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The USDA Graduate School: Government Training in Statistics and Economics, 1921-1945

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Abstract

The USDA Graduate School was founded in 1921 to provide statistical and economic training to the employees of the Department of Agriculture. The School did not grant degrees, but its graduate courses were accepted for credit by a significant number of universities.

After its founding, the activities of the School grew rapidly to provide training in many different subject areas for employees from almost all Government Departments. The training in statistics provided by the School was often highly advanced (instructors included Howard Tolly and, later, Edwards Deming), while the economics taught displayed an eclectic mix of standard and institutional economics. Mordecai Ezekiel taught both economics and statistics at the school, and had himself received his statistical training there. Statistics instruction in 1936 and 1937 included seminars from R. A. Fisher and J. Neyman, and courses on sampling theory involving Lester Frankel and William Hurwitz became important after 1939. The instruction in economics was noticeably institutionalist in the period of the New Deal. Towards the end of the period considered here the instruction in economics became narrower and more focused on agricultural economics.

The instruction given provides a basis for understanding the sources of the relative statistical sophistication of agricultural economists in the interwar period. It also provides a light on the place of institutional economics in the training of government economists through the same time span. It is noteworthy than within the USDA Graduate School, and in contrast to the Cowles Commission, statistical sophistication co-existed with an approach to economics that was not predominantly neoclassical.

1. Introduction

The United States Department of Agriculture (USDA) is a Department of the US Government that has a considerable history in the practice of applied statistics and economics.[1] In 1921 Henry Cantwell Wallace was appointed as Secretary of Agriculture, taking over a Department already well known for its research in agricultural science, but which had not, under the previous Secretary David Houston, encouraged further graduate training for its staff. Wallace, and his new Assistant Secretary, Elmer D. Ball, were of different minds. Ball, in particular, was concerned about the loss of scientists from the Department and wrote to Wallace in April of 1921 suggesting "a system of graduate training within the Department" (Brewster 1985, p. 3). At the same time Wallace himself was concerned to extend the Department's expertise in the area of agricultural economics.

In 1922 Wallace appointed Henry C. Taylor[2] as Chief of the new Bureau of Agricultural Economics (BAE). Taylor had also expressed concern about the level of economic and statistical expertise of his staff and was interested in providing opportunities for further training. It is worth emphasizing the significance of the BAE. By 1929 "the BAE had more social scientists than the rest of the federal government combined" (Banzhaf 2006, p. 14). In terms of economics:

> The BAE brought together by far the largest group of research-orientated economists that had ever been assembled in the United States and presumably in the World. It became the central institution of the agricultural economics profession, maintaining close ties with agricultural

> economists in land-grant colleges and experimental stations and collecting, processing, and interpreting vast quantities of statistical data (Fox 1989, p. 55).

The concentration of statistical economists in the Department of Agriculture is a feature of its history and is clearly related both to the abundance of data available, on both agricultural production and prices, and to importance of the agricultural sector in terms of economic policy. Of course, the Department itself was not the only center for research on agricultural economics and agricultural statistics. Important programs in agricultural economics existed at Cornell, Wisconsin, Michigan State, Iowa State College, and elsewhere, and in 1933 Iowa State established its famous Statistical Laboratory.

The contributions to econometric analysis made by agricultural economists in the 1920s and 30s (especially, but not exclusively, those working for the BAE) has been the subject of a number of papers by Karl A. Fox (1986; 1987; 1989), and, more recently, by H. Spencer Banzhaf (2006). This group included Mordecai Ezekiel, Howard Tolley, Frederick Waugh, Louis Bean, W. J. Spillman, Holbrook Working, and E. J. Working, among others.[3] What is emphasized in the discussion of their work is the relative sophistication of their statistical analyses and the significance of their contributions to demand and price analysis, particularly in the areas of multiple regression methods, errors in variables issues, and identification problems. This community of agricultural econometricians certainly knew of and communicated with the econometricians at Cowles,[4] but they were more methodologically and theoretically eclectic and their work

had a more applied and normative policy focus. For these reasons Banzhaf has called the agricultural economists of this period "the other economics department" (Banzhar 2006). Although the existence of the USDA Graduate School is mentioned in passing in some of the literature, the training it offered and its role in developing the statistical sophistication of the agricultural economists and other Government employees of the 1920s and 30s have not been examined in detail.

A second aspect of the economics to be found at the USDA, especially in the period of the New Deal, is its institutionalist dimension. This has to be approached quite carefully as a substantial part of agricultural economics, the economics of Henry Taylor's text book, *Agricultural Economics* (Taylor 1905) for example, was what might be called "generally neoclassical" in its discussion of markets and prices. Nevertheless, agricultural economists had a sense of the sometimes perverse workings of agricultural markets, the problems of rural poverty, land conservation issues, and other problems brought to the fore by the Great Depression. Many economists of an institutionalist bent became involved in the Department of Agriculture and in the Agricultural Adjustment Administration of the New Deal years.

A number of these economists, including Rexford Tugwell, Mordecai Ezekiel and Gardiner Means, formed the core of a group who pursued a "planning" or "structuralist" agenda as a solution to the Depression (Hawley 1996). One issue highlighted in Means' work was that of the inflexibility of many industrial prices relative to agricultural prices, resulting in a loss of "price balance." In 1936 Ezekiel put forward his "industrial expansion plan" designed to provide a coordinated increase in output and income across all sectors of the economy (Ezekiel 1936). Ezekiel and Means were both members of the

National Resources Committee, but after 1937 the thinking of the Committee as a whole (including, by 1940, Ezekiel himself) shifted from the structuralist/planning research agenda pursued by Means, to a more Keynesian position developed originally from work by Laughlin Currie (Lee 1990; Rutherford and DesRoches 2008). Louis Bean also worked closely with Ezekiel on economic policy at that time. As most of the instruction in economics undertaken by the USDA Graduate School was provided by employees of the Department of Agriculture, an examination of the economics instruction provides insight into the economic philosophies embodied in the Department and their changes over time, and very nicely indicates the evolving state of the profession on issues involving the use of statistics, mathematical methods, and the institutional and neoclassical approaches.

This paper focuses on the training given by the USDA Graduate School in statistics and economics between 1921 and 1945. The objectives of the paper are to show both the statistical sophistication of the training provided by the School, and the eclecticism of its economics. These aspects of the School's teaching must have impacted on the conduct of statistical work within the government, on the economics to be found in the USDA and more widely within government agencies of the time, and on the character of agricultural economics more generally. The end date was chosen as after that point the training in economics became noticeably narrower, with the institutionalist element in the economics instruction becoming much more attenuated.

2. The USDA Graduate School: An Overview[5]

During the summer of 1921 Elmer Ball chaired a committee, including L. C. Gray,[6] then with the Office of Farm Management and Farm Economics, on the formation of a "system of advanced instruction." The memorandum produced by this committee in August of 1921 recommended the provision by the Department of opportunities for advanced study in order to improve the efficiency of the Department's work and to aid in the recruitment and retention of the most able people (USDA Graduate School Records, Box 18). It was recommended that instruction be informal and given outside office hours, that the School be self-supporting through the collection of fees, that arrangements be made for the acceptance of credits by other institutions, that cooperative arrangements be made with other institutions in the Washington DC area, and that Department regulations be altered to encourage employees to undertake advanced training both at the School and at other universities. It was supposed that students would mostly come from the Department of Agriculture. It was not intended that the School be able to grant degrees, but that a student might fulfill a good part of the requirements for an advanced degree and transfer their credits to a degree granting university. The committee also recommended a list of possible courses, at both a "general or fundamental" level and at an "advanced or graduate" level. The subjects suggested included various areas of agricultural science, statistical methods, and agricultural economics (History of the Graduate School 1964, p. 12).

Instruction at the School was provided predominantly by people otherwise employed by the Department of Agriculture or other government agencies. Classes were held outside of regular office hours, and modest fees were charged to defray costs. The Annual Reports of the Graduate School (USDA Graduate School Records, Box 4) occasionally contain information on

the institutions that had given credit for their courses. Initially these tended to be institutions in the Washington DC area, for example Modecai Ezekiel transferred his credits to the Robert Brookings Graduate School (headed by Walton H. Hamilton, a leading institutional economist) and completed his PhD there in 1923. Over time the list of universities accepting Graduate School credits expanded to include Columbia, Cornell, Yale, Harvard, Johns Hopkins, Chicago, California, Michigan, New York, Illinois, Iowa, and numerous others. Cooperative arrangements with American University began in 1936 with the AU School of Public Affairs. A short time later American University and the USDA Graduate School were also cooperating on a significant number of courses in economics, as well as a few in statistics, with the USDA Graduate School explicitly listing AU courses in its annual announcements of courses and AU giving credit for Graduate School courses in those areas. This arrangement with American University encountered difficulty after 1940 and ended after the 1944/45 year (Report of the Director, 1943-1944, USDA Graduate School Records, Box 4).[7]

The Graduate School grew in terms of numbers of courses offered and numbers of students, eventually moving well beyond the original vision. In 1921 the School offered 11 courses and the number of courses remained quite small until expanding in the early 1930s and again in the mid 1930s, reaching 43 in the 1935/36 year including eight courses in economics, five in mathematics and Statistics, and a substantial number of language courses, as well as technical courses in subjects such as photography and glass blowing.[8] The arrival of the New Deal had substantial effects along a number of dimensions. The numbers of instructors available to the School, the numbers of course enrollments (which increased dramatically), and the range and number of courses offered all increased substantially. In 1933 the Department of Agriculture had 26,544

employees, but this almost doubled by 1936 and doubled again to 106,217 in 1937.[9] The extent of the Graduate School's activity thus increased dramatically and this increase was sustained through the 1940s. In 1941/42 year, its 20th Anniversary year, the Graduate School listed a total of 127 courses offered in the Fall and 118 in the Spring as well as 16 courses in the Summer. The courses available from American University were in addition to these. In economics, the Graduate School offered an undergraduate course in principles, 10 courses described as "Graduate and Advanced Undergraduate" (plus another seven cross-listed with AU), and six "Graduate Courses" (plus three cross-listed with AU). In statistics there were six undergraduate courses listed, four "Graduate and Advanced Undergraduate," and 11 "Graduate Courses" (plus two cross listed with AU) (USDA Graduate School Records, Box 1, Catalogs 1921-1956).

The 1940 year saw the establishment of subject matter Departments replacing the original system of subject matter subcommittees, which had by then virtually ceased to exist outside of economics. The following eight Departments were set up: Biological Sciences (including biology, botany, genetics, bacteriology, plant and animal pathology, and cytology), Physical Sciences (chemistry, physics, meteorology, astronomy, geography, and soil sciences), Mathematics and Statistics, Engineering and Mechanical Arts (architectural and mechanical drawing, engineering, graphic presentation, and glass blowing), Language Aids (foreign languages, English, literature and drama, editing and writing, and speech), Social Sciences (economics, history, sociology, philosophy, psychology, and public law), Public Administration (management and supervision, accounting and auditing, financial administration, administrative law, personnel administration, and public relations), and Office Skills (secretarial training, clerical

training, shorthand, office procedures, government correspondence, and business English). This system remained in effect through the period considered here (History of the Graduate School, 1964, pp. 20-23).

The student body saw related changes. The total number of course registrations began in the 1921/22 year at 319. This number rose to 414 the following year and then declined to 111 in 1926/27 before starting an upward climb to 505 in 1930/31, then dipping again in the next few years reaching the low 290s in 1932/33 and 1933/34. From then on the numbers rose steadily reaching 7,863 in 1944/45. As these numbers indicate, the student body developed well beyond the Department of Agriculture and the Graduate School became the provider of further educational opportunities for the Federal Civil Service generally. This shift began in the mid 1930s as a result of other government agencies asking for permission to let their employees attend classes, and again was accelerated by the demands of the New Deal. The first year in which a breakdown is given is for 1931/32 when 291 course registrations were from members of the USDA and 194 from outside the Department. Ten years later there were 1,369 course registrations in the Fall and Spring terms from within the USDA and 4,858 from other departments and agencies. Employees from the Census, from the Departments of Commerce, Labor, Treasury, Social Security Administration, and many other agencies became well represented.

The Graduate School, USDA, still exists—now serving over 200,000 participants in about 1000 courses per year. Its focus has become as broad as the professional development needs of the Federal Civil Service. Its legal status, long the subject of debate and confusion, has become established as “a non-appropriated fund

instrumentality (NAFI) government entity."[10] Most of the discussion of the Graduate School either published or to be found in the archives deals with the history of the school from the point of view of what became its mission of professional development for the Federal service as a whole.[11] The focus of what follows is much narrower—the specific courses and programs offered in statistics and economics and their relationship to the history of American economics and econometrics in the period up until1945. As will be seen, the USDA Graduate School provided highly advanced training in statistical technique, but combined with an economics that was pluralistic and included much that was of a clearly institutional character. Interwar institutional economics is usually associated with the type of empiricism found at the National Bureau of Economic Research, while the development of econometrics is more generally associated with the anti-institutionalist group at Cowles. As will be seen below, at the USDA and its Graduate School and among agricultural economists more generally, what became known as econometric methods were combined with considerably more eclectic attitudes to economic theory.[12]

3. Instruction in Statistics

In the first years of the Graduate School the offerings in statistics were fairly limited. An introductory statistics course was given and a single Advanced Statistical Methods course. From the Fall of 1923 onwards this advanced course was listed at the graduate level. From 1921 through to the 1925/26 year, Advanced Statistical Methods was taught primarily by Howard Tolley. The course covered a full year (two terms) and used Yule's *Introduction to the Theory of Statistics* (1911). The course descriptions vary

a little, but one term generally dealt with correlation (simple and multiple), curve fitting and applications, and the other term with the theory of sampling and its applications, and/or time series and index numbers. It was from Tolley's course that Ezekiel first "got started on statistics" (Ezekiel 1957, p. #1 – 6). A few years after completing his PhD at the Brookings Graduate School, Ezekiel returned to the Graduate School as an assistant to Tolley in teaching the course Advanced Statistical Methods. This was in the 1926/27 year. The Advanced Statistical Methods course was then taught by Tolley and Ezekiel jointly through the 1929/30 year. In 1930/31 the course was taught by C. F. Sarle and E. J. Working.[13] At this point the course is described as dealing in the first term with the theory of sampling and its application to the collection and analysis of statistical data (using the text by Yule), and in the second term covering simple and multiple correlation, both linear and curvilinear, and problems of time series analysis, using Ezekiel's new book *Methods of Correlation Analysis* (Ezekiel 1930). The course was then taught by Ezekiel (assisted by B. R. Stauber) for a term before being taken over by C. M. Purvis. The course content remained much the same, but R. A. Fisher's *Statistical Methods for Research Workers* (1928) was used in addition to Yule and Ezekiel's books.

In addition to courses, the Graduate School often played host to visitors who gave lectures or series of lectures. R. A. Fisher gave two lectures at the School on the "Development of the Modern Concepts of Statistical Theory" in the 1930/31 year. Unfortunately, copies of these lectures do not appear to be available in the archives of the School.

This period was also one during which Eziekiel, Tolley and E. J. Working made important contributions to applied statistics. Tolley and Eziekiel (1923) presented the

Dolittle method for computing multiple correlations and regressions, and Eziekiel (1924) developed his graphical method for dealing with curvilinear multiple regression problems. Louis Bean[14] (of whom more below) developed a short cut method (Bean 1929). Ezekiel's 1930 book *Methods of Correlation Analysis* was primarily concerned with what would now be called applied regression analysis. According to Fox, "Ezekiel's book was definitely on the frontier" and "by far the most comprehensive work on applied regression analysis published up to that time" (Fox 1989, p. 67). Working was also closely involved with the debates surrounding the statistical estimation of demand relationships (Working 1927).

Several things occurred in and around 1933 to change the instructional program in statistics. Edwards Deming[15] began teaching at the School in 1933 and he offered a new full year course (in addition to Advanced Statistical Analysis) called "Adjustment of Observations." In the first term the course dealt with the theory of errors, Fisher's fiducial tests of hypotheses respecting parent populations. Bayes' theorem, Laplace's generalization, and the posterior method of estimation were applied and compared with fiducial inference. No text was used but papers by Helmert, Gosset ("Student"), R. A. Fisher, Karl Pearson, Neyman, Egon Pearson, Shewhart, Keynes, Molina, and Wilkinson were used. The second term treated the subject of least squares and empirical curves from the "general and simplifying view point made possible by recent developments." Various methods of estimating the parameters of an empirical formula were discussed and some attention given to Karl Pearson's Chi-square test for goodness of fit (USDA Graduate School Records, Box 1, Announcement, September 1933). This course together with the Advanced Statistical Analysis course gradually became more elaborate

but remained the core of the statistics teaching at the Graduate School through the 1937-38 year. Some other courses were introduced. In 1935/36 Deming offered a course in Advanced Mathematics for Students in Economic Theory and Statistics covering both linear algebra and calculus, including Taylor series, moments of curves, the Jacobian, and various topics in integration. Later in the same year an Intermediate Mathematics for Students in Economic Theory and Statistics course was introduced, designed to "move along somewhat slower" than the advanced course. In following years these courses developed into a substantial series of courses in Mathematical Preparation for Statistics and courses in Differential Equations and Applications. In the 1937/38 year M. A. Girshick[16] began teaching at the Graduate School, offering courses on Multivariate Analysis including "higher algebra" and mathematical statistics.

In September of 1936 R. A. Fisher visited the Graduate School and gave three lectures on the subject of "Statistical Inference and the Testing of Hypotheses." In April 1937 J. Neyman visited and gave a series of lectures and conferences. Neyman's lectures were on the theory of probability, probability and experimentation, and on the testing of statistical hypotheses. The conferences concerned issues involving field experiments, plant breeding, statistical methods in economic and social research (census by sampling and other problems), time series and related problems in economics, statistical estimation, and an "outline" of the theory of confidence intervals. Both of these sets of lectures, and the conferences and discussions were printed up and published by the Graduate School (Fisher 1936; Neyman 1938a). Neyman's lectures, in particular, involved issues at the forefront of statistical research at the time and brought attention to Neyman's 1934 article on the representative method (Neyman 1934). Issues relating to sampling were just then

coming to the forefront of Government statistical work due to the 1937 "Check Census of Unemployment" (Duncan and Shelton 1978, 44). Those recorded as participating in discussions with Fisher and Neyman included Milton Friedman and Sidney Wilcox who were then working on a survey of family expenditures.[17] Friedman's questions to Neyman involved the issue of ranked data in taking a sample from a full survey. As a direct result Neyman wrote a paper dealing with this issue, suggesting a solution based on his concept of inductive behavior (Neyman 1938b; see also Friedman 1937).[18] The following year two lectures were given by Frank Yates (on the design of factoral experiments and contrasts between the methods of correlation and regression), and a series of four lectures on The Statistical Method from the Viewpoint of Quality Control were given by Walter Shewhart.[19] Later, Deming regularly offered courses on quality control.

From about 1939-40 the offerings in mathematics and statistics underwent a further considerable expansion. The list of courses for 1940/41 is divided into two categories: mathematical preparation for statistics, and statistics. The former lists a total of 15 courses, some offered only every two, three, or four years. Of these, six are listed as undergraduate (including basic algebra, calculus and analytic geometry) and the rest as advanced undergraduate and graduate (including calculus, differential equations, linear algebra, interpolation and finite differences, theory of functions). In statistics seven undergraduate courses (some with multiple sections) and 14 advanced undergraduate and graduate courses are listed. Again it is clear that there is a rotation of some of these courses over a period of two or three years. Among the advanced courses listed are Graphic Correlation (Bean), Theory of Probability (Girshick), Adjustment of

Observations (Deming), Least Squares (Deming), Multivariate Analysis (Girshick), and Analysis of Variance (Girshick). In addition, the Graduate School began offering leading edge courses on sampling theory and methods (USDA Graduate School Records, Box 1, Educational Courses, 1940-41).

As mentioned above, sampling methods had been experimented with in 1937 with the check census of unemployment, but "the first practical application of probability sampling to a current reporting system in the Federal Government appears to have been the Sample Survey of Unemployment, which was put into operation at the beginning of 1940 by the Works Progress Administration" (Duncan and Shelton 1978, p. 47). This survey was conducted by J. Stevens Stock and Lester R. Frankel[20] (Frankel and Stock 1942). Following on from Neyman's lectures in 1937, the next instruction in sampling methods given at the Graduate School was in the form of two lectures given in October 1938 by Frederick F. Stephan as a part of the course Special Topics in Statistics. This was followed by two lectures from W. G. Cochran in January 1939 and a full term course, added in the spring of 1940, on Sampling Methods in Social and Economic Data taught by Stock and Frankel themselves. This was only the second course on sampling to be offered anywhere in the world (Frankel and King 1996, p.70).[21] The 1940/41 course listings include two courses on sampling, the Stock and Frankel course noted above and a course on the Theory of Sampling taught by J. Cornfield and W. D. Evans. Sample methods were also introduced into the decennial census in 1940 and Edwards Deming became the Mathematical Advisor to the Census Bureau. In the 1941/42 year a course on Theory of Sample Surveys was added, given by William Madow and William Hurwitz,[22] and from the 1943/44 year Deming organized a regular seminar on sampling. M. H.

Hansen also taught along with Madow and Hurwitz, and notes from their courses on sampling became the basis their 1953 text book (Hansen, Hurwitz, and Madow 1953).

A further formalization of the program in statistics came in the 1942/43 year with the availability of "Certified Statements of Accomplishment in Statistics." These could be achieved in one of four areas of concentration: processing of data, social sciences, biological and physical sciences, and design and interpretation of sampling surveys. In this particular year, Milton Friedman offered a course on Statistical Analysis of Economic and Social Problems and Frederick V. Waugh[23] a course on Statistics of Agricultural Economics (the latter listed as a course in economics). Friedman's course was described as "Selected topics in the application of statistical methods to demand and cost curves, business cycles, income distribution, measurement of inflationary gaps, etc." (USDA Graduate School Records, Box 1, Bulletin of Information and Courses 1942-43, p 18). The list of courses available for the Certified Statement of Accomplishment in Statistics for the 1942/43 year is reproduced in Appendix 1 (USDA Graduate School Records, Box 1, Bulletin of Information and Courses 1942-43, pp 10-11). Friedman did not teach at the Graduate School again, but Waugh continued to offer courses in agricultural economics and social welfare issues (see below). Other notables involved in statistics instruction at this time were the biostatistician Jerome Cornfield, later involved in the debate over smoking and cancer, and Solomon Kullback, who became involved in the statistics associated with information theory (the Kullback-Liebler information measure). Overall, the program provided training in mathematics and applied statistics of a type that would have been difficult to obtain at other graduate schools. This program

remained largely the same through the rest of the period considered here, although by 1947 Girshick, Stock and Frankel had all ceased to teach at the Graduate School.

Outside of actual course offerings, the second edition of Ezekiel's *Methods of Correlation Analysis* appeared in 1941. Deming and Girshick provided advice on the "more mathematical sections" and especially those dealing with "the sampling significance of results" (Fox 1989, p. 67). Between 1943 and 1946 Girshick was working with T. Haavelmo at Cowles on a five equation model of the US demand for food using the limited-information maximum likelihood method (Fox 1989, p. 57). Waugh was also on the forefront of statistical research, becoming "the first economist to apply Hotelling's method of canonical correlation" (Fox 1989, p. 69; Waugh 1942).

4. Instruction in Economics

In terms of economic instruction the offerings in the early years were both few in number and quite variable. The 1921/22 year saw, in the first term, Henry Taylor teach a course on agricultural economics and, in the second term, a course on the Economics of Commodity Marketing was offered and a course on Agricultural Prices taught by O. E. Stine.[24] In 1921 and 1922 Mordecai Ezekiel was a student and took agricultural economics from Taylor, and a seminar given by John D. Black on production economics.

The following year (1922/23) saw a division into General and Graduate courses with a general level course, Elementary Agricultural Economics, taught by L. C. Gray, and graduate course, Advanced Economic Theory, taught by Taylor and C. L. Stewart in the first term followed by a Course on Land Economics in the second term, listed as being taught by Gray and by Richard T. Ely, who was in Washington that term.[25] The

course description provided for Advanced Economic Theory is interesting. It is described as "A review of important economic theories and their application to present day problems" and "A critical study of the principal schools of economic thought, such as the English Classical School, the German Historical School, and the Austrian Psychological School" (USDA Graduate School Records, Box 1, Announcement 1922-23, p.2). The next year (1923/24) the graduate courses changed completely with a Course on Credit, Currency and Prices with Special Reference to the Influence of the Federal Reserve System being offered in the first term by E. A. Goldenweiser and a course on Economic Cycles offered in the second term by Walter W. Stewart. Stewart had been a colleague and student of Veblen's at Missouri, a colleague of Walton Hamilton's at Amherst before joining the Federal Reserve to develop their Research and Statistics Division in 1922.[26]

The next two years show very little economics instruction, with only one half year course on international trade (with reference to agriculture) actually being offered. Things revive in the 1926/27 year with the introduction of a course in Price and Price Relationships taught over a full year by Ezekiel and Louis Bean. The first half dealt with Price Movements and Business Cycles and the second with the Economic Basis of Price Analysis, with both parts of the course much concerned with the statistical analysis of price movements. In 1928/29 Bean's part of the course was replaced by a term on consumption economics taught by Warren Waite.[27] This configuration continued into the next year, but with Bean returning with a course on Business Cycles in Relation to Agriculture that he offered in most years through 1933/34 (as a full year course from 1931/32). The course on Price and Price Relationships was replaced in 1930/31 by a year

long course in Economic Theory taught by E. J. Working and C. F. Sarle. The following year a one term version of the Price and Price relationships course was taught by E. J. Working, and a one term seminar in Elementary Mathematical Economics was offered (but withdrawn after a few weeks for lack of students) by Ezekiel. In addition to this, a course in the History of American Agriculture taught by Everett Edwards[28] was introduced in 1927/28. The course focused on social and economic history and became a staple offering, continuing throughout the period considered in this paper and growing from a one term to a full year course.

The vast majority of these courses were taught with a relation to agriculture and agricultural issues, agricultural prices, and agricultural markets, but they were not all focused on agriculture and most cannot be described as having a tightly neoclassical character. Many were more empirical than theoretical. Ezekiel's course on prices spent time on different methods of arriving at prices, identification issues, issues of time and dynamics, price trends and levels, and seasonal and periodic variations. Waite's course on consumption started with the social and economic conditions that affect consumption, the effect of changes in income and price on consumption, elasticity, and "changes in consuming habits of the people." Bean's course on cycles in relation to agriculture discussed the place of agriculture in various cycle theories, the relationship between the agricultural and industrial sectors of the economy: the influence of such things as industrial and financial conditions, employment, and the purchasing power of "city consumers" on agricultural prices and incomes, and the impact of agricultural conditions on business activity.

The Economic Theory course given by E. J. Working and C. F. Sarle in 1930/31 is particularly interesting as Working was more orientated to neoclassical theory than Ezekiel or Bean. It is clear the course is intended to be a course in theory and the course description contains a pitch for the importance of economic theory for the "best work" in applied economics. The description continues, however, as follows:

> Current theories of value and distribution as developed by Classical, Austrian, and Neo-Classical schools of economic thought will be analysized (sic) and appraised. The course is intended to enable the student to develop an understanding of the "traditional" economic doctrine and to give him a basis for judging the merits of those parts of economic theory concerning which there is ground for divergence of opinion. Some attention will be given to the doctrines as developed by the Historical, Mathematical, and Institutional schools of economics (USDA Graduate School Records, Box 1, Announcement 1930-1931).

Ezekiel's proposed seminar in Mathematical Economics is also of interest both because he thought of offering such a course at all at that time and because his description indicates both an interest and a concern. The course is described as paying "as much attention to the validity of the assumptions under existing economic conditions as to the theory itself," while at the same time claiming that mathematical economics is "basic to much of the research work in economic statistics and economic research" (USDA Graduate School Records, Box 1, Announcement, January 1932).

One other Graduate School event in should be mentioned. Over the period February and March 1930 the School organized a series called "Special Lectures in Economics." This included E. B. Wilson talking on "Scientific Method in Economic Research," John R. Commons on "Evaluating Institutions as a Factor in Economic Change," Frank Knight on "Fact and Interpretation in Economics," and John D. Black on "Analytic Methods in Agricultural Economic Research" (USDA Graduate School Records, Box 7, Lectures). Wilson discussed mathematical and statistical methods (sampling, regression and time series). He clearly felt mathematical methods were necessary for certain complex problems, but also argued that the mathematical method was "likely largely to remain the work of a small fraction of the students in economics" (USDA 1930, p.4). Commons, of course, stressed the importance of institutions in human behavior, the importance of participation as a method of inquiry into the functioning of institutions, the role of the courts, his concept of reasonable value, and the importance, for the evaluation of agricultural policy, of the distinction between cooperative marketing and collective bargaining. Knight provided his usual critique of scientism and of notions of "social control." In his lecture, Black distinguished between pure science, specialized pure science, and applied science and emphasized the significant contributions to be made by agricultural economics of the specialized pure science type (rather than from the more applied work). Black argued for a mixture of methods, historical and cross-sectional, quantitative and qualitative, but was somewhat critical of the "institutional approach" for failing to develop and apply more analytical methods to their subject matter:

> I fear that I am compelled to state that thus far institutional analysis has reached only the point of cross-sectional description and historical narration in qualitative terms. The institutional writers content themselves with talking about institutions, telling us what they are like and along what lines they have evolved. . . . The time has about come when the institutional researchers will need to do something more than talk about their institutions, when they will need to weigh them and measure their attributes, and then show the amount of social force they have exerted in the past , and are exerting in the present (USDA 1930, p.33).

Economics instruction over the course of the 1930s expanded significantly and took on a cast affected both by new developments in economics and the problems and issues of the Depression and the New Deal. The 1933/34 year saw the descriptions of Bean's course on Business Cycles in Relation to Agriculture make specific reference to the 1929-1933 depression and the efforts made to initiate revival. The course, however, does not appear to have actually been given and dropped out of the listings in subsequent years. H. J. Wadleigh[29] offered a full year course Theory of Prices and Price Making, the second part of which dealt with theories of imperfect competition, monetary and business cycle theory, and "the institutional school of economics," as well as "welfare economics and social control." The following year the course title was changed to Recent Developments in Economic Theory with the focus primarily on new developments in imperfect competition and monetary economics and business cycles, including Keynes's *Treatise on Money*.

A new course on the History of Economic Thought taught by Max Wasserman was introduced in 1934/35.[30] The last part of this course covered "recent and modern developments" defined as institutional, quantitative, and welfare economics, and including Veblen, Pigou, J. M. Clark, J. R. Commons, and R. G. Tugwell. Wasserman also taught a course on Inflation in Theory and Practice (USDA Graduate School Records, Box 1, Announcement, August 1934). [31] The year after (1935/36) Wasserman introduced a Graduate Seminar in Economics and a course in Money and Banking. That year also saw a long series of 22 Lectures in "Current Economic Problems" including lectures by Alvin Hansen, Isador Lubin, Calvin Hoover, Jacob Viner, Eveline Burns, Joseph Schumpeter, E. A. Goldenweiser, H. Parker Willis, Edwin Nourse, Morris Cooke, David Saposs, Clarence Ayres,[32] and Harold Moulton. Outside of economics, courses were offered in Administrative Law, and Federal Jurisdiction and Procedure, both containing material on legal questions concerning New Deal legislation.

The next year saw a vast increase in the offerings in economics. These included the Graduate Seminar (Wasserman), History of Economics (Wasserman), Contemporary Economic Problems (Wasserman), History of American Agriculture (Edwards), Economics of Instability (Ezekiel and Bean), Wages and Economic Insecurity (Edward Berman[33]), The Rise of Modern Industrialism in the US (James Wood), Evolution of Economic Institutions (M. T. Wermel[34]), Agricultural Prices (F. L. Thomsen[35]), and International Trade (L. Volin). The courses on Trade and the Rise of Modern Industrialism were offered but not given. Courses in Economics in French and Economics in German were offered and given. Wasserman's course on contemporary problems dealt with a range of issues, including necessary reforms to the capitalist

system, problems of machine industry, agricultural problems, control of industry and trade, unemployment, social security, consumer protection, housing, and wages and hours of work. Wages and Economic Insecurity covered a vast range of issues in labor economics and labor legislation with a distinctly Wisconsin orientation. The course on Economic Institutions is described as examining the fundamental institutions of Modern Capitalism, "such as Private Property, the Price System, Machine Technique, and Business Enterprise," a noticeably Veblenian terminology (USDA Graduate School Records, Box 1, Announcement, September 1936). These courses were supplemented by ten lectures on "Frontiers of Law and Economics," but no details of this series could be found. A lecture series was also given on the USDA and its Objectives, including a lecture by R. G. Tugwell on Conservation and Land Use.

Many of these courses (or close substitutes for them) were also offered in the following two years, along with Money and Banking (Wasserman), Comparative Current Economic Systems (Berman), and Political Economy and the Law (Joseph Blandi[36]). Courses on Trade Unionism and Labor Law (Berman) replaced Wages and Economic Insecurity, with the latter course giving particular attention to the Wagner Act, Social Security legislation, decision affecting minimum wage laws, and "the controversy over the Supreme Court" (USDA Graduate School Records, Box 1, Announcement, September 1937). In the following year courses on Labor Law and Labor Problems and Policies were offered by David Ziskind[37] and a course on Current Social Legislation, and a course on The Development of English Economic and Governmental Institutions were also offered.

In this period many of the courses had a focus on labor and social legislation, on issues of instability and insecurity, on law and economics, and on institutional development and history. Instructors such as Ezekiel and Bean were actively involved in the New Deal debates over agricultural policy and the problems of instability more generally. Ezekiel's work in and around 1938 included work on his Industrial Stabilization Plan, statistical work on the savings behavior of individuals, and his well known paper on cobweb models and supply adjustment lags as a reason for instability even in agricultural markets characterized by competitive conditions (Ezekiel 1937; 1938; 1939). The significantly institutionalist nature of the economics instruction is quite obvious from the course descriptions. Somewhat in this vein there was also a lecture series "Democracy" given in 1938 including lectures by Thurman Arnold, Walton Hamilton, Charles Beard, Ruth Benedict, and Charles Merriam, among many others.

The late 1930s also saw the expansion of cooperation with American University into economics and this remained a feature until 1944/45. As noted above, the Graduate School organized itself into more formal Departments in 1940 and the economics course announcements began listing many courses offered by American University as well as its own. America's entry into World War II brought about a number of war training courses in 1942 and the first organized Summer Program that included courses on price regulation and "economic warfare."

After 1940, however, things began to change in the economics offerings. Questions were asked about the Graduate School and its philosophy and "New Dealish" teaching came under attack from Republican Richard N. Elliot, then Controller General.[38] One of the outcomes was a refocusing of the Graduate School offerings in economics on

agricultural economics. More general courses on economics tended to be those offered by American University (for as long as that relationship lasted). For the 1940/41 year the Graduate and Advanced Undergraduate courses in economics offered by the Graduate School itself were History of Economic Thought, Economics of International Trade. Current Foreign Trade Problems and Policies in Relation to Agriculture, Social and Economic History of American Agriculture, Production Economics, Farm Management, Principles of agricultural Finance, Economics of Cooperative Organization, Action Programs of the Department, Principles of Land Appraisal, Principles of Insurance, Cotton Marketing, Economies of the Nations of Latin America, and History and Development of Price Policies. David Ziskind did, however, continue to teach a number of courses on labor law, the labor movement and unemployment.

At the Graduate level the School offered Economics of Consumption (Wermel), Economics of Imperfect Competition (Wermel), forecasting Demand for Agricultural Products (Thomsen), Agricultural Price Analysis (Thomsen), and a seminar on Agriculture Under Changing World Conditions (O. C. Stine). The courses by Ziskind and Wermel continued to have an institutionalist component. Wermel's course on imperfect competition is interesting as it includes not only Joan Robinson and Edward Chamberlin's work, but also A. R. Burn's *Decline of Competition* (1936) and Walton Hamilton and Associates' *Price and Price Policies* (1938). In subsequent years this course continued to focus on case studies of pricing in specific industries. His course on consumption is also full of the institutionalist language of planes of consumption, standards of living, consumer organization, and consumer protection.

Ezekiel returned to economics instruction in the 1941/42 year with a one-time course on Economic Problems of the Postwar World. At that time Ezekiel was doing a substantial amount of empirical work on saving and consumption (Rutherford and DesRoches 2008) and had shifted his support to Keynesian style expenditure programs from his earlier advocacy of planning. His course outline speaks of giving attention to theories that bear on underutilization of resources and labor, including monopolistic competition and saving-investment equilibrium and to statistical materials relating to the structural problems of readjustment (USDA Graduate School Records, Box 1, Bulletin of Information and Courses 1941-42, p. 18). In 1943/44 two new courses began to be offered in agricultural economics: Welfare Aspects of Economic Policy by Waugh and Richard Been and War and Post War Food Policy by Waugh and R. H. Allen. These courses contained material relating to Waugh's own previous work on estimating the marginal utility of money and his work on food policy, particularly in providing the theoretical rationale for the food stamp plan (Fox 1989, p. 69; Waugh 1938).[39]

By the end of the period considered here, the economics program had sub-sections in economics, agricultural economics, labor economics, and economic theory. Most of the courses offered have been mentioned above, but in the economics section a new course entitled Econometrics: Mathematical and Statistical Analysis of Economic Problems was introduced in the fall of 1944, taught by Been using H. T. Davis' *The Theory of Econometrics* as a text. This is the first time the term "econometrics" was used in a course description. Economic theory courses (apart from those offered by AU) were History of Economic Thought (Wasserman), Economics of Imperfect Competition (Wermel), and Post-War Economic Problems (Wermel).

The program offerings in economics continued to grow, but became increasingly specialized. In 1945/46 the economics offerings were divided between a Division of General Economics, including general economic theory, monetary and fiscal, international trade, consumption economics, labor economics, marketing, and research in social sciences; a Division of Economic and Social Policy; a Division of agricultural Economics; and a Division of International Relations. Ezekiel taught on occasion (courses either on Reconstruction and Full Employment or on Research Methods in Social Science) as did Bean (Measurements of Economic Activity). Gardner Means taught on Imperfect Competition and Price Regulation starting in 1946, and one can find other institutionalist elements in courses on consumption (Margaret Reid taught at the Graduate School in the late 1940s) and in other areas, but these gradually become less characteristic of the offerings as a whole. The courses on business fluctuations moved to become, by 1947, a course on Keynes, Hansen, Robertson, Lange and the "Stockholm group" (USDA Graduate School Records, Box 1, Bulletin of Information and Courses 1947-48, p. 91)

From the mid 1940's the focus on agricultural economics increased further. In 1946 the Graduate School introduced a Certified Statement of Accomplishment in Agricultural Economics, and from then on the offerings in economics, other than in agricultural economics, began to decline quite markedly. By 1950 only 11 general economics courses (3 of them undergraduate) were listed, and not all of these were offered in any given year.[40]

5. Concluding Remarks

The USDA Graduate School clearly was, and still is, a remarkable organization and its contributions go far beyond anything discussed here. For the purposes of this paper there are a number of characteristics that are worth special emphasis. In terms of statistics, the instruction offered was often highly advanced. That the School could provide regular instruction by individuals such as Tolley, Ezekiel, Deming, and Frankel, as well as special lectures from R. A. Fisher and Neyman, is historically significant. This level of instruction, available to economists and others in the USDA and elsewhere in the Federal Government, must have had much to do both with the statistical expertise shown by many of the agricultural economists of the time, and with what Duncan and Shelton (1978) have called the "revolution" in Government statistics that occurred in the 1930s. It is often forgotten how much was done in statistical research, particularly in applied areas, by statisticians and economists in Government employ, working largely outside of (although in contact with) the academic world (see also Duncan and Shelton 1992). Deming had a particularly important role here due to his previous contacts with both Fisher and Neyman. It is difficult to find out who received training from the Graduate School as the archives do not contain lists of students, but Leslie Kish has spoken of the importance of his experiences at the USDA Graduate School in his own development. On Deming he mentions his "unusual ability to get hold of somebody's important idea and develop it," particularly in the case of Neyman. Deming invited Neyman to give "his famous lectures at the USDA" and Deming "adopted his philosophy" (Frankel and King 1996, p. 71).

In terms of economics, the instruction offered was, at least until well into the 1940s, extremely broad, and focused on much more than agricultural economics only. Even in the 1920s the program offered in economics demonstrates that pluralism of ideas and methods so characteristic of American economics in the interwar period (Morgan and Rutherford 1998). In the 1930s this characteristic becomes even more pronounced. That the USDA Graduate School would offer courses on the history of economic thought and economic history tells one something about the philosophy of those heading up the program. Of course, the New Deal and the much expanded role for Government that it involved had a major impact at the Graduate School, but the scope of the courses offered and their nature reflected more than just the immediate needs of Government agencies as created by New Deal legislation. Neoclassical theoretical ideas were by no means absent from the instruction at the school in the 1920s and 30s but there was a clear and substantial institutionalist component. To some extent the various opinions and disputes concerning the usefulness of the "institutional approach" that were a feature of interwar American economics can be seen in the course descriptions and the content of lectures given at the School. This institutionalist component only died out gradually over the course of the 1940s. In terms of this relatively pluralistic attitude, it is also relevant that Ezekiel attempted to offer a course in mathematical economics as early as 1932. From his perspective this was a development that deserved attention. In later years most institutional economists were to become more dismissive of mathematical modeling.

A final observation about the Graduate School is that its statistical sophistication was not wedded to well-specified neoclassical or Keynesian models. Through the period studied here, advanced statistical technique coexisted with more empirical, applied, and

institutionalist sensibilities. It is true that the work by E. J. Working and, later, Waugh was aligned to neoclassical concepts in demand theory, but Ezekiel and Bean taught regularly in both the statistics and economics programs, something that indicates that the statistical training they offered (particularly on regression analysis) was felt to be quite consistent with institutionalist economic ideas. Moreover, the important work on sampling, that became such a notable feature of the Graduate School instruction in statistics in 1940, came in good part out of the policy concerns of the New Deal and the related survey work on unemployment and household expenditure conducted by people such as Stock, Frankel, Friedman, Wilcox, and others. This work was underway even before the widespread adoption of Keynesian ideas and had more to do with the policy concerns and research agenda of the New Deal "planners" such as Ezekiel and Gardner Means than anything else (Stapleford forthcoming). The close linking of econometrics to structural economic models that was to become such a feature of the work done at Cowles was not a dominant aspect of the work done at USDA, or of the teaching provided by the Graduate School.

Notes

[1] In 1948, the first year these figures are available, the Department of Agriculture listed almost 14,000 employees in "research, statistics and extension" out of a total employment in the Department of 82,000. Historical Statistics of the United States, Millennial Edition On Line, Table Da 1425, US Department of Agriculture—employees: 1861-1999 and Table Da1426-1432 US Department of Agriculture—employees by function: 1948-1999.

[2] Henry Taylor is sometimes seen as the "father of agricultural economics." He wrote *Agricultural Economics* (1905). He was at the University of Wisconsin until 1919 and helped found the Department of Agricultural Economics there. He was first hired to the USDA by Wallace's predecessor.

[3] For a more general look at the history of agricultural economics up until the early 1930s see Henry C. Taylor and Anne Dewees Taylor (1952). For a general discussion of the history of econometrics, including the contributions of the agricultural economists, see Morgan (1990).

[4] Ezekiel gave papers at Cowles conferences for example. See also Fox (1989, p. 57).

[5] The information in the section is drawn largely from a manuscript entitled "The History of the Graduate School" (1964), and from the annual reports and catalogs of the Graduate School. USDA Graduate School Records, 1921-1976, at the National Agricultural Library, Box 1, Box 4, and Box 18.

[6] L. C. Gray was a Wisconsin PhD (1911). He taught at Wisconsin until 1913 and made important contributions to the theory of exhaustible resources.

[7] AU and George Washington University eventually refused to give credit for USDA Graduate School courses on the grounds that these courses were subsidized by government and represented unfair competition.

[8] Glass blowing was presumably intended to train people in the production of laboratory equipment.

[9] Historical Statistics of the United States, Millennial Edition On Line, Table Da1425, US Department of Agriculture—employees: 1861-199.

[10] This terminology comes from the Graduate School's web page. The history of the debate over the School's legal status will not be reviewed here. The Graduate School itself has four very large white binders of material labeled "GS History/Legal Status."

[11] See Woods (1938), Kaufman (1940), Rohbraugh (1947), Brewster (1985). The School itself produced a self evaluation in 1949 and a history in 1964 (USDA Graduate School Records, Box 18 and 20).

[12] This can also be seen in the economics and statistics done at Iowa State and also at Wisconsin over the same period.

[13] Then both with the BAE.

[14] Louis Bean had an MBA from Harvard and worked in the BAE. He became an Economic Advisor in the Agricultural Adjustment Administration where he worked closely with Ezekiel.

[15] W. Edwards Deming had a PhD from Yale and had studied with Fisher, Pearson and Neyman in England. He was employed as a physicist in the Bureau of Chemistry and Soils.

[16] Girshick had studied under Wald at Columbia where he received his PhD. He later joined RAND.

[17] This was being undertaken for the National Resources Committee. For discussion on this and other work on consumption during the New Deal see Stapleford (forthcoming).

[18] For discussion of Friedman's problem and Neyman's solution see Teira (2007).

[19] These lectures were also published by the Graduate School (Shewhart 1939).

[20] Frankel had been a student of Harold Hotelling's at Columbia.

[21] The first such course was offered at Iowa State in the spring of 1939 by W. G. Cochran.

[22] Hurwitz was another Columbia student and a statistician with the Bureau of the Census.

[23] Waugh was a Columbia PhD and then went to Europe where he worked with Ragnar Frisch. He was a member of the BAE, but only taught at the Graduate School from 1942. See Fox (1989).

[24] O. E. Stein was a well known agricultural economist, trained at Ohio and Wisconsin, and Principal Economist at the BAE.

[25] It is not clear from the available material whether Ely did participate in the instruction of this course.

[26] For discussion of Stewart's Career at the Federal Reserve see Yohe (1982). For his connections with Walton Hamilton see Rutherford (2003). Goldenweiser was at that time Assistant Chief Statistician, Federal Reserve Board.

[27] Senior Agricultural Economist, BAE.

[28] Agricultural Economist, BAE.

[29] Wadleigh was a member of the BAE, and then Senior Economic Analyst, Department of State.

[30] Wasserman was Economic Advisor, Resettlement Administration.

[31] An undergraduate course in introductory economics was also reintroduced, taught by L. Volin and then by E. W. Braun. Volin was with the BAE.

[32] Ayres was briefly involved in the New Deal as Director of the Consumers' Division, taking over from his friend Walton Hamilton. Ayres's lecture concerned Government and the Consumer.

[33] Berman taught at the University of Illinois and wrote *Labor and the Sherman Act* (1930) which contained a brief introduction by John R. Commons and a Foreword by Felix Frankfurter. He was Senior Economist, Works Progress Administration.

[34] Wermel was an economist with the Resettlement Administration and wrote *The Evolution of the Classical Wage Theory* (1939).

[35] Thomsen was a PhD from Wisconsin and a Senior Agricultural Economist, BAE. In 1939 this course was taught jointly with O. C. Stine.

[36] Blandi was a law professor from Johns Hopkins and an expert on the history of business corporations.

[37] David Ziskind held a JD from Chicago and a PhD from Johns Hopkins and was Labor Adviser to the NRA.

[38] Elliot wrote a report on "Schools and Training Courses in Government Departments" 76th Congress, 3rd Session, Senate Document 182.

[39] Banzhaf (2006) sees some of Waugh's work as anticipating more recent "hedonic" models.

[40] The current economics offerings are quite restricted and appear to be limited to the undergraduate level.

Appendix I

COURSES LEADING TO CERTIFIED STATEMENT OF ACCOMPLISHMENT IN STATISTICS

With Concentration in One of the Following Fields of Accomplishment

PROCESSING OF DATA	SOCIAL SCIENCES	BIOLOGICAL AND PHYSICAL SCIENCES	DESIGN AND INTERPRETATION OF SAMPLING SURVEYS
BASIC COURSES—Required of all candidates			
L-2-2. Algebra for Statistics *A.. George Carlton*	L-2-2. Algebra for Statistics *A.. George Carlton*	L-2-2. Algebra for Statistics *A.. George Carlton*	L-2-2. Algebra for Statistics *A.. George Carlton*
L-2. Graphic Methods for Presenting Statistical Data *R. G. Hainsworth*	L-2. Trigonometry and Geometry for Statistics *A. George Carlton*	L-2. Trigonometry and Geometry for Statistics *A. George Carlton*	L-2. Trigonometry and Geometry for Statistics *A. George Carlton*
L-2-2. Introduction to Statistical Analysis *Drs. Solomon Kullback, Benjamin Tepping; Messrs. C. M. Purves, Sidney Wilcox, Joseph Steinberg*	L-2-2. Introduction to Statistical Analysis *Drs. Solomon Kullback, Benjamin Tepping; Messrs. C. M. Purves, Sidney Wilcox, Joseph Steinberg*	L-2 or 3. Introduction to Experimental Design *Dr. Otis A. Pope* or L-2-2. Introduction to Statistical Analysis *Drs. Solomon Kullback, Benjamin Tepping; Messrs. C. M. Purves, Sidney Wilcox, Joseph Steinberg*	L-2-2. Introduction to Statistical Analysis *Drs. Solomon Kullback, Benjamin Tepping; Messrs. C. M. Purves, Sidney Wilcox, Joseph Steinberg*
SPECIALIZED COURSES—24 credits, selected from appropriate field of application, required of all candidates			
U-2. Machine Tabulation *Milton Kaufman*	I-3-3. Calculus *Dr. E. J. Finan*	I-3-3. Calculus *Dr. E. J. Finan*	I-3-3. Calculus *Dr. E. J. Finan*
U-2. Advanced Study of Tabulating Equipment *Milton Kaufman*	G-2-2. Interpretation of Statistical Calculations *Alexander Sturges*	G-2 or 3. Design and Analysis of Complex Experiments *Dr. A. E. Brandt*	G-2 or 3. Design and Analysis of Complex Experiments *Dr. A. E. Brandt*
G-2. Planning of Statistical Inquiries *Dr. Philip M. Hauser*	G-2. Planning of Statistical Inquiries *Dr. Philip M. Hauser*	G-3. Quality Control *Dr. W. Edwards Deming*	G-2-2. Theory of Functions *Dr.C. Winston*
G-2. Office Procedures and Estimates *Dr. Philip M. Hauser*	G-2. Office Procedures and Estimates *Dr. Philip M. Hauser*	G-2-2. Interpretation of Statistical Calculations *Alexander Sturges*	G-3-3. Statistical Inference *Dr. W. Edwards Deming*
GU-2-2. Selected Statistical Problems *Dr. John M. Smith*	G-2. Sampling in Social and Economic Surveys *J. Stevens Stock and Lester R. Frankel* or G-2. Theory of Sampling *Jerome Cornfield and W. D. Evans*	G-3. Interpolation *Dr. W. Edwards Deming* or G-2. Statistics of Crop Estimation *Dr. A. E. Brandt*	G-2-2. Theory of Sample Surveys *Drs. William Madow and William Hurwitz*
G-2-2. Interpretation of Statistical Calculations *Alexander Sturges*			G-2. Linear Algebra *M. A. Girshick*
G-2-2. Population Statistics *Dr. Philip M. Hauser*	G-2-2. Population Statistics *Dr. Philip M. Hauser* or G-2-2. Statistical Analysis of Economic and Social Problems *Milton Friedman* or G-2-2. Statistics of Agricultural Economics *Dr. F. V. Waugh*	G-3-3. Statistical Inference *Dr. W. Edwards Deming*	G-2-2. Multivariate Analysis *M. A. Girshick*
		G-2-2. Statistical Methods for Research Workers *Dr. William G. Madow*	G-2. Analysis of Variance *M. A. Girshick*
	G-2-2. Psychological and Educational Statistics	G-3. Least Squares and Curve Fitting *Dr. W. Edwards Deming*	G-2-2. Modern Statistical Theories *Dr. Joseph Daly*

ELECTIVE COURSES

U-3. Higher Algebra—*Dr. E. J. Finan* (may be substituted for Linear Algebra as a prerequisite for Multivariate Analysis)
U-2. Coordinate Geometry and Vectors—*Dr. Sebastian Littauer*
U-1. Nomograms—*Eugene Rasor*
GU-2-2. Advanced Calculus
G-2-2. Differential Equations
G-2-2. Theory of Infinite Processes—*Dr. C. Winston*
G-1. Interpolation, Approximation, and Quadrature—*Dr. J. Shohat*
G-2-2. Theory and Application of the Characteristic Function—*Dr. Solomon Kullback*

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