Comment: Academic Politics and the Teaching of Statistics

Harold Hotelling, Jr.

I. INTRODUCTION

The republication of two papers on how statistics should be taught poses a problem that is all too familiar to social scientists: given that a solution to a problem has been proposed, and given that the proposed solution has not been repudiated by scientists in the area despite decades of study, why has it not been put into effect? A nonstatistician reading the papers can certainly apply some ideas of how academic decisions are made in practice and speculate on the length of time, or more precisely on the finiteness of the length of time, until the adoption of Hotelling's proposals.

Statistics as a subject has rather more political force within the university than do professional statisticians. The widespread references to Hotelling's papers are consistent both with enthusiasm for the correct teaching of statistics and with the hope of centralizing its teaching in one academic unit. This paper is an effort to explore the political and economic forces that have resisted the changes proposed by Hotelling almost half a century ago, together with some thoughts on their author based on personal acquaintance.

The papers themselves appear to have enduring attention from the professional community. The welcome present reissue recalls thoughts expressed in 1960, on the occasion of Hotelling's 65th birthday. In a *Festschrift* of that year (Olkin, Ghurye, Hoeffding, Madow and Mann, 1960), Jerzy Neyman (1960) graciously gave Hotelling's work some of the credit for subsequent improvements, especially at the great centers of statistical theory, but warned that "the current practices of offering statistical courses in substantive departments are only too often the same as those described and ridiculed by Hotelling." "The Teaching of Statistics" was included in the *Festschrift* at Neyman's suggestion, although in retrospect the inclusion may have constituted preaching to the choir.

William Madow (1960), writing in *The American Statistician* the same year, was evidently more optimistic: speaking of specialists in other fields teaching statistics in their own departments, "... there is no doubt that the quality of their teaching of statistics is much better than was the case when Hotelling's papers first appeared." Nevertheless, the inescapable impression is that the place for introducing statistics to the college student is within a Department of Statistics, only reluctantly to be combined, in smaller institutions, with the Department of Mathematics: "Moreover the teaching of statistics cannot be done appreciably better by mathematicians ignorant of the subject than by psychologists or agricultural experimenters ignorant of the subject" (Hotelling, 1940). Although combining the teaching in one department does not reduce the university's total load, it is certainly believable to an economist that advantages of specialization could be great even apart from considerations of class size. Our question of why separate courses persist requires us to turn to perceptions of how organizations such as universities behave, and what equilibrium is likely to emerge from some allocation of interests and bargaining power. We may divide the evidence into changes in statistics, changes in universities and changes in the role of departments within universities.

II. CHANGES IN THE ROLE OF STATISTICS IN THE UNIVERSITY

The role of the university has changed greatly since 1940, but the form has been maintained in such a way as to obscure the difference in role or, as the new breed of administrators prefers, "mission." The expansion of higher education to include about half of all high school graduates, as well as maintaining the customs of professorial ranks and some sort of research expectations at all but very unpretentious schools, has meant that the emphasis and mean academic ability of the college student are different. The vocational forces and loosening of core curricula have greatly diffused the direction of undergraduate education. The state of mathematics education in high schools appears to leave calculus as the same barrier that figures in both of Hotelling's papers. The effects of the present shift in age distribution toward including many older students are not yet known.

What is known is the virtual explosion of statistics and the recognition of its role not only in the social, biological and agricultural sciences to which Hotelling referred, but also to entire new specialties in

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engineering, business and health professions which have come into existence and become popular majors for undergraduates. Statistics has penetrated into legal theory beyond the stage of expert witnesses; its use in the law of discrimination in employment is almost as central as in the insurance business. It is almost fair to say not only that every educated person has some statistical training, but also that relatively uneducated people *know* that statistics is basic.

The penalty of success is sometimes oversimplification. The explosion of statistics is associated not only with its force in answering research questions, but also with its awesome accessibility. Hotelling's papers chronologically bracket the end of the precomputer age. They contemplate statistical laboratories with calculating machines, and prophetically mention "conflicting claims regarding machines and laboratories" (Hotelling, 1949). They do not fully address the spectacle of tens of thousands working more or less comfortably with SAS, SPSS or BMDP, or taking their lessons with Explore, Gauss or some other microcomputer package. The garbage-in-garbage-out syndrome would not, however, have been surprising. There might have been some worry at what now seems a profound step: the inclusion of linear regression tools in Release 2 of the enormously popular Lotus 1-2-3. This move, along with the lively advertising of powerful specialized microcomputer software, has unleashed powerful tools to the millions, sometimes with magazine articles comparing packages and adding a few tips. We are already seeing impossibly precise extrapolations of time series price data, to take only one example. The work done so well by Darrell Huff in *How to Lie with Statistics* will have to be brought up to date to refute the subtler fallacies of uncontrolled computer spread.

If statistical analysis has worked itself so deeply into the system, with electronic tools completing the task, there may be no realistic prospect of reclaiming it for the experts in the field. The future may even be decentralization, with the statistician occupying special positions in various departments, with the possibility of professional isolation now experienced by lawyers in business schools, ethics teachers in medical schools, economists in public policy schools and public policy people in economics departments. The probability is low, however; statistics is not only a rich field of inquiry—so are law, ethics and so forth—but also so much in demand that a critical or department size mass is likely. The question is whether a department is likely to emerge and, if so, is likely to gain political control of a standard introductory course.

III. DEPARTMENT POWER

Hotelling's satirical portrayal (1940) of the introduction of a statistics course in another department is fortunately no longer fully accurate. The change, however, has been in the statistical training of the economist or engineer rather than in the reallocation of responsibility for the course. The durability of introductory statistics courses in multiple departments is a function of several variables other than the merits of instruction in statistics. The itch to include special applications from the outset is undoubtedly strong, so much so that statistical textbooks conscientiously parcel out their examples among fields of application, apparently in proportion to the anticipated sales. Alternatively, the author gives up and directs the text explicitly to "statistics for nursing." It may be that the material in a principles course has greater stability than at the time Hotelling wrote; he refers in the 1940 paper to work on a treatise that even then had gone on for some time. Amazingly, this treatise will apparently be published. Adrian Darnell, an economist and statistician at the University of Durham, has done a great deal of work with Hotelling's papers, which the family donated to Columbia University. Darnell has concluded that enough of the book was actually written to justify publication along with associated work on Hotelling's economics papers.

The dispersal of introductory courses is attributable, however, to many reasons other than the itch to include applications. Inertia and budgets clearly play a role. The expansion of the demand for statistics instruction has been steady rather than discontinuous, allowing deans and department heads to bring in courses one at a time, each time with a clear application in mind. A vice president or provost finds it much simpler to accede to a request for one more position than to call for a new enterprise, and the department is happier with another position and control over the course. Less mentionably, various parts of the university have at various times been perceived as the last refuge of students unable to master more demanding or more popular subjects; the common response to sudden popularity has been to raise standards, spilling the C student into other fields. A department perceiving that its own students are significantly above or below the mean ability in the institution is likely to be sensitive to the costs of leveling, and to teach its own statistics ostensibly to specialize but actually to isolate.

None of these explanations, however, fully satisfies an economist. Two great themes of economics, both the objects of much study since 1940, are especially relevant. One theme is "rent-seeking," or the incentive to obtain institutional powers that give one a monopoly. In a market economy, such a monopoly permits extra profits; typical examples include protection from foreign competition or regulatory cartels such as the airlines possessed until 1978. In a bureaucratic or nonmarket economy, such power allows the

acquisition of extra positions, secure funding, research support, new buildings and other institutional resources. This, indeed, is the other great relevant theme, the economics of government or bureaucratic behavior; it is associated with the work of such economists as James Buchanan and Gordon Tullock. Hotelling (1949) anticipated one modern threat with a warning about too close a relationship with commercial enterprise. The dangers of market failure (the distortions or inefficiencies of an unrestricted market) are now seen as balanced not by an automatically beneficent government but by a government itself subject to distortions and inefficiencies. Furthermore, university bureaucrats are seen as by no means exempt from the incentives of other government and nonprofit organizations.

These approaches, applied to the question of the introductory statistics course, suggest that the centralization process has been approached without the most appropriate bargaining technique. An analogy may be drawn with the economics of occupational licensure. A new occupation comes into existence and gradually defines itself. A professional association calls for higher standards, begins to limit membership according to some educational standard and eventually petitions the legislature first for some formal recognition and then for exclusive power to carry on the profession. Once a collective monopoly of this sort is established, it is persistent.

A second example of licensing is the process of accreditation of professional schools. The existence of centralized interest groups *outside* the university has allowed the representatives *inside* the university to claim extra resources. The effect is strongest with law and medical schools, whose graduates face extensive licensing examinations and which themselves face strong accreditation bodies from the professions themselves. Thus law and medical schools develop significant power within the university to which they are officially subordinate. Business schools, having weaker outside forces (there is no licensing examination for captains of industry and accreditation is less crucial) command fewer resources. Other departments have even less bargaining power. Some, such as chemistry, work to impose standards by an accreditation process. Indeed, the American Statistical Association has developed guidelines, but they address the curriculum for statistics majors, not the introductory course.

IV. CONCLUSION

Does the teaching of statistics boil down to a turf battle? The accusation will be made. The cordial initial reception of "the teaching of statistics," and its adoption as the position of the Institute of Mathematical Statistics, can be viewed as a collective, even if not explicit, effort to consolidate the position of the statistical expert, a position that is no longer in question but which raises questions of centers of power. A subtler point is that the effect of centralizing the introductory course represents a judgment that, at the margin, the student should be exposed to extra statistics rather than extra doses of the field of application. Hotelling, more than almost anyone else, knew the power of statistics and the advantages of at least minimal literacy in the subject. The remaining problem is to persuade those who take the same view of their own application fields and are acutely conscious of the constraints in training their majors. Hotelling (1949) reduced the problem somewhat by carrying to its conclusion the idea that statistics should be spread among departments:

> "This may work out well if the appointee is an able and energetic scholar deeply devoted to his subject, if he is placed immediately in the highest professorial rank, and if he does not feel under an obligation to devote himself too exclusively to the special interests of the department of which he finds himself a member."

Modern academic policies and resource limitations make it unlikely, to put it mildly, that many statisticians will find themselves in such a professional situation, although the passage is autobiographical; Hotelling moved from Stanford to the Columbia economics department in 1931 under just such an arrangement. In the present day, there is no doubt that real statistical research is centered in the department, but there is also no doubt that the department will no more have a monopoly than mathematics or English will. It would be deplorable indeed if the decentralization of statistics, both inevitable and fruitful in so many ways, were to be accompanied by a debasement and isolation of statistics jealously preserved in nooks and crannies about the modern university. Hotelling's papers stand in constant rebuke to those who would bring on the isolation.

The papers are one aspect of an exciting and fascinating career, reaching far into economics and other fields. To grow up meeting R. C. Bose, S. N. Roy, Wassily Hoeffding, Maurice Kendall, Harald Cramer, Herbert Robbins, Jerzy Neyman, W. Edwards Deming and even Ronald Fisher, would be an irreplaceable experience for anyone with the least breath of statistics. It will be understood, however, if one concludes with a thought of Walter Smith (1978) in his obituary essay:

> "He was imbued with an optimism that nothing would impede the progress of his academic enterprises, arising, one felt, from a firm belief that whatever forces ruled the universe shared his views. He invariably spoke well of others, never exhibited envy, and he charmed with a courtly,

old-world manner that was entirely natural to him and free from guile."

We can always be thankful for scholars whose influence, foresight and inventiveness are combined with such a character.

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Comment

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I welcome the opportunity to comment on Harold Hotelling's articles on statistical education, particularly because many of us are concerned about our directions in this area, even to the point of asking seriously "Are we really doing it right?" Certainly, as statisticians, we know that we must be willing to experiment and make changes (at least small ones) in striving for optimality. Hotelling recognized this and states that "no syllabus in use today can be expected to survive a few more years of research." As new statistical methods and ideas develop, changes *must* be made even though we know that the optimum will never be achieved. However, we must continue to chase it for if we do not, our programs will dry up and fossilize.

One major issue he addresses in both articles is "What sort of persons should be appointed to teach statistics?" He makes it clear that it should be someone who has "a profound and thorough knowledge of statistical methods" and "a genuine sympathy and understanding for applications." At the university level, he emphasizes that publication of scholarly research has always been accepted as the best proof of an understanding of your field. Because a good teacher of statistics must be familiar with recent advances (even if outside his or her specialty), we need even more good expository articles today (as compared to the 1940s) written by some of the leaders in research in those areas.

To illustrate the importance of research to the teaching of statistics, I will use myself as an example (not that I am a great researcher). I like to think I know *a little* about M, R and L estimation, and this knowledge helps me add a little excitement to teaching a nonparametrics course, either beginning or advanced. For example, at a very early stage of an elementary course (not necessarily nonparametrics), many textbooks (including my own) suggest that $\bar{x} \pm 2s/\sqrt{n}$ serves as an approximate 95% confidence interval for the population mean μ provided the sample size n is reasonably large. Of course, if the underlying distribution is normal, there is no problem; really there is no problem if the underlying distribution is almost symmetric with reasonable tails. But suppose we have a very skewed, heavy-tailed underlying distribution. Then we have a different story and, in some cases, that confidence coefficient might be as small as 65 or 70% because $\bar{x}$ and s are then highly correlated (they are uncorrelated in symmetric cases). How many teachers of statistics really know that? In particular, at that point in the course, the students really should be informed that something else should be done in this case (e.g., transforming the data or using robust methods) even if the details cannot be explained at the level of the course.

Hotelling argues (and rightfully so) that most mathematicians will not be very good teachers of statistics; and those that are asked to do it should be given "a furlough for a year or two" to obtain proper training. That is, mathematicians *and* statisticians should experience some good applications before being asked to teach statistics. I can really speak with some experience here because I earned my PhD in mathematics in 1950. Although I wrote my thesis on a statistical topic under the direction of Allen Craig, I really knew very little in the way of statistical applications. I taught some great courses in mathematical statistics in the 50s; but is wasn't until the 60s—or even the 70s—that I truly saw the importance of some of the methods, like those in design of experiments. That is, while I knew all that theory about those quadratic forms, I really could not design a good experiment. A

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