical Institute, had also prepared reports on statistical education in countries of the Middle East, Ceylon, Pakistan and Yugoslavia.

At the Rio de Janeiro meeting the committee found that the material available was not yet adequate for the preparation of a comprehensive international survey. During the discussion at the meeting of the Statistical Education Committee, it was suggested that the Indian Statistical Institute should assist in completing the survey and in preparing the final report. On behalf of the Indian Statistical Institute we accepted this responsibility; and it was agreed that the Indian Statistical Institute would try to secure from different countries such further information as might be possible.

In the second half of 1955, fresh requests were sent from both the International Statistical Institute and the Indian Statistical Institute, and much additional information was obtained from a large number of countries in the first half of 1956. The present report is based on the information received through the International Statistical Institute and the Inter-American Statistical Association, and also directly by the Indian Statistical Institute.

To promote uniformity of presentation and comparability, a list of items, on which information was to be supplied, had been communicated to all concerned. The reports received from the different countries, however, varied considerably in coverage as well as the relative emphasis on different aspects of statistical teaching. This unevenness is inescapable as it reflects the diversity of teaching arrangements and has necessarily given rise to some diversity in the account given for individual countries.

Part Two of the report gives for each of the 25 countries surveyed information relating to 1954 or 1955, based on the papers and reports submitted by various scholars whose names are mentioned under each country considered.

To all the contributors, who have so kindly supplied information, we express our grateful appreciation on behalf of the Statistical Education Committee. On behalf of the Indian Statistical Institute, we also express our thanks to the International Statistical Institute for the opportunity given to us to co-operate in the preparation of this report.

P. C. MAHALANOBIS

PART ONE

GENERAL SURVEY

INTRODUCTION

Statistics in its present form is the result of the fusion of two streams of activities. One was descriptive and primarily concerned with the collection and utilization of statistical data for purposes of government, trade, and industry; and which naturally led to the use of statistical totals, averages, ratios, etc. The other, at first associated with calculations relating to games of chance, was concerned with fluctuations or variations in observational data which supplied the basis for the theory of probability and mathematical statistics. Statistics thus has a dual aspect; one primarily as data; and the other, primarily as method concerned with inferences based on observational data. This dualism found expression in the historic fact that research and teaching of statistics tended to become associated chiefly with two entirely different subjects—economics and mathematics. In every case the chief concern of statistics must be with observational data.

The concept of probability emerged after the great developments in astronomy and physics had placed the Newtonian view of the world on a sound foundation. Some kind of law and order having been established in the world of physics, it became possible and necessary to examine the margin of uncertainty in inductive inference. Subsequently, theoretical physics found it increasingly necessary to adopt a statistical approach which led to the formulation of the principle of uncertainty in physical measurements. The use of statistics in the scientific field has two aspects; firstly, as the means of improving the efficiency of collecting observational data with the help of the theory of design of experiments and sample surveys; and, secondly, as the process of using such observational data for scientific inference with the help of the theory of estimation, testing of hypothesis and other methods. The task of statistical theory is to draw such valid inferences as may be possible from the given observational data treated as a sample. In this sense, statistical theory supplies the logic of scientific inference. On the theoretical scale, statistics is, therefore, an essential tool for the advance of science.

On the applied side, statistical methods are being increasingly

used in highly specialized fields. This has given rise to many special subjects such as actuarial work, biometry, econometry, psychometry, sociometry, statistical quality control and industrial statistics, vital and medical statistics, etc. As R. A. Fisher has pointed out: 'It is to the statistician that the present age turns for what is most essential in all its important enterprises. They are the "back room boys" of every significant enterprise. In the all-important field of scientific research it is they who plan and design the experimental or the observational surveys, and it is they who are again called upon to analyse the results, to assess the evidence and to separate what is clearly demonstrated from what still requires confirmation.' The importance of statistics has rapidly increased, and the demand for professional statisticians and for the teaching of statistics is rapidly increasing in consequence.

As an applied science, statistics has necessarily two aspects, one local and the other universal. The purpose of statistics also differs from country to country. There is therefore need of a common language and common standards for communication between different nations and of the formulation of technical methods which would be transferable on a wide scale. The theory of statistics has a special position; it supplies the foundations of inductive inference and in doing so it uses the calculus of probability and other mathematical apparatus. Statistics thus includes in its scope the most abstract mathematical work, principles and methods relating to the design of experiments and surveys, and to drawing valid inferences from observational data, and a very large volume of applications in many different fields of specialized activities. The organization of the teaching of statistics, therefore, shows great diversity from one country to another or even within the same country. General courses in statistics are sometimes given in close association with economics and politics or, with mathematics or specialized courses, they are provided in connexion with particular subjects, such as agricultural science, education and psychology, medical science, engineering, business administration and commerce, etc. The need of providing professional training at a high level is, however, gradually leading to the emergence of statistics as a subject of separate study at the university level and to the organization of separate departments or institutes of statistics for this purpose. The need of examinations to establish reliable standards of professional knowledge and skill has been also receiving increasing attention.

To sum up, statistics, at present, is almost a name for a group of subjects which have often developed independently and some of which still remain in many ways separate disciplines. Statistics in the form of observational data constitute the subject matter of natural and social sciences and also supply the basis for decisions in adminis-

tration and in social and economic affairs. The methods of analysis and interpretation, on the other hand, share many of the characteristics of logic and mathematics which, however, would have no meaning except in relation to observational data of one kind or another. Statistics, therefore, has some of the characteristics of applied sciences such as medicine or engineering. At the same time, on the theoretical side, statistics may also claim to supply the logical foundations for inductive, that is, scientific inference. Thus, it is inevitable that the teaching of statistics shows a great diversity of organization, since it is sometimes closely associated with economics, or mathematics, or with other individual subjects such as psychology, engineering, etc. Teaching of statistics must be more unified; fortunately, a movement in this direction has already begun and is likely to gain steadily in strength.

OBJECTIVES IN THE TEACHING OF STATISTICS

For purposes of instruction, statistics may be treated as (a) a part of general education; (b) a main subject of study; (c) ancillary to other subjects; and (d) a vocational subject.

STATISTICS AS PART OF A GENERAL EDUCATION

Statistics viewed as the basic tool for dealing with experimental and observational data for the advancement of scientific knowledge can well claim to form a part of general education. A report of the committee appointed by the Royal Statistical Society in 1944 states: 'The statistical approach is so fundamental to the modern way of looking at things—the affairs of everyday life as well as scientific theories and experiments—that it should form part of the mental equipment of the educated man, which it is not at present.'

Little progress, however, seems to have been made towards the realization of these objectives. In only one country, Spain, and very recently in 1953-54, statistics was included as a part of the mathematics curriculum for the school leaving certificate. In other coun-

tries, such as Sweden and Italy, statistics is never taught without a definite career objective. However, undergraduate teaching in statistics in many countries may be said to supply some elements of a general education. In the U.S.A. the numerous courses in statistics attended by university students from all faculties to some extent serve this purpose. So do the courses attended by hundreds in the faculties of economics in Yugoslavia or U.S.S.R., or of commerce in Egypt. In Japan, instruction in statistics as a part of general education was received by nearly 5,000 students in 1953-54. The statistical courses for undergraduate students of commerce and mathematics in India and Pakistan, the introductory courses given in countries such as Ceylon, Israel and Lebanon, Poland and Spain also belong to the same type. Such courses are not, of course, deliberately designed as a part of general education nor have they an avowed cultural aim, for there is seldom any provision in these courses for teaching the logical foundations of the subject. The instruction also fails to go deep enough into applications to enable a student to learn when and how to use statistics as a tool in his particular field of work.

To make statistics an integral part of a general education, teaching should perhaps begin at the secondary school level. Through such subjects as arithmetic, geography, physics, chemistry, and biology, the statistical approach could be introduced and the pupil could be made to think in terms of aggregates, variation, and relationships among variables. Experiments on these lines have shown promising results; but there is objection in most countries to the introduction of statistics at such an early stage on the ground that the pupil may not have sufficient maturity of mind and that in the hands of unskilled teachers statistics as a school subject may degenerate into a dull and unreal appendage to arithmetic.

STATISTICS AS A MAIN SUBJECT OF STUDY

The object of teaching statistics as a main subject of study, naturally, is to lay the foundations for the formation of professional statisticians both in the field of theory and of practice. 'Individual workers would specialize in particular fields in accordance with their own preference. Many would apply their minds to closely practical applications; and some to the development of the mathematical technique and the formulation of logical concepts. The number of persons working in the different fields would be determined naturally, partly by the demand for particular types of work and partly by the supply of men of the required aptitude and ability.'

There is evidence that most of the universities recognize the professional aspect of statistical education; but most of them, again,

lack the necessary resources to provide adequate practical experience. In only a small number of countries is there provision for practical training in special fields of application. In Sweden, for instance, the intermediate courses in the Stockholm School of Economics, while covering a good deal of theory, require the students to carry out a small-scale market analysis. In the Argentine universities the vocational objective is given emphasis in the university programmes of statistical teaching. In the U.S.S.R. there is extensive provision for giving practical training under actual working conditions.

On the whole, however, the universities have left the responsibility of providing professional education to government departments or specialized statistical institutions. The latter have arisen in several countries as a result of the urgent need to bring together a group of professional workers for purposes of research, advisory work, and direct participation in statistical projects. In Poland, the Academy of Planning and Statistics at Warsaw, and in the U.S.S.R., the Institute of Economics and Statistics, Moscow, are specialized institutions which have large teaching and research programmes directed mainly to economic planning. The Indian Statistical Institute is an example of an independent central institution which provides facilities for professional training and research and also undertakes project work for government and other agencies covering a wide field from mathematical statistics and sample surveys to operational research and planning. This institution seeks to combine academic teaching and professional training. Although the need for similar institutions is being increasingly recognized in many countries, the chief obstacles to their development lie in the inadequacy of available funds and the lack of a sufficient number of experienced statisticians to take up the work.

STATISTICS AS A PART OF OTHER SUBJECTS

The teaching of statistics as a part of economics had started quite early. As statistical methods began to be used in the physical and social sciences, statistics found a place in many teaching programmes as an ancillary subject. Statistics is primarily the tool of quantitative analysis, whatever be the nature of the observational data. Some knowledge of statistical methods is therefore of great value to a scientific worker; it may enable him to make routine statistical applications in his own field; in the case of more advanced applications, it may make it possible for him to explain his requirements and the background of his problems to the expert statistician. The better the means of communication between the scientist and the statistician the more fruitful their collaboration.

This can be achieved in two ways. Students of science may take some courses in statistical methods with special reference to their own subject. Statisticians may specialize in the application of statistics in particular subject fields. Thus, in practically every country, courses in statistics are given for students of commerce and economics, education and psychology, agriculture and forestry, biology, demography and health, engineering and other subjects. Students of statistics, on the other hand, are often given facilities to acquire basic knowledge of special subject fields. Advanced students of mathematical statistics in this way specialize in agricultural field trials, biometry, psychometry, econometry, sample surveys, statistical quality control and other subjects.

VOCATIONAL AIM OF UNIVERSITY EDUCATION

One criticism of university teaching of statistics is that in many countries it is much too academic and does not fit the students to take up professional work. Certain universities seem to believe that their function is not to impart training for a professional career, but to give a broad general education; they hold the view that universities should aim at producing men with an understanding of the fundamentals of statistics, and that even in post-graduate teaching the aim should be scholastic rather than vocational. Employers often complain that they find it difficult to get any useful work from men fresh from the universities; and take the view that, statistics being essentially a professional subject like accounting, engineering or medicine, university students should have some practical experience as well as knowledge of basic theory when they start their career. This need is fully appreciated by many universities; and has given rise to the growth, in some countries, of agencies or institutions which collaborate with the universities in the training of professional statisticians. However, in most cases, even when the universities recognize the importance of vocational interests, they lack facilities to provide professional training.

EDUCATION IN STATISTICS

Statistics is taught in the universities in all the educationally advanced countries. Everywhere statistics is one of the newest subjects, but there is already a large demand for its teaching.

However, very few universities provide professional training in statistics, and students obtaining university degrees and diplomas in statistics often find themselves insufficiently prepared for their professional tasks. Graduates in economics, commerce, psychology, biology or agriculture who have taken elementary and intermediate courses in statistics tend to take up professional work more easily than graduates in pure statistics. Under present conditions it seems necessary that university graduates should receive further training before entering the profession.

VOLUME OF CURRENT TEACHING

Most of the teaching in statistics is given in the universities. More than three-quarters of the universities provide courses in statistics which vary greatly as to level of teaching and subject content. Among countries included in the present survey, the position, in regard to number of courses given annually, seems to be the best in the U.S.A., the United Kingdom, India, and Japan. In the U.S.S.R., a large number of courses are given at higher educational institutions. Countries like Brazil, Egypt, Pakistan, Poland and Spain provide a large variety of courses; while Ceylon, the Middle East and other countries offer a very limited choice.

In the U.S.A., 44 large institutions having a student strength of over 3,000 each offer 563 courses. None of the larger institutions gives less than 3 courses, 8 give more than 20 courses and the average is 12 per institution. In the United Kingdom, there are about 240 undergraduate courses distributed over 35 institutions, of which 7 give more than 20 courses. India offers a variety of courses in statistics in about 25 universities and other institutions, both at the undergraduate and post-graduate levels. In the U.S.S.R. there are 35 'chairs' (separate departments) of statistics distributed among higher educational institutions. In Japan, elementary statistics forms part of the curricula in as many as 63 national, 20 public and 62 private institutions (including junior colleges).

Other countries in this survey where statistics has an important place in the universities are Argentina, Australia, France, Federal Republic of Germany, Poland, Spain, Sweden and Yugoslavia.

INSTITUTIONS GIVING EDUCATION IN STATISTICS

The importance given to statistics in a country can also be measured by the number of independent departments or schools established within or outside the framework of its universities. Conditions appear

to be most advanced in this respect in the U.S.A., the United Kingdom, the U.S.S.R., and India. In the U.S.A., though the actual number of statistical departments in the various universities is not known, it may be inferred from the proportion of courses given in statistics that possibly in one-fifth of the institutions there are independent departments of statistics. There are several important centres of statistical teaching and research in the universities in the U.S.A., for example, in California (at Berkeley), Chicago, Columbia, Iowa State College, Johns Hopkins, Michigan, North Carolina, Princeton and Stanford. In the United Kingdom, there are separate departments in about 6 universities. Of these, the London School of Economics with its 36 courses a year, and University College, London, are the more important. University College is also the only institution in the United Kingdom which teaches for the bachelor's degree in statistics. In the U.S.S.R., out of 35 chairs of statistics in various institutions, 6 are in the Institute of Economics and Statistics in Moscow. In India, 10 universities have departments of statistics, most of them giving courses at the undergraduate and post-graduate levels. In addition to these universities, the Indian Statistical Institute provides professional courses at a post-graduate level. In Poland, 10 universities have arrangements for teaching in statistics and specialized professional training is given at the Academy of Planning and Statistics, Warsaw.

There is at least one well-established institution for statistical education in each of the following countries: Argentina (Institute of Statistics, Faculty of Economic Sciences, Litoral), Brazil (National School of Statistical Sciences), France (Institute of Statistics in the Faculty of Economic Sciences, University of Paris), Italy (Faculty of Statistical, Demographic and Actuarial Science), Spain (School of Statistics, University of Madrid), Sweden (University of Uppsala) and U.S.S.R. (Institute of Economics and Statistics, Moscow). Australia, Pakistan and Yugoslavia each have 2 universities with independent departments of statistics. The report from the Federal Republic of Germany indicates the existence of some independent statistical departments in the universities. There is a department of statistics in the Hebrew University, Jerusalem. In no other country covered by this survey (except perhaps in Japan, for which the position is not known) has statistics attained the status of an independent university department.

STATISTICS AS A MAJOR SUBJECT IN UNDERGRADUATE COURSES

Although statistics has figured for many years in the curricula of courses for degrees in mathematics and economics in a large number

of universities, degrees in statistics have come to be instituted only in a few countries, for the most part since the second world war. In the U.S.A., as observed earlier, 13 of the 44 large institutions give major undergraduate courses. There is only 1 university in the United Kingdom offering a B.Sc. (Special) degree. In India, bachelor's degrees are awarded in about 11 universities and in Pakistan in 2 universities. In Sweden, the *Filosofie Kandidat* degree with statistics major can be taken in at least 2 universities. In the U.S.S.R., institutions giving higher training in statistics award the degree of 'economist'. In other countries, universities offering a first degree in statistics are limited to 1 or 2.

The full course for the B.A. or B.Sc. degrees, pass or honours, takes either three or four years. In the U.S.S.R., the course at the Institute of Economics and Statistics is for four years. The *Filosofie Kandidat* in Sweden has no prescribed period, but ordinarily takes three or four years. In Europe, diplomas are usually based on two-year courses. In Yugoslavia, the diploma is awarded after a course of four years.

The undergraduate courses in statistics as a major subject are sometimes given entirely in the department of statistics in a few countries but usually such courses are given in the department of statistics as well as in other departments, such as mathematics, economics or commerce, or sometimes psychology or public administration.

EDUCATION IN STATISTICS WITH OTHER SUBJECTS

The importance of statistics as an ancillary subject is well recognized. Teaching in statistics is given in many universities to both undergraduate and post-graduate students of mathematics, biology, economics, commerce, business administration, psychology, education, sociology, medicine, agriculture and engineering; and the courses range from the elementary to the advanced, and from the descriptive and empirical to the highly theoretical and mathematical.

Judged both by the number of courses given and the number of institutions giving the courses, economics (including commerce and business administration) is the subject with which statistics is most frequently associated as a subsidiary subject for undergraduate courses. Relatively large numbers of courses in statistics are given to undergraduate students of economics in the following countries: Argentina, Egypt, Poland, Sweden, United Kingdom, U.S.A., U.S.S.R. and Yugoslavia. The reports received indicate that practically every institution in these countries gives at least one statistical course in economics. In the U.S.S.R., statistics is an obligatory part of the teaching in all institutions of economics and in all faculties of

economics in technical institutes. In India, statistics is generally combined with economics for the M.A. degree but rarely for the B.A. degree. Statistics is almost always taught for degrees in commerce. In Australia and the Federal Republic of Germany nearly all the faculties or departments of economics offer courses in statistics.

The extent to which statistics is obligatory for students of economics and commerce varies from centre to centre. Courses in statistics appear to be compulsory for about half the number of students of economics in the United Kingdom. In the U.S.A., statistics is regarded as essential for graduation in business administration and economics; in Poland and Yugoslavia it is compulsory for all students in the faculties of economics and in India it is compulsory for about half the number of students of commerce. In the U.S.S.R., courses in both general and mathematical statistics are obligatory for graduates in economics and in engineer-economics.

Next to economics, mathematics is the subject most commonly associated with ancillary statistics in university courses. In Canada, France, India, Pakistan and the Netherlands, the majority of courses in statistics are combined with mathematics. In the United Kingdom and the U.S.A. it is combined with economics first and then with mathematics. It appears that in the above countries over 75 per cent of the institutions teaching mathematics provide at least one course in statistics. In the Federal Republic of Germany, probability and mathematical statistics are taught in nearly half the number of mathematical faculties; and courses in mathematical statistics are given in the departments of mathematics in Poland and Spain; whereas in some countries like Argentina and Egypt very little of statistics is taught with mathematics. When in association with mathematics, statistics is an optional subject in most countries.

For psychologists, undergraduate courses in statistics exist in nearly 60 per cent of the institutions in Australia, Sweden, the United Kingdom and the U.S.A. In Egypt, India, Pakistan, Spain and Yugoslavia, statistical courses along with psychology are occasionally given. In the fields of education and sociology, statistics is taught mainly in Sweden, the United Kingdom, the U.S.A. and the U.S.S.R. Statistics is found rarely in undergraduate courses in biology; the United Kingdom is an exception. The Argentine universities have systematic courses for students of medical hygiene. Statistics is taught with agriculture in Argentina, Japan, Poland, Spain, Sweden, United Kingdom, U.S.A., U.S.S.R. and Yugoslavia. As regards engineering and technology, Canada, Japan, Netherlands, Poland, Spain, United Kingdom, U.S.A. and U.S.S.R. provide statistical courses at university level. But in view of the growing importance of statistics in these fields, the teaching even in these countries is still inadequate.

Most of the ancillary courses mentioned here are introductory courses, where no previous knowledge of statistics is assumed. In some cases they are followed by intermediate courses which require more mathematics and some knowledge of the field of application. Although the value of statistics is recognized for advanced work generally, and as a special tool for research in different sciences, presumably owing to lack of facilities, teaching of statistics along with other subjects is carried out only to a very limited extent at the post-graduate level. Almost as exceptions, a few post-graduate schools and special institutes in some of the scientifically and industrially advanced countries give post-graduate courses on theoretical and applied statistics.

POST-GRADUATE EDUCATION IN STATISTICS

It is usual for a university to develop post-graduate courses in a subject only after it has sufficiently organized its undergraduate teaching in that subject. In statistics, however, one finds extensive post-graduate teaching without corresponding undergraduate courses. A good example is the United Kingdom, which has more than eight institutions teaching for post-graduate diplomas or degrees in statistics, while only one provides teaching for a bachelor's degree in statistics. This arrangement has its origin in the belief that graduates in mathematics can become mathematical statisticians after a year or two of post-graduate study, with the result that post-graduate courses in statistics are usually open to graduates in mathematics only.

The period required, in most countries, for the master's degree is two years and for the Ph.D. degree three years after the bachelor's degree. For a diploma at some centres one year is prescribed, and at others two years. There is, however, considerable variation in the regulations of different universities, particularly in respect of graduates from foreign universities. In the U.S.A., there are over a dozen post-graduate (or, as it is called in America, graduate) centres. Most of the students entering the doctoral course in statistics come after major undergraduate work in mathematics, although occasionally students from biology or sociology are also attracted to graduate work in statistics. The master's degree, lower than the doctor's, is taken by about 50 per cent more students. In the United Kingdom, there are post-graduate diplomas in statistics at 6 universities for which systematic teaching is provided; in addition, most universities award doctoral degrees based mainly on research work. In India, courses for the M.A. and M.Sc. degrees in statistics are provided at 9 universities; and diplomas are given by 1 or 2 universities. The

Indian Statistical Institute gives a three-year professional course to masters in statistics, mathematics, economics, etc. The doctor's degree in India is exclusively a research degree for which regular courses are not prescribed. Argentina, Australia, Pakistan and Sweden have post-graduate teaching programmes to a limited extent. The Institute of Statistics, Paris, and the School of Statistics, Madrid, offer a two-year diploma in statistics. Yugoslavia awards the doctor's degree two years after the diploma. The *Philosofie Licentiate* and *Doktorate* degrees are awarded in Sweden after the *Kandidat* degree with statistics major. In the U.S.S.R., the candidate's degree is the first degree and a prerequisite for the higher doctorate degree.

EXTENT OF STUDENT PARTICIPATION

The importance attached to a subject in the educational system of a country can be assessed to some extent by the number of students studying the subject. Unfortunately, it has not been possible to obtain data from all the countries about students taking courses at different levels in statistics. But the figures available throw some light on the general features of student enrolment in recent years. In Yugoslavia, in 1953-54, about 10,000 students belonging to the faculties of economics, law and agriculture or to the vocational schools had taken courses in statistics. In Japan, the total number in 1953-54 is reported to be of the order of 32,000, mostly, of course, at junior levels. In Egypt, during the same period, the students in the faculties of commerce who took introductory statistical courses exceeded 2,500. In the Federal Republic of Germany, the number of students taking statistical courses in the universities (excluding technical universities) was about 4,000 in 1955. In India, the number of students studying statistics as a special subject for the B.A./B.Com. degree is of the order of 5,000 per year; the number admitted in 1954-55 to the B.A./B.Sc. (pass or honours) courses with statistics as the main subject was 377, the corresponding admission to the M.A. and M.Sc. courses being 185. In the United Kingdom, the number of students who presented at least in one paper in statistics in the final examination for a first degree was 504 during the session 1954-55. In Poland, the 12 vocational secondary schools of economics specializing in statistics by themselves trained about 1,000 candidates in the two years 1953-55. Figures for the U.S.A. are not available but the number is likely to be very large considering the large number of institutions and the variety of courses. In the U.S.S.R. teaching in statistics is provided on a very large scale through institutions of many different types. France also must have a large contingent of students taking statistics in the special schools and universities. In

other countries, in general, the numbers are small. For example, the Netherlands had only about 650 students concerned with statistics in 1954–55. In Pakistan, the number studying for degrees in statistics (B.A. and M.A.) was less than 150.

TRAINING IN STATISTICS

A distinction is sometimes made between education and training in statistics. In its most limited sense, training is concerned only with the direct and immediate development of necessary skills to perform specified jobs. According to this view, the basic concepts and theories of statistics are matters of education. The demarcation between education and training has some value in drawing attention to the dual aspects of statistics but is not to be regarded as separating two independent functions. The two are complementary; and the same individual should receive both education and training. Experience everywhere has shown that education in statistics must incorporate some elements of training; and training at every level must be combined with some education.

At present training is being provided in several ways and at different levels. Some of the universities and scientific institutions, while primarily engaged in education and research, either undertake the organization of training courses or assist other institutions in such undertakings. Sometimes the same teachers may handle both the educational and the training courses but these are attended by different sets of students; in such cases education and training cannot be properly combined.

Ad hoc training for persons already in employment who may not have had previous education in statistics is also important. The employees are usually workers in government departments or in private enterprises who are required to use statistics for the performance of their daily work. Training of this type is usually given by professional statisticians from within the departments or enterprises, and only occasionally by teachers from universities or scientific institutions. In some countries, facilities exist for persons in employment to attend training courses at universities or institutions.

Owing to the growing demand for professional statisticians and the increasing range of applications, a new type of institution seems

to be emerging in the form of a self-contained institute, having an expert staff in different branches of statistics and associated subjects, actively engaged in research and consultative and project work, and providing both education and professional training at different levels in intimate contact with applications. The great advantage of such institutes would be the possibility of combining education and practical experience for purposes of professional training in statistics; as is done in medical training.

TRAINING IN UNIVERSITIES AND SCIENTIFIC INSTITUTIONS

In the Australian universities, students taking regular courses in statistics often include persons in employment; at the New South Wales Technical University, nearly half the number of students are part-timers. Melbourne University gives courses for persons working in biology, medicine, physics and engineering; and the Perth Technical College has a course in applied statistics intended for engineers, chemists and architects. In Brazil, courses are provided by the National School of Statistical Sciences, at different levels, for persons who are to enter administrative positions. In all Yugoslav universities, courses in statistics are open to persons employed in positions requiring the use of statistics.

Some other universities also give special part-time courses for persons in employment. Lahore University (Pakistan Institute of Statistics) has a certificate course (one year) and a diploma course (two years); the Institute of Statistics, University of Paris, has a *Certificat d'aptitude* (certificate course) and a *Diplôme de statisticien* (diploma in statistics); it has also training courses for engineers and business administrators. The University of Litoral (Argentina) has a three-year course of 'public administration statistics and administrative statistics' in which a number of subjects, including statistics, is taught. The Faculty of Economic Sciences of the University of Córdoba, in the same country, has a four-month course for national, provincial and municipal employees. The University of Madras (India) has a two-year evening course in statistics. University College, London, provides an evening course for civil servants working in the city. Short intensive courses are available in the U.S.A., both for elementary instruction in statistics and for keeping statisticians acquainted with recent developments; in most of the big cities, evening courses are given by the universities. Some of the larger statistical centres have developed attractive summer school programmes in which both introductory and advanced courses are given. In the U.S.S.R. the educational and technological institutions provide evening courses in all urban areas for persons in employ-

ment; courses of instruction through correspondence are also offered which are later supplemented by practical training.

Some vocational schools and scientific institutions also contribute to training in statistics. They range from small institutions giving short courses to large institutions giving extensive training in their respective subjects. Among the vocational type may be mentioned the School of Economics and Agriculture, in Yugoslavia, which imparts instruction in statistics to a large number qualifying for junior posts. In Poland there are 12 vocational secondary schools of economics which specialize in statistics. The *grandes écoles* (specialized schools) in France give short courses on theoretical statistics as well as applications. They are classified under (a) technical high schools; (b) engineering schools; (c) schools of economics, social science and business administration; and (d) art and trade schools. In Egypt, the Schools of Social Science give some training in statistics. In Israel, the School of Law and Economics offers training to civil servants and other government employees in theoretical and applied statistics.

The scientific institutions in different countries, which provide training in statistics, are usually devoted to advanced studies in special fields like mathematics, actuarial science, engineering, agriculture, medicine, economics, banking, demography, etc. Some, like the Indian Council of Agricultural Research, Delhi, giving a diploma in agricultural statistics, have intensive advanced courses. The Mathematical Centre in Amsterdam arranges short courses in applied statistics and operational research. In the Federal Republic of Germany, the Technische Akademie Bergisch-Land organizes cycles of about 20 lectures of the seminar type on technological applications of statistics.

TRAINING BY STATISTICAL INSTITUTIONS

Independent institutions which are mainly devoted to the study of statistics and are not constituents of universities are still very few. They nevertheless perform very important functions in the training of professional statisticians by following up and supplementing the work of the universities and other institutions. An example is the Indian Statistical Institute which is engaged in a wide range of teaching activities in statistics and applied subjects. It has a whole-time three-year advanced course for training professional statisticians, a short-term (six months) statistician's course mainly for persons in employment, part-time computers' training courses, and periodic training courses in statistical quality control, design of experiments, etc. It also gives training to statistical officers from government

departments and provides facilities of advanced study to senior workers from government offices, universities, or private business houses. The courses cover both theory and practice and opportunity is given for practical training in the various projects and surveys conducted regularly by the institute. Facilities are also available for specialized training in biometry, psychometry, agricultural experimentation, economic planning, mechanical tabulation, data processing, statistical organization, etc.

Another good example is the School of Application of the National Institute of Statistics and Economic Studies in Paris. It was founded for the purpose of training the staff of the National Institute of Statistics and now also trains statisticians for public and private organizations. The school provides a two-year statistician's course (*ingénieurs-statisticiens-adjoints*).

The Academy of Planning and Statistics, Warsaw, is another institution which provides professional training in statistics. In Egypt, the Institute of Statistical Studies gives a two-year diploma course for persons already employed in statistical work in the Ministry of Finance and other government agencies.

The situation in the U.S.S.R. in respect of training in statistics is perhaps unique. The higher institutions of teaching aim at producing statisticians to serve the different sectors of the national economy, and much of the teaching is given through practical training. The Institute of Economics and Statistics in Moscow is a central institution for research and professional training at the highest level.

The need of establishing objective standards of professional competence has also given rise to professional examinations conducted by statistical societies and associations. The first step in this direction appears to have been taken when the Indian Statistical Institute appointed a committee in 1935 to examine this question. On the recommendation of this committee, examinations for the award of statisticians' diploma and computers' certificate were started in 1938 and have been held since then all over India. In 1944 the Royal Statistical Society of London appointed a committee for a similar purpose, and on the recommendation of this committee, started holding professional examinations. More recently, statistical societies and associations in some other countries, such as the Ceylon Statistical Society and the Egyptian Statistical Society, have begun to provide training courses, and conduct examinations for the award of certificates.

EMPLOYEE TRAINING

Owing to the very rapid expansion of statistical activities during and after the war, many government departments and private concerns

have been obliged to recruit persons without previous training in statistics. In some countries, universities or other institutions provide special courses for persons in employment. Such facilities are extremely limited, however, and employers are often obliged to have employees trained in one way or another while they are on the job.

In some countries there is provision for organized 'in-service' training which can be defined as the improvement of persons already trained for the performance of more advanced types of work, usually within the agency in which they are employed. This type of training is best given in a setting in which real work is being done and where the trainee has an opportunity not only to acquire advanced skills but also to broaden his knowledge, interests, and aptitudes. The need for such training is recognized in the courses given by the Sampling Department of the Directorate General of Statistics in Mexico. The syllabus includes mathematics, probability, and statistical theory relating to sampling. The practical aspect is given the greatest emphasis and an essential part of the training is practical work carried out in connexion with the activities of the Sampling Department. The federal agencies of the U.S.A. arrange systematic in-service courses in statistics in collaboration with the universities. Thus the Graduate School of the Department of Agriculture has a programme for government employees in Washington which, in range and quality, equals those of the best universities.

In the Federal Republic of Germany, university-trained graduates in economics or commerce, who are selected for superior posts as statistical advisers or heads of departments, have to take practical training as probationers in statistical offices, working successively in all the departments. For personnel at lower levels, in-service training is organized periodically by their own offices. In Yugoslavia, the Government Statistical Offices in the State give in-service training at elementary and advanced levels. At the Federal Statistical Offices in Belgrade, advanced courses are given for officials from various federal agencies and from the statistical offices of the Republics. In India, the Central Statistical Organization, New Delhi, arranges in-service training for statisticians from the statistical offices of the State Governments and Central Ministries; the C.S.O. organizes annually short courses for senior statisticians and courses of longer duration for junior statisticians, covering methodology and applications in special fields. In-service training for agricultural workers and primary investigators are given periodically in the Indian Council of Agricultural Research and the Directorate of Economics and Statistics in the Ministry of Food and Agriculture. In the U.S.S.R., training on a large scale is provided by the Central Statistical Board at its headquarters in Moscow as well as in its many branches all over the country.

EDUCATION AND TRAINING BY INTERNATIONAL AGENCIES

The expansion of statistical activities during and since the second world war created a very high demand for trained statisticians throughout the world. In many countries, especially those which are economically underdeveloped, trained statisticians were urgently needed to assist in national development programmes. These needs, in turn, created problems of education and training which became a serious concern of governments, national institutions and international organizations. Soon after its formation in 1946, the Statistical Commission of the United Nations recognized the need for providing over a wide area opportunities for education and training in statistics. In its session of 1949, Ecosoc adopted a resolution urging Unesco and the International Statistical Institute 'to take appropriate steps to further the improvement of education in statistics on an international scale'. By this time, Specialized Agencies of the United Nations and other international organizations had also directed their attention to the problem.

TRAINING CENTRES

As a result, a large number of short-term training centres were organized in various parts of the world, covering subject fields selected according to the needs of the country. Between 1948 and 1954, about 30 such centres were set up, attended by approximately 1,600 trainees, with 21 countries acting as hosts. FAO, WHO and ILO, with the co-operation of the United Nations or of such agencies as the International Statistical Institute and the Inter-American Statistical Institute, were responsible for carrying out this training. The four UN/FAO centres for training in agricultural and population censuses held in Mexico (1948), Paris (1949), Cairo (1949) and New Delhi (1949-50) had a total of 189 participants from 40 countries. The population and health statistics training centres sponsored by the UN/WHO and held in Santiago (1950), in Ceylon (1951), in Tokyo (1952) and in Afghanistan (1954) had a participation of 153 persons from 39 countries. In addition to the systematic instructions at these centres, the programme included a number of informal seminars and trainee programmes. The main subjects covered were statistical methods, labour statistics, biostatistics, agri-

cultural and population censuses, experimental design, sampling, agricultural statistics, population and health statistics, fisheries, sample survey techniques and national income statistics.

The object of these centres was to meet the specific needs of the surrounding countries and to achieve immediate improvements in national statistics through direct instruction on selected topics. The work had to be carried on with the assistance of governments and local organizations which was freely forthcoming. The scope of the training was confined to one or two aspects of applied statistics according to local needs. The duration of the centres ranged from 2 to 16 weeks.

In addition to short-term centres, a few have been set up which are, in a sense, permanent. The International Statistical Education Centre, Calcutta, was established in 1950 for the education and training of statisticians for the countries of the Middle, South and Far East. It is sponsored by Unesco and is operated jointly by the International Statistical Institute and the Indian Statistical Institute. Financed initially by a grant from Unesco, its cost is now borne mainly by the Government of India. The ISEC in Calcutta conducts courses of nine months' duration with a curriculum conforming broadly to university education standards supplemented by practical training. Between 1950 and 1955 eight terms were completed, attended by 192 persons from 16 countries. Another International Statistical Education Centre with similar objectives was established at Beirut in 1953 under the sponsorship of Unesco and the International Statistical Institute. This centre in four terms between 1953 and 1956 has trained 141 persons from 16 countries. The Statistical Training Centre of the University of the Philippines, Manila, sponsored by the Government of Philippines and the United Nations was established in 1954. The centre provides two-year academic courses at the University of the Philippines leading to the M.A. degree in statistics. This centre also organizes short term in-service training. Up to the end of 1954, it had trained 71 participants, including 35 academic students.

ROLE OF THE INTERNATIONAL AGENCIES

The international agencies have already made valuable contributions to the extension of statistical education and training, but there is ample scope for further efforts. Assistance by the international agencies could continue toward developing regional as well as national centres. The regional centres in fact provide not only a broader basis of education through mutual contacts and exchanges of experience between trainees from different countries, but can also

constitute a training ground for international co-operation. W. R. Leonard in his paper 'On International Experience in Statistical Education', presented at the meeting of the International Statistical Institute in Rio de Janeiro, makes a distinction between a regional centre and a world-wide centre. The former has distinct advantages in broadening opportunities and supplying a realistic background for training, while in a world-wide centre a participant may have to adjust himself to a completely alien culture and, in addition, become trained to solve problems that might never arise in his own country owing to wide differences in the economic and social conditions. For underdeveloped countries it is the regional centres which are likely to be particularly useful, provided the courses are suitably oriented towards national as well as regional needs.

ORGANIZATION OF TEACHING

The organization of a teaching programme is often determined ultimately by the facilities available. Teaching of statistics in the universities follows the same general pattern as for other subjects; and training courses are organized on the basis of available resources. Specialized statistical institutions have developed their own systems of teaching which usually are wider in scope.

A team of competent teachers, a good library, calculating machines and other laboratory equipment, and material for demonstration are essential to the successful teaching of statistics. It is particularly useful for students of statistics to participate in current projects. The teaching may be imparted through lectures, laboratory work, seminars, tutorial work, demonstrations, directed reading, or operational exercises. A system for the assessment of student performance is also an essential part of a teaching organization; written, oral, and practical tests are the usual methods which may be usefully supplemented by performance in statistical projects where possible.

CENTRALIZATION OF TEACHING

In specialized statistical institutions, the organization of teaching would be centralized and oriented towards the statistical objectives.

Such institutions are, however, still extremely few in number in the whole world. In every country, the greater part of the teaching is at present done in universities; opinion seems to be divided as to the advantages of centralizing all teaching in a single department of statistics as against decentralizing, i.e., providing teaching in statistics in different departments. In the universities, courses in statistics for students of economics, commerce, mathematics, agriculture and engineering are usually given by the departments themselves; departments of psychology, education, and biology usually make use of the department of statistics, if there is one, or else of the department of mathematics. Amongst teachers of statistics there is no general agreement as to whether the introductory course at least should be given in a single department of statistics for all students, thus avoiding duplication of effort. The suggestion has, however, been made that even if courses are given in different departments, the teachers should be drawn from a pool, either constituting a central statistical department or forming a part of the department of mathematics. It is argued that this arrangement would be more economical and would also make available more competent teachers. There is, on the other hand, a possible objection that the specialists in statistics might lack adequate familiarity with the main subject field of the students and thus fail to impart a sense of reality to the statistics taught. In any case, active collaboration between the various departments would be the only way of proper utilization of available resources.

METHODS OF TEACHING

The most common method is by lectures—the only means available when the class is large. In Egypt the size of a class of B.Com. students taking a statistics course is reported to be approximately 500. In India a commerce class includes as many as 150 students. In Japan, Yugoslavia, and certain other countries, the general courses are taken by large numbers. When classes are small, lectures are combined with discussions. In some institutions, lectures are followed by seminars, particularly in post-graduate courses in which staff members and advanced students take part. The emphasis on seminars varies a great deal; in some countries the time allotted is taken up entirely by lectures. As regards undergraduate education in statistics, there is little individual teaching, although its value is everywhere recognized. The shortage of teachers of statistics is the obstacle—particularly so in Egypt, Ceylon, India, Pakistan and the Middle East countries. At the post-graduate level, of course, there is considerable individual teaching and discussion.

Laboratory work for practical exercises using calculating machines is almost everywhere considered an important part of teaching in statistics. This is intended to give training in computation and also experience in the application to the analysis of statistical data of theory acquired from lectures and reading. At University College, London, it is stated that 'often with the help of experimental sampling, they try to drive home some of the ideas introduced in the lectures; to show how the models work and how unexpectedly good some approximations are; to illustrate sampling variation, the distributions of alternative estimators, the meaning of such concepts as the power function of a test and the randomization act'. At that institution, the practical side of instruction is very much emphasized; each student has a calculating machine at his disposal and can work with it whenever he has leisure.

In general, the curricula of studies for the major courses in statistics devote one-third to one-half the total time to practical work. The exceptions are courses on probability, distributions and tests, where laboratory exercises are negligible. For the applied courses, the time devoted to practical work is variable. Unfortunately, in many countries the lack of calculating machines and other equipment prevents proper attention being given to laboratory work. Where students are many and calculating machines are few, the practical work is severely restricted; sometimes there is no practical work at all, for example, in commerce, economics and psychology courses in most countries.

Field work appears to be very restricted even for those studying economic and commercial statistics. Economic and social surveys, market surveys and family budget inquiries appear occasionally in university programmes. In agricultural statistics it is quite common to have some field experience of crop surveys and layout of experiments. Training in large-scale operations like the collection of data, machine tabulation and processing, analysis and writing reports, etc. are included in the teaching programme only in the specialized statistical institutions or in the national or international training centres. Only in the U.S.S.R. is the *practicum* or practical work arranged under actual working conditions in industrial enterprises, construction works, State and collective farms, transport enterprises and other organizations, and at later stages in the statistical offices in the provinces, regions, republics and the Central Statistical Board itself which ensures sound training in professional work at different levels.

METHODS OF TESTING COMPETENCE OF STUDENTS

Examination methods vary considerably in different countries. In some, the final examination is entirely written; in others it is part

written and part connected with practical work; and in others it is part written and part oral. Theoretical tests are in many cases followed by practical tests; for candidates taking the bachelor's courses with statistics major, there are always practical examinations requiring work on calculating machines. For the introductory courses taken by students of mathematics and the social sciences in most countries no systematic practical tests with the use of calculating machines are given as practical training is not included in their curricula. Assessment is usually made on the basis of written papers, one or two of which may contain some simple numerical problems for which only statistical and mathematical tables would be necessary.

Oral examinations are sometimes held to supplement written and practical examinations at the post-graduate stage, but rarely at the undergraduate stage. In some of the Indian universities there is a *viva voce* test for the M.A./M.Sc. degree in statistics. In Sweden an oral test usually accompanies the written, on completion of each course. In all countries the oral test is part of the examination for such research degrees as the master's and doctor's degrees.

Some examinations require an essay or a dissertation on a topic selected by the student which may or may not have been covered by lectures. The M.A. degree or diploma examination at some centres (e.g., Lahore, Sydney, Paris, Delhi, London) requires a dissertation or a paper in part-fulfilment of the conditions. The master's degrees of the American universities involve the preparation of a thesis, either a report on original research or an expository review of some branch of statistics. The higher doctoral degrees always require a major thesis based on original research. In some European countries such as France the thesis has to be defended before an audience.

Examinations conducted by statistical institutions or statistical societies and associations require written as well as practical tests. For the more advanced type, a *viva voce* is necessary.

Although examinations in some form or other are almost universal, at some places the examination is given less emphasis, the performance of students during the course being considered more important.

CONDITIONS AFFECTING TEACHERS

There is a shortage of qualified teachers of statistics in almost every country covered in the present survey. This shortage is particularly acute in the underdeveloped countries (Ceylon, Egypt, Israel, and the Arab countries included in this survey) where there is no provision for higher teaching in statistics and therefore no possibility of

expanding a domestic source of supply. The general shortage in most countries is partly due to the fact that salaries of university teachers are much lower than those of persons with similar qualifications in public or private statistical employment. Furthermore, university chairs in statistics are not numerous, nor are there many senior teaching posts; improvements in this matter would depend on the establishment of separate departments of statistics in universities. Owing to the difficulty of recruiting persons with high qualifications in statistics, the teaching of statistics as an ancillary subject is left to staff who hold degrees in other subjects.

In recent years, the system of visiting professors has been introduced at several centres, particularly in the U.S.A. and in India, and the results have been very satisfactory. Statistically backward countries can benefit much by securing visiting professors or experts from abroad to give advanced lectures, guide research and also assist in statistical projects. Some attempts are being made to place qualified statisticians at the disposal of underdeveloped countries through assignments under the United Nations Technical Assistance and other agencies providing technical aid at an international level. The volume of such assistance is, however, still very meagre and requires to be greatly expanded.

CURRICULA OF STATISTICAL COURSES

The scope of statistics is so wide that teaching must inevitably be provided at many levels and in many ways. The curricula of education and training in statistics are therefore of various types, differing in content, duration, emphasis on application, etc.

PREREQUISITES FOR COURSES IN STATISTICS

It is generally recognized that, to enter a course in statistics, a student should have some knowledge of mathematics. There is a fair amount of uniformity in the mathematical prerequisites for undergraduate courses in all countries. Knowledge of elementary calculus is

required for those taking courses in mathematical statistics, while school mathematics is accepted as sufficient for students of economics. For post-graduate courses in statistics, a good degree (preferably with honours) in mathematics or statistics is usually considered necessary. In some places a degree in physics is considered to be a suitable foundation for post-graduate work in statistics or sometimes a degree in engineering may also be accepted. Whatever the subject field in which statistics is taught and whatever the level of teaching, auxiliary courses in mathematics are usually given; the level of the mathematical course, however, varies a great deal depending on the level of teaching of statistics.

SYLLABUSES

Introductory courses. The content of introductory courses in universities varies greatly from one subject field to another and to a lesser extent within the same field. Probability and mathematical statistics may be given in a course for undergraduates in mathematics while purely descriptive statistics and simple statistical applications are taught to undergraduates in economics, commerce, psychology, etc. There is also large variation in the practical work required for different courses. The elementary courses usually include descriptive statistics, elements of probability, binomial and normal distributions, and standard errors. To this basic syllabus is added, in a number of countries, curve fitting, large sample tests, and index numbers. Courses for students majoring in mathematics place more emphasis on probability calculus, sampling distributions, sampling tests, correlation and regression with more than two variables. For students of economics, psychology, biology, etc., the syllabuses cover relevant statistical applications.

Intermediate courses. These usually include probability, small sample theory, tests of hypothesis and estimation. Additional topics i. e., analysis of variance and co-variance, design of experiments, analysis of time series, design of sample surveys, demography, educational statistics, economic statistics, agricultural statistics, etc., have a place in intermediate courses in many countries. In some of the more advanced countries these courses sometimes cover applied subjects such as biometry, econometry, genetics, actuarial statistics, statistical quality control, factor analysis, social measurements, etc. These intermediate courses are intended primarily for those who may have to use statistics in other fields and are meant mainly for undergraduates, although post-graduate students in other fields may be required to attend some of them.

Courses for the bachelor's degree in statistics. The courses for the

bachelor's degree in statistics usually follow the same logical order, with descriptive statistics and elementary probability theory coming first, followed by courses in mathematical statistics and, lastly, application courses. The syllabus (except for the applied part) follows a fairly uniform pattern in most universities, though there are differences in the time allotted to each topic and in the depth of treatment. Some of the following advanced topics are generally included in the curriculum for the B.Sc. degree: advanced probability, multivariate analysis, sequential theory, advanced design of experiments, analysis of time series, sampling techniques, psychometry, econometry, mathematical genetics, biometry, population statistics, statistical quality control.

Courses for the post-graduate degree in statistics. There is much variation in the post-graduate courses from country to country. In Argentina, the subjects for the doctor's degree (which is the first degree) cover a wide range including courses in actuarial analysis, econometry, industrial statistics, sample surveys, and philosophy of statistics as a science. In Rome, for the two-year diploma, in addition to mathematics and statistics, courses are given in anthropology, health statistics, sociology, legal statistics, biometry and demography; the doctor's degree in statistical and demographic sciences involves the study of actuarial mathematics, advanced economic statistics and development of population, while the doctor's degree in statistical and actuarial sciences covers the fields of actuarial mathematics, social insurance and economics. The one-year diplomas of the British universities cover broadly the same theoretical ground but may include different advanced topics such as stochastic processes, multivariate analysis, decision functions, etc.; they all require at least one paper in an applied field. At Oxford, two special papers must be chosen out of six subjects, one of which must be the mathematical theory of statistics, the other choice being made from applications to social studies, experimentation, sampling, biometry and psychology. In the U.S.A. the Ph.D. curriculum is divided between mathematics, theoretical and applied statistics, work in a special field, and the preparation of a thesis. In statistics, the basic courses are usually as follows: probability and distribution theory, estimation, tests of hypotheses, least squares and analysis of variance, multi-variate analysis, theory and practice of sample surveys, and design of experiments. More specialized courses may also be provided, for example, sequential analysis, stochastic processes, decision theory, non-parametric inference, operational research, etc.

Training courses. Most of the curricula of training courses combine statistical theory and mathematics with applications and practical work. The curricula usually include general statistical principles and methods, sampling theory and practice, statistical organization and

statistical procedures in particular fields of application, which usually include economics, agriculture, industry, population and health, biology, education, finance, commerce, transport, etc. Courses for professional statisticians given by the Indian Statistical Institute in Calcutta, the Department of Agriculture in the U.S.A., the Sampling Department of the Directorate General of Statistics, Mexico, the Federal Statistical Office in Yugoslavia, include advanced mathematical topics.

RESEARCH

Statistics is a subject which offers abundant scope for research. Statisticians all over the world are engaged in active research in the mathematical foundations as well as in applied branches of statistics. Contributions to research appear periodically in the statistical journals published in different parts of the world, the more familiar among them being the *Journal of the Royal Statistical Society* and *Biometrika* (United Kingdom), *Journal of the American Statistical Association* and *Annals of Mathematical Statistics* (U.S.A.), *Sankhya* (India), and *Metron* (Italy). There is also a very large volume of papers on applied subjects which appear in appropriate journals in special fields.

Research has an important bearing on the teaching of a subject. The stimulation of research aptitudes in the students is an important responsibility. Research papers, in turn, supply material for teaching. In fact, 15 or 20 years ago, when there were scarcely any textbooks in statistics, advanced teaching depended almost entirely on papers published in journals and memoirs.

RESEARCH FACILITIES

In recent years, with the rapid expansion of teaching in statistics, educational institutions in many countries have built up facilities for research and made provision for the award of research degrees. University research in statistics is most in evidence in the U.S.A., the United Kingdom, India, Japan, France, Italy, and Sweden. The U.S.A. awarded the largest number of Ph.D. degrees (117 during the

four years 1950-53); next would probably come the United Kingdom. Generally, however, research in statistics is not well developed in the universities in most countries. The position is much more favourable in the specialized institutes of statistics, some of which are independent institutions though some are closely associated with universities. Typical examples are the university institutes of statistics in Berkeley (California), Litoral (Argentina), North Carolina, Oxford, Paris, Rome, the London School of Economics, the School of Statistics in Madrid, the Institute of Economics and Statistics in Moscow, and the Italian Statistical Institute. They have fairly large staffs and good facilities for research, consultative and project work and usually give a number of intensive and advanced courses at a post-graduate level. The students in such institutes thus get both guidance and facilities for research. Also, the presence of a large number of post-graduate and research students offer opportunities for discussions and exchange of views. In some of these institutes, the students are also given facilities for gaining experience in applied projects of many kinds.

RESEARCH SUBJECTS

Broadly, research students in most universities take up theoretical subjects; the reason seems to be that the necessary facilities as well as guidance for applied research are not usually available in universities. In some countries, e. g., France, the subjects of research in the universities are mainly mathematical, following the mathematical tradition of the country. In specialized statistical institutes, students are often engaged in applied problems in sample surveys, experimental design, econometrics, psychometry, biometry, quality control and industrial statistics.

ADMISSION REQUIREMENTS

Practically, any graduate who has taken some courses in statistics or has some experience of statistical work could register for research, but usually those with mathematics, statistics or economics are preferred. There are differences in the period of study after registration for the submission of the thesis for a research degree. For the master's degree, it is generally two years. For the Ph.D., the period is three or four years. Certain universities prescribe longer periods for graduates from universities other than their own. Normally those who have already received a junior doctorate (Ph.D. in some countries, and the candidate's degree in other countries) are entitled

to submit a thesis for the award of the senior doctorate degree (D.Sc.), but there are usually no prescribed periods of study.

RESEARCH DEGREES AND TITLES

A great majority of the universities which teach statistics at intermediate and advanced levels make provision for students to take research degrees. The usual research degree is the doctorate (the Ph.D. or its equivalent) awarded on the basis of a dissertation. In the U.S.A., a written examination has to be taken before presentation of the thesis for the Ph.D. In the United Kingdom, a qualifying examination is sometimes required. In India there is no written examination for the Ph.D. but all candidates must have taken a master's degree or its equivalent. In several universities, the master's degree is partly a research degree, awarded on the basis of written papers and a dissertation; this is the practice in all American universities. In the United Kingdom, India and Australia, the master's degree can be obtained by research, but it is usually based on a written examination and is considered to be a first step to the Ph.D. degree. Higher research degrees such as the D.Sc. are awarded to persons holding a first research degree, and entirely on the basis of published research work. Research workers in institutions other than universities, either obtain professional titles such as associateship, fellowship, etc. of their institutions, or degrees from universities which recognize their work.

PROBLEMS AND PRIORITIES

This report surveying 25 countries shows a very uneven development in arrangements for the teaching of statistics. In the three most highly industrialized countries of the world, the United Kingdom, the U.S.A. and the U.S.S.R., the teaching of statistics is most highly developed. Other industrialized countries in Europe, as well as Japan and Australia, also have fairly good arrangements for statistical education or training. But, in general, statistics occupies a minor place in the universities in the underdeveloped countries, with the single exception of India.

The association between industrialization and the teaching of statistics is not fortuitous. Important developments in statistics have usually occurred during periods of social and economic expansion or growth of new movements in science and technology, and in times of war. There must have been much use of statistics for purposes of administration or of trade during the rise of great States or empires all over the world in the past. Economic statistics as well as the use of probability in scientific reasoning began to develop vigorously in Europe during the industrial revolution and the period of the growth of the physical sciences. The basic concepts of variability, regression, and correlation were introduced and elaborated soon after the formulation of the theory of evolution. The need of improving the efficiency of the collection of the observational data led to the theory of the design of experiments and the design of sample surveys. The need of attaining precision and validity in drawing inferences from such data led to the theory of estimation and the testing of hypotheses. There was a large expansion of statistical services during the second world war. Since the cessation of hostilities there has been an even greater expansion of statistics for purposes of scientific research, economic rehabilitation, and economic development.

In the underdeveloped countries, it is also being increasingly realized that economic development calls for an increasing volume of reliable statistical information which can be supplied only through the rapid expansion of the statistical services. The problem is in no way different from that of industrial development in countries where capital is least found and most required. For the development of statistics in an underdeveloped country, an adequate supply of professional statisticians is the basic capital required. Assistance at the international level can be of great help in this connexion. Though some assistance is already being provided by the United Nations and its Specialized Agencies, it is, however, quite inadequate.

The demand for statisticians is so urgent that it is necessary to consider the problem in two parts, one short-term and the other long-term. The first step is to build up specific statistical skills to fulfil minimum demands; and for this purpose emphasis should be given to short-term training courses and on-the-job training. There are no doubt risks in using inadequately trained personnel, but this risk can be minimized by supervision and guidance from experts who in the first instance must be supplied from the more developed countries.

There is also need of a longer-term programme, the object of which would be to help the underdeveloped countries to develop fully trained professional statisticians of their own. This can be achieved through institutions like the International Statistical Education Centres sponsored by Unesco and maintained with the help of the

International Statistical Institute and of other interested organizations; and also by providing scholarships for advanced study in the statistically advanced countries. In this way, as an increasing number of professional statisticians becomes available, it would be possible gradually to organize the teaching of statistics in underdeveloped countries.

It is of interest to note that in an underdeveloped country like India, modern statistical methods began to be applied to solve problems of rainfall and flood control, agriculture, and economic planning, thus giving opportunities for theoretical and applied researches, which led to the organization of teaching on an extensive scale. Indian experience shows that progress in underdeveloped countries can be rapid when statistical work and teaching are closely related to national needs.

There are also some problems in the statistically more advanced countries. Facilities are still lacking in most universities for student participation in practical applications. This can be secured to some extent by more active collaboration between different departments. Departments of statistics might also accept project work from outside, which would foster a closer integration of theoretical studies with practical applications.

Even in the most highly developed countries there would be great advantages in establishing self-contained specialized institutes of statistics at a national level which would be engaged in both research and project work and would thus be able to provide professional teaching at the highest level. Such specialized institutes could act as focal centres for regional and international schools and seminars and thus assist underdeveloped countries. These specialized institutes could also serve as centres for meetings of experts from different countries for the exchange of experience. In this way, these institutes could provide a suitable medium for the implementation of schemes prepared by the United Nations, Unesco and other Specialized Agencies, for the promotion of international collaboration.

In conclusion, mention may be made of one matter of great importance in connexion with the teaching of statistics. A set of internationally accepted conventions relating to statistical concepts, definitions, technical terms, and symbols would greatly facilitate the use of publications originating in different countries, and make communication easier between different nations. In statistics, emphasis must necessarily be given to the special needs of each country or region. It is, therefore, all the more necessary to establish and develop some wide conceptual framework for the whole world, within which regional and national standards would find their place. This can be achieved only through the active collaboration of national, regional, and international agencies and institutions.

PART TWO

SURVEY OF INDIVIDUAL COUNTRIES

SURVEY OF INDIVIDUAL COUNTRIES

In order to ensure maximum comparability for the national reports and papers from the 25 countries selected, it has been found necessary to alter in many cases the presentation of the texts. The following statements are therefore based on the original papers submitted, but they do not necessarily reproduce them in full.

ARGENTINA¹

FACILITIES FOR TEACHING

Historical Review

The teaching of statistics in Argentina really began in 1913 when a School of Statistics was created in the Faculty of Economic Science in the University of Buenos Aires and a course was started dealing with descriptive statistics, demography and quantitative economics. In 1927, a second school of statistics was created in the Faculty of Economic Science of the National University of Litoral. In 1932 this school was developed into the present Institute of Statistics. The institute was responsible for starting a course in mathematical statistics in 1948 and for guiding and conducting statistical research.

Teaching Centres: Degrees and Diplomas in Statistics

The centres where statistics is taught at present in Argentina are

1. Based on an original paper by Guido O. Liserro entitled 'Courses of Statistics in Argentina .

located in the universities of Buenos Aires, Cordoba, Cuyo, La Plata, Litoral and Tucuman.

It is possible to take a doctor's degree only in the University of Litoral. In the faculties of economic sciences, courses for accountants and economists are provided in all these universities. For students of the exact sciences, courses in statistics are available in three faculties, at Buenos Aires, La Plata and Tucuman. There are courses for students of medical hygiene in the faculties of medical sciences at Buenos Aires, La Plata and Litoral (post-graduate students only). Courses in statistics are given in agricultural and veterinary sciences at all universities except Cordoba. In only one university, namely Cuyo, is there a course in the faculty of education.

Neither in medical nor in engineering schools has statistics yet been introduced though its importance is pretty generally realized.

Careers for Statisticians

Many of the graduates in statistics are absorbed in industry and a good number enter the teaching profession; for some years, however, the State will be the main employer of statisticians in the ministries and State and municipal statistical offices. A few of the graduates in mathematical statistics are reported to be working in sister universities of Latin America.

ORGANIZATION OF TEACHING

Requirements for Admission

To enter a university in Argentina a student must have completed five or six years in a secondary school. The prerequisite for taking up courses in statistics is mathematics, covering algebra, logarithms, trigonometry and geometry. Students in some faculties such as those of economic sciences and agriculture may not have taken mathematics at secondary school and they are therefore given a one-year course in mathematics. In the faculties of medical sciences, however, there is generally no preliminary course in mathematics.

The requirements for admission to the course for a doctor's degree in mathematical statistics, is the completion of secondary studies at any national school of the republic (commercial and technical schools, national graduates or normal teachers).

Courses in Statistics: Aims, Duration and Content

The aim of teaching statistics in the various faculties, as mentioned earlier, is to make workers familiar with current statistical methods

of value in their fields. The teaching is particularly important for those taking up advanced studies, teaching or research.

With the year 1953, by a resolution of the Board of Rectors of the Argentine Universities, the plans of study and programmes were made uniform. The usual duration of university courses to qualify for a doctor's degree is three years.

In the six faculties of economic sciences and in the School of Economic Sciences in the Technological Institute of the South, a course called 'methodological statistics' is given in the second year for accountancy. About three hours per week are devoted to these courses. The programme covers attributes, frequency distributions, moments, interpolation, least squares, components of time series, co-variance, curve fitting, Pareto curve, biometric functions, binomial schemes and their limits. Also included in the course are distribution problems, correlation, regression and population problems.

In the schools of agriculture and veterinary sciences, a course on statistical computation and biometry is given in the second year along with a course of mathematics. The syllabus consists of arithmetic mean, dispersion, χ^2 , F, theory of correlation and regression, analysis of variance, analysis of time series and index numbers, etc. The course on probability in statistics given to the students of exact sciences includes mathematical analysis and lays stress on probability and theory of inference. The course is given in the third year. A similar course is given under mathematical physics in the University of Eva Peron.

In medical sciences, statistics is taught only to post-graduate students and to doctors. The standard of these courses corresponds in general to the book on medical statistics by Bradford Hill.

The degree course in mathematical statistics of the National University of Litoral extends over three years. The subjects include both theoretical and applied statistics and, in addition, mathematics, political economy, industrial statistics and econometrics. The curriculum is briefly indicated in Appendix A.

There is also a course of public administration statistics and administrative statistics in the University of Cordoba which is open to those who have completed secondary school studies in a national commercial school. The duration is three years and the subjects covered are the following: *first year*: fundamentals of economics; fundamentals of accountancy; mathematical analysis; general economic geography; *second year*: methodological statistics; public law from the economic point of view (the part of administrative law); economics, first course; finance, general course; national economic geography; *third year*: economic geography and social statistics; surveys—rural, urban, industrial and census; economics, second course; finances of Argentina; public accounts. The student has also

to undergo an examination in translation of some of the following languages: French, English, Italian and German.

Methods of Teaching

The teaching in Argentine universities appears to be mostly through lectures supplemented by seminars and practical work. For students of mathematical statistics, there are facilities at the University of Litoral for practical experience in industry as well as agriculture.

Teachers

Statistics has a chair in each of the faculties of economic sciences, agronomy and medical hygiene. The Institute of Statistics, however, has a large complement of qualified staff who are interested in research.

Centralization of Teaching in Statistics, and Co-ordination

Obviously, each faculty in a university has its own teaching arrangements. No information is available on the extent of co-ordination of teaching activities in statistics between two or more faculties in the same university. The Institute of Statistics, although belonging to the Faculty of Economic Sciences at Litoral, functions as an independent department with its own programme of teaching and research.

TRAINING

Training in Universities and Professional Institutions

In Argentina, some of the faculties provide courses to persons in employment. For instance, the Faculty of Economic Sciences of the University of Cordoba started in 1953 a course of statistics for national, provincial and municipal employees. The duration of the course is four months and classes are held daily at which attendance is obligatory. At the end of the course a certificate is given on the basis of an examination. The content of this course lays emphasis on general descriptive methods and applications, census, economic surveys, time series, index numbers, etc.

The Superior School of War and Aeronautics gives courses in statistics and calculus of probabilities at university level.

In 1954, the University of Litoral created a School of Public Administration to meet the urgent need of the Argentine Government to train its officials in the methods and practices of administra-

tion. Public officials can join the higher course of public administration of the school and in this course elementary statistics of a general and administrative kind is taught.

RESEARCH

The Institute of Statistics is the focal point of all statistical research in Argentina. Besides theoretical work a large volume of applied research has been possible. In Gran Rosario two institutions were recently started—the Experimental Centre of Economico-Statistical Research and the Institute of Population. These offer scope for applied research in the Institute of Statistics at Litoral, which is near Rosario. Rosario, the second largest city in the republic is an industrial centre of great importance, and the region is well developed for agriculture and livestock farming. Thus it offers facilities for the application of statistics in industry as well as to agriculture.

CONCLUSIONS

In Argentina, advanced courses in statistics are of recent origin. The first emphasis appears to be on theoretical statistics, the applications side not being well developed. Except for economics, the value of statistical methods in the social sciences has yet to be realized. Medical and engineering schools also have little statistical teaching, although in the Medical Faculty, there are courses on medical hygiene. It is significant that almost all agriculture and veterinary faculties have courses in biometry and statistics.

The position of statistics in Argentina can be seen from the fact that from 1913 to 1952, 3,627 students, and in 1953 about 400, received courses in statistics. The number of students who registered for and completed the *carrera* (career) of mathematical statistics is given in Appendix B. A large number of students appear to leave year after year and only a handful proceed to graduation. Of the 70 who joined in 1948, only 11 graduated.

In 1940, under the auspices of the Argentine Social Museum, the Society of Statistics of Argentina was formed. In its place in 1952, the present Argentine Society of Statistics was created. This has, as one of its main functions, the intensification of studies and research in statistics and collaboration in the realization of the statistics required by the country and also the training of statisticians. This society is assisting in the progress of statistical education in the country by bringing together statisticians in the universities and outside, collaborating with private and public bodies and establishing contacts with outside statisticians.

A P P E N D I X A

Plan of studies of mathematical statistics of the National University of Litoral

FIRST YEAR

Basic subjects of the plan (84 hours each per year): statistics, demographic analysis, algebraic analysis, political economy I.

Auxiliary courses: course of calculus—calculating machines (84 hours), pictorial and graphical statistics (30 hours).

SECOND YEAR

Basic subjects of the plan (84 hours each per year): mathematical statistics, actuarial analysis, infinitesimal calculus and analytical geometry I, higher mathematics I, political economy II.

Auxiliary courses: seminars on census (30 hours), mechanical equipment (84 hours).

THIRD YEAR

Basic subjects of the plan (84 hours each per year): theory of sampling, calculus of probability, econometrics, infinitesimal calculus and analytical geometry II, higher mathematics II, industrial technology, philosophy of the exact and statistical sciences.

Auxiliary courses: seminars on economic sample surveys (30 hours).

A P P E N D I X B

Number of students registered in the mathematical statistics course from 1948-54

	1948	1949	1950	1951	1952	1953	1954
First year	70	54	87	88	114	103	60
Second year	1	33	35	39	65	60	29
Third year	1	..	24	42	42	26	12
Successful candidates				11	9	10	1

AUSTRALIA¹

FACILITIES FOR TEACHING

Teaching Centres: Degrees and Diplomas

Statistics as a university discipline is fairly well established in most faculties in Australia although it was introduced only in recent years. The largest concentration of courses is found under mathematics and, next, economics. Major courses in statistics are not yet common in Australian universities.

Statistics as an undergraduate major can be taken in the University of Western Australia for the B.A./B.Sc. or honours degree. The University of Sydney offers major courses in statistics in the Departments of Mathematics, Economics and Psychology and also in the School of Public Health and Tropical Medicine. Major courses are given in the University of Melbourne by the Departments of Statistics and Economics.

The important centres giving minor courses are the following: University of Western Australia. There is a compulsory course in economic and social statistics for the bachelor's degree in economics and there are also obligatory courses for undergraduates in psychology and agriculture.

University of Queensland. Offers two one-unit and half-unit courses for the four-year mathematics honours; and also a one-unit in the Faculty of Commerce and smaller courses for botany, agriculture, psychology, etc.

University of Sydney. Minor courses for mathematics students.

University of Melbourne. Gives courses in the Departments of Mathematics, Psychology, Education and Agriculture.

New South Wales University of Technology. The School of Mathematics gives compulsory courses to students of food technology, wool technology, civil and electrical engineering.

Perth Technical College. Has courses in applied statistics for engineers, chemists and industrialists; also in descriptive statistics for the diploma in public administration.

1. Based on the following original papers: 'Australian National University', by E. S. Watson; 'University of Western Australia', by A. L. Blaker; 'University of Queensland', by H. M. Finucan; 'Universities of New South Wales', by R. S. G. Rutherford; 'University of Melbourne', by M. K. Belz.

At the post-graduate stage, the Australian National University, Canberra, gives special courses for the research degrees of M.A. and Ph.D. Sydney University has provision for taking mathematical statistics as a topic for the M.Sc. degree in mathematics, and post-graduate courses in experimental design and statistical methods applied to chemistry are available in the New South Wales University of Technology.

In Australian universities, the duration of study for the B.A./B.Sc., degree is three years and for the honours, is generally four years. The curriculum for the honours is different from that of the pass. The M.A./M.Sc. degree can be taken by thesis or by examination and thesis, the period of study for honours graduates being one year.

Careers for Statisticians

There is apparently a large scope for employment for statistics-trained graduates in offices of the Federal and State Governments. For those majoring in statistics, teaching and research offer attractive openings. The report on Sydney University says that the large majority of students taking B.Econ. with statistics enter government service, while the market research firms, banks and insurance companies absorb the greater part of the remainder, but that there is a growing (and unfilled) demand from private business. Professor Belz says that the majority of statistics-trained graduates from Melbourne join the civil service, generally in its various research departments, and that the others are in the research sections of banks. The very small numbers that take all the three statistics courses find employment in the Division of Mathematical Statistics of the Commonwealth Scientific and Industrial Research Organisation or in university departments elsewhere.

ORGANIZATION OF TEACHING

Requirements for Admission

For joining any university, one must be a matriculate. No special mathematical prerequisites are necessary for taking a minor course in statistics. But for an advanced course, whatever be the subject matter field, mathematics (algebra, calculus, etc.) is a requirement and usually a course in mathematics has to be taken before going on to statistics. For instance, at Sydney University, for taking Statistics I, the B. Econ. students do not need any special mathematical qualification, but for Statistics II, they must have completed Mathematics I or had equivalent mathematical training.

Courses in Statistics: Aims, Duration and Content

There is considerable diversity in the courses both at elementary and advanced level in the different universities. Major courses in mathematical statistics are given in the second and third years with a further course in the fourth year for honours.

At the University of Western Australia, Nedlands, the first unit which is available to science students who have passed first year mathematics, consists of about 70 lectures and 50 hours of practical work. This course is essentially of the standard in C. E. Weatherburn's book *Mathematical Statistics*. The second unit is taken by those who have passed or are doing the third year pure mathematics unit; 70 lectures, 20 hours of seminar work and 100 hours of practical work are allotted to this unit, which basically follows A. M. Mood's *Introduction to the Theory of Statistics*. The third unit consists of selected topics from advanced mathematical statistics.

The major courses given by the Department of Mathematics at the University of Sydney follow a similar pattern with an important difference, namely, that it is more theoretical with little place for practical work in the curriculum. In fact, honours students are given two courses on mathematical statistics, one in the third year and one in the fourth year and two further courses in the fourth year on the mathematical theory of analysis of variance and analytical probability.

At the University of Melbourne, there are three main courses for the statistics honours. About 26 weeks are devoted each year with three lectures and three to six practical hours a week. The courses are so designed that Theory of Statistics I may be taken by students in the Faculties of Arts, Science, Economics and Commerce and Engineering; Statistics II by students in arts and in certain science and engineering courses, while Statistics III is intended for students proceeding to honours. There are prerequisite courses in mathematics in the curricula. The syllabus is given in Appendix A.

From the above account it is clear that the major courses in mathematical statistics are designed to train research workers and teachers of statistics, and not statisticians suited for governmental work or business. The courses given to students of economics, however, have the latter objective, although even for them, the theoretical bases are considered quite important.

Taking the curriculum of the courses organized by the School of Statistics in the Faculty of Economics at Sydney University, it is seen that all students take a common introductory first year (three subjects) and that, in the subsequent three years, the students take three successive courses in statistics, three courses in economics, one in mathematics and one further optional subject (which is, in the majority of cases, a further course in mathematics).

Statistics I is designed to provide a broad survey of the main statistical methods used in economics; Statistics II is designed to lay the general mathematical foundation of statistical theory; Statistics III is designed to make the student familiar with latest developments like econometrics. Details of the content of the course are given in Appendix B.

At Melbourne, the Department of Economics gives a basic course in statistics, compulsory for all students in the Faculty of Economics and Commerce. A small number, nearly all honours students, take the further course in mathematical economics. These students will also have taken Statistics I given by the Statistics Department.

The elementary courses given for economics and commerce degrees are of a uniform pattern at all centres, covering mainly descriptive statistics, index numbers, time series, population problems and Australian official statistics. The emphasis on practical and computational work, however, differs, from almost no time to nearly half the total time being allotted to it.

The aim of teaching statistics in courses in psychology is to give students a general understanding of the concepts and practice in applying them. The subject is taught in each of the three years of the pass and four years of the honours course and covers topics like tests of significance and factor analysis. The considerable importance given to psychological statistics is seen from the fact that four courses are given at both Sydney and Melbourne. There is a good amount of practical work in the early stages.

Compulsory undergraduate courses for technologists and engineers at the New South Wales Technical University are given in the second or third year, duration ranging from 30 to 72 hours. At Melbourne, a course called 'statistics for engineers' is obligatory.

'Biometrics' (25 lectures and 25 tutorials) appears in the curriculum for the B.Sc. (Agriculture) students in the University of Western Australia. At Sydney University, two courses in medical statistics in the School of Public Health and Tropical Medicine are given as part of the diplomas in tropical medicine and in public health. In these courses emphasis is laid on applications to epidemiology. The courses for commerce, education, zoology, physics and forestry are elementary ones. It is somewhat surprising that teaching of educational statistics in relation to psychological studies is so advanced.

Post-graduate teaching in statistics does not appear to have made much headway in Australian universities. Though there is provision for the M.Sc. and Ph.D. degrees in two or three universities, no organized courses are yet available. The exceptions reported are courses in experimental design and mathematical chemistry at the New South Wales University of Technology.

Methods of Teaching

The curricula of courses in statistics contained in the Australian reports show the great importance attached to practical work of the laboratory kind, the exercises being taken mainly from the respective subject fields. For courses in mathematical statistics given in a mathematics department, there is limited practical work with calculating machines; the teaching is done mainly through lectures and tutorial. For statistics major courses in economics, the method of lectures and practical training is employed except in Melbourne, where the lecture method is supplemented by tutorial. In psychology, time is equally divided between lectures and practical work.

Usually, essays, written work and seminars are features of advanced teaching at honours level. Post-graduate teaching is mainly through discussions and seminars with some lectures. Individual attention appears to be possible in many centres as the students are very few in number.

There is no indication in the reports of any field work even for those studying economic statistics and survey methods.

Methods of Testing Competence

The method of testing is by written and practical examinations. A thesis for the M.Sc. degree in mathematical statistics is a requirement in the Sydney University. This degree could be taken by thesis alone or by an examination supported by a minor thesis.

Teachers

There are not enough men trained in statistics to teach the subject in Australian universities. This is due to the fact that statistics was introduced into university studies only recently. Several go abroad for advanced training, particularly to the United Kingdom, and return to take up teaching. Still, the mathematical tradition is strong and the mathematics teaching staff gives many of the courses in statistics.

Part-time staff are employed in the University of Queensland for teaching students of commerce and economics. There are part-time lecturers also at Sydney for the courses in mathematical statistics.

Centralization of Teaching in Statistics, and Co-ordination

In only two universities do we find separate departments of statistics. There is a Department of Statistics in the University of Melbourne which has the triple function of providing courses in mathematical statistics, giving practically oriented service courses, and acting as a

consultation centre. This department is responsible for giving courses to engineering and agricultural students and also general courses on statistical methods for research workers and on application of statistical techniques.

The second university is Sydney, where there is a School of Statistics in the Faculty of Economics.

Generally, courses in mathematical statistics are located in the mathematics departments. Economics and psychology departments conduct their own teaching in statistics. Thus, practically, there is no centralization of teaching in statistics anywhere. Each subject department uses its own staff members.

TRAINING

Training in Universities

With the rapid expansion of social services and with a growing economy, Australia is requiring large numbers of statistically trained personnel. An increasing need is felt to providing some training in statistics for persons in engineering and agriculture, and for livestock experts and administrators. At a few universities provision has been made for admitting such persons as part-time students and for giving special courses.

At the New South Wales Technical University, part-time students who are in employment account for more than half the students attending the courses in statistics for engineers and technologists. At Melbourne, there is a sprinkling of employed persons amongst the students. The following two courses are run especially for such groups and cater for graduates in a wide variety of fields, e.g. biology, medicine, physics and engineers: (a) Statistical methods for research workers (30 lectures and 30 practical classes). (b) Application of statistical techniques (teaching is informal and by tutorials and seminars which may extend over three hours a week; practical work consists of six hours of computation together with the prosecution of a special project appropriate to the professional interest of each student).

The Perth Technical College gives a course on applied statistical methods (30 hours lectures and 30 hours tutorials) mainly for industrialists, engineers, chemists and architects. It gives an introduction to statistical concepts leading to quality control and other industrial applications. Another course (35 hours lectures and 35 hours practical classes) forms a first-year unit for the diploma of public administration.

The New South Wales government offers cadetships from time to

time whereby boys leaving school are employed part-time by the New South Wales Bureau of Statistics and Economics and concurrently take the economics courses of the Sydney University. All these courses are open to evening students.

In-Service Training

There is not much information regarding in-service training in government departments, in industry or agriculture. The Division of Mathematical Statistics of the Commonwealth Scientific and Industrial Research Organisation has a wide range of activities and undertakes training of its employees giving them special advanced courses in statistics.

The Sampling Techniques Branch of the Commonwealth Bureau of Census and Statistics arranges lectures and field work for its recruits who are graduates in statistics or in economics including some statistics. The Head of the Branch gives lectures on sampling theory and other members of the Branch lecture on special features of current surveys.

RESEARCH

There are only three or four centres where there is provision for research leading to the M.Sc. or Ph.D. degrees. At the Australian National University, Canberra, one of the functions of the Department of Statistics (which is located in the Research School of Social Sciences) is post-graduate training for M.A. and Ph.D. degrees. Research guidance as well as special lectures in mathematical statistics and statistics in economic and medical research are available. Seminars are held every fortnight. There are at present three students, two for Ph.D. and one for M.Sc. The degrees are purely research degrees.

At Melbourne University, research courses are available for M.A. and Ph.D. degrees, the fields being mathematical statistics and applied statistics; the problems in the latter arise out of outside inquiries seeking statistical advice. There are at present three students. Research requiring statistical methods is carried out in the departments of Economic Research, Commerce and Economics of this university. There are five research students for M.Com. and Ph.D. degrees. The New South Wales University of Technology has one student for the M.Sc. degree.

Teaching is considered more important than research and this partly explains the very small number of doctorates in statistical subjects produced in Australia.

CONCLUSIONS

Statistical education, especially on the applied side, is in an early stage of development in Australia except in two or three important centres. The tendency has been to concentrate attention more on mathematical statistics. Economics and psychology are two fields in which statistical applications are widely taught. The courses given are generally elementary and do not go far enough to include advanced topics in econometrics and psychology.

Statistics in education and sociology have not received adequate attention. There is little scope for students of physical sciences. Applications to agriculture and livestock farming are also not sufficiently covered in the university courses and very often the graduates have to pick up statistical methods while working at some research institution.

Comparing different universities, the importance of statistics as a major subject of study is realized best in the University of Sydney and to a smaller extent in the Universities of Melbourne and Western Australia. There are, however, proposals for introducing major courses in a few other centres, e.g. in the Canberra University College and the New South Wales Technical University.

The present position of post-graduate teaching and research needs strengthening if the growing needs of the country are to be met. More graduates in economics and biology should be induced to continue in the universities for undertaking research in statistical techniques relevant to their subject fields.

The student enrolment for the different courses in statistics is not large. The figures available from the reports from Australia are given in Appendix C. It is likely that all those taking courses in statistics, major or minor, are employed in suitable posts. Persons with degrees in mathematical statistics are finding employment in research organizations. But these cannot fit properly into the statistical offices of the State governments or into commercial and business houses. More commerce and economics graduates trained in statistics will have to be produced.

There appears to be close co-ordination between university teaching departments and research organizations like the Commonwealth Scientific and Industrial Research Organisation, the Commonwealth Board of Census and Statistics. Statisticians from such institutions assist in the teaching programmes of university departments. These in turn give consultative service in statistics. This collaboration is giving valuable results.

APPENDIX A

Curricula and organization of courses in the Department of Statistics, University of Melbourne¹

Theory of Statistics I. Statistics as a branch of scientific method. Graphical representation of data. Frequency distributions. Mean values and dispersion, skewness and kurtosis. Elements of the theory of probability distributions. Theory of sampling. The t , F and Chi-square distributions. Significance tests. Regression and correlation. Analysis of variance. Experimental design. (Two lectures and two practice hours per week which will be extended to three lectures and three practice hours from 1956 onwards.)

Theory of Statistics II. Discrete and continuous probability distributions, univariate and multivariate. Characteristic functions. Derivation of the common sampling distributions. Theories of point and interval estimation. Theory of significance tests. Probability theory. Regression analysis and linear hypotheses. Design and analysis of complex experiments. (Three lectures and six practice hours per week with an essay on a selected topic for honours.)

Theory of Statistics III. (a) Probability theory, advanced theory of estimation and hypothesis testing, multivariate analysis, order statistics; (b) selection from distribution-free methods, sequential analysis, decision functions, sampling techniques, advanced experimental design, linear programming, mathematical genetics; (c) thesis on a selected topic. (Three lectures per week, with practice classes.)

APPENDIX B

Syllabus for the courses in statistics for the Bachelor of Economics degree of Sydney University

Statistics I is designed (a) to provide those students who do not wish to proceed further with a broad survey of the main statistical methods used in economics, and (b) to provide, for those students who intend to proceed with statistics an introduction to the concepts and methods which will be developed more fully in later courses. The intention is primarily to enable students to read, with a sound understanding, statistical results they may encounter in their later work. Students are, however, able to gain some practical facility in applying simple techniques.

The course includes collection of data; tabulation; visual presentation; measurement of central tendency and dispersion; weighted averages and index numbers; an elementary treatment of the decomposition of time series into trend, cycle, and seasonal components; linear regression and simple correlation; a brief introduction to linear multiple regression and correlation (for three variables); an elementary introduction to the methods of sampling and of statistical inference; sampling distributions; the testing of hypotheses and estimation of population parameters; simple problems in the sampling of attributes and of variables; Australian statistical sources.

Students are required to do several exercises during the year, relating to these topics.

1. There are 26 weeks of lectures per year.

Candidates for honours are given extra work, including a more detailed examination of Australian official statistics. The precise nature of this work is determined from year to year.

Statistics II students are required to have taken Mathematics I, or any other special course in mathematics that may be provided before they may enter Statistics II.

The course in this year is designed to lay the general mathematical foundations of statistical theory, though economic applications determine both the choice of topics and the emphasis they receive. It comprises: elementary theory of probability; the standard distributions—binomial, Poisson, normal, Gram-Charlier and the Pearsonian system; the nature and use of generating functions; sampling distributions; sampling surveys in theory and practice; large and small sample theory; the *t*, Chi-square and F tests; multivariate distributions; multiple and partial correlation; the detailed technique of correlation analysis.

Honours candidates are required to examine particular topics in greater detail by means of essays, other written work, and attendance at extra lectures. From time to time special lectures on topics not listed above may also be provided.

The *Statistics III* course is designed to make the student familiar with the latest developments in econometrics. For that reason candidates for the degree in economics are not admitted until they have completed the course in Economics III. Other students are required to show considerable knowledge of recent developments in economic theory.

The topics studied include, but are not confined to: problems of model building and of identification; advanced multivariate analysis, including confluence analysis, principal components, discriminant functions and weighted regression; special problems of time series; the trend, oscillatory and periodic movements; auto-correlation; recent developments in mathematical economics, with reference both to the economic and mathematical aspects.

Honours students are also required to undertake an analytical statistical inquiry.

APPENDIX C

Student statistics, 1954-55

Canberra, University College	
Elementary statistical methods for B. Com.	15 to 20
University of Western Australia	
Mathematical statistics:	
First unit	6
Second unit	5
Sydney University, Department of Economics	
Honours	12
Pass	11
Irregular pass	5
New South Wales University of Technology	
Food technology	7
Wool technology	4
Civil Engineering	35
Statistics in experimental design	20
Statistical methods applied to chemistry problems	70

University of Melbourne, Department of Mathematics

Main course:	
Theory of statistics I	22
Theory of statistics II	3
Theory of statistics III	1
Service course:	
Principles of statistics	6
Statistics for engineers alone	120
Statistical methods for research workers	25
University of Melbourne, Faculty of Economics and Commerce	
Statistical methods	143

BRAZIL¹

FACILITIES FOR TEACHING

Teaching Centres and Courses

In Brazil, the problem of statistical education can be considered at two levels—one, the internal, which consists in professional training in the schools and faculties, and the other, the external, which involves education of the people. There are considerable difficulties in developing the latter as a psychological resistance is reported amongst the people to any innovations or changes in the existing system.

The teaching of statistics in the universities exists mainly in the schools of engineering, agronomy, economics, actuarial and social sciences. There is considerable disparity in the levels of teaching between different faculties and between the same faculty in different universities. The teaching of statistics is not properly co-ordinated with the teaching of other subjects, i.e. its applications in the subject-fields are not carefully thought-out and emphasized. Nor is the mathematics required for courses in statistics properly developed and its teaching is not carefully timed, with the result that the teacher of statistics has often to interrupt his plan of work.

Besides teaching of statistics as an ancillary subject in the schools of economics, actuarial engineering and social sciences, etc., there is provision for advanced teaching in the National School of Statistical Sciences. The objective of this institution is professional teaching

1. Based on an original paper by Lourival Camara entitled 'Statistical Education in Brazil'.

courses of an advanced kind leading to the doctor's degree. These are specially designed to meet the national needs of Brazil; they are adjusted to suit the culture of Brazil and are not patterned on American experience. The courses given at the National School are intended to train professional statisticians who have the degree of bachelor of statistical sciences.

ORGANIZATION OF TEACHING

The requirement for admission is completion of the secondary school course. But the mathematical equipment of students is rather insufficient. Hence, it is suggested that an intensive training in mathematics for at least six months should be given so as to fit them for taking higher courses in statistics. The curricula of the courses for the bachelor's degree would then consist of mathematical formation, statistical formation, statistical applications, and professional complementation.

The mathematical formation is given in the first two years of the course through the following subjects: mathematical analysis, higher analysis, calculus of finite differences, matrix algebra, orthogonal functions and theory of measure.

The statistical formation comprises descriptive statistics, statistical analysis, calculus of probability, statistical probability, statistical inference, experimental designs and techniques of sampling. The applications of statistics relate to demography, agriculture, biometry, industry and commerce. The professional subjects which serve as complementary to the rest are economic geography, analysis of time-series, econometrics, analysis of economic forecasting and constitutional law.

The National School of Statistical Sciences also gives an introductory course of intensive character of one year's duration consisting of the following subjects: mathematics, statistics, mechanigraphy, economic geography and English. Under mathematics are taught elementary algebra, mathematical analysis and analytical geometry, under statistics specially the technique of sampling; and under economic geography aspects of national economy in the light of geographic factors. Mechanigraphy teaches mechanical methods, rationalization and the elaboration of questionnaires and processing of data collected. The introductory course is meant for the scholars of Latin American nations selected by Unesco and the Inter American Statistical Institute.

In Brazil, courses are available for persons who desire to enter administrative posts. These in-service type of courses comprise type-writing (elaboration of tables), designs (graphic representation) and

computations of statistical coefficients such as the average, median, mode and standard deviation. Besides these courses at elementary level, courses are also given, though not regularly, for persons in higher positions. The teaching includes moments, adjustments, distributions, correlation, index numbers and analysis of time-series as well as calculations of demographic coefficients and sampling methods.

Proposals for Improvement

The present bachelor of statistics courses are considered not adequate to fulfil their objectives. It is suggested that some more specialized subjects be included, e. g., agricultural statistics, demographic statistics and industrial statistics. The curriculum will then have a three-year course of mathematics and statistics and a one-year course of specialization. These proposals are reported not to have materialized yet. It is also suggested that statistical teaching should start in the secondary school. The first cycle might cover averages, measures of variability and graphical representation; the second, frequency distributions, moments, curve-fitting and notion of simple correlation. At intermediate level, before entering the higher schools of economics, actuaries and statistics, engineering, etc. the courses should cover compilation of statistics, elements of discrete probability, classical distributions, adjustments (methods of moments, least squares and orthogonal polynomials) correlations (partial and multiple), index numbers, time-series and sampling. At the higher level, there should be two types of course—professional for bachelors of statistical sciences and auxiliary for students in schools of engineering, medicine, agriculture, public administration, philosophy, etc.

CANADA¹

FACILITIES FOR TEACHING

Teaching Centres and Courses

There are about 23 Canadian universities and colleges which give courses in statistics. A breakdown of these courses according to the

1. Based on an original paper by Nathan Keyfitz and J. A. Sawyer, entitled 'Statistics Courses offered in Canada'.

faculty in which they are taught is as follows: mathematics, 40 per cent of total courses given in Canadian universities; economics or commerce, 20 per cent; psychology, 10 per cent; education, 10 per cent; sociology, social work, forestry, agriculture, nursing, biology, engineering, each less than 5 per cent of total.

There does not appear to be a department of statistics in any Canadian university except perhaps in Laval. Statistics can be taken as a major subject only in the departments of mathematics. Two of the largest centres which provide major courses in statistics are the University of Toronto and the University of Manitoba. Both these universities have developed outstanding courses in actuarial science many years ago and from the teaching in these courses statistics has grown.

ORGANIZATION OF TEACHING

The courses in statistics given by the University of Toronto are the following: an introductory course in statistics; biostatistics including tests and elements of experimental design; elementary probability and statistics; a laboratory course in numerical computation; advanced statistics and probability; regression theory and analysis of idioms; a laboratory course in numerical computation with applications to advanced problems in statistics and actuarial science; a course in basic statistical theory and least squares for students in astronomy.

The statistics courses in the University of Manitoba are the following: elementary statistical methods; statistical methods based on the calculus; statistical theory covering distributions, regression; sampling theory and non-parametric methods; statistical methods for research workers; theory of sampling.

A review of the courses given in Canadian universities shows more courses in the departments of mathematics than in any other department. Actually every mathematics department in the country has at least one course in statistics; in general, these lay a rather limited stress on applications and deal with formal development of theory. Those who take these courses are either students of mathematics, or have enough training in mathematics, although they may belong to the fields of biology, economics, etc.

The courses in statistics in Canadian mathematics departments number more than 30. In the departments of economics and business administration, there are about 24 courses in all. These courses are generally elementary time series and correlation, placing somewhat less stress on probability and statistical inference. Following economics is psychology and then education, each with about 10 courses,

and, next, sociology with about five courses. In the natural sciences, courses are given in the departments of forestry, genetics, agronomy, epidemiology and biometrics, zoology and physics. The need for statistics in these specialized fields is of course the main reason why students take such courses, but, aside from this, students are said to be taking these courses as part of general education.

The main centres of teaching statistics in each of the important subjects (i.e. those giving two or more courses) are the following universities: mathematics: Toronto, Manitoba, Mount Allison, McGill, Queen's, Alberta and Saskatchewan (the last university gives four courses); economics: McGill, MacDonald College, and British Columbia (the last university gives four courses); psychology: Toronto and Dalhousie; education: Ontario College of Education; business administration: Institute of Business Administration, Toronto, School of Business Administration, West Ontario.

It is reported that Canadian students prefer to do their advanced work in mathematical statistics in American universities, though Canadian schools, for example, the Universities of Toronto and Manitoba, offer extensive graduate programmes. Post-graduate courses in statistics in applied fields also exist in several universities. The main graduate schools and the subject-fields in which courses of statistics are given are the following: McGill: economics and political science, nursing psychology and social work; Toronto: business administration, economics, biometrics, zoology and public health administration; West Ontario: mathematics and physics; Manitoba: actuarial mathematics and statistics; Saskatchewan: business and farm management. A few other universities, even though they have no graduate schools, give advanced courses in statistics, for instance Queen's University, Universities of Alberta, McGill and British Columbia.

TRAINING AND RESEARCH

No information is available on in-service training in Canada. The Dominion Bureau of Statistics had certain courses for persons in employment, but perhaps they are now discontinued. Professional societies, such as the American Society for Quality Control, have limited training programmes.

There is no outstanding centre of research in statistics in Canada, although research work in mathematical statistics is conducted in some universities. Outside the universities, there is the Summer Study Group in economics, which has been held at Kingston University for the past three years and a similar group in mathematics held at the same centre. It is common for anyone seeking a research degree to go to the United States or the United Kingdom.

CEYLON¹

FACILITIES FOR TEACHING

Teaching Centres and Courses

In Ceylon there are not many statistically trained persons to meet the demands of government and business. There are very limited facilities for training men to fill even junior statistical posts. The University of Ceylon and the Ceylon Technical College are the two centres where courses in statistics are given.

At the University of Ceylon an elementary course in statistics is required to be taken by all students majoring in economics for the bachelor's degree. A further course is given to those who select statistics as a special subject. The elementary course is given during the second and third years of the four-year curriculum. The special course comes in the third or fourth year and is taken by not more than six or seven students.

ORGANIZATION OF TEACHING

The syllabuses are similar to those of the corresponding courses at London University. For the special subject, mathematical statistics, economic and other applied statistics are covered. A course in mathematics is also required. Besides laboratory practicals, some experience in collecting and tabulating statistical data is provided through several weeks of work in the Government Department of Census and Statistics.

In the Department of Mathematics there was teaching for a separate 'paper' for the B.A. which has since been discontinued. In 1955 statistics was to be introduced as a special subject for the B.Sc. degree upon the return of two members of the department after studies abroad.

There was no full-time staff devoted to statistics in the Economics Department till 1954. The Director of Census and Statistics and the Economist in the Division of Economic Research of the Central Bank were participating in the teaching programmes assisted by one or two

1. Based on an original paper by Hildegard Kneeland, entitled 'Statistical Education in Ceylon'.

lectures in economics. The position regarding staff must have improved now.

In the Ceylon Technical College there is a four-year course leading to a diploma in commerce and another three-year part-time evening course leading to a diploma in accountancy.

The curriculum for the diploma in commerce includes obligatory courses on statistical methods and their application to business. These are given in the second and third years with two hours a week allotted to them. During the fourth year, an additional course in applied statistics is taken by students who specialize in industry and trade.

The diploma course in accountancy is open to persons employed in accountancy, auditing or similar work in business establishments or in public offices. Applicants for admission must hold the senior school certificate or its equivalent and must pass an entrance examination. During 1952-53, 115 trainees were admitted. In the curriculum for the diploma in accountancy, a course in elementary statistics is given to all students during the second year. There are one or two full-time teachers and also some assistance is given by the Director of Census and Statistics.

During 1952, the Director of Census and Statistics arranged for a four-month course of in-service training in the elementary statistics employed in government offices. About 40 persons attended the first term. The programme included two or three lectures per week and an additional three hours of practical work adapted to meet individual requirements. It was proposed to increase the duration of training to six months and also to add a second course to those who have completed the first course.

CONCLUSIONS

The position of statistical education in 1953, as reported by Miss Kneeland, does not appear to be satisfactory. There was no department of statistics and no teaching at post-graduate level even in the Faculty of Economics. Neither mathematical statistics nor applied statistics was taught anywhere at intermediate or advanced level. The main difficulty was staff. The position may have improved after the return of several teachers who had been sent for advanced studies abroad. It was hoped that a department of statistics would be set up and that this would also look after the teaching in various departments of the university. With the shifting of the university from Colombo to Peradenya, the part-time assistance given by the Director of Census and Statistics and other government officials may not be available.

There is an urgent need to provide evening courses in Colombo for employees in government offices and business houses. The university, which is now located outside Colombo, cannot be expected to organize such courses. The Ceylon Statistical Society, inaugurated in 1953, can perhaps undertake such training. It is reported that a committee of the society has drawn up schemes for a diploma course in statistics (four years' duration) and also at an elementary level, for computers and field survey training.

EGYPT¹

FACILITIES FOR TEACHING

Historical Survey

The chief centre for teaching statistics in Egypt is the Cairo University, formerly called Fuad I University. Established in 1908 as a private college, it was transferred to the government in 1923 and has since expanded, incorporating certain specialized schools. It now has nine faculties with a total enrolment of about 25,000 (1953-54).

The two other government universities which provide teaching of statistics are the Ibrahim University, established in Cairo in 1943 by the expansion of the former Higher Institute of Financial and Commercial Studies, and the Alexandria University, founded in 1942 as Farouk University. The American University at Cairo, founded in 1922 as an independent institution supported by private funds and with an enrolment of about 900, also provides some undergraduate teaching in statistics.

Teaching Centres: Degrees and Diplomas in Statistics

None of the universities offers a degree in statistics. The subject occurs as subsidiary to other main subjects. The Faculty of Commerce at Cairo University teaches statistics to undergraduates in

1. Based on an original paper by Hildegard Kneeland entitled 'Statistical Education in Egypt'.

commerce. It is an obligatory subject for M.Com. students taking economics. There is also provision for specialization in statistics at the post-graduate level. The B.Com. and M.Com. degrees require study for periods of four and two years respectively.

The Institute of Statistical Studies established in 1948, primarily for government employees, awards after two years of study, a diploma in statistics to persons holding a bachelor's degree regardless of the nature of their undergraduate training. There is some statistics in the curriculum of the Institute of Insurance.

In the Faculty of Science, Cairo University, the Mathematics Department includes some statistics in its courses. In the Faculty of Law a course in statistics is given as part of the requirement for the diploma in economic studies which is open to bachelors of law.

At Ibrahim University, statistics is taught to undergraduates in commerce specializing in economics and to post-graduates in economics. The Faculty of Commerce at Alexandria University offers some elementary courses in statistics.

The Division of Extension of the American University offers the B.A. degree in social studies, after three years of study. It is open to persons in employment. The curriculum includes a compulsory basic course in statistics, and additional training in the collection and analysis of statistical data in connexion with courses on methods of social research, population problems, etc.

Some training in statistics is given in two schools in Cairo under government supervision—the Higher Institute for Social Studies and the School of Social Service. The duration of training is four years and diplomas are awarded.

Careers for Statisticians

There is a great shortage of qualified statisticians in Egypt and persons who have studied some statistics in their economics courses find employment in junior posts in government offices and business concerns. The few receiving post-graduate diplomas and degrees take up responsible statistical careers.

ORGANIZATION OF TEACHING

Requirements for Admission

For admission to the bachelor's course, the secondary school certificate is necessary. At Cairo University only those who specialize in literary studies or mathematics are admitted, the latter are required for the compulsory course in elementary statistics. To do further

work in statistics, the students should choose pure economics in the B.Com. course.

For the B.A. degree in social studies of the American University, the conditions for admission require at least two previous years of university work and a good command of English.

Courses in Statistics: Aims, Duration and Content

For the B.Com. at Cairo University, the student makes two choices after his second year of study: (a) between commerce and economics, and (b) within commerce, between accountancy and business administration and within economics, between pure economics and political science. All the students in the third year have to take an elementary course in statistics. Both statistical methodology and applied statistics are covered. In the fourth year, those taking pure economics have an advanced course in statistics which includes probability, time series and further work in applied statistics.

At Ibrahim and Alexandria universities there are courses in statistics for undergraduates organized by the faculties of commerce, the standard being similar to that at Cairo University.

Details are not available of the courses for the M.Com. degree at Cairo University. Some statistics is required for completing the Ph.D. degree in the Faculty of Commerce at Ibrahim University.

At the American University, statistics is taught in the third year of the social studies course. The emphasis is mainly on sociological applications. About 120 students are admitted, most of whom are employed in social work, teaching or government service.

No information is available about courses in statistics in the mathematics and science departments of the universities.

Methods of Teaching

A special feature of Egyptian universities is the large number of students attending each class. For undergraduates in the commerce faculties it is of the order of 500: the reason is the great deficiency in staff. The specialization classes, like those in pure economics, are however small—about 20. Seminars or discussion classes are out of the question. The only method of teaching compulsory statistics is by lectures. Individual teaching is hardly possible even for M.Com. students.

There does not seem to be much practical training to supplement lectures in statistics. There is a great shortage of calculating machines.

A few textbooks in Arabic are published, on which students mainly depend. Advanced students use books in English and French.

Methods of Testing Competence

In view of the very large numbers, the only method available to the teachers and university authorities for testing students' competence is the annual written examination.

Teachers

There are very few qualified teachers of statistics in Egypt. To recruit statisticians, the usual method of sending promising young men abroad for advanced studies is followed. But the demand in government departments is so great that only a few go in for teaching.

TRAINING

Egypt has recognized the urgent need to provide training facilities for persons who require statistics in their professions. The Institute of Statistical Studies was established in 1948 with the primary object of providing training for those already employed in statistical work in the Ministry of Finance and other government offices. There is a two-year diploma course open to all persons with a bachelor's degree. About 12 lectures a week are devoted to statistics in the curriculum.

The classes are held in the afternoons after government and business offices close. During 1953, 1,950 were admitted in the first year, but only 70 attended regularly; of these 45 took the examination and only 20 passed. For the second year's work about 40 were enrolled but only 15 passed the final examination. Recognition is given to the diploma for promotion in government departments.

The Institute of Insurance provides a two years' study leading to a diploma. Admission is open only to those holding bachelor's degrees in commerce or science. A course in statistics is required during the first year; two hours a week are devoted to it. In 1953, 20 students joined the first year.

The Association of Statistical Research was established in 1939 for the purpose of giving practical experience in planning and carrying out statistical surveys. Undergraduate students in the Faculty of Commerce at Cairo University could receive training through this association.

The Social Research Centre of the American University, started in 1953, has a three-fold objective: (a) to collect and analyse data indicative of trends in social phenomena in the Middle East; (b) to train Egyptian and other Arab students in techniques of social research; and (c) to encourage, guide and help to finance social research projects in the area. This centre has trained a good number of Egyptians in socio-economic and demographic surveys.

RESEARCH

Recently some provision has been made for research for the Ph.D. degree in the Faculty of Commerce of the Cairo University. But by 1955 no student had in fact taken up research. Further information is not available.

CONCLUSIONS

The numbers receiving statistical education at the elementary level are fairly large and this is an advantage for building up an effective introductory and advanced system of training in statistics. But the weakness in basic training in arithmetic and the antipathy of most of the students towards mathematics are reported to be obstacles in the way of establishing major courses of study in statistics.

Some advanced courses are available, mainly to those taking pure economics, and it should be possible to introduce further specialization in sampling, econometrics, national income and social accounting. Statistics in other social fields, such as psychology, education, population studies, needs greater emphasis and suitable courses should be given in those fields. Likewise, modern statistical techniques of agricultural experimentation, crop surveys, etc., would be useful for graduates in agriculture and for agricultural research workers.

The main obstacles to the development of the educational programme are lack of adequate funds for providing teaching staff and laboratory equipment, and lack of statistical literature in the Arabic language. At present little opportunity is given for practical training in university departments, owing to the lack of desk calculators and other equipment. The position with regard to books is slowly improving, with the assistance of the International Statistical Education Centre at Beirut.

With regard to teaching staff, until advanced and research courses are under way, a sufficient number of competent teachers will not be available. Outside assistance would be of great value.

The present teaching seems neither in method nor in content to be well suited for professional work in government departments—where the largest demand exists. Steps must be taken to give the students a real feeling for live data, to make them actually participate in the collection, compilation and analysis of statistical material, and to make them familiar with the system of official statistics in Egypt. A field type of training will have to supplement classroom teaching for most courses.

In the government statistical offices there are at present a large number who have received no formal education in statistics, but who

require a knowledge of general statistical methods. Arrangements for in-service training are urgent.

FRANCE¹

FACILITIES FOR TEACHING

Teaching Centres: Degrees and Diplomas

In France, the teaching of statistics, in all its various aspects, is done mainly at the following two institutions in Paris: the Institut de Statistique de l'Université de Paris (Institute of Statistics of the University of Paris), founded in 1923, and the École d'Application de l'Institut de la Statistique et des Études Économiques (School of Instruction at the National Institute of Statistics and Economic Studies), founded in 1942. These two organizations, although differing from each other as to courses of study, objectives and fields covered, work in a completely co-operative spirit.

The Institute of Statistics is under the administration of the faculties of the University of Paris. Its aim is the teaching of statistical methods and their application to all fields where problems exist. The institute awards a *certificat d'aptitude* (teacher's certificate) after a year's study and a *diplome de statisticien* (diploma in statistics) at the end of two years' study.

The Institute of Statistics in 1952 created the Centre de Formation des Ingenieurs et Cadres aux Applications de la Statistique (training centre for engineers and staff on the applications of statistics). Its principal object is to bring together business executives who are interested in the large range of industrial applications of statistics.

The School of Instruction of the National Institute of Statistics and Economic Studies has as its objective the training of statisticians for public and private organizations including their own staff. It gives a two-year course for *ingénieurs-statisticiens* (qualified statisticians) and a one-year course for *statisticiens-adjoints* (statistical assistants).

In addition to these two main organizations, there is a long-standing tradition in French universities of teaching statistics in the faculties of law, science, medicine and pharmacy.

1. Based on an original paper by E. Morice, entitled 'Statistical Education in France'.

In France, university teaching in economics is given in the law faculties. Instruction in statistics (general study and applications to economics) now exists in most law faculties. The *Doctorat ès sciences économiques* (doctorate of economic sciences)¹, created a few years ago, includes an obligatory examination in statistics as part of one or other of the preliminary higher diplomas (political economy or economic science). The reorganization of studies for the *licence* (first degree) has introduced since 1955 a specialized degree in political economy including in the third year obligatory instruction in statistics and methods of observation. Courses on demographic statistics are also given at the universities of Paris, Nancy, Bordeaux and Algiers.

In the faculties of science of the universities of Paris, Lyons² and Bordeaux courses are available in the theory of probability and mathematical statistics corresponding to a certificate which counts towards the degree of *Licence ès science*. Courses at different levels are also available; they deal with statistical applications in a specialized field of study or are complementary to courses in mathematical analysis or in various scientific disciplines.

In the faculties of medicine and pharmacy, the teaching of statistics is not well developed. At Paris, Rennes and Bordeaux there is provision for some teaching in medical and biological statistics.

In addition to the universities, the *grandes écoles spécialisées* (specialized schools) in France include statistics in their courses. It is expected that this teaching will be expanded in most of these schools. In Appendix A a list is given of some schools (as in 1955) with the statistics courses offered. They may be classified as technical schools, engineering schools, schools of economics and social sciences and schools of business administration. The teaching of statistics has recently been included in the first year classes of technical colleges.

ORGANIZATION OF TEACHING

Requirements for Admission

For admission to the courses leading to the certificate of higher studies of probability theory and mathematical statistics in the

1. The doctorate of economic sciences can be taken by the holder of the first degree of *licence* completing successively the higher diploma in political economics and the higher diploma in economic science and finally submitting a thesis.
2. The Centre of Mathematical and Physical Studies of Beirut (Lebanon) which is attached for examination purposes to the Faculty of Science at Lyons, has organized the preparation of a certificate of mathematical statistics.

faculties of science, a student should have completed the higher studies for the *licence* in mathematics. For courses of statistics for the diploma in political science or the diploma in economic science, some mathematical prerequisites are necessary but usually the standard of mathematics of the students is weak. In only a few centres, for example at the Institute of Statistics of the University of Paris, is adequate preparation in mathematics given.

Courses: Aims, Duration and Content

The courses offered at the Institute of Statistics for the certificate and diploma students are the following (the number of lectures is given in parentheses):

Obligatory courses. Elementary statistical methods—descriptive statistics (20); statistical analysis (30); practical work (12 classes). Theory of probability (25); mathematical statistics (25); practical work (25 classes). Machine methods; general principles and punched card machines (20).

Optional courses. Demography and vital statistics (25); economic and social statistics (25); econometrics (25). Statistical methods applied to biology and agricultural experiments (20) and practical work. Statistical methods applied to business management (20); to techniques and research in industry (20); to medicine (20) and practical work in econometrics (10). Factor analysis (10). Mathematical genetics (10). Statistical methods applied to life assurance (20) and to accidents and injuries (20). Agricultural statistics (10).

Other courses. Mathematics (matrix algebra); general economics; accountancy and analysis of balance sheets; mathematical theory of financial operations.

The School of Instruction of the National Institute of Statistics and Economic Studies gives courses in statistics which are compulsory for all students. Those studying for the two-year diploma in statistics attend some of the courses at the Institute of Statistics of the University of Paris (theory of probability, mathematical statistics, demography, economic and social statistics, econometrics) for which supplementary practical work is arranged. In addition to these, the students attend a certain number of courses in theoretical and applied statistics organized by the school. These are: machine methods; theory and practice of sampling; applied statistics; statistical analysis of time series; theory and measurement of productivity; economic models; economic analysis of trade cycles; national accounts; sociological statistics. There are also various courses in the following subject-matter fields: economic theory, descriptive economics and foreign languages.

The students taking the course for statistical assistants follow a

syllabus similar to the preceding one. In addition to statistical methods and machine methods, the applied subjects covered are demography, price, production and trade statistics, agricultural, social and financial statistics. These courses which are accompanied by ample practical work, are rounded off by courses in mathematics, political economy, economic geography and foreign languages.

In the law faculties, statistics studied under the curriculum for the diploma in political economy or in economic science is of an elementary standard as the students' level of mathematics is low. The teaching includes a large descriptive section (observation, collection of data and presentation), indices, statistical series, correlation and elements of statistical forecasting. As a specimen, the syllabus of the compulsory course entitled 'statistical techniques' for the diploma of economic sciences in the University of Lyons is given in Appendix B.

For students of science in the science faculties, there are courses in probability and mathematical statistics and application to such sciences as biology, psychology, physics, etc. A large part of the teaching is devoted to probability. The courses are briefly indicated below:

Paris: lectures in statistics as part of the course on genetics.

Dijon: course of statistics for the benefit of biologists (25 hours).

Rennes: course in mathematical methods in physics comprising elements of probability theory and mathematical statistics.

Strasbourg: course on probability theory and mathematical statistics obligatory for candidates for certificates in theoretical physics and advanced astronomy (25 hours).

Algiers: course on probability theory for students in theoretical physics; course of statistics as part of the studies for the certificate of psycho-physiology (15 hours of lectures and 25 classes of practical work).

Toulouse: course on probability theory and statistical methods as part of the certificate of applied analysis (25 hours).

Grenoble: course of statistics; applications to technology (quality control), to physics and number theory (stochastic estimates).

In the faculties of medicine and pharmacy the following courses are given:

Paris: the course on medical physics includes a few lectures on statistics. In addition, there is a course on statistics applied to medicine at the Institute of Statistics of the University of Paris, the course on mathematics, preparatory to the applied sciences, includes about ten hours devoted to probability theory and mathematical statistics.

Rennes: elementary statistical teaching as part of the course on medical physics.

Bordeaux: course on statistical methods in biology (12 lectures).