If economists understood cooperation, and the loss and damage from competition, they would no longer teach and preach salvation through competition. They would, instead, lead us into optimization through cooperation.

A school of business has an obligation to prepare students for management in the future. Why should a school of business waste the student's time by teaching him how business is carried on today, and how to swim to the top in the present system? This kind of teaching will neither help our students in their future careers, nor help our balance of trade. The teaching of statistics should make it possible for students to prepare themselves for the future, not for the past.

There is heavy demand for positions and for consultants that possess the required knowledge. The demand increases, while the supply lags.

The country is being ruined by best efforts, not guided by the theory of management for optimization. There is no substitute for knowledge.

Comment: A U.K. Perspective on Applications in Business and Economic Statistics

Peter G. Moore

THE UK SCENE

Commenting fruitfully on Professor Roberts' interesting paper from a U.K. standpoint makes it necessary to outline the U.K. educational scene, highlighting some of the more important differences between U.K. and U.S. educational policies.

The basic structure of the U.K. system is highly elitist. Only about 15% of children enter tertiary education (mainly at universities or polytechnics), with relatively few staying in full-time education after the minimum school-leaving age of 16. Virtually all boys and girls who stay on at school after the age of 16 and complete their education to age 18 enter tertiary education. This creates a marked schism between leavers at age 16 on the one hand, and the graduates who enjoy full-time education to age 21, or even later, on the other hand. One consequence of the system is a shortage of craftsmen/technicians, so that graduates have to carry out basic industrial tasks that would be done by technicians or craftsmen in other countries.

There is substantial pressure in the U.K. to increase the number of entrants into tertiary education. Achieving this depends critically upon increasing the number of schoolchildren remaining at school after the age of 16, a task that has not yet been energetically tackled. One of the major constraints is the "GCSE" (General Certificate of Secondary Education), and "A" level examination systems, the examinations being taken at 16 and 18 years old, respectively. Most pupils aim to take five or six GCSE subjects and then, if they continue in education, work for their A levels. These are normally taken in three subjects (occasionally only two and, rarely, four), drawn principally from the subjects studied at GCSE level. These subjects then dictate the programme of studies entered upon at university. Hence, for example, unless the "A" levels include mathematics and physics, it is unlikely that a student could enter university for a degree in engineering, mathematics, physics, etc. This process forces subject choices to be made at around 14 for the GCSE subjects which, in turn, dictate the A level choices. Thus the needs for specialist bachelor degrees are felt right down the educational system as far as the 13 year old.

A recent government-appointed committee on sixth form (i.e., 16–18 year olds) education recommended a change in the A level system to give a broader educational base up to age 18 (say five subjects), a change which was rejected by the government. There is nevertheless a strong feeling, amongst educationalists and employers, that reform along these lines is essential to enlarge the pool of 18 year olds possessing a good quality broad education.

MATHEMATICS VERSUS NUMERACY

In the U.K. literacy has received considerably more attention than numeracy, and indeed is seen to have greater standing. A distinction can be made between mathematics and numeracy. While the amount of mathematics required in those working in business or commerce is relatively modest, unless they are

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specialist experts, it is essential that everyone should have a good sense of both numeracy and the basic concepts of probability. This needs to be combined with robust common sense, together with the ability to communicate effectively both orally and in writing.

As Roberts rightly states, the vast majority of statistical work in a business rests upon a relatively small number of statistical concepts. Examples are graphical and tabular techniques for display, exploratory analysis, time series analysis, simple design of experiments, basic sampling theory, quality and improvement techniques, Bayesian decision theory, regression analysis, simulation concepts, etc. The active pervasion of such simple tools into the everyday work of any organization depends critically on the attitude of management. Where management is supportive, good results can be obtained.

The concepts of quality and productivity are coming more and more to the fore as companies fight for business in the increasingly competitive global markets. It therefore demands of companies that they take steps to maximize their emphasis on these two concepts. To do this requires the cooperation of the workforce as a whole to undertake substantial training. There are lessons from the use made of basic statistics in Japan and the United States to enlarge quality and productivity that need to be carefully considered and acted upon in the U.K. and in Europe generally.

THE AVAILABILITY OF STATISTICIANS

Statisticians are not government registered as are doctors, solicitors, etc., and hence the precise numbers of practicing statisticians in the U.K. is unknown. The Royal Statistical Society conducted a study of the supply and demand for statisticians in the U.K. in 1985. Universities and polytechnics produced about 800 graduates a year qualified in statistical methods. Full-time statisticians in post was estimated at 4,000 with a current annual intake of about 130 new graduates. Given the regular wastage, e.g., from those moving from a statistical post to a managerial position, such an annual entry seems insufficient to maintain the statistical community. At the same time, other evidence suggested that there had been a diminution in the number of full-time statisticians working in industry and commerce in recent years. This perceived trend is borne out by falling attendances at meetings and conferences in industrial statistics in recent years, while papers in *Applied Statistics* (a Royal Statistical Society journal whose specialist aim is to promote papers that analyze contemporary practical problems) have tended to be dominated by university academics with few papers from authors in commercial organizations.

Although the number of full-time statistical academics rose in the period 1970 to 1985, most entered tertiary education; few work in secondary education. In more recent years, cuts in universities have squeezed numbers of staff in subjects like statistics, maybe because they are seen by many as providing building blocks for other subjects, rather than being subjects in their own right.

THE MBA AND STATISTICS

The background of U.K. graduates is important in designing an MBA curriculum. Many of those who apply to enter a Business School to study for an MBA have had no further formal mathematical training beyond the age of 16. This lack has serious consequences. At most, but not all, business schools (including the London Business School), it has been a policy to admit top quality graduates, with appropriate work experience, even if their mathematical attainments are below what the school ideally desires.

In such circumstances, aptitude for mathematics does have to be demonstrated. At the London Business School, where the average age of entry is 28, we have tried hard (not always successfully) to integrate those who have an arts background with those who have a more scientific background. Our experience is that many who have had little in the way of developed numeracy skills commonly demonstrate innate numeracy skills. For such entrants, we offer remedial classes in basic mathematics prior to entry, together with rather more small tutorial group sessions than would be normal, in those core courses that demand good levels of numeracy (e.g., decision science, econometrics, finance). In these and other ways, we aim to integrate the student body by the end of the second term (quarter) of the six term programme. There is always the risk with students from such different backgrounds that a division will emerge between those who are people-based managers who eschew mathematics, and those who are management-science-oriented managers who tend to ignore the human resource angle. While there is a spectrum of managerial approach, we strive to ensure that graduates appreciate both dimensions of approach and can adapt themselves appropriately to the situations that they may face.

A final point is the belief held in many quarters that upward mobility comes easiest via one of the well established professions. Hence the popularity in the U.K. of medicine, law and, more recently, accountancy. It is noteworthy that Mrs. Thatcher, with her first degree in chemistry, rapidly decided to study to be a lawyer since that provided a better entry point for substantive advancement, particularly in politics. Currently many engineers and scientists switch to

accountancy after their first degree. This is not wrong in itself—a sprinkling of engineers and scientists among accountants and lawyers is a good thing—the worry is the current scale of the one-way switching. Career planning for scientists and engineers needs urgent reconsideration in today's technological world.

THE ROLE OF THE STATISTICIAN

The statistician should not be primarily seen as a human counting machine. It is his or her job not only to get the figures, but also to delve behind them. Without that delving, measurements by counting can be barren. Roberts quotes the well known and best-selling book, *In Search of Excellence* by Tom Peters and Robert Waterman. Some 43 successful U.S. companies, measured by the bottom line, are examined and the broad conclusion drawn that it is the implementation that primarily determines success; productivity and profitability primarily comes via people.

There are weaknesses and simplifications in the Peters and Waterman analysis. First, the authors presume a narrow definition of success. The historical financial data used to judge success neglect measures of the quality of concurrent development efforts in technology, marketing and developing management skills. Such attributes, with others, are essential to ensuring continuing excellence and constancy of purpose. It is entirely possible that some of the perceived "excellent" companies are simultaneously no longer excellent in terms of those inner activities, their failings to be revealed with time.

Secondly, the study examined only successful firms, eschewing the use of a random sample, or even some form of matched sample. How can one tell whether or not other firms, less successful in financial terms, do not rate equally highly on the traits studied? One clue is that, five years on from the publication of the book, many of the 43 firms in the sample studied were no longer regarded as examples of successful firms on the financial criteria used, even though their working practices did not seem to have changed much over time. There is little positive proof in the book that good implementation *by itself* is a recipe for long term corporate success.

What the book does provide is a timely reminder that fundamental concerns are frequently being forgotten, and that a "back to basics" movement is required from time to time to maintain achievement levels in terms of quality and service. This leads inexorably to the proposition that, while good implementation of policies is essential, overall success in the long run demands a sense of direction and top quality decision making to drive the organization in the desired direction.

MANAGEMENT PHILOSOPHY

The paper makes reference to the work of Raiffa and Schlaifer. I believe this work has been more seminal than Roberts' suggests. Decision analysis has not become a panacea for scientific management, just as operational research failed to achieve this status in the 1950's and the 1960's. Nevertheless a great deal of improvement has occurred through general acceptance of the thought processes engendered. One basic consequence has been that more executives are able to take a fuzzy problem, cut away the fuzz and sharpen up the profile to expose the hard core of the problem. In particular, the decision analysis approach has clarified the need first, to decide upon and examine the range of options open to an organization; second, to consider the evaluation of benefits that success would bring; and third, to assess the nature and magnitude of the risks associated with different courses of action.

Such a movement has, however, created a schism amongst statisticians. Taking an active role in decision analysis implies skating on thin ice in terms of the demarcation between the role of the statistician, *qua* statistician, and the role of a decision maker. Brown (1987), writing in a British journal on American experiences, brought out this dilemma well. Brown, a well known exponent of decision analysis, was clearly acting in the situations he described as an extra arm to the decision maker; he was probing, querying, feeding in information, massaging the data, pointing up options, testing utilities, etc. The purist would argue he was going well beyond the role of the professional statistician and had thereby left statistics as such. Brown (and his ilk) would argue that he was delicately and deftly helping the decision makers to come to *their* own decision, not Brown's. The objectives, the value judgments, and the interpretation of possibly conflicting information would still belong to the decision makers. They would still own the decision and be the ever important champions, even though the statistician would have been a substantive partner in the process.

The case for the more limited role is illustrated by the writings of a distinguished Dutch statistician, Hamaker (1977), who concluded that statisticians were not—or ought not to be—decision makers. He saw only a limited—albeit important—field of advice for statisticians in their professional role. Suppose in a real life situation a market research statistician is tending advice concerning the launch of a new product. While the statistician would be expected by the manager concerned to give the factual results to market survey(s), he or she would also commonly be expected to expound on their utility, their implications and appropriateness together with comparisons with other surveys that may have given rather different

responses. Hamaker argues that this activity goes beyond the legitimate bounds of a statistician.

If the statistician distinguishes between established facts and deductions and opinions, then directly related judgmental inputs to the decision maker can be made. The same would be true of lawyers tendering advice. They can state the law, but then legitimately give their opinion on the likely legal consequences of alternative courses of action, where the law does not cover the situation in a black and white fashion. It is worth noting that lawyers are not inhibited from becoming members of Boards of Directors; they are able to walk the tightrope between their role as a lawyers and their role as a decision maker. If statisticians feel inhibited from going any further than the preparation of data and their analysis, there is a danger that their role will increasingly be perceived as that of a technician rather than as an executive and they will be marginalized. Widening does carry some implications. For example, I believe that statisticians ought to have a basic knowledge of accounting and cost control processes, since so much statistical data is used as a background for financial calculations.

In general, the compartmentalized roles of professionals are breaking down, with far more cross-activity taking place. Deregulation in U.K. and Europe has seen to this, although there is a long way to go to integrate individual professions. It is unclear, under the new regime, how professional standards can be maintained and, indeed, enhanced. Statisticians do not have statutory regulation as is the case with accountants, doctors, lawyers, etc. There is a need for a self-regulating and monitoring arrangement so that those who have need for effective statistical advice can be aware of the standing of the individual. Whilst statistics should become a way of thought for all well educated persons, an important and continuing role remains for the expert.

Comment

John Neter

Harry Roberts has prepared a most interesting and provocative essay on applications of statistics in business. Roberts is concerned about the extent of statistical applications in general, and in business in particular. Other professions also are concerned about the relatively limited uses of their methodologies. The professions of management science and operations research are cases in point. But Roberts' main purpose is not to dwell on the current situation of relatively limited applications of statistics to business problems. Instead, Roberts' intent is "to place major emphasis on constructive suggestions for improvement of business practice by more effective use of statistics."

In proceeding from an assessment of the extent of current use of statistics in business to a consideration of means of improving business practice through an increase in the use of statistics, Roberts wanders on a somewhat rambling and repetitious path. Nevertheless, I am delighted that *Statistical Science* has provided this opportunity to a senior statistician to speak from his heart and to be able to make personal reflections from his many years of teaching and consulting experience without being confined to a tightly written scientific style.

Roberts paints his themes with broad brushstrokes and I do not wish to let quibbles with some details obscure my comments on Roberts' major themes. I shall therefore mention just a few instances where I have some disagreements with, or questions about, Roberts' details.

I concur with Roberts' assessment that statistical applications in business today are far below their potential level. However, with all of the developments in the use of statistical sampling in auditing that have occurred in recent years, I would not say that use of probability sampling in auditing is relatively rare. I certainly would agree that probability sampling in auditing still is utilized far less frequently than it might be.

In his discussion of the use of statistics to study cause and effect in business, Roberts cites observation after direct management intervention designed to improve process performance as an experimental study. Clearly, this would not be a formalized experiment where treatments are assigned randomly to experimental units.

When discussing expert systems in statistics, Roberts is concerned that these systems will duplicate the

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