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ALFRED WATSON MEMORIAL LECTURE

MODERN STATISTICS IN BUSINESS AND COMMERCE

THE following is the full text of the seventh Alfred Watson Memorial Lecture which was delivered on 27 February 1956 by **M. G. Kendall, M.A., Sc.D.**, Professor of Statistics at the University of London.

INTRODUCTION

WHEN I graduated in mathematics in 1929 there were, broadly speaking, only two careers open to me. Either I could enter the Civil Service, which was tantamount to giving up mathematics altogether; or I could teach mathematics at school or university, which was tantamount to giving up the use of mathematics in a practical sphere. A few brilliant students had a third possibility—of staying up and doing research; and some of the applied mathematicians found their way into laboratories or observatories. But on the whole we mathematicians were a drug on the market, and if any of us thought of going into business or commerce it was on the strength of our general personality and intelligence, not on our mathematical qualifications, which would have been regarded by many employers in those days as a negative asset.

At that time there were no degrees in statistics except at University College, London; and if there had been, the situation for a theoretical statistician would have been much the same. A few enlightened firms and trade associations, even in those days, found it worth their while to employ graduate statisticians as such at something above the clerical level, but the opportunities offered to the young graduate were so rare and so special that statistics was not a career so much as an accident of employment.

Contrast this situation with that of the present time, twenty-five years later. Mathematicians and statisticians are now at a premium. Many of my students who are not liable for military service seem to get jobs even before the results of their examinations are known, and I believe this is a fairly common experience. The pull from industry and commerce is, in fact, so great that we have difficulty in recruiting to the teaching profession. Some of this is due to the general full-employment situation in which we have been living since the war; and some of the demand comes from the technological side of industry, with which I am not primarily concerned in this lecture. But, even when we discount these other factors to the full, it remains true that over the past fifteen years there has been a most remarkable increase in the intake of statisticians and actuaries into business and commerce. I see no signs of a slackening in the demand. It seems a fair inference that business and commerce feel that they are getting value for money. It is, in short, accepted that the statistician has a part to play in the commercial enterprise, and it is that part which I am proposing to discuss.

Statistics in the sense of the science of handling and summarizing numerical data is, of course, a routine part of the administrative control of almost any business. It may involve little more than elementary accountancy and the day-to-day handling of records and market information—punctuated perhaps by occasional imaginative flights, as when notes are required for the chairman's speech at the company's annual general meeting. For a firm of any

size, especially with a retail market, the sheer volume of this routine work may itself raise theoretical statistical problems, to some of which I shall refer later. But, by and large, this side of the company's activities does not call for statistical powers of a very high order. It is what many business men understand by statistics and it is undeniably important. But it is not what I am proposing to talk about. I want to consider the contribution which the statistician can make, by virtue of his theoretical training, his habits of thought, and his way of going to work, to the organization, control and development of the commercial enterprise.

THE STATISTICIAN AND HIS WORK

Let us, first of all, get some idea of what sort of being the statistician is, and what kinds of things he does. There is a very objectionable, but very revealing, expression sometimes used by business men in referring to professional help which they receive: 'I have', they will say, 'a tame statistician (or a tame mathematician, or even a tame economist) to do certain things for me.' What they mean is that their own experience is so wide and their own judgment so sure that they need only subordinate help on matters of comparative detail such as finding out facts; and, moreover, that it is unsafe to allow much freedom to their amanuenses because, left to themselves, such persons produce wild and woolly ideas which are quite capable of wrecking the business. Not all business men, by any means, take this view. Some of them will admit that professional workers occasionally throw up ideas which are worth considering, provided that they are allowed to do it in a back room. The attitude reflected in the phrase, however, is clear enough. One may draw on the statistician's technical knowledge but not on his general judgments.

This would be rather annoying if it were not so often justified. The arrogance of the man who will back his judgment at all costs against the obvious facts is matched only by the arrogance of the man who will back the obvious facts at all costs against his judgment. It is for this reason that many teachers of theoretical statistics lay such emphasis on the importance of practical work. A training in mathematics or in mathematical statistics engenders, among our weaker brethren, a feeling that what they do must be right, because it *is* mathematical, and that anyone who refuses to accept conclusions based on these unassailably exact modes of reasoning must be either stubborn or stupid. There are few, if any, such characters in business, because it has the power to purge itself very rapidly of self-inflated elements. But there are a number of them elsewhere who have yet to learn the virtue of humility and they do not enhance the reputation of the profession as a whole.

The true place of the statistician in business lies, I think, between the extremes. He is not a hack whose duty it is to devil for more enlightened minds; neither is he an adept of some mysterious cult which gives him secret keys to all the problems which confront the business man. To use a statistical concept, I would say that the statistician has no single place in business, but a distribution of places. In some he is little more than a clerical assistant; in others he both collects and interprets facts; in others again he may control development policy and even create it; and finally there are always a few gifted individuals who can rise right to the top of a business, the late Lord Stamp being a case in point.

The statistician's way of going to work may be very briefly described as trying to see wood for trees; that is to say, trying to get some sort of control over large aggregates by reducing them to order. Everything in statistics ultimately stems from this, but some of it branches out so far that the primary trunk may be lost to view. For example, the necessity for controlling error in numerical results and of measuring their precision implies that the statistician has to spend a great deal of time on the design of enquiries. Again, it is part of the statistician's work to formulate judgments in a quantifiable way and to quote the odds in favour of success in following alternative courses of action. The technical way of putting this is to say that he develops a branch of scientific inference in terms of the theory of probability and of statistical aggregates in order to make statements of an uncertain kind with measurable precision. You could also say that he runs a book against the universe. Neither form, perhaps, is very suitable for explaining his activities to the business man. One is not concrete enough and the other is not discreet enough. Perhaps a fairer way of expressing it would be to say that the statistician tries to condition judgments in a scientific way. There is a story of an individual who, when asked whether he was sure about something, replied that he was so sure that he was willing to swear to it in a court of law; but he added that he wouldn't like to bet on it. That man had the making of a statistician, who is a practising probabilist, and not only has to measure the probability of success, but stake something on his calculations.

The true statistician is an extrovert, an experimental scientist, who is concerned to discuss truth in the external world. But he has, in his background of theoretical training, a very substantial amount of mathematics and, as many of you will know, there is a natural distrust among business men of a man who who thinks in mathematical terms. This is due to the fact that there are two distinct types of men who are known as mathematicians. One type uses mathematics as a tool in his assault on knowledge—the greatest mathematicians, such as Newton and Gauss, were of this kind; the other uses mathematics as a form of escape and builds a world of his own without any reference to realities. I do not know how far actuaries encounter this distinction, but it is apt to be carried over into theoretical statistics. There is the theoretical statistician, who is primarily concerned to solve a practical problem, and brings out his technical expertise only when necessary to do so; and there is the theoretical statistician, who is mainly concerned to do mathematics in a statistical language and is interested in organizing his own ideas, not in the patterns of events. Both types, I hasten to add, may do useful work and I should be the last to criticize the use of mathematics as an escape mechanism. But the distinction is very necessary when we are considering theoretical statistics in business. Admirers of Nigel Balchin's novels may remember an incident in *A Sort of Traitors* in which the hero, tired, ill, dispirited and crossed in love, turns for consolation to the first volume of Kendall's *Advanced Theory of Statistics*. This is undoubtedly one of the most poignant moments in contemporary literature. I am sorry to have to add that he does not find it there, but I think Mr Balchin's judgment on the psychological point is sound enough. A man for whom mathematics is an instrument of inquiry may have great contributions to make to business and commerce; a man for whom they are an escape may be a complete failure. It would be useful if we could set up a criterion to distinguish the two types, for the benefit of prospective employers; but this is a problem I must leave to the psychologists.

Following these generalities about the statistician and his ways, I suppose the proper thing to do would be to survey the whole field of business and commerce and to point out where there is scope for his activities. Apart from the fact that I have no qualifications to attempt such a survey, I think that it might very possibly bore you. It would certainly bore me. Instead, I propose to pick out a few topics for discussion as typical of the general situation. Every business has its own problems and, in my own limited experience, the statistician can often make useful contributions towards solving them. But many of them are specialized, and, so far as I can on this occasion, I want to speak of methods which are of fairly general application.

SAMPLING AND FACT-FINDING INSIDE THE BUSINESS

Let us first of all consider the problem of finding out what is going on *inside* a business. For a large concern this is quite a serious problem. Something is known by everybody, and everything is known by somebody, but most people would agree—and I do not say this in any critical spirit—that it is sometimes very difficult to obtain an overall view of some particular aspect, especially at short notice. Systems of factory and office organization can cope up to a point. But for an organization of considerable size they may defeat their object, partly by accumulating a large volume of expensive clerical staff and hence adding to the overheads of the business, and partly by getting themselves snowed under with records which no one ever has time to analyse. Only too often the main criterion which is chosen to measure the efficiency of the business is the margin of profit in the balance sheet.

Now this is precisely the kind of situation with which a statistician is trained to cope. He does not try to look at everything. His technique is to find out what is wanted by looking at as little as possible, that is to say by taking a sample. For this reason a large part of his training is concerned with sampling techniques and the reliability thereof. It is simply not true that a statistician in business spends his time urging people to provide numerical information. A lot of his time is spent in trying to persuade them not to collect information, or at any rate not to collect unnecessary information; and hence he endeavours to cut down records, to simplify forms, to avoid the duplication of effort, and to persuade management to rely on intelligent sampling instead of on complete censuses and enumerations. The statistician does not, in spite of a general impression to the contrary, revel in a mass of figures. Nothing pleases him more than to be able to give the relevant information without collecting a mass of figures. He is, so to speak, an economizer in numerical information.

This capacity for collecting representative information on a sampling basis gives him, very often, a kind of roving commission inside the business. He does not merely analyse figures which come in by routine; he goes out to collect information and to report on matters which would normally escape notice. At any moment he may be asked to find out, for example, what is happening to stocks in local branches; why the labour turnover figures are giving anomalous results; whether the accident rate is affected by the installation of new machinery; whether recruits from one type of school do better than those from another; where the bottlenecks are and why they are there; and a host of other things. And, what is often a most material point, he is asked to find out quickly.

An employer who was listening with a jaundiced ear to what I was saying might well observe that all these things were being done constantly in a firm with any pretensions to efficiency and that he did not need a statistician either to run his business or to teach him how. Up to a point he would be right. But only up to a point. Apart from the consideration that fact-finding is almost a profession in itself, there are in theoretical statistics certain habits of thought which are not common in commerce and which, when brought to bear on commercial situations, may throw some entirely new light on them. The idea of a frequency distribution, for example, is as fundamental to problems of absenteeism as the life table is to problems of pension schemes. The idea of probability is as necessary in quality control as the idea of sales resistance in marketing. Some business men evolve these ideas for themselves. Nearly all business men understand them when properly explained. But this does not affect the general thesis.

Perhaps this is as good a stage as any to make two general points about the statistician's work. How much knowledge of theoretical statistics does a man need in order to do a practical statistical job? I do not propose to try to answer this in detail, but a short answer is: more than you might think. Like many professional men, such as lawyers and accountants, statisticians may have behind them a large body of detailed training and expertise which is only called into play comparatively rarely. But it is not on that account unimportant. It gives an invaluable background to judgments and procedures. A good deal of the success which statisticians have in tackling business problems is not that they think of new ideas but that they think of the old ideas in a new way.

The second point is a kind of converse to the first. Numerical examination and graphical presentation may themselves, without any appeal to advanced concepts, bring about a marked improvement in the efficiency of a process. They may not settle an argument but they focus it. For example, since the war we have seen an enormous expansion of what is generally termed quality control. A few years ago I was taken to see the famous Ford production line at Detroit, and while going round the factory was gratified to see control charts everywhere. I was told that there had been some resistance to the introduction of quality control but that in the first year of trial it saved the company a million dollars. This being money, even to the Ford Corporation, quality control from then onwards was a highly favoured activity! Now quality control is indeed a statistical method, but comparatively speaking a very elementary one; its success, which is undeniable, is due, I think, mainly to the fact that it draws a picture (literally) of what is happening and makes people think about what they are doing. It is really very striking how often one can surprise oneself by watching what one is doing. We do not need an elaborate example from the business world to demonstrate this; everyone who has ever tried to keep detailed records of his personal expenditure over a period will be familiar with the shocks which that process entails.

I have spoken of the discovery of facts about the actual business process, by way of illustrating the first main task of the statistician. The field covered by the fact-finding and interpretative aspect of his work is, of course, much larger. Apart from the production and management of his firm, he may have to look backwards to the supply of labour and raw materials and forwards to its marketing points at home and abroad, with a weather eye on trade generally and competitive trades in particular. There is scarcely any pie in which he may

not be invited to put a finger; and this enables me to make another general point. Statistics is not, or at least need not be, a dull profession. It requires patience and persistence, but anyone with an inquiring mind is never short of problems which challenge his imagination.

PREDICTION AND STOCHASTIC PROCESSES

I proceed to the second main class of statistical duties, those of forecasting and predicting; the problem, not of finding out what is going on, but what is likely to be going on in months to come—a problem with which actuaries are very familiar in such things as vital and financial statistics.

I have here to admit that among the large volume of nonsense which has been written about prediction, the contribution of statisticians has, in the past, been outstanding. The reason is fairly plain to see. When we graph a happening over a period of time it often presents an appearance of regularity. The mathematician leaps at this and tries to fit functions to the data, which is often a sensible thing to do, and then to use those functions to extrapolate beyond the range into the future, which is often a nonsensical thing to do. To be fair to him, we should concede that he is only doing systematically what many people do intuitively and that he is at least no worse than the intelligent guesser. The drawback has been that as a general rule he has been no better.

This was the situation until about 1930, when it finally dawned on statisticians that in the world of economics—and in many other spheres which are outside the scope of this discussion—progress was not deterministic but contained an essential element of chance. The failure of observation to fit mathematical functions was not due to inaccuracy in our measurements but to some chance elements in the mechanism of the system under observation. This led to the formation of what is now known as the theory of stochastic processes, that is to say, of processes which pass through a series of states, proceeding from one state to the next according to the laws of probability, not to deterministic laws. As so often happens, we then found that we had been living all our lives in stochastic processes without realizing it. For example, congestion problems in manufacturing, the delivery of materials and so forth are stochastic processes; like traffic problems, they depend on the fact that a good deal of what occurs during the life of a phenomenon does so at random. Reactions of demand to supply, of capital investment to changes in interest rates, of markets to controls, are in the nature of stochastic processes; there is in them an element of deterministic relation intermingled with unforeseen random occurrence. I believe that the whole of the classical theory of economics can be expressed in terms of stochastic processes, and I should expect to find that a good many of the prediction problems which arise in commerce and business are really stochastic in nature.

In one way this is entirely as it should be. The word 'stochastic' derives from a Greek word meaning a marksman, one who has a shot at something; and in the predictive side of statistical work two thousand years later we use the same metaphor as the Greeks: we have a shot at it. Anybody can do so, and most people do. But the statistician has two advantages over the average man; first of all he has had some training in marksmanship; and secondly he knows, or tries to find out, how accurate his weapon is, so that he can tell how near he is likely to be to the truth.

The theory of stochastic processes, like other branches of statistical theory, has not yet solved a lot of the problems which it sets out to attack. But it can tell us, sometimes, how far a solution is possible and where to look for it, or it can tell us how doubtful any answer is bound to be. This last may sound a rather poor recommendation. To a business man the development of a science of doubt appears very like an admission of failure. He likes to receive from his advisers clear, crisp and unambiguous statements; and he is apt to judge their value by their ultimate verification, whether they turn out to be right by luck or by judgment. An employer once said to me 'Don't tell me how unreliable you are. You tell me what is going to happen. I'll do my own doubting.'

This is a most unreasonable attitude but it is not uncommon. I sometimes wonder whether the most important qualification of all in business may not be the ability to steer a middle course in matters of interpretation to management; to hold firm to the principle that some forecasts must inevitably have a wide margin of error, without giving the impression that one's mind is so full of doubt as to make one's work a waste of time. Employers must learn to use statisticians. Statisticians must learn to have courage in their forecasts. It takes a lot of courage sometimes, because a man is remembered mainly by his mistakes. But I think it is very necessary.

LINEAR PROGRAMMING

I turn now to a branch of method which has attracted a great deal of interest in the past five years—what is known as linear programming. This deals with the problem of allocating resources in some optimal way: to arrange a factory so as to minimize idle time on expensive capital equipment; to organize an air route so that machines are in the right place at the right time and carry the greatest amount of payload with the minimum expense; in short, to run a business as efficiently as possible and to maximize profits subject to certain conditions imposed by the technology of the process, the maintenance of good industrial relations, and so forth. This, of course, is what every good business man tries to do; and many men have succeeded in doing it by innate ability and hard work. But as businesses become more complicated it becomes increasingly difficult for single minds or boards of directors to accomplish maximum efficiency by the light of nature alone. We might as well be honest about one other point too. As businesses become larger and more monopolistic it becomes increasingly difficult to measure their efficiency. We need not throw a brick at any particular business to make this point; let us throw it instead at organizations which are unlikely to throw it back: how do we measure the efficiency of the National Coal Board, or British Railways or the National Health Service? It is no answer to say that they make or lose so much per annum, or that they are better or worse than they used to be. What we should like to be able to find out is whether they are as good as they might be; and for many businesses there is exactly the same problem.

Linear programming tries to provide a partial answer to one of the problems in this field. It deals, as I have said, with the problem of maximizing profit, or some other more socially acceptable variable, under given restrictions imposed by the nature of the problem. It has had some success in the examination of transport problems and, for example, mixing problems in metallurgy and the preparation of animal feeding stuffs. Mathematically, what the formalized

problem amounts to is maximizing a function subject to certain equations imposing the constraints. In practice, for real situations, the mathematical problem is apt to become rather complicated and to tax the resources even of an electronic computer. It is still an open question whether the theory of linear programming can help a particular industry or a particular firm in an industry. We must also beware of new techniques whose exponents are apt to be carried away by their own enthusiasm; or, to put it on a much lower plane, we must be on our guard against men who would like to invent jobs for themselves. However, it seems to me that linear programming has at least reached this stage, that although it may prove not to be of benefit to a particular organization, there are few organizations which would be wise to ignore the possibility that it could help them.

A point worth mentioning here is that, unfortunately, those businesses which are big enough or wealthy enough to spend time and money on such methods are usually efficient enough not to benefit so much from them. The problem of maximizing efficiency may be compared to the problem of climbing to the highest point in a range of hills. The lazy, inefficient or indifferent firm may not have attained a very high altitude; but on account of its nature it is not likely to seek or to welcome advice about getting any higher. The more alert organization is constantly on the lookout for methods of ascension; they may not be direct and occasionally they may go the wrong way, but if you continually move upwards you are bound to get to a summit sooner or later. What linear programming, or more generally, a systematic study of the planning problem may do, is one of two things: it may point a direct way to the top and not leave the path to a rather aimless jostling in a vaguely upwards direction; and it may point out that although the organization has got to the top of a hill and is bound to go downwards however it moves in short steps, there may nevertheless be a higher hill in the district which it would pay to scale. An example is the transfer of ships from steam to diesel engines; some steamers were run at very great efficiency; within practical limits any modification of policy of running them would have lost money; but a switch of the fleet to oil-fired diesels was nevertheless an advantage in the long run, even if it did mean going downhill for a while in order to climb a higher peak.

In its more limited aspects linear programming is a mathematical subject, not a statistical one. But in practice it often becomes highly statistical, first of all because a great deal of the raw data is statistical and only a statistician can tell whether it is worth while using elaborate analytical techniques on them, and secondly, because we may have to use statistical methods to solve the purely mathematical problems.

OPERATIONAL RESEARCH

Since the war there has grown up a keen interest in a subject called operational research. It has a society and a journal of its own, but not, I think, a simple definition of what it does. But precise definitions apart, its basic motivation is fairly clear. During the war a number of distinguished scientists were taken out of their laboratories and put to work on urgent problems involving human beings in one aspect or another. They found that research in the field was rather different from research in the physical sciences; but they nevertheless found that their training and methods of approach were capable, in many instances, of application and adaption. The result has been the

congregation of a number of people who are interested in doing research on human problems in a scientific way—not a new idea, perhaps, but novel in its extent and its bias towards practicality.

In the widest sense, I suppose, almost every inquiry in business or commerce, including production processes involving human beings, can be described as operational research. In a narrower sense, any inquiry which involves quantification and proper design might be so described. But instruments are fallible and human beings much more so, and the measurement and description of human behaviour accordingly subject to all kinds of error. This is one of the main reasons why statisticians are often concerned in operational research; or, I would prefer to put it the other way round, why the operational research worker needs help of a statistical character.

THE STATISTICIAN ON BUSINESS ORGANIZATION

Up to this point I have been on ground which personally I feel to be fairly firm. Many practical examples could be given of the work which statisticians are doing in the various fields I have mentioned, that is to say, in the running of the business, in helping it to adjust itself to its commercial environment, in forming an intelligent view of things to come and in planning the layout of its resources. Many others could be given of statistical work in more detailed fields of technology or marketing, the standardization of manufactured products, the design of experimental inquiries, the effectiveness of advertising campaigns, personnel management, consumer surveys and so forth. But I now want to take a broader view and consider what sort of contributions statisticians might make to the theory of business organization itself. This perhaps sounds rather vague and I had better come at once to some specific examples.

It seems to me that one of the chief causes of industrial unrest at the present time is the impersonal way in which we organize our labour forces. There is nobody to grumble to who can do anything about it. In the old days a grievance could always be carried to some individual who had very full powers and often could redress it himself if he thought fit. Nowadays it has to be referred to a remote centre of control which can only move very slowly. An appeal to Caesar loses much of its power if it has to be made on a form in triplicate. It is, of course, very difficult to assess the effect of such factors on industrial relations, but my own view is that they are very considerable. Unofficial strikes, for example, have developed since the trades unions themselves grew into impersonal organizations. The general tendency towards decentralization in government and, to some extent, in industry is an implicit recognition of the fact that, however highly integrated a business may be financially, men work much better when they are in personal contact with the authority directing them. One of the few major industries in which we never have strikes is the Mercantile Marine.

This raises some extremely interesting administrative questions. How big should administrative units be? Why do you have thirty men in a platoon, a maximum of fifty in a class of school-children, a hundred on a board of governors and five or six on an executive committee? There are all sorts of reasons determining the optimum sizes of groups, and in general it is not possible to point to a particular group, irrespective of individual circumstances, and to say that it ought to be of a specified size. It nevertheless appears true that under the multifarious circumstances which determine the way in which

group organization comes about, there are certain general statistical laws appearing. It almost seems as if an organization must have a natural shape.

There are several examples of this kind of effect known to exist and I will mention three of them. The most famous is the Pareto law of distribution of income, which says effectively, that the number of people earning a given income x varies inversely as some power of x, the power in question usually being in the neighbourhood of $2\frac{1}{2}$. Nobody knows quite why this law operates, although some recent research is beginning to throw a lot of light on it, but it provides a fair representation of the facts and has weathered seventy or eighty years of intense social change without being very much affected. You can be suspicious of a law like this if you wish; but you cannot deny its usefulness. It is said, for example, that during his work at the Inland Revenue, Stamp used it effectively to track down tax-evaders by noticing whereabouts the returns departed from expectation to a substantial extent. It provides the only answer I know to the problem of how much more you should pay the man in charge than the man under charge. If I were working in a sizeable business in which the salary structure was very much out of line with the Pareto curve I should look for some special explanation. And if it were not forthcoming I should expect trouble sooner or later.

Another example of a similar kind is the characteristic pattern of absenteeism. Here again, there are hundreds of reasons why an individual may be absent at any one time; but they appear to result in a statistical constancy of behaviour which enables us to compare one business with another or to trace the effect of various measures within the same business. Again, if I were concerned with absenteeism I should use such distributions as a standard against which to measure my own company's experience. It might depart a long way from the standard; there might be very good reasons for its doing so. But at least I should know how unusual the experience was and where to start on the problem of analysis and the search for remedial measures.

The same kind of distribution seems to operate in the distribution of business by size. We have been accustomed for many years now to think of businesses as integrated horizontally as well as vertically, growing in size, extinguishing the little man and continually approaching monopoly. There are certainly industries where this has taken place. But there are many others where the little man is not extinguished, especially in the distributive trades. The question to which the statistician might well direct his attention is whether it is not more efficient, in the sense of giving better service to the public for the same outlay, to perpetuate this distribution with more small units and fewer large ones. It has, for example, been a grievance with farmers for many years, that credit in the agricultural world was very much more effectively handled when the bank manager had a greater degree of autonomy and was not strictly limited in his actions from headquarters. I am not, you will understand, arguing either way on these contentious matters. I merely point out that they are subjects to which the statistician can make a contribution.

It is, of course, one thing to claim that statistical studies of the general theory of business organization can be useful. It is another to suggest that these studies should be carried out by statisticians employed inside the business. Most business men, I think, would be allergic to the idea and on the whole I do not see much to favour it myself. Such studies are probably best carried out in universities or in the central departments of trade organizations. At the same time, I hope it would be agreed that a general knowledge of such subjects

might form a useful part of the background training of practising statisticians. The working statistician, in fact, is rather like a general practitioner in medicine. He spends a lot of time on very ordinary complaints, and perhaps one may add, a lot of time filling up forms; but he needs to be able to diagnose very accurately and to call for specialist help where necessary.

THE SUPPLY OF STATISTICIANS

I take it that in addressing an audience of actuaries I do not need to preach overmuch to the converted, and there are certain points which can be passed over with little more than a mention. I do not need to emphasize the importance of ensuring that the primary data are reliable, the pitfalls which the inexpert can fall into, the necessity for practical experience in interpreting numerical data. I think, too, that many of you can provide better examples than I of success or failure of the statistical approach in business. I shall take it as established for the rest of the discussion that there are many opportunities for the employment of statistical methods in business, and that in some concerns at least there is enough scope to justify the employment of a statistician. We then arrive at the critical question which is causing a lot of headaches in universities—or at least in my university—at the present time. Granted the demand, how do we ensure the supply?

Statistics in some form or other is now taught in nearly all the universities and university colleges; but the phrase 'in some form or other' covers a multitude of sins of commission and omission. At an elementary level it may be an option for a degree in some quite different subject such as geography or medicine. Apart from the B.Sc. Special at London there is no degree for which the student takes three continuous years of study at the subject. Generally speaking it is a subsidiary, and not a very popular subsidiary at that. Some universities have a diploma in statistics, which involves a year's study, but a fourth year which many students cannot afford. The teaching institutions in London and elsewhere do their best to cope with a demand from part-time students but they cannot fill the requirements of the situation completely. Last, but by no means least, the Institute itself has incorporated a good deal of basic statistical training in its own examinations.

It is no criticism of any of us to say that the whole situation is profoundly unsatisfactory. There is, moreover, a feature of the demand situation which makes it more so. With fair regularity about once a month I get a request from some organization for a statistician; but in many cases these requests relate to new positions which have recently been created, and not to vacancies in organizations which can do their own training. The consequence is that what is wanted is not a newly fledged graduate with some theoretical knowledge and no experience, but an individual who has had about two years in a business or some commercial environment going through the formative process generally known as 'having the corners knocked off'. Such persons are naturally in very short supply. If this were a temporary effect one would not be unduly worried, even though it might take some years before the effect wore away. But under our present set-up it seems to me more in the nature of a permanent fault in the system.

A dictator could, no doubt, put this right very quickly. He would make sure that the careers advisers in schools were aware of possibilities in statistical work; he would see that adequate and full courses in statistics were given

at universities; and he would ensure that some practical training was either incorporated in them or added at the end. But failing a dictator we are still faced with the problem of finding some solution, however partial.

It is here, perhaps, that bodies like the Institute can help. I am not at all sure what is the right way to tackle this problem but I am inclined to think that it would yield most easily to joint action by the various bodies concerned. The Royal Statistical Society and the universities are obviously very much concerned but one does not expect very forceful action from the latter and the R.S.S. itself is to a major extent a learned, not a professional body. The Association of Incorporated Statisticians is an examining but not a teaching body; the actuaries' organizations both examine and teach but do not cover the whole field of statistics. Between them all, however, they command the knowledge and the talent; and I imagine also that the actuaries' organizations have behind them a good deal of experience of the kind of work which would be required. If we are to contend that statistics can contribute something to business, perhaps we may concede that a business-like approach may contribute something to statistics.

I will admit that I had some difficulty in preparing this lecture. I wanted to give examples of the use of statistical methods in business and commerce without mentioning specific organizations, without going into technicalities and without dwelling on matters of minor or ephemeral interest. Such references as I have been able to make to concrete cases have therefore been less definite than I should have liked if they were to catch the attention of busy men. Let me, in conclusion, try to remedy that shortcoming by inviting you to reflect, on the way home, how much better and brighter your lives would be if some of the problems which beset us could be solved by statisticians; and I will mention only those on which, to my knowledge, statisticians are, or have been, working. As you wait for your bus you will have the satisfaction of knowing that the stability, power and even type of oil used for lubrication in that vehicle have been the subject of statistical experiment; that the familiar phenomenon of six buses with the same destination all arriving together is a special case arising in the theory of queues, which is fairly well understood by statisticians even if the remedy cannot be applied; and if you catch a cold while waiting you will know that the queuing of patients at doctors and hospitals can be largely avoided by suitable statistical control. The evening paper which you buy will have been subject to a number of readership surveys to find out who you are and why you buy it, which bits you read, where advertisements have to be to catch your eye and whether you introduce it into the family. You may be stopped in the street or visited in your home to find out what you, the consumer, think about tobacco, toothpaste or television. If you call in for a drink you may be sure that what you consume has been the subject of anxious statistical thought in preparation, distribution and marketing. Such children as greet you form part of a post-war cohort which is being carefully watched by town planners, education authorities and firms manufacturing ready-made clothing. If you turn on the radio you will remember that many of its parts were made under statistical control and that the Audience Research Department of the B.B.C. conducts something like a million interviews a year to make sure that your tastes are being met. And as you climb into bed you may perhaps reflect that the statistician is at large all around us; and that his methods have a very great part to play in the organization of the wonderfully complex system of business activity that controls our daily lives.