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Research in Agricultural Economics 1919-1990: Seventy-two Years of Change

by

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The emphasis and focus of agricultural economics research in academic departments, the U.S. Department of Agriculture, and in other institutional think-tanks undergoes continual change. Theoretical models and quantitative methods are developed by agricultural economists or are borrowed from other disciplines, evolve, become widely used, then wane in popularity, and finally are discarded in favor of other, newer techniques. This process has led researchers to quantitative methods which for each era gain major attention within agricultural economics. The mix of specific quantitative techniques chosen for conducting agricultural economics research reveals preferences for research methods by agricultural economists at any point in time.

In this article, we trace the historical development of analytical (quantitative) research techniques used in empirical agricultural economics research by examining the articles in volumes of the *Journal of Farm Economics* (*JFE*) and the *American Journal of Agricultural Economics* (*AJAE*) from its inception in 1919 to 1990, a total of 72 years. We first determine for each article whether or not empirical results were obtained and then identified the particular quantitative technique employed in order to obtain the results. Then articles are classified with respect to the type of quantitative technique employed. As we reviewed the literature, we attempt to identify studies which marked the first appearance of a particular quantitative method in a *JFE* or *AJAE* article. We analyze key trends and illustrate them with a series charts to reveal changes in quantitative techniques used by researchers in writing for the *JFE* and *AJAE*. Finally, we explore the implications of these trends for future agricultural economics research.

Article Classification

Included in our data base were only writings appearing in the *JFE* or *AJAE* we could reasonably classify as "refereed articles". Although usually refereed, short articles and notes, comments and replys and invited papers from proceedings of meetings were all excluded from the data base. The *JFE* and *AJAE* were not necessarily always consistent over time with respect to what was called an "article." In particular, from 1972-74, comparatively few "long" articles appeared, along with a larger number of "short articles" and "notes." As a result, there were fewer articles classified for this period than for prior or later years. We divided the articles into five categories:

1. *Econometrics*. These articles employed some form of regression analysis, analysis of variance, or in the 1930s and 40s, correlation analysis. We further divided these articles into two subcategories labeled as *single equation* and *simultaneous equation* models. The single equation category also included the articles from the 30s and 40s relying on analysis of variance and correlation.

2. *Mathematical Programming*. This category was also divided into two subcategories labeled *linear programming* and *nonlinear programming*. The linear programming (LP) category included many specialized extensions to the basic LP model, such as integer programming and separable programming. The nonlinear programming category primarily consisted of articles employing quadratic programming, with other nonlinear programming techniques also represented in a few instances.

3. *Dynamics*. *Computer simulation* and *dynamic optimization* were the two subcategories represented here. Computer simulation included primarily articles employing nonoptimizing computer simulation models. Dynamic optimization included models employing dynamic programming and optimal control.

4. *Other Quantitative.* This category included all articles in which an empirical analysis was conducted but the quantitative techniques did not logically fit in any of the other categories. Articles placed in this category employed techniques such as stochastic dominance, game theory, input-output analysis, Bayesian decision theory, factor analysis, Markov chains, and Box Jenkins/Spectral Analysis/ARIMA. In the early years, a few articles reporting results and analyses from primary surveys were also classified in this category.

5. *Non-Quantitative.* This category included articles that were primarily: (a) verbal analyses and descriptive studies, (b) analyses employing mathematics in the presentation of the theory relevant to an agricultural issue, but without quantitative empirical analysis, and (c) articles that calculated economic concepts such as producer and consumer surplus, benefit/cost ratios and the like by relying on secondary data and elasticity estimates.

Through the mid 1970s, this classification system worked quite well, but many articles written in the late 1970s and 1980s became increasingly difficult to classify according to these criteria. Articles have sometimes employed several quantitative techniques in combination, sometimes even comparing results obtained from different techniques. Many of the articles employing two or more quantitative techniques in combination are identified in the bibliography. Usually one technique was dominant. Most of the recent articles employing more than one technique used simulation to generate predictions and forecasts from econometric models and were classified as econometric, not simulation. We classified each article according to what we believed to be the primary technique employed.

Appendix Table 1 summarizes the data obtained from this literature search. The total number of papers that fulfilled our definition of an "article" is listed. We listed the data as percentages of the total to permit comparisons across years in which the total article numbers varied. The counts in each category for each year may be obtained by multiplying the appropriate percentage by the total number of articles for the year.

Evolution of Quantitative Agricultural Economics by Time Period

Figure 1 uses six pie charts to provide snapshots of the mix of articles at the start of each decade and for other selected years. These additional years were selected because they were particularly important in identifying emerging trends.

Less than 5 percent of the articles 21 articles counted in 1950 employed a quantitative technique, and the quantitative technique of choice was least squares regression or multiple correlation analysis. By 1957, nearly 30 percent of the articles employed a quantitative technique, and linear programming was the research tool of choice. In 1960, only 4 years later, nearly 42 percent of the articles employed some type of quantitative technique, with one-fourth of the article employing singe-equation regression. In 1965, over half the articles employed a quantitative tool, the dominant tool was least squares regression (one-third of the total articles). The use of quantitative methods by 1970 had expanded to the point where over 78 percent of the articles used a quantitative tool. Note, in particular, the shift from singe to simultaneous equation estimation techniques between 1970 and 1972, with simultaneous equation models becoming the dominant technique in 1972, and the proportion of non-quantitative articles experiencing a further decline. Linear programming as applied to spacial equilibrium problems became more important, and 10 percent of the articles employed simulation. Dynamic optimization models were still not widely used in 1972.

By 1980, econometrics, particularly simultaneous equation models, was still the leading technique but the proportion of the total articles declined somewhat. Linear and nonlinear programming were still strong as was computer simulation. The major change was the increase in the proportion of articles using dynamic optimization techniques, particularly optimal control. The year 1990 was quite different from 1980 as well. The dominant technique was econometrics, with the preponderance of these studies using simultaneous equation methods. Studies using linear and nonlinear programming have all but disappeared. Computer simulation remained strong, but there were fewer dynamic optimization studies published than in 1980.

1919-1950

Prior to 1950, there were very few articles that met our definition of "quantitative." However, pre-1950 issues of the *JFE* still provide insight with regard to the introduction of quantitative techniques in agricultural economics. The quantitative roots of the profession go back a long time. The first algebraic formula to appear in the *JFE* appeared in Hopkins (1921). Spillman's 1923 work integrating marginal analysis with regression techniques to estimate crop and livestock production functions was an important precursor of later econometric research. One cannot help but be impressed at the quality of this highly innovative early effort that was written even prior to the development of the "Cobb-Douglas" production function.

Calculus in the *JFE* first appeared in a 1927 article by Henry Schultz, in which he illustrated a concept using a derivative. Those interested in pre-war linear programming precursors might find Elliot's 1928 article dealing with techniques for "programizing" a farm worth reading.

In the 1920s and 30s, researchers sometimes drew lines through scatter plots of data and these plots appeared in articles, but the actual regression coefficient was not calculated. These articles were classified as "econometrics."

There was little use of quantitative techniques in the 1930s and 1940s. We counted only 7 articles during the 1930s and 9 articles in the 1940s in which regression or correlation analysis was employed, and nothing with the quantitative and theoretical sophistication of the earlier Spillman articles. During this period, regression was largely viewed as a subset of correlation analysis, consistent with the content of Ezekiel's classic 1930 text, and many researchers appeared to be applying techniques from Ezekiel's book to agricultural data.

The 1950s

The 1950s saw the beginnings of rapid expansion in the widespread use of quantitative methods, in part based on pre-1950 efforts by Geoffrey Shepherd, Karl Fox, Mordecai Ezekiel, Henry Schulz and others. In our view, three articles represented significant milestones: (1) Frederick Waugh's 1951 article that introduced linear programming by using it to solve a minimum-cost dairy ration problem; (2) Paulson and Smith's 1953 article extolling the virtues of IBM "punch card" equipment in agricultural economics research; and (3) Richard Foote's 1953 article that introduced techniques for estimating a simultaneous system of equations and the application of these techniques to a four-equation model of the feed-livestock economy.

Waugh is credited with the first *JFE* article using linear programming. The IBM punch card machine in Paulson and Smith was "computer precursor," more nearly like an electric "card sorter" than an electronic computer, but the IBM computer card used for data input to mainframe computers until the 1980s retained the design of the data card Hollerith developed (*circa* 1900) and used with the pre-computer punch-card accounting machines. Foote's 1953 article in which a simultaneous equation system was estimated was particularly innovative, especially considering that Theil's mimeo discussing the Two Stage Least Squares estimation technique was published the same year. [Of course, E.J. Working's paper outlining what later came to be known as the identification problem of simultaneous equation models appeared much earlier, not in the *JFE* but in the 1927 *Quarterly Journal of Economics*. Haavelmo had published a simultaneous equation estimate of the marginal propensity to consume in 1947, and he and Girshick applied simultaneous equations to estimate the demand for food. Klein's simultaneous equation model of the U.S. economy was published in 1950., and a Cowles Commission monograph (Koopmans, ed.) on simultaneous statistical inference also appeared in 1950.]

The late 1950s was also a period of considerable innovation. More and more researchers were employing regression. But the emerging quantitative tool of the day was linear programming, particularly as applied to the farm planning problem. In one year, 1957, the number of articles employing linear programming exceeded the number of articles employing some form of regression analysis.

In 1959, Loftsgaard and Heady published an article they titled "Application of Dynamic Programming Models to Optimum Farm and Home Plans." However, this article did not employ dynamic programming as the term is now used but instead employed a multiperiod linear programming model. A better term for what Loftsgaard and Heady did might be, as Burt and Allison (1963) suggested, dynamic *linear* programming, not the generally recognized *dynamic programming* of Bellman (1957). Semantic arguments aside, Loftsgaard and Heady built a sophisticated linear programming model that incorporated a multi-year planning horizon.

The 1960s

The early 1960s was a period of time in which mainframe computers were in their infancy, but as the decade progressed, universities purchased larger and therefore more useful machines. Agricultural economists increasingly interested in quantitative analyses were among the early users of the new machines, particularly for estimating regression equations and solving linear programming models. Before the advent of the computer, researchers employing regression were very careful about selecting variables for inclusion in a regression equation. A change in an equation specification might mean days (if not weeks) of additional work for a statistical clerk. With the new computers, it now became possible for researchers to estimate several different regression equations before deciding on a "final" functional form for inclusion in the journal article. "Let's try all the possibilities" became the methodological approach chosen by some researchers.

Researchers interested in linear programming were equally enthused about the potential of the computer for solving models that were impractical to solve by hand. As a result, models became increasingly complex but with additional realism, as new activities (enterprises) were added and more detailed constraints could be added (i.e. weekly or monthly, rather than annual labor constraints).

Many new quantitative techniques appeared in the 1960s. Yaron and Heady get credit for the introduction of a nonlinear programming precursor in 1961. Edwards combined nonlinear programming and nonlinear regression in 1962. Burt introduced the "real" (Bellman's) dynamic programming in 1963. Takayama and Judge published the first quadratic programming article in 1964. An article by Halter and Dean and another by Zusman and Amiad appeared in the August, 1965 *JFE*, both employing computer simulation. Merrill introduced the first stochastic programming application in the same issue of the *JFE*.

The 1970s

By the 1970s, regression analysis had become "econometrics." Computer software and hardware had evolved to the point where the new techniques for estimating simultaneous systems of equations such as two and three stage least squares (Zellner and Theil, 1964) could be applied to agricultural data nearly as easily as single equation regression models could be estimated. Agricultural economists placed a good deal of confidence in the realism and potential predictive performance of the newly constructed simultaneous equation models containing large numbers of equations, and models grew ever larger.

By the early 1970s, many agricultural economists, aware that linear programming solvers were able to readily identify enterprise mixes, also became confident that the new "stepwise" regression packages that chose variables for inclusion in a regression equation based on their accumulative contribution to explained variation would ultimately solve problems with respect to identifying the "correct" model specification. The promise of these packages was short-lived, and by the mid 1970s, a number of papers had been written suggesting that the conclusions based on estimators derived from "stepwise" procedures could be misleading (Freund and Debertin, 1975; Wallace, 1977). The use (at least *admitted* use) of these techniques declined as the decade progressed.

The 1970s also marked increasing use of more than one quantitative technique in the same article. For example, econometric simulation employed regression analysis to estimate parameters. These parameters then became part of a computer simulation model. (Examples: Mann and Paulsen, 1976; Edwards and Parikh, 1976. We classified the primary research technique employed as simultaneous equation estimation.) Conner and Hammonds (1975) combined linear programming and regression. Shumway and Chang (1977) compared supply functions estimated via linear programming with those estimated from regression. Chien and Bradford (1976) used a linear programming model as an optimizing portion of a larger computer simulation model of the farm firm growth process (we classified this study as simulation). Byerlee and Halter (1974) developed a computer simulation model that contained an input-output model (also classified as simulation). Hochman, Regev and Ward (1974) presented an optimal control model that also employed least squares regression (classified as dynamic optimization.)

The 1980s

The trend toward combining two or more quantitative techniques in a single article and toward the increased use of specialized quantitative techniques accelerated during the 1980s. Optimal control models and simultaneous equation econometric models were frequently combined with computer simulation. Simultaneous equation models incorporating new refinements for dealing with problems such as autocorrelation occupied a large proportion of the *AJAE* pages. Risk was incorporated into an increasing number of models.

A comparatively high proportion of articles used highly specialized quantitative techniques during the 1980s, such as tobit analysis, kernel estimation, Monte Carlo analyses and stochastic dominance. For example, Richardson and Ray (1982) employed optimal control theory, perturbation analysis and computer simulation in their study of commodity programs.

Most of the articles written during the 1980s used econometrics as the primary quantitative technique, with simultaneous equation estimation techniques used in over 50 percent of the published research. Dynamic optimization and computer simulation remained popular. Non-quantitative articles accounted for 16.3 percent of the total during the decade. Quadratic programming was more widely used, accounting for eight articles during the decade. Stochastic dominance first appeared in a 1981 article by Kramer and Pope, and was used in 21 articles during the 1980s.

The Evolution of Quantitative Agricultural Economics by Type of Technique

Figure 2 illustrates with an area chart the percentage of articles that were placed in each of the five categories. In 1950, 20 of 21 articles (95 percent) were classified as non-quantitative. By 1990, only 7 of 92 articles (7.61 percent) were classified as non-quantitative. Although the overall trend was upward, there was considerable year-to-year variation in quantitative articles as a percent of the total. In particular, notice that in 1976, nearly 96 percent of the total was quantitative with only 2 of 48 articles classified as non-quantitative.

Econometrics

Figure 3 breaks down the econometrics data into single versus simultaneous system models. Foote's 1953 article and Ladd and Tedford's 1959 article applying Working's methods for estimating long-run demand elasticities were the only two pre-1966 articles classified as simultaneous. Simultaneous equation models comprised 12 percent of the total articles in 1966 but over 23 percent by 1972. For a period of time, the popularity of simultaneous equation models declined, and they represented between 12 and 15 percent of the total in the late 70s. There has again been considerable growth in popularity of simultaneous equation models, in 1990 comprising over 41 percent of the total.

Techniques for estimating simultaneous systems of equations were increasingly used in the 1960s and 1970s. E.J. Working's seminal paper was rediscovered in the 1960s, and stimulated interest in simultaneous equation modeling among agricultural economists (as did Foote's 1953 paper).

Models in the early 1970s became larger in terms of numbers of equations estimated simultaneously, placing ever larger burdens on the size and quality of data set. These econometric techniques all required that the researcher be able to separate variables into two categories: those endogenous to (determined within) the system and those exogenous to (influencing, but not determined within) the system. As models grew, it became more and more difficult to find variables truly exogenous to the system being modeled.

Increasing disenchantment with simultaneous equation estimation techniques in the late 1970s and early 1980s centered on several other problems. Parameter estimates were at best biased but consistent (Theil,) and did not lend themselves to formal hypothesis testing. Despite the theoretical case made for least squares bias when ordinary least squares was applied to simultaneous structural equations (Working), and the theoretical promise of some of the techniques for obtaining consistent estimates of parameters on endogenous variables (Theil, Zellner and Theil), researchers discovered that in many applications, parameters obtained using simultaneous equation estimation techniques were not very different from those obtained by employing simpler, single equation approaches.

Interpretation was also a problem. Elasticity estimates were short-run estimates, but how short is the short run? In comparison, a single equation model generated parameters far easier to interpret for use by policymakers.

Simultaneous equation techniques were all rooted in the underlying assumption that at least some economic events occur contemporaneously. While this was not unlike the timeless, static environment upon which much of the neoclassical theory is based, no two events (say a price change and a quantity change) occur at precisely the same time. This was exactly what Nerlove was arguing in his 1958 book on distributed lag models. Recently, however, our data reveal that econometrics, particularly simultaneous equation techniques, have experienced renewed emphasis, even as interest in many of the other quantitative techniques declines. Approximately 63 percent of the 1990 *AJAE* articles (58 of 92) were econometrics-based.

Mathematical Programming

Figure 4 illustrates the data for linear and nonlinear programming. The pattern is very different from that of econometrics. Progress made in solution approaches for linear optimization problems just prior to and during World War II had a major impact on research within agricultural economics. Interest in linear programming occurred in three waves, the first wave, centered around 1957, was the period of time when simple linear programming models that selected enterprises on a farm or balanced feed rations were published. In the second wave, centered on 1971, applications largely consisted of models depicting routing and spatial equilibrium problems. This was also the period of time when Center for Agriculture and Rural Development at Iowa State was building large-scale LP models dealing with interregional agricultural competition. The third wave occurred from 1975-77. Many of the models developed in this period involved extensions to the basic LP model, including techniques such as mixed integer, separable, and recursive programming. Improvements in computer design made possible ever larger mathematical programming models, and allowed applications of nonlinear programming and other optimization techniques to problems in which the assumptions of basic linear programming were increasingly viewed as too restrictive.

Despite its usefulness in extension farm management, the popularity of mathematical programming (with the important exception of dynamic optimization models) among researchers is not what it once was. The only nonlinear programming technique that became somewhat popular was quadratic programming, particularly when used in conjunction with models dealing with risk and uncertainty. We were surprised at the small number of articles in recent *AJAE* volumes that employ any form of mathematical programming, linear or nonlinear.

Computer Simulation and Dynamic Optimization

Figure 5 illustrates trends in computer simulation and dynamic optimization. In the 1960s and early 1970s, computer simulation differed from mathematical programming in that computer simulators did not maximize or minimize an objective function. During this period, researchers chose sides, and the proponents of mathematical programming techniques debated with the computer simulation advocates. Proponents of mathematical programming advocated the superiority of a technique which leads to an optimal solution. In contrast, those supporting simulation stressed the realism and comprehensiveness of their models, and argued that at least a "nearly optimal" solution within a simulation could be found, admittedly often only with considerable effort.

These debates no longer continue. In their survey of systems analysis and simulation, Johnson and Rausser (pp. 176-83) treat optimal adaptive control and other dynamic optimization models as subsets of simulation. Day, however, treated dynamic programming as part of his discussion of mathematical programming. The distinctions between computer simulation and mathematical programming are becoming increasingly blurred, despite the fact that a computer algorithm that solves for the optimal control over continuous time is constructed quite differently from a linear programming algorithm.

We classified articles employing nonoptimizing computer simulations as computer simulation and articles employing dynamic programming or optimal control as dynamic optimization. As is evident from Figure 5, we found considerable year-to-year variation in article numbers employing these techniques. Burt and his coauthors were responsible for most of the pre-1980 articles employing dynamic programming, but more recently many other authors have been using dynamic programming as well. The early 1980s was the period of time when optimal control was quite popular, but the percentage of articles employing optimal control techniques has declined substantially since the early 1980s. Tronstad and Taylor; and Cacho, Kinnucan and Hatch are examples of 1991 articles employing dynamic optimization methods, while Wahl, Hayes and Williams employ dynamic econometric simulation.

Other Quantitative Techniques

In addition to the aforementioned categories, a number of other specialized quantitative techniques have been used over the years. Figure 6 traces these trends. Normally, only a few articles employing these specialized techniques are written; the technique is abandoned, and another technique appears.

Several studies using input-output analysis were authored in the 1960s, as were studies using queuing theory, path analysis, game theory, and nonparametric statistics. Other techniques employed in the 1970s and 1980s included Box Jenkins, ARIMA and spectral analysis, factor analysis, network models and stochastic dominance. While some of these quantitative techniques attract considerable attention for a few years, none of these techniques has yet to occupy a continuing long-term position.

Of course some of these techniques might be viewed as specialized adaptations of one of the other categories--for example, Box Jenkins/ARIMA/spectral analysis is specialized econometrics; input-output analysis and game theory models are specialized forms of linear programming.

Non-quantitative Articles

Even in recent years, a considerable number of articles in the *AJAE* did not employ any quantitative empirical technique. Some of these articles attracted considerable attention, sometimes greater professional attention than the quantitative articles of their time. Among the widely cited non-quantitative articles are Castle's 1968 methodological article dealing with scientific objectivity. Schuh's award-winning 1974 article on the exchange rate and U.S. agriculture relied on inferences drawn from tables of secondary data rather than quantitative tools. Another example of this type an article is the one dealing with producer and consumer surplus issues by Subotnik and Houck (1976). Other non-quantitative articles included Randall's 1974 article on academic responsibility, Berry's 1980 discussion of the peer review process, and Grove's 1979 article on natural resource issues. Ladd's 1974 model of an agricultural bargaining cooperative used calculus for exposition of the theory, but did not present an empirical analysis. His 1979 article dealing with creative thought in agricultural economics research relied on verbal arguments for exposition.

Journal Editors and Quantitative Techniques

Figure 7 illustrates the use of various quantitative techniques for the years 1950-90 with the editors for each year designated, and Figure 8 summarizes the same data by editor. Because of the carryover of articles from one editor to the next, data in Figures 7 and 8 should be interpreted with caution. There is little evidence to support the assertion that individual editors in some manner favored certain quantitative techniques over others. Rather they largely appeared to follow the quantitative trends of the profession. The 1976 volume (Tomek) had the highest percentage of articles we classified as quantitative. Rhodes reduced the proportion of quantitative articles in 1978 and 1979, but the percentage increased again in 1980 (Figure 7). Barry's percentage of quantitative to total articles was highest, although Houck, Tomek and Just/Rausser were also very high, each at over 80 percent of the total (Figure 8).

Directions for Future Research and Implications for the Profession

It is often dangerous to extrapolate from historical data in an effort to forecast emerging trends: It is especially difficult to forecast when historical data changes as rapidly as the data we have collected. Buttel, a sociologist, in 1985 argued that "Agricultural Economics has become so quantitative that many departments will now favor an undergraduate mathematics major over an undergraduate social science major in graduate admissions... Economics thus is increasingly losing its identification as being a *social* science, and agricultural economics is becoming more of a discipline of applied mathematics."

Although Buttel's perception may overstate the case somewhat, there is no question that agricultural economics research will continue to employ increasingly sophisticated mathematical techniques. This is readily apparent from the data compiled here. However, there is potential danger in allowing the emphasis on quantitative application to be relegated to a empirical illustration status rather than a substantive portion of the applied research effort. But earlier solution-oriented and technique approaches led to a "have model, will travel" mentality that in some instances hampered originality (Just and Rausser, p. 1179). Articles that suggest that a renewed emphasis on theory may be an emerging trend include Chambers and Paarlberg; Lapan, Moschini and Hanson; Meyer and Robison; and Quiggin. All are theoretical articles are from the February, 1991 *AJAE* and none have an empirical component.

Interest in research based on duality relationships continues to increase. Agricultural economists increasingly recognize that duality theory is not an *alternative* to neoclassical production and consumption theory, but rather a *logical outgrowth* of neoclassical theory. The key assumptions underlying duality theory, such as non-negative marginal products and non-increasing marginal rates of substitution, are more restrictive than the assumptions usually employed in neoclassical theory, but make sense if one is to, for example, derive the specific form of a cost or profit function from an underlying production function. Fuss and McFadden (1978) remains the basic reference, Dupont's article (1991) is an example of recent research employing duality theory.

It would not be surprising to see as much or more emphasis be given to the theory of dynamic optimization in advanced theory courses as is given to optimization of the static model. If intertemporal problems are to receive emphasis, more effort will need to be devoted to assuring that graduate students have the sophisticated quantitative skills needed. The continuing popularity of distributed lag models is, in some respects, the econometric analogy reflecting research interest in the role of time in decisionmaking.

Topics dealing with risk and uncertainty perhaps should have equal status with dynamic optimization. Risk and uncertainty and dynamic optimization are closely intertwined in that risk and uncertainty often occurs because of the time required for production. Those working in risk and uncertainty have been hampered by the lack of a general conceptual and methodological framework equal to the status attained by optimal control or dynamic programming. Risk and uncertainty research is characterized by a heterogeneous mix of topics and various methodological approaches, many of which are unrelated, including everything from the use of futures markets to the treatment of weather employing game theory techniques. Financial economists who work with capital asset pricing models and with stochastic dominance generally feel that their efforts are on the leading edge of risk and uncertainty research but this viewpoint is not yet widespread throughout agricultural economics. Examples of 1991 articles emphasizing risk and uncertainty include Meyer and Robison and Lapan, Moschini and Hanson.

Research involving applications of nonparametric approaches within an agricultural setting is becoming of increasing interest to members of the profession. Of particular interest are the potential applications to agricultural systems of ideas presented in two articles by Varian (1982, 1984). Both of Varian's papers are applications to microeconomics of theorems derived by Afriat. They are seminal works that perhaps will become widely cited within the agricultural economics literature.

Do the types of quantitative techniques in fashion in large measure determine the problems which agricultural economists address, or do the applied problems determine the type of quantitative techniques employed? In other words, is the technique used a function of the problem being addressed, or is the problem chosen a function of the techniques that are available? It would be ludicrous to assume that agricultural economists choose first the quantitative technique to be employed and then search for a problem upon which to apply the technique. But it would be equally ludicrous to assume that most agricultural economists choose applied problems without considerable awareness of the particular quantitative tools that might be used for analysis.

Agricultural economics is an applied discipline, and the types of quantitative techniques employed reveal what the profession thinks is important. Clearly, once a particular quantitative technique becomes available, its popularity with the profession will depend on its applicability to applied problems. New techniques become popular because of their usefulness in solving a wide array of applied problems. Earlier techniques wane in popularity because applied problems change, new techniques emerge that are useful in addressing these new problems, or improvements in old techniques reduce limitations imposed by the earlier techniques.

Our analysis focused on the popularity of techniques as revealed by the frequency of their use in the *AJAE* and the *JFE* over time. Obviously, there are many other journals and other research and extension publications which report the results of research conducted by agricultural economists, and in the future this analysis could be broadened to include other journals that publish articles by agricultural economists, research and extension bulletins and other publications.

Another possible way to trace the evolution of these techniques would be to analyze the use of techniques by first classifying articles by the type of applied problem being solved. That is, identify several different types of applied problems and issues addressed by agricultural economists, and then, for each type of problem, trace the changes and improvements in quantitative techniques employed by agricultural economists.

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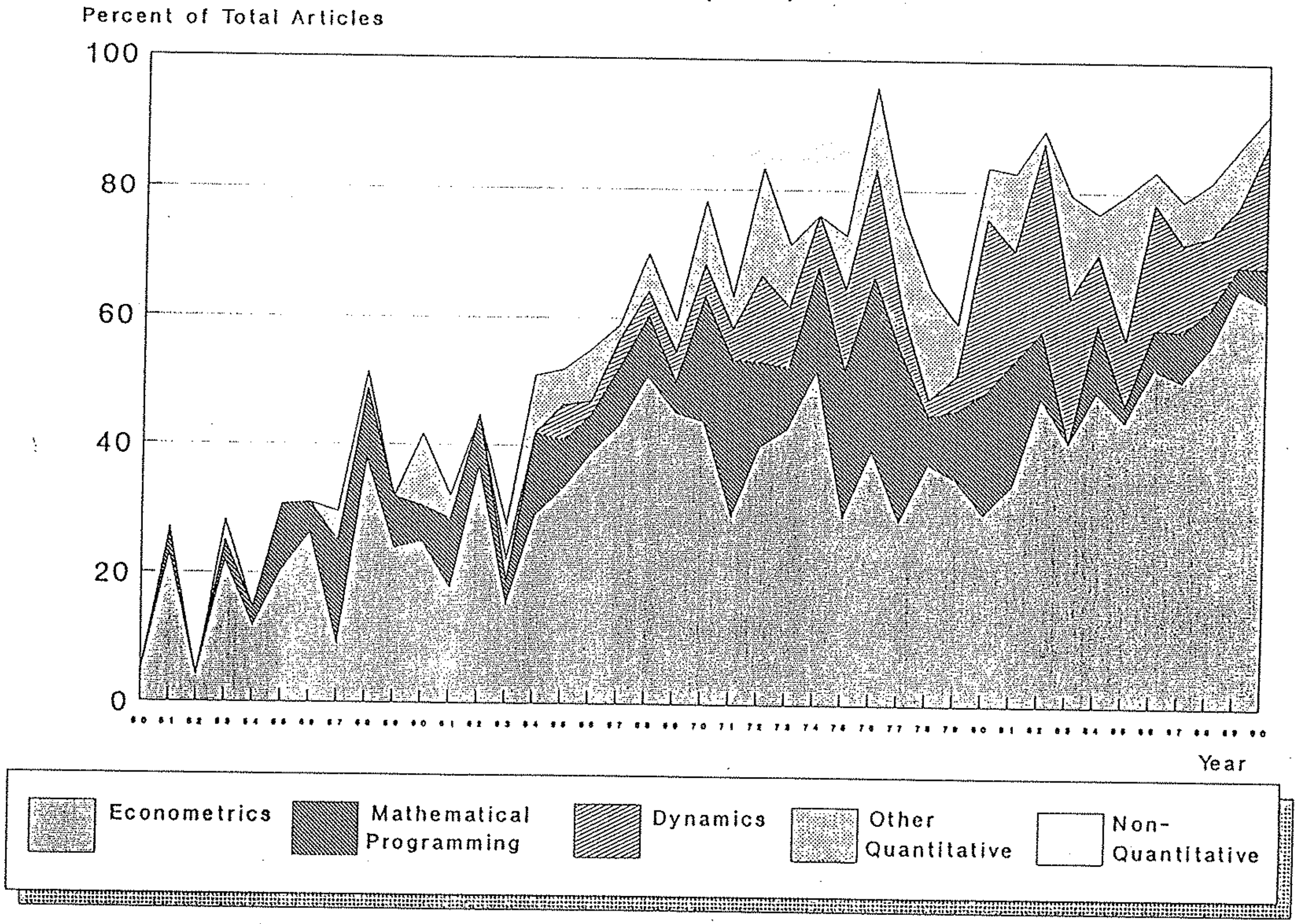
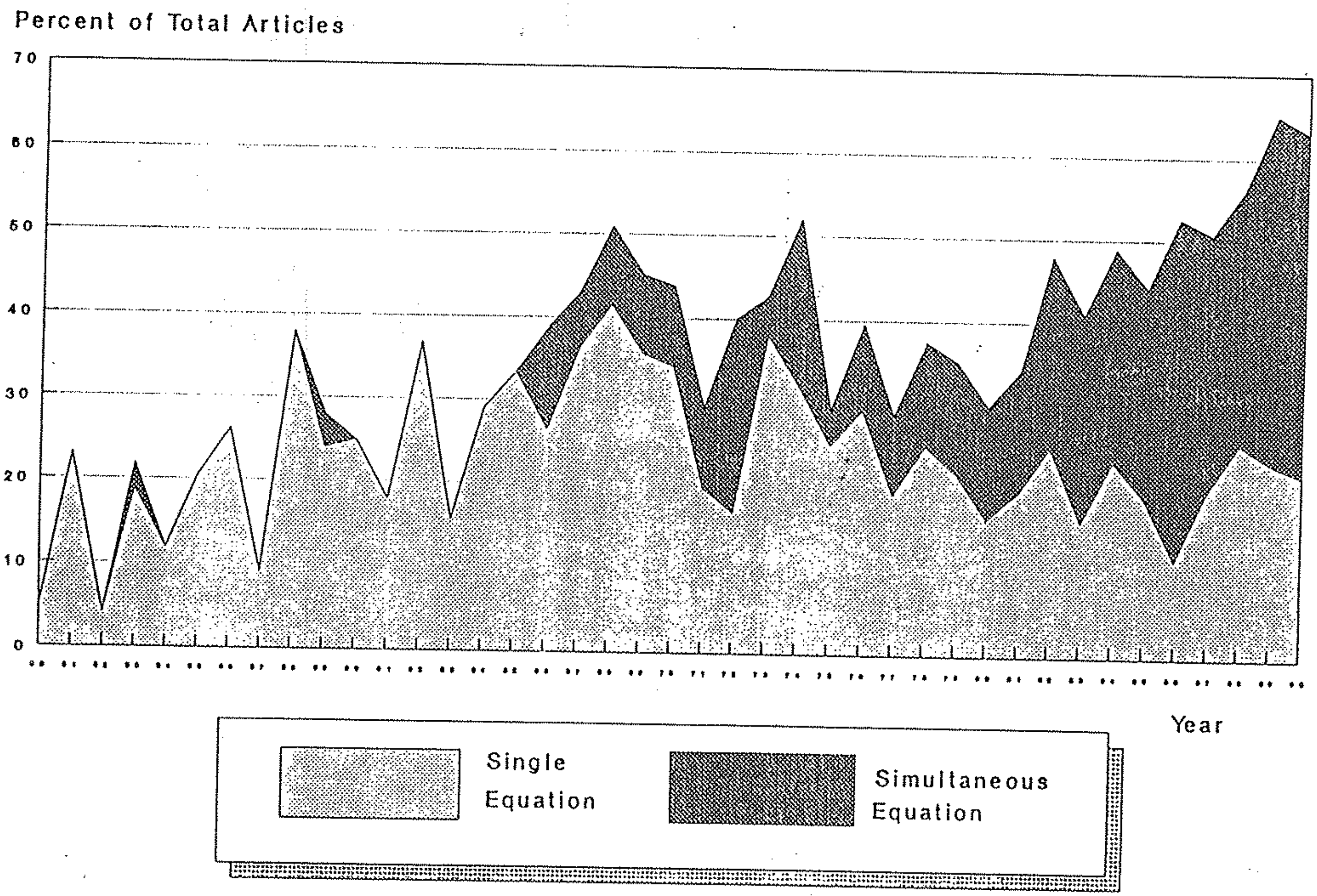
Figure 1. Mix of Quantitative Methods Used in *AJAE* (*JFE*) Articles, Selected Years.

Figure 2. Percent of Total Articles Employing Various Techniques, 1950-1990.



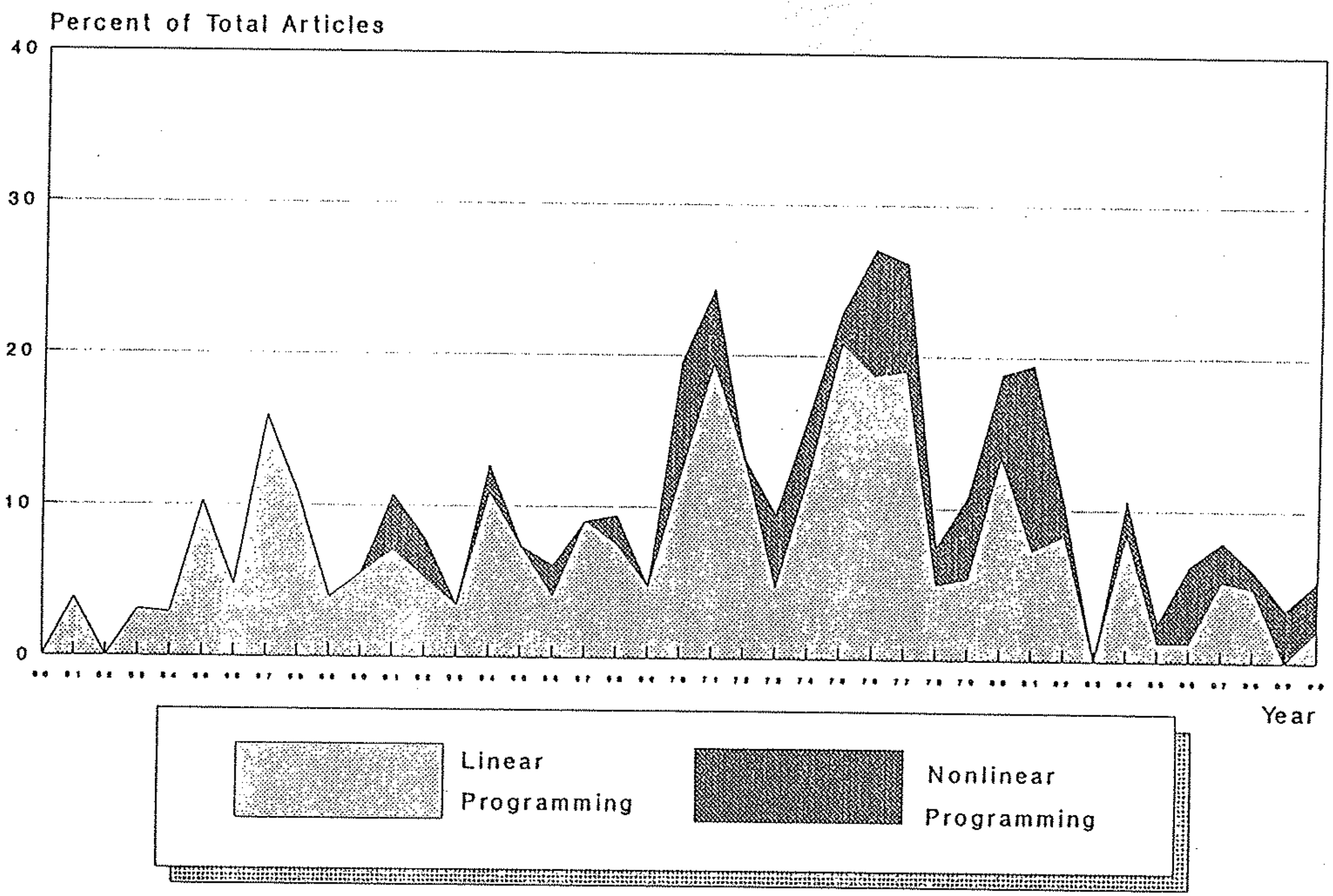
Percentages are for the Journal of Farm Economics or the American Journal of Agricultural Economics.

Figure 3. Percent of Total Articles Employing Single and Simultaneous Equation Econometrics, 1950-1990.



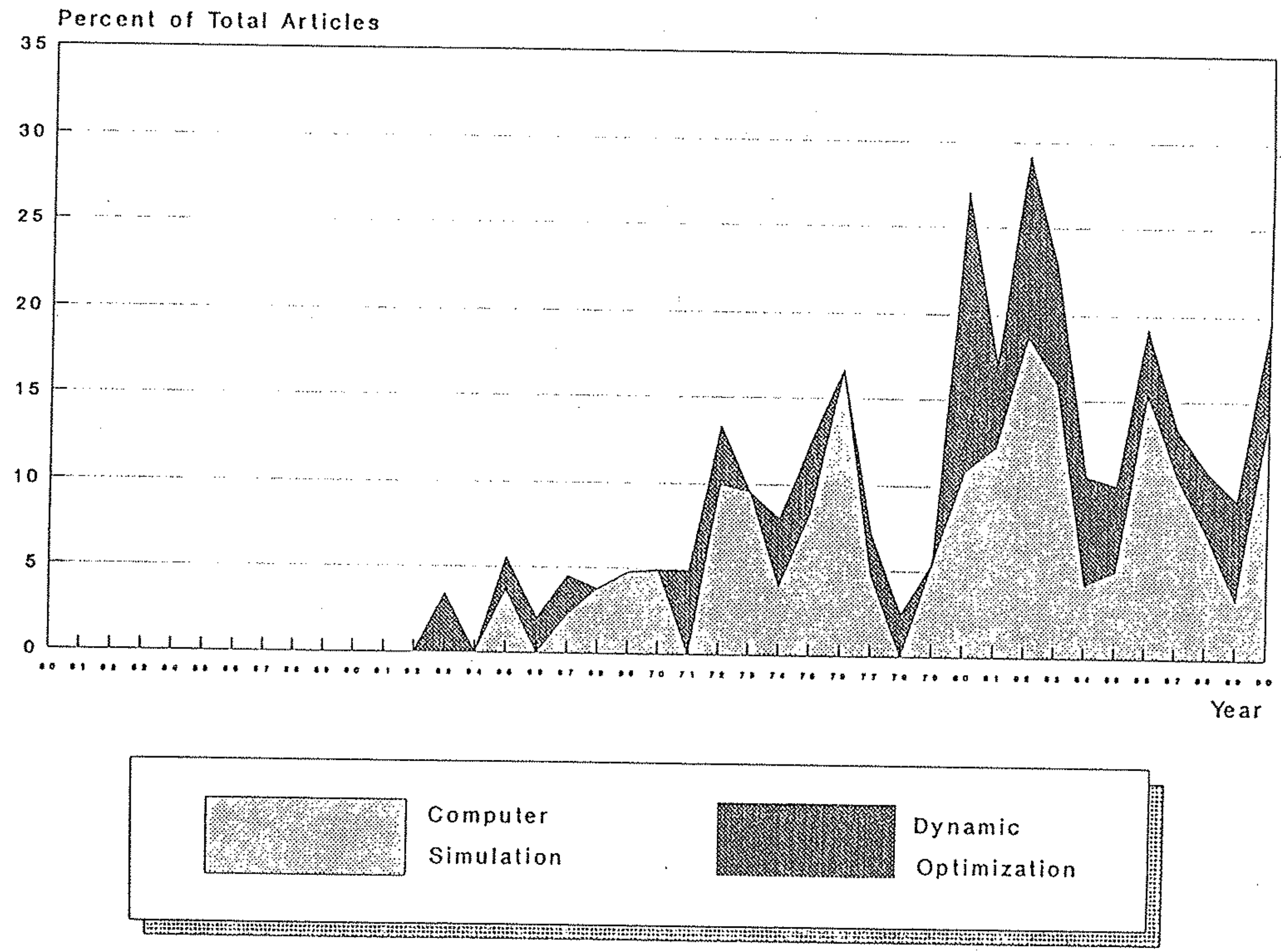
Percentages are for the Journal of Farm Economics or the American Journal of Agricultural Economics.

Figure 4. Percent of Total Articles Employing Mathematical Programming, 1950-1990.



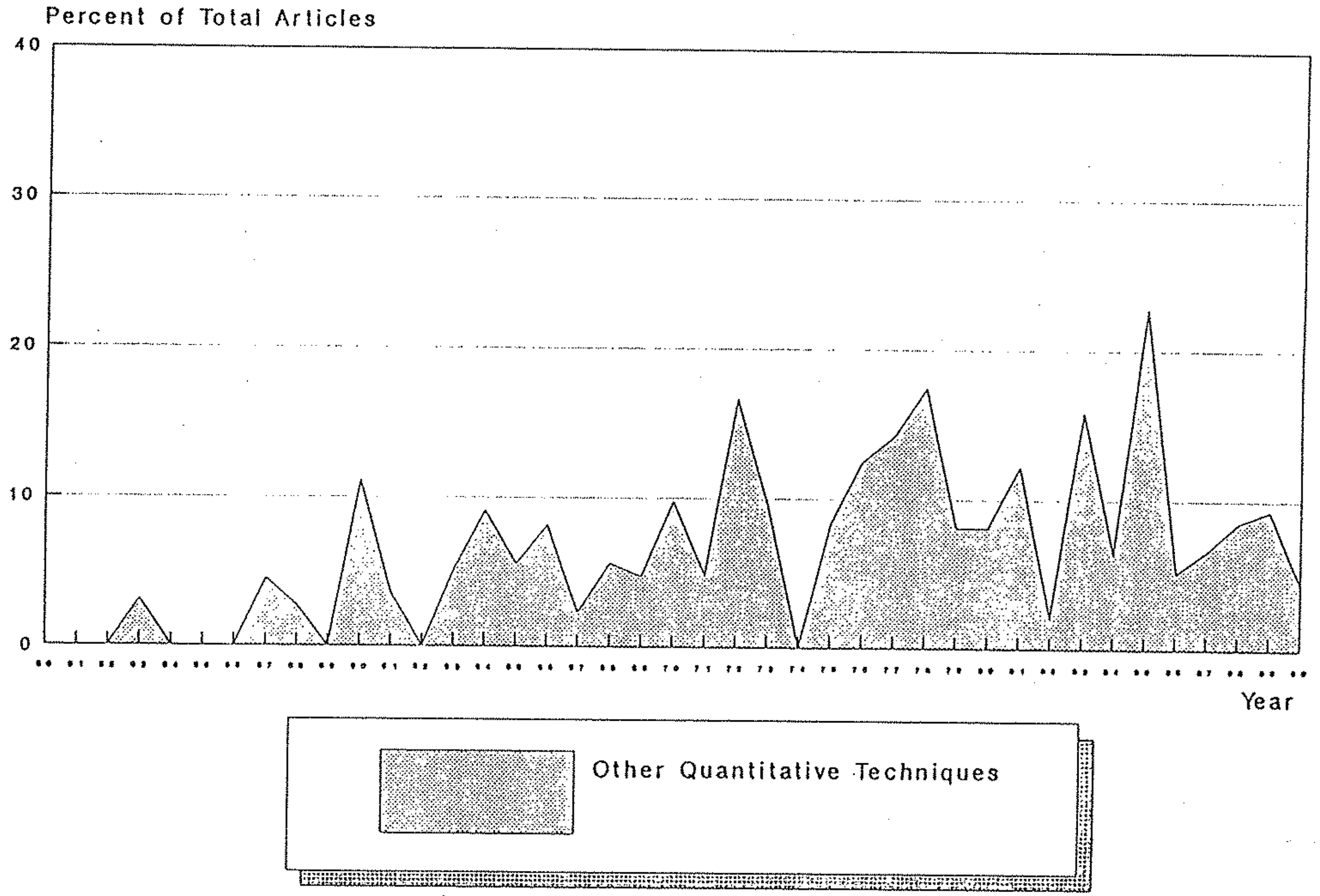
Percentages are for the Journal of Farm Economics or the American Journal of Agricultural Economics.

Figure 5. Percent of Total Articles Employing Computer Simulation and Dynamic Optimization, 1950-1990.



Percentages are for the Journal of Farm Economics or the American Journal of Agricultural Economics.

Figure 6. Percent of Total Articles Employing Other Quantitative Techniques, 1950-1990.



Percentages are for the Journal of Farm Economics or the American Journal of Agricultural Economics.

Figure 7. Editors of the A.J.A.E and Quantitative Methods Employed, 1950-90.

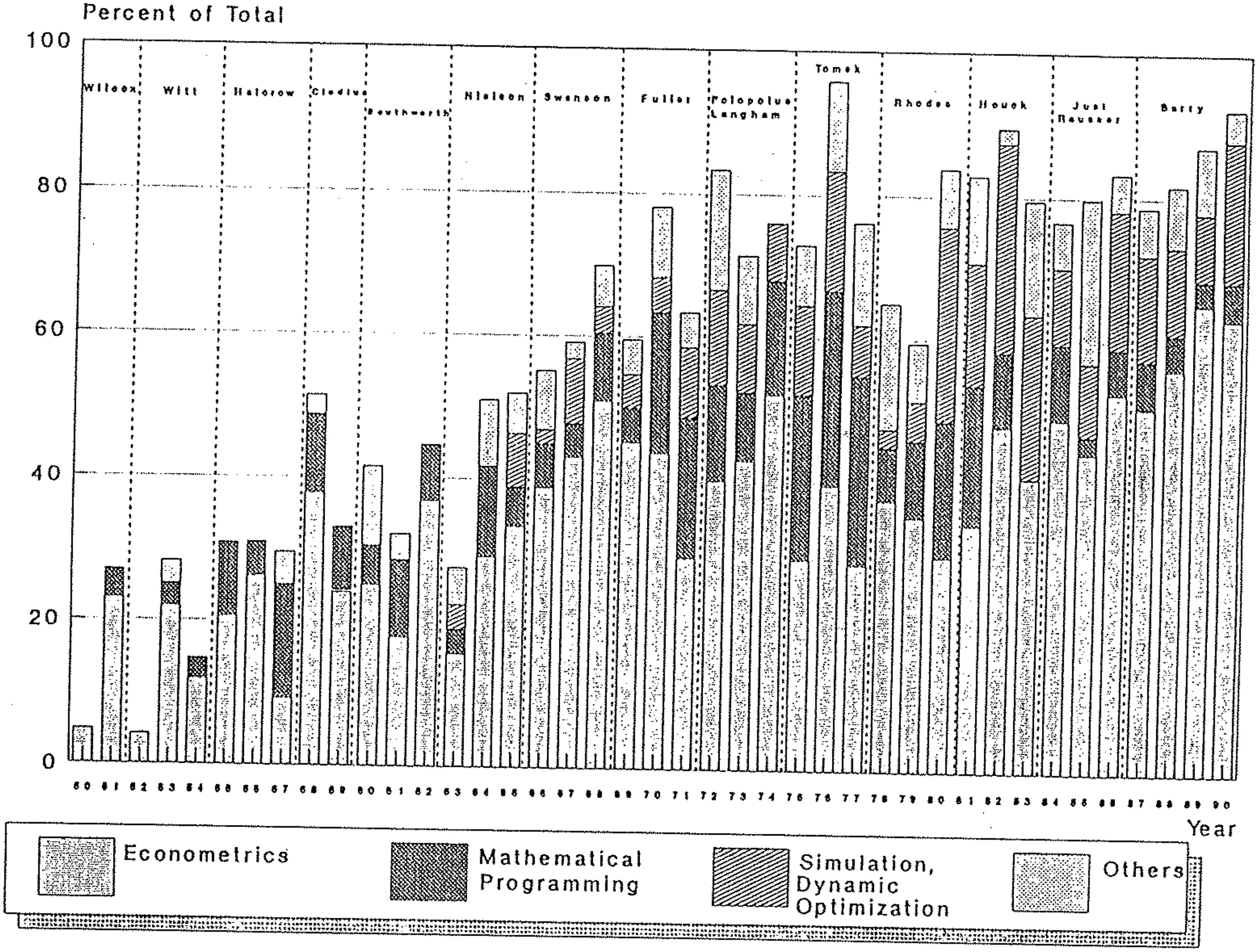


Figure 8. Summary of Quantitative Techniques by AJAE (JFE) Editor, 1919-1990.

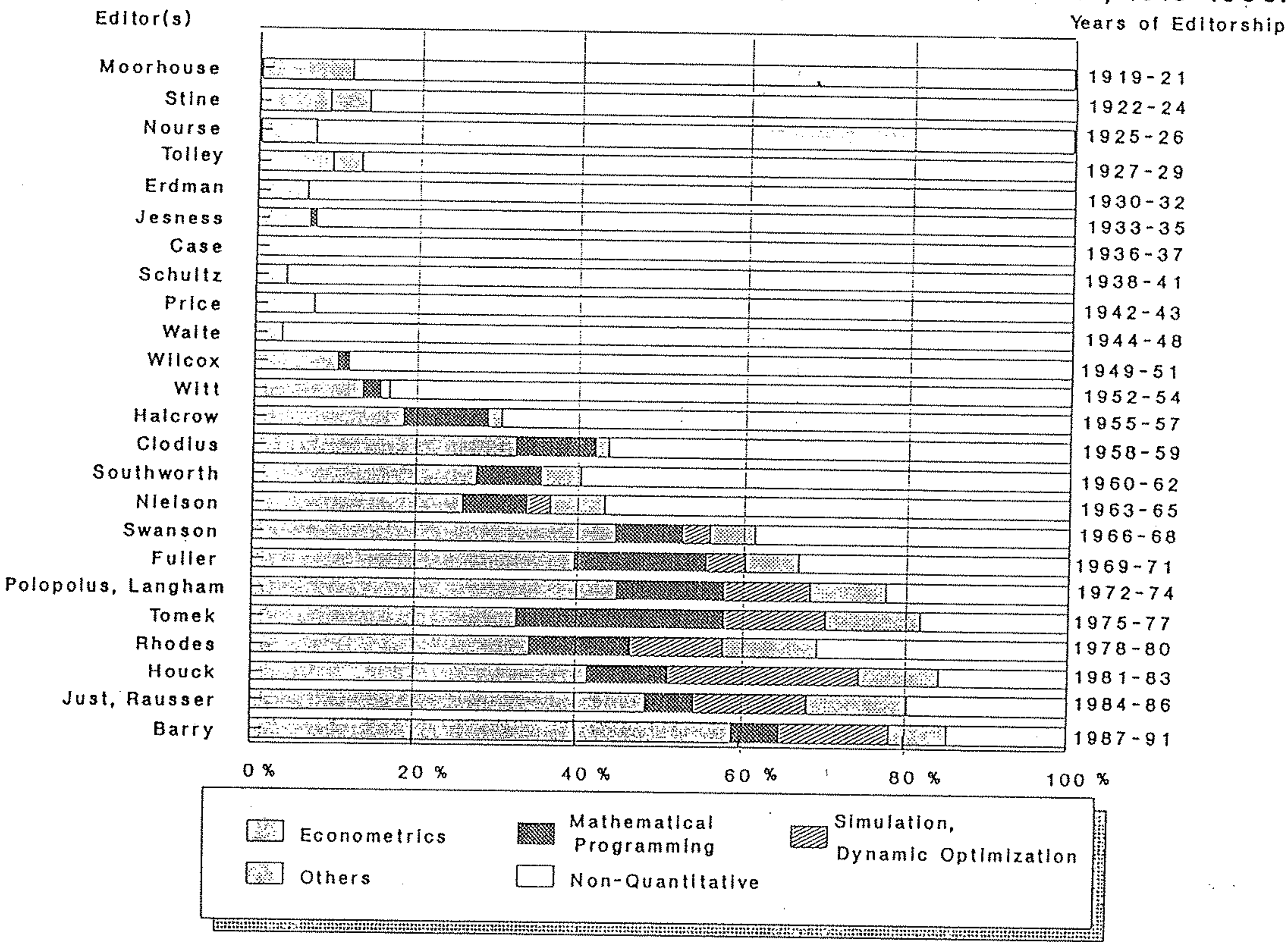


Table 1. Percent of Articles in the *American Journal of Agricultural Economics (Journal of Farm Economics)* by Type of Quantitative Method Employed, 1919-1990.

Year	Single Equation	Simultaneous Equation	Linear Programming	Nonlinear Programming	Dynamic Optimization	Simulation	Other Quantitative	Non-Quantitative	Total Articles	Year	Single Equation	Simultaneous Equation	Linear Programming	Nonlinear Programming	Dynamic Optimization	Simulation	Other Quantitative	Non-Quantitative	Total Articles
1919	0.00	0.00	0.00	0.00	0.00	0.00	6.67	93.33	15	1955	20.51	0.00	10.26	0.00	0.00	0.00	0.00	69.23	39
1920	0.00	0.00	0.00	0.00	0.00	0.00	15.79	84.21	19	1956	26.19	0.00	4.76	0.00	0.00	0.00	0.00	69.05	42
1921	0.00	0.00	0.00	0.00	0.00	0.00	9.09	90.91	22	1957	9.09	0.00	15.91	0.00	0.00	0.00	4.55	70.45	44
1922	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	16	1958	37.84	0.00	10.81	0.00	0.00	0.00	2.70	48.65	37
1923	14.29	0.00	0.00	0.00	0.00	0.00	7.14	78.57	14	1959	20.00	4.00	8.00	0.00	0.00	0.00	0.00	68.00	25
1924	12.00	0.00	0.00	0.00	0.00	0.00	4.00	84.00	25	1960	25.00	0.00	5.56	0.00	0.00	0.00	11.11	58.33	36
1925	6.45	0.00	0.00	0.00	0.00	0.00	0.00	93.55	31	1961	17.86	0.00	7.14	3.57	0.00	0.00	3.57	67.86	28
1926	6.06	0.00	0.00	0.00	0.00	0.00	0.00	93.94	33	1962	36.84	0.00	5.26	2.63	0.00	0.00	0.00	55.26	38
1927	10.71	0.00	0.00	0.00	0.00	0.00	0.00	89.29	28	1963	15.52	0.00	3.45	0.00	3.45	0.00	5.17	72.41	58
1928	0.00	0.00	5.88	0.00	0.00	0.00	0.00	94.12	17	1964	29.09	0.00	10.91	1.82	0.00	0.00	9.09	49.09	55
1929	12.50	0.00	0.00	0.00	0.00	0.00	0.00	87.50	16	1965	33.33	0.00	7.41	0.00	1.85	3.70	5.56	48.15	54
1930	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	14	1966	26.53	12.24	4.08	2.04	2.04	0.00	8.16	44.90	49
1931	6.25	0.00	0.00	0.00	0.00	0.00	0.00	93.75	16	1967	36.36	6.82	9.09	0.00	2.27	2.27	2.27	40.91	44
1932	9.52	0.00	0.00	0.00	0.00	0.00	0.00	90.48	21	1968	41.51	9.43	7.55	1.89	0.00	3.77	5.66	30.19	53
1933	5.26	0.00	0.00	0.00	0.00	0.00	0.00	94.74	19	1969	35.71	9.52	4.76	0.00	0.00	4.76	4.76	40.48	42
1934	5.00	0.00	0.00	0.00	0.00	0.00	0.00	95.00	20	1970	34.15	9.76	12.20	7.32	0.00	4.88	9.76	21.95	41
1935	4.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00	25	1971	19.51	9.76	19.51	4.88	4.88	0.00	4.88	36.59	41
1936	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	19	1972	16.67	23.33	13.33	0.00	3.33	10.00	16.67	16.67	30
1937	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	32	1973	38.10	4.76	4.76	4.76	0.00	9.52	9.52	28.57	21
1938	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	28	1974	32.00	20.00	12.00	4.00	4.00	4.00	0.00	24.00	25
1939	8.33	0.00	0.00	0.00	0.00	0.00	0.00	91.67	12	1975	25.00	4.17	20.83	2.08	4.17	8.33	8.33	27.08	48
1940	4.76	0.00	0.00	0.00	0.00	0.00	0.00	95.24	21	1976	29.17	10.42	18.75	8.33	0.00	16.67	12.50	4.17	48
1941	5.26	0.00	0.00	0.00	0.00	0.00	0.00	94.74	19	1977	19.05	9.52	19.05	7.14	2.38	4.76	14.29	23.81	42
1942	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	20	1978	25.00	12.50	5.00	2.50	2.50	0.00	17.50	35.00	40
1943	13.64	0.00	0.00	0.00	0.00	0.00	0.00	86.36	22	1979	21.62	13.51	5.41	5.41	0.00	5.41	8.11	40.54	37
1944	4.55	0.00	0.00	0.00	0.00	0.00	0.00	95.45	22	1980	16.22	13.51	13.51	5.41	16.22	10.81	8.11	16.22	37
1945	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	23	1981	19.51	14.63	7.32	12.20	4.88	12.20	12.20	17.07	41
1946	4.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00	25	1982	25.00	22.92	8.33	2.08	10.42	18.75	2.08	10.42	48
1947	4.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00	25	1983	15.91	25.00	0.00	0.00	6.82	15.91	15.91	20.45	44
1948	3.70	0.00	0.00	0.00	0.00	0.00	0.00	96.30	27	1984	23.40	25.53	8.51	2.13	6.38	4.26	6.38	23.40	47
1949	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	22	1985	18.99	25.32	1.27	1.27	5.06	5.06	22.78	20.25	79
1950	4.76	0.00	0.00	0.00	0.00	0.00	0.00	95.24	21	1986	11.54	41.03	1.28	5.13	3.85	15.38	5.13	16.67	78
1951	23.08	0.00	3.85	0.00	0.00	0.00	0.00	73.08	26	1987	20.00	30.67	5.33	2.67	2.67	10.67	6.67	21.33	75
1952	4.17	0.00	0.00	0.00	0.00	0.00	0.00	95.83	24	1988	25.61	30.49	4.88	1.22	3.66	7.32	8.54	18.29	82
1953	18.75	3.13	3.13	0.00	0.00	0.00	3.13	71.88	32	1989	23.26	41.86	0.00	3.49	5.81	3.49	9.30	12.79	86
1954	11.76	0.00	2.94	0.00	0.00	0.00	0.00	85.29	34	1990	21.74	41.30	2.17	3.26	5.43	14.13	4.35	7.61	92