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Statistics in U.S. Universities in 1933 and the Establishment of the Statistical Laboratory at Iowa State

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Abstract. The Iowa State Statistical Laboratory was established in 1933, with George W. Snedecor as director. The forces leading to this early creation of a formal unit are described, including the roles played by Henry A. Wallace and R. A. Fisher. Preceding this account, the state of statistics in 1933 is outlined, with special emphasis on U.S. universities. The lives and contributions of several leading personalities are sketched.

Key words and phrases: History of statistics; statistical texts in 1933; G. W. Snedecor; H. A. Wallace; R. A. Fisher; H. L. Rietz; H. C. Carver; H. Hotelling.

1. INTRODUCTION

With characteristic facetiousness Stigler (1996) has advanced the proposition that (in the United States) "Mathematical Statistics began in 1933." It is the purpose of the present article to describe another more concrete statistical event in a Depression year infamous for the rise of Adolf Hitler: the creation of the Statistical Laboratory, "the first unit of its kind in the United States," at what was then Iowa State College.

Probabilists and statisticians as well as users of statistics had, of course, existed in U.S. universities for many years. They worked mostly in isolation, without any formal structure, within departments of Mathematics, Economics, Psychology, Education, Business and many others. There were exceptions in the health sciences and economic statistics. Notably, Johns Hopkins had a Department of Biometry and Vital Statistics as early as 1918, headed by Raymond Pearl, and the University of Pennsylvania's Department of Economic and Social Statistics was founded in 1931. However, the Iowa State Statistical Laboratory may have comprised the first grouping of "mainline" statisticians recognized as deserving a unit of their own.

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We will begin by attempting to sketch highlights of the statistical scene around 1933, with emphasis on U.S. universities, and will then turn to the special circumstances that made possible the Statistical Laboratory at Iowa State.

2. STATISTICS AROUND 1933, ESPECIALLY IN U.S. UNIVERSITIES

2.1 The State of Knowledge

By 1933, R. A. Fisher had developed the analysis of variance as a very useful tool, had initiated the design of experiments, had derived the distributions of statistics needed in the small-sample theory introduced by Student and had done his basic work on the theory of estimation. Correlation and regression theory had been well established by Francis Galton, Karl Pearson and Udny Yule. 1933 happened to be the year Karl Pearson retired, at age 76(!), from University College London, where he had founded the Department of Applied Statistics in 1911, itself preceded by the Galton Laboratory. An American view on him at retirement is given by Camp (1933). Following their earlier introduction of likelihood ratio tests, Jerzy Neyman and Egon Pearson published their first Neyman–Pearson theory paper including their Fundamental Lemma in 1933. The study of time series had been well launched, mainly by Yule, and in 1933 early results in multivariate analysis had been obtained by Karl Pearson, R. A. Fisher, John Wishart and

Harold Hotelling. In the theory of probability, 1933 saw the publication of Kolmogorov's fundamental axiomatization.

2.2 The U.S. Scene

For the very early history of U.S. university instruction in statistics, going back to 1880 at Columbia College, we refer the reader to the valuable account in Walker (1929). The period 1920–1944 is sketched by Harshbarger (1976). It is clear that by 1933 the usefulness of statistics was sufficiently appreciated for major universities to offer a course or courses in their Mathematics Department or at least in some discipline using statistics.

First, however, some more general U.S. background. By December 1932, the American Statistical Association (ASA), founded in 1839, had reached a membership of 1,975 including, as we read in Secretary King's report, "26 members unable to pay dues but carried on rolls at their request": in fact, the Association had lost 290 members during the preceding 12-month period, mainly due to the Depression. A quick idea of the interests of members can be gained from the topics proposed for the annual meeting in Cincinnati, December 28–31, 1932 (*J. Amer. Statist. Assoc.* **27** 204): Methodology, The Depression, Gold, Wages and Standards of Living, Business Profits, Economic Theory in the Light of Statistical Analysis of Business Phenomena, Problems Met by Teachers of Statistics and by Company Courses in Statistical Methodology, Public-Finance Statistics, Methods of Congressional Apportionment, Hospital Statistics, Vital Statistics. The heavy emphasis on economics is underlined in the Presidential Address by Irving Fisher of Yale University: "Statistics in the service of economics." The meeting was held jointly with various largely economic associations, the most mathematical being the Econometric Society, founded in 1930.

In 1933 The formation of the Institute of Mathematical Statistics (IMS) was still two years in the future, but the *Annals of Mathematical Statistics* had been launched in 1930 by Harry Carver of the University of Michigan, under sponsorship of the American Statistical Association. Articles in the first five volumes carry handwritten formulae and are signed. Volume 6 for 1935, still under ASA sponsorship, announces the organization of the Institute of Mathematical Statistics, looks fully professional and contains the first directory. I counted 118 individual and 98 library members, with 14 and 33, respectively, having foreign addresses.

The directory also provides us with some clues on the teaching of mathematically oriented statistics. Individuals sometimes give only their home address, but I estimate that at least 61 are affiliated with U.S. universities. "Concentrations" occur at Harvard (7), Minnesota (6), University of Michigan (5), Columbia (3), Chicago (3), Berkeley (2), Ohio State (2), University of Iowa (2) and Wisconsin (2). At least 38 U.S. universities or colleges are represented by one or more members, also 51 by their library. Notably missing from both lists is Princeton University, although Wilks is on the next list, published in 1937. Looking ahead in our narrative we note that Iowa State College is represented only by its library; the third much larger list, published in 1941, includes both Snedecor and Cochran.

2.3 Leading Figures

To gain a firmer grip on the U.S. statistical scene around 1933 it is helpful to look at some of the leaders of the profession. The following biographical sketches concentrate on the more mathematical statisticians and are essentially truncated at 1933. However, references are given to fuller accounts. It has recently come to my notice that the same three principals have also been singled out in Neyman (1976).

Henry L. Rietz (1875–1943). Rietz has been called the "dean of American mathematical statisticians" (Craig, 1986) and was to become the first President of IMS in 1936. After receiving a Ph.D. in group theory from Cornell, he joined the University of Illinois in 1903. By 1904 "a demand arose for some course in statistics. None of the members of the mathematics department were particularly prepared to give such a course but Rietz was induced to try it" (Crathorne, 1944). In 1905 he was appointed statistician of the College of Agriculture and subsequently divided his time equally between the College and Mathematics. His first of many statistical publications was a 32-page appendix in 1907 to a treatise on breeding by E. Davenport, the Dean of Agriculture.

In 1909 Rietz became a charter member of the American Institute of Actuaries. His interest in actuarial science continued throughout his long tenure as head of the University of Iowa Department of Mathematics, 1918–1942, resulting eventually (1965) in the present Department of Statistics and Actuarial Science. By 1933 he had directed seven Ph.D. dissertations at the University of Iowa, including in 1931 that of S. S. Wilks, who was quickly to assume a leadership role.

Rietz was also a prolific author of books in mathematics. In 1924 he was editor-in-chief of a *Handbook of Mathematical Statistics* and in 1927 he published his well-known Carus Monograph, *Math-*

ematical Statistics. The monograph does not cite any of R. A. Fisher's work on the analysis of variance. Of particular historical interest, therefore, is the review paper (Rietz, 1931) on applications of small-sample theory. By numerical calculations, Rietz points out, for example, that where "classical" large-sample theory, applied to small samples, may lead us to declare two means significantly different, the "Student theory" may not do so. He states that the latter is to be preferred when the assumption of normality is at least approximately satisfied, but goes on to illustrate the dangers of ignoring the assumption. He notes that two-sided tests cope better than one-sided tests with departures from normality. Of course, Rietz was not alone in cautioning against the too-ready use of Fisherian small-sample theory. In particular, he cites theoretical or "experimental" studies on the effect of nonnormality by, for example, P. R. Rider, W. Shewhart and E. S. Pearson.

Harry C. Carver (1890–1977). Appointed in 1916 by J. W. Glover of the University of Michigan to add courses in probability and statistics to Glover's program in actuarial science, Carver became the driving force in the development of mathematical statistics at Michigan (Craig, 1978). In the early 1930s he was joined by C. C. Craig and A. H. Copeland, and in 1936 by his student P. S. Dwyer. He was an inspiring teacher and by 1941 had directed 10 Ph.D. students. In the 1920s Michigan was one of very few universities offering courses in mathematical statistics. Although Carver's publication list in statistics was quite small, he became a national figure when, at his own expense, he established *The Annals of Mathematical Statistics* in 1930 and served as founding Editor. His purpose was to provide a medium for the publication in the United States of papers with substantial mathematical content. Only an extraordinary person could have ventured to take the risks involved, given the times and the limited number of individuals then working in mathematical statistics.

Harold Hotelling (1895–1973). A truly giant figure in both statistics and economics, Hotelling had already made his mark by 1933. After a B.A. in journalism and an M.S. in Mathematics from the University of Washington, he hoped to develop his understanding of economics and statistics at Princeton (Darnell, 1988). However, finding "there was no one there who knew anything about either subject," he obtained a Ph.D. in mathematics in 1924, with a dissertation in topology. Hotelling then joined Stanford University, first its Food Research Institute and in 1927 its Mathematics Department. He soon introduced courses in statistics and began to publish major papers in both mathematical statistics and economic theory. In 1931 he continued these activities at Columbia University as Professor of Economics and over the following 15 years attracted numerous outstanding students and colleagues, beginning with Wilks in 1931–1932.

Hotelling's early papers in statistics include the famous ones on the generalization of Student's ratio in 1931 and on principal components in 1933. A list, complete up to 1959, is given in the outstanding Festschrift edited by Olkin et al. (1960). Hotelling also was a frequent and insightful book reviewer. His early vision is apparent in a 1927 review, in the *Journal of the American Statistical Association* (*JASA*), of Fisher's *Statistical Methods for Research Workers* which concludes with the words: "The author's work is of revolutionary importance and should be far better known in this country." Hotelling went on to review the next six editions, visiting Fisher at Rothamsted in 1929. He was the early U.S. exponent par excellence of Fisherian methods and his influence on statistics in America was profound.

Hotelling's (1931) brilliant paper in which he finds the null distribution of his T^2 statistic was motivated by a problem raised by Karl Pearson (1926) "in connection with the determination whether two groups of individuals do or do not belong to the same race, measurements of a number of organs or characters having been obtained for all individuals." However, the correlations between the several measurements on the same individual seemed to pose an insuperable obstacle.

To tackle this problem Hotelling first considers (in slightly modernized notation) a random sample $X_{i\alpha}$ $(i = 1, \ldots, p,\ \alpha = 1, \ldots, N)$ from a p-variate normal population with means μ_i and covariances σ_{ij} $(i, j = 1, \ldots, p)$. With S_{ij} the usual unbiased estimator of σ_{ij}, he defines A_{ij} as the cofactor of S_{ij} in $|S|$ divided by $|S|$, the determinant of the S_{ij}. His first bold step is to take

$$T^2 = \sum_{i=1}^{p} \sum_{j=1}^{p} A_{ij} Y_i Y_j,$$

where $Y_i = (\bar{X}_i - \mu_i)\sqrt{N}$, as a "measure of simultaneous deviations" from the hypothetical means μ_i. He notes that, for $p = 1$, T^2 reduces to the square of Student's t.

Thus, without using matrix notation Hotelling arrives at the statistic now usually written as $T^2 = \mathbf{Y}'\mathbf{S}^{-1}\mathbf{Y}$ (e.g., Anderson, 1984, page 161). He points out the applicability of T^2 to Karl Pearson's two-sample problem and to the comparison of regression coefficients.

As a second key step Hotelling invokes a result in tensor analysis in order to state that T^2 is an absolute invariant under all homogeneous linear transformations. This allows him to take the $X_{i\alpha}$ to be independent with equal variances and then to devise a geometric argument inspired by R. A. Fisher's use of geometry in deriving statistical distributions. Finally, prior to the existence of tables of the F-ratio, he points out that, with $n = N - 1$,

$$z = \tfrac{1}{2}\log(n - p + 1)T^2 - \tfrac{1}{2}\log np$$

can be referred to percentage points of Fisher's z with p and $n - p + 1$ degrees of freedom, given in Fisher (1928, Table VI).

The crucial invariance of T^2 under nonsingular linear transformations is interestingly discussed in Hotelling (1954), as pointed out by Morrison (1990, page 135). However, it is Hotelling's remarkably simple result, rather than his argument, that has become a classic. Later writers on T^2, and there have been many, have increasingly employed matrix algebra in their proofs, beginning with Hsu (1938), who obtained the nonnull distribution of T^2. Historically, it is also worth noting whom Hotelling does not cite. There is no reference to Wishart (1928), where the joint distribution of the S_{ij} is developed, or to the likelihood ratio approach of Neyman and Pearson (1928), which would have produced a test statistic equivalent to T^2 (e.g., Anderson, 1984, page 157).

This paper is one of the "breakthroughs" in Kotz and Johnson (1992). In his introduction to the reproduced paper Anderson (1992) points out that Hotelling spent the academic year 1929–1930 with Fisher at Rothamsted. Although he was very familiar with Fisher's work, "Hotelling seemed not to realize" the close relation of his work to Fisher's (1924) derivation of the null distribution of the multiple correlation coefficient R^2. For R^2 the invariance property presented no difficulty. The relationship between T^2 and R^2 is made specific in, for example, Anderson (1984, page 191). Anderson (1992) also draws attention to Wilks's generalization of the analysis of variance (Wilks, 1932), written when Wilks spent a postdoctoral year with Hotelling at Columbia.

We deal more briefly with Hotelling (1933), introducing principal components. The term is due to Hotelling, who expresses his indebtedness to the psychologist Truman Kelley for asking many of the questions for which this long paper provides elegant answers. The problem is to replace measurements $x_1, \dots, x_p$, taken on each member of a group, by "some more fundamental set of independent variables..., perhaps fewer in number than the x's, which determine the values the x's will take." Hotelling assumes that $X_1, \dots, X_p$ have a multivariate normal distribution and takes the independent variables (the principal components) to be standardized linear functions of the X's. This leads him quickly, by ordinary algebra, to the characteristic equation now more concisely written as

$$(1) \qquad |\mathbf{R} - \lambda \mathbf{I}| = 0,$$

where $\mathbf{R}$ is the $p \times p$ matrix of *observed* correlations (not necessarily of full rank) and $\mathbf{I}$ the unit matrix of order p (compare, e.g., Anderson, 1984, page 453).

Hotelling remarks that equations such as (1) "were first studied in connection with the perturbations of the planets" and that it is known from the theory of determinants that all the roots $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p$ of (1) are real. He points out that the largest root λ_1 will give the principal component accounting for "as large as possible a part of the total variance," evidently unaware that Pearson (1901) had already taken this first step in finding planes of closest fit to systems of points in space. Hotelling, however, goes on to finding all the principal components, provides an iterative solution and illustrates his procedures on educational test data supplied by Kelley.

It should be noted that many of the 1935 members of IMS were not primarily mathematical statisticians. For example, the just mentioned Truman L. Kelley, Professor of Education at Harvard, made important contributions to psychometrics and in 1924, when at Stanford, published his influential text *Statistical Method* (see his entry in the *International Encyclopedia of the Social Sciences*).

2.4 Some Other Personalities Mentioned Above

Raymond Pearl (1879–1940). Pearl was a great admirer of Karl Pearson, whom he visited at University College London for the academic year 1905–1906. Pearson's Department of Applied Statistics was established in 1911. Pearl headed the Department of Biometry and Vital Statistics in the newly formed School of Hygiene and Public Health at Johns Hopkins from 1918 to 1925. Continuing at Hopkins as Professor of Biology, he was succeeded by his colleague, Lowell J. Reed. Pearl was a larger-than-life figure whose bibliography carried over 700 entries, including 17 books on biological, social and statistical issues (Jennings, 1943). He founded the *Quarterly Review of Biology* in 1926 and *Human Biology* in 1929, and served as first editor of both. He was president of ASA in 1939.

Helen M. Walker (1891–1983). Walker taught at Teachers College, Columbia University, from 1925 to 1957. Like Pearl she was an admirer of Karl Pearson. Following her historical study (Walker, 1929), she became the author or coauthor of several well-known elementary statistical texts and wrote a number of historical articles. In 1944 she served as President of ASA, the first woman to do so. For biographical notes see *J. Amer. Statist. Assoc.* **53**, 206 (1958).

Willford I. King (1880–1962). King was a prolific author of articles and books on economics and economic statistics. His book, *The Elements of Statistical Method*, published in 1912 by Macmillan, New York, was one of the earliest statistical texts to appear in the United States. He was ASA Secretary–Treasurer from 1925 to 1935 and President in 1935. King plays a major role in Stigler (1996).

2.5 Texts Available in 1933

In listing many of the more important statistical texts available in 1933, we will not confine ourselves to statisticians in academe, or to the United States. The list (following the list of references) is constructed from books cited in the *Annals* or *JASA* for 1933 and is longer than might have been thought. When a book has gone through several editions, we give only the latest edition prior to 1933. For texts relating to probability, see the extensive bibliography in Keynes (1921).

3. THE IOWA STATE STATISTICAL LABORATORY

The early history of statistics at Iowa State was shaped predominantly by three men: first and foremost, George W. Snedecor (1881–1974), but also, as we shall see, Henry A. Wallace (1888–1965) and R. A. Fisher (1890–1962). Of course, many others, experimental scientists, applied statisticians and Iowa State administrators, contributed significantly.

Snedecor joined the Iowa State Mathematics Department in 1913 with a B.S. from the University of Alabama in 1905, five years of college teaching experience in the South and a Michigan A.M. in physics in 1913. His preparation in statistics is uncertain, although it is plausible to think that he benefitted from J. W. Glover's courses at Michigan on the mathematical theory of statistics. Appointed as an Assistant Professor, Snedecor was promoted to Associate Professor in 1914. He soon found himself involved in helping research workers, especially in agriculture, in the design and analysis of their experiments. Fostering this activity was to be his life's mission. An agricultural state, Iowa as early as 1858 had passed a bill to "provide for the establishment of a State Agricultural College and Farm" (Ross, 1942, page 18). When the famous Morrill Land-Grant Act was proclaimed in 1862, Iowa was ready and "became the first state to signify official acceptance of the grant" (Ross, 1942, page 40). A strong tradition of research in agriculture and the biological sciences had developed by the 1880s, so that Snedecor found stimulation and support for his work. J. M. Evvard of the Department of Animal Husbandry was a particularly valuable supporter whose influence was possibly crucial in the establishment of the Statistical Laboratory (Cox and Homeyer, 1975, page 273).

The Iowa State College catalogue for 1914–1915 shows new courses in the Department of Mathematics entitled "Probability and Least Squares" and "Mathematics as Applied to Social and Economic Problems." By 1919–1920 the course offerings had stabilized essentially to "Statistical Method of Interpreting Experimental Data" (SM) and "Biometric Methods of Interpreting Agricultural Data" (BM). The former carried 3–5 quarter credits, with a calculus sequence prerequisite; the latter, "primarily for students doing major work in the biological sciences," carried 3 credits with no prerequisites.

No doubt, these early years were an important learning period for Snedecor, preparing him to profit from the stimulus and boost provided by a series of 10 Saturday afternoon lectures given, in the winter or spring of 1924, by Henry A. Wallace. Wallace was to become the New Deal Secretary of Agriculture (1933–1940), Vice President in Franklin D. Roosevelt's third term (1940–1943), Secretary of Commerce to Harry S. Truman (1946) and Progressive Party Presidential Candidate in 1948. Born into a distinguished Iowa family, he was a 1910 graduate in agriculture from Iowa State, and class valedictorian. In 1921 he had become editor of *Wallaces' Farmer* in Des Moines, following the appointment of his father, Henry C., as Secretary of Agriculture. Thus H. A. had easy access to the experts at the Bureau of Agricultural Economics, an agency set up by his father.

From boyhood Wallace had been experimenting with the crossing of plants, especially corn, and in 1926 he founded the still very successful Pioneer Hi-Bred Corn Company. Coupled with this activity was a keen interest in a statistical study of the factors influencing corn yields. Later (Wallace, 1951) he reminisced:

> My work on cycles began in about 1913, when I began to study the relationship of weather to corn yields, of corn supply to corn prices, the relation of corn prices to hog prices, the cycle of hogs, the cycle of cattle, the cycle of horses, and so on. I did that as a preliminary to getting into more serious and careful statistical work. As a result of studying the relationship of corn weather to corn yields, I ran across the work of H. L. Moore, the Columbia University professor. He had put out some very careful statistical analyses involving the relation of independent variables to a dependent variable, expressing them by regression lines and correlation coefficients. Suffice it to say that I became proficient at doing work of that kind, using a key-driven calculating machine to facilitate matters. I thought that the people at the Iowa State College of Agriculture and Mechanical Arts at Ames were not sufficiently current in that field. I went up and met with several of the professors and sold them on the idea that they should be able to evaluate their experimental work much more accurately if they had more adequate statistical background.
>
> As a result, they employed me for ten weeks to conduct a statistical course.... There was no one in the class of some twenty who was not either a professor or a post-graduate student.

I suppose the last sentence reflects some justifiable pride by one who stopped with a B.S. After describing the first warming-up problem of the course, Wallace continues:

> Then I took another problem which was interesting to them as agricultural people—the relationship between farm land values in the different counties—for which there were census figures—and the yield of corn per acre. We used an average of ten years for which we had crop reporting figures. We used the percentage of the crop land in corn, for which we had census figures; the value of the buildings per acre, for which we had census figures; and so on. We took up various independent variables bearing on the dependent variable of the value of the farm land per acre. That was the problem which I set to them, which later was embodied in a bulletin put out by Iowa State College entitled *Correlation and Machine Calculation*.

Wallace wrote the first draft of the bulletin. Snedecor, the statistician in the audience of mainly agricultural and biological research workers, put the material in final shape to produce a publication of just 47 pages (Wallace and Snedecor, 1925) that reached worldwide circulation. From subsequent correspondence and statements it is clear that Wallace remained proud of his important early role in fostering statistics at Iowa State.

Spurred on, George Snedecor according to the 1925–1926 Iowa State catalogue expanded BM to two 3-credit courses, the second described as "Multiple Correlation and Machine Calculation"; a third quarter was added in 1927–1928. Snedecor also offered a 3-credit biomathematics course.

The bulletin, Snedecor's first publication, at the age of 42, apparently set free his pen, both for research papers and expository articles and books. His *Statistical Methods*, first published in 1937, later coauthored by W. G. Cochran and now in its eighth edition, was a phenomenal success. The text has nearly 2,000 entries in the Science Citation Index for 1995.

More immediately following the bulletin came a series of papers, single-authored, or jointly authored with agricultural colleagues. A. E. Brandt, soon to become Snedecor's right-hand man, entered the scene during these years and contributed significantly to statistical and computational research. In 1926 Brandt wrote a M.S. thesis and in 1932 a Ph.D. dissertation, both under the Iowa State geneticist D. W. Lindstrom. The thesis, which was quite statistical, already followed closely "the methods of the bulletin." Brandt was particularly skilled in computational methods.

A preliminary step in the creation of the Statistical Laboratory was now taken by the newly appointed President of the College and the Head of the Mathematics Department. In a 1940 Iowa State College Bulletin featuring the Statistical Laboratory we read:

> The Department of Mathematics of Iowa State College is noted for its willing and effective cooperation with people having problems in applied mathematics. In statistical applications Professor Snedecor took the lead shortly after joining the staff in 1913. Following the lectures of

> Dr. Wallace, the demand for professional help in statistics grew so rapidly that in 1927 President R. A. Hughes and Professor Smith instituted the Mathematics Statistical Service with Professor Snede cor and Dr. A. E. Brandt in charge. Calculating and punched card tabulating equipment was installed. . . .

Activities clearly intensified. In 1928 Brandt published three articles with a computational emphasis and Snedecor wrote on the uses of punched card equipment (Snedecor, 1928). Snedecor's student, Gertrude Cox, made her first publishing appearance in 1930, and in 1931 completed the first M.S. thesis in statistics at Iowa State, through the Mathematics Department. Also, Snedecor made a major revision of the bulletin (Wallace and Snedecor, 1931) incorporating "some of the elegant methods devised by Dr. R. A. Fisher for testing the significance of the various correlation statistics." He was finally promoted to full professor.

A good example of the kind of joint paper Snedecor tended to be involved in is provided by Schultz and Snedecor (1933). Schultz was Professor of Economics at Iowa State and later, at the University of Chicago, a Nobel Laureate in economics. The primary purpose of the paper was to show that the powerful new method of analysis of variance deserved the attention of economic statisticians. This was done through a careful discussion of a two-way and then a three-way analysis of variance of Iowa hog prices received by producers from 1924–1925 to 1930–1931, by months and by districts. No algebra appeared; the procedure was explained entirely arithmetically, from the data provided.

The same approach was used in a small book in which the F-statistic made its first appearance (Snedecor, 1934, page 15). In ignorance of a 1932 tabulation by Mahalanobis (Box, 1978, page 325) Snedecor took the small but immensely popular step of replacing Fisher's z by the simpler F, defined as (larger mean square)/(smaller mean square). He gives tables of upper 5% and 1% points of F calculated from Fisher's tables for z, leaving the reader to infer that the symbol F was chosen in honor of Fisher. The latter continued to prefer z, but could not ignore F in view of its wide acceptance. Hence, beginning with Fisher and Yates (1938), their Table V includes percentage points of both z and the "variance ratio e^{2z}"!

Although Hotelling was then rightly regarded as the primary exponent in the United States. of the new Fisherian approach, Snedecor was among the first in this country to recognize the extreme importance of Fisher's statistical methods. Moreover, he was able to arrange a six-week visit by Fisher in the summer of 1931. This was made possible by an enlightened Graduate College program that each summer brought in a distinguished lecturer whose work was of interest to several departments (Lush, 1972). Fisher gave three lectures a week based on *Statistical Methods for Research Workers* and three more on either the theory of statistics or *The Genetical Theory of Natural Selection*. He was also active in the discussion of experimental work by the local staff. The visit was a great success and no doubt boosted the standing of statistics as a discipline at Iowa State. Fisher paid a return visit in 1936, at which time he was awarded an honorary D.Sc., his first.

The final element important in the establishment of the Statistical Laboratory was Iowa State President Hughes's emphasis on the administrative efficiency to be gained by centralization, especially in a time of economic stringency. The way this affected statistical activities can be clearly seen from annual Reports of the President to the Faculty, available in the Department of Special Collections, Iowa State Library (Melde, 1990). On September 17, 1930, he wrote:

> For some years the College has been fortunate in having a Hollerith machine available for use by any department. . . . Recently a plan has been worked out for the operation of the machine by the clerical staff of the Agricultural Economics Section, which uses it largely. . . . I hope all departments using statistical methods will inform themselves fully of these facilities and use them wherever possible in preference to setting up separate statistical organizations.

By September 16, 1931, President Hughes had decided to pass the authority for computing on to George Snedecor:

> The computing facilities of the college have been unified under the control of the mathematics statistical service, cooperating with the Agricultural Economics computing department. This makes possible a uniform policy, covering not only adding and computing machines, but also the Hollerith tabulating equipment. . . . All new computing machines bought hereafter by the college will be purchased on the requisition of Professor Snedecor. He will also repair or replace all worn-out machines. We now have

> over 100 of these expensive machines in use on the campus and it is only through a central director in full charge of all of them that we can insure their economical use . . . .

Clearly, the use of statistics had become an important element in the college's growing research program. In 1932, Iowa State ranked 13th among the nation's universities in the number of Ph.D. degrees awarded (Ross, 1942, page 356).

The effect of the Depression on the college, such as reduced enrollment and reductions in salary, is clearly acknowledged in the Report for September 21, 1932. No reference is made to statistics, but the Statistical Laboratory is born on July 1, 1933, as an institute under the President's office, with George W. Snedecor as Director. The laboratory's functions are described in the College Catalogue for 1934–1935 under five headings: Research; Statistical Counsel; Teaching; Computation Service; and Calculating Machines. It is explained that the laboratory is not a department of instruction, but that members of its staff devote part of their time to teaching statistics in the Mathematics Department.

Snedecor, Brandt and Cox were the initial faculty members of the Statistical Laboratory. Their teaching on the theory side was supplemented by other members of the Mathematics Department.

This completes our story. As a brief epilogue we may note that the teaching arrangement continued even when the laboratory staff was substantially increased as a result of a cooperative agreement in 1938 with the U.S. Department of Agriculture. A key appointment was that of W. G. Cochran, who soon took the initiative in setting up a Ph.D. program. Courses and research activities now multiplied. The laboratory had frequent visitors interested in establishing similar statistics programs (Cox and Homeyer, 1975). However, a department was not formed until 1947 when Snedecor had reached mandatory retirement age as Director and all the other individuals mentioned here had departed. See also David (1984).

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