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**A
SURVEY OF
AGRICULTURAL
ECONOMICS
LITERATURE**

VOLUME 2

*Quantitative Methods
in Agricultural Economics,
1940s to 1970s*

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Gordon C. Rausser, and Lee R. Martin, editors*

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Appendix (Part IV). A Brief Review of the Literature by Subject Category

The references at the end of Part IV include, in addition to the sources cited in the text, many sources dealing with various other aspects of agricultural economic information systems and a large number of periodical sources of agricultural economic data. In the present section the major postwar references not cited elsewhere are classified by subject category.

Originally we had hoped to include in Part IV a complete listing of the principal periodical sources of data available to United States agricultural economists. It was our plan to identify the periodicals and to provide information on the sources and data series maintained by each periodical. Constraints on time and the magnitude of the proposed task ruled out this alternative. Although preparation of an exhaustive listing of the principal periodical sources was not feasible, many of these sources are included in the references at the end of Part IV.

An important outgrowth of our inquiry was the discovery that work now being undertaken will eventually fill this gap and will generate new contributions to the agricultural economics information system. In a letter of February 28, 1977, Gaylord E. Worden, then director of the Data Services Center of the Economic Research Service and now with the Statistical Policy Division, Office of Management and Budget, wrote as follows:

We have our concepts pretty well decided and have started active recruitment for someone to lead this new thrust. The Data Resource Cen-

ter will be a part of our data management services in the Data Services Center, a service division in ERS.

The Data Resource Center would be a computer supported information base containing available and constructed documentation on data used in ERS and other data that would be available to ERS. The information would answer as many as possible of the types of detailed subject matter questions from researchers as well as technical information needed by the data processing staff. The Center would also track statistical and data base activities at the federal level and other key areas to keep the ERS research staff better informed on changing availability of data, etc.

Over time, *the Center could add capability to access bibliographic and information bases needed by the research staff and include more documentation on data uses, data flows, research models and research systems used in ERS.* For example the type of information in Agricultural Handbook No. 365 could be a part of the system and updated fairly routinely and automatically. [Italics added.]

For detailed information on the data series currently maintained by the ERS, the SRS, and the AMS, see USDA Agriculture Handbook 365 and USDA Miscellaneous Publications 1088 and 1308. New publications in agricultural economics from the ERS and the SRS are listed inside the back cover of the ERS monthly periodical, *Agricultural Outlook*.

Information Systems and Purposes

The references in this category include a few publications on the issue of statistical confidentiality and on data interpretation. The remainder of the publications in this category are broad in their approach. Dunn [1974] provides many other useful references on information systems and privacy.

Sources. Bancroft [1972]; Bolling [1956]; Bowman [1968]; Callander [1949]; W. W. Cochrane [1961]; Cox [1962]; Demsetz [1969]; Dunn [1966, 1974]; Fellegi [1972]; E. N. Gilbert [1958]; Hayek [1945]; Hildreth [1967]; Hirshleifer [1971]; Juster [1970]; Klein [1971]; Kuhn [1970]; G. E. Lee and Nicholson [1973]; Lunde [1975]; Marschak [1971]; Orcutt [1970]; Rosenblatt, Glaser, and Wood [1970]; Schnittker [1963]; Shannon and Weaver [1969]; Shoemaker [1962]; Simerl [1962]; Simpson [1966]; Szaniawski [1967]; Trelogan [1962]; Weeks [1972]; Weeks, Schluter and Southard [1974]; Weiner [1974]; Wells et al. [1954]; Wickens [1953]; Wilcox and Ebling [1949].

Theoretical and Operational Concepts

Increased interest in the conceptual foundations of information systems has

generated a steady flow of publications, although many more deal with problems in the development of operational concepts or variables than with the development of satisfactory theoretical constructs. Only one reference in this category deals with data interpretation. The development of operational and theoretical constructs receives some attention from writers of articles in the other categories, particularly in "Critical Evaluations."

Sources. Ackerman and Riechen [1964]; Arrow [undated]; Bachman et al. [1948]; Berndt and Christensen [1974]; Birnbaum [1962]; Christensen [1975]; Christensen and Manser [1975]; Ducoff and Hagood [1947]; Fritsch et al. [1975]; Fromm [1973]; E. N. Gilbert [1958]; Griliches [1963]; Herriot and Spiers [1975]; Hickman [1964]; Horring [1961]; Hotelling [1958]; Houthakker [1968]; Howe, Handy, and Traub [1975]; Hulten [1974]; Hurley [1962]; Koffsky [1962a]; Marion and Handy [1973]; Marshall [1962]; Masucci [1962]; Mighell [1969]; Naive, Cox, and Wiley [1957]; Nikolitch and McKee [1965]; Nybrotten [1953]; Pallesen [1962]; Randall [1968]; Randall and Masucci [1963]; Randall and Rojko [1961]; Rymes [1972]; Schnittker [1959]; Shaw [1967]; Sheehy and McAlexander [1965]; Sheldon [1960]; Siegel [1956]; Star [1974]; Stine [1946]; USDA, ERS [1972a, 1972b]; Vining [1953]; Weeks [1972]; Weeks, Carlin, et al. [1972]; Welsch and Moore [1965]; Winkler [1963]; Zusman [1967].

Data Collection Methods

There is a large body of literature on the methodology of data collection, particularly on data obtained from sampling. Many of these studies come from statisticians and economists who are producing numbers, even though they are often focused on methodology, with the methods illustrated by application to numbers. We would characterize them as more constructive than critical.

Sources. ASA, Advisory Committee [1953]; Backrock and Scable [1967]; Bailer [1973]; Bailer and Tepping [1973]; R. M. Brooks et al. [1974]; Buse [1973]; Clausen and Ford [1957]; R. S. Cochrane [1965]; Ferber [1966]; Finkner [1952]; French and Kranz [1957]; Grieves [1954]; Hall [1969]; Hansen and Hurwitz [1946]; Hartley [1962, 1965]; Hendricks [1949]; Hendricks, Searls, and Horvitz [1964]; Houseman [1947, 1949, 1950, 1953, 1957]; Huddleston [1950, 1965, 1968, 1971]; Hurley and Smith [1951]; Jebe [1952]; Jebe and Clifton [1956]; Jessen [1947, 1955]; Kelly [1958, 1963]; Kirkbride [1969]; Kish [1962]; Knutson and Harmston [1950]; McGregor and Frost [1959]; McVay [1947]; Neter and Waksberg [1964]; Reed [1949]; Rogers [1965]; Scholl and Burkhead [1949]; Shaffer [1959a, 1959b, 1959c]; Shaudys [1969]; C. C. Smith [1952]; Stout [1962]; Sud-

man and Ferber [1971]; R. G. Thompson [1963]; Trelogan [1966, 1968a, 1968b, 1971]; Tsai [1973]; Vickery [1956]; Vincent [1959]; Vogel [1973, 1975]; Wallace [1955]; West [1965]; W. H. Williams and Mallows [1970].

Evaluations of Methodology

The methodologies employed in information systems are frequently criticized in the literature. Evaluations and suggestions for improvements come from analysts within the information system and elsewhere.

Sources. Abel [1962]; Adelman and Griliches [1961]; Bailey, Muth, and Nourse [1963]; Boxley, Gibson, and Hoffnar [1964]; Budd [1971]; Ducoff and Bancroft [1945]; Edgington [1963]; Ferber [1949]; Foote and Bean [1951]; Foote and Fox [1952]; Foote and Weingarten [1958]; Gale [1968]; Gonzalez [1973]; Houseman [1972]; Houseman and Reed [1954]; Jorgenson [1964]; Light, Mosteller, and Winokur [1971]; McHugh [1961]; Morgan and Sonquist [1963]; Puterbaugh [1961]; Sarle and Robinson [1949]; Sell-tiz et al. [1964]; Wales and Ferber [1963]; Wigton and Kibler [1972].

Evaluations of Information Systems, Programs, Concepts, and Data

Rarely does the program of the annual meetings of the American Agricultural Economic Association not include a session on agricultural economic data. The peak may have been reached when almost all of the November 1939 issue of *Journal of Farm Economics* was devoted to eleven articles in this area, including several excellent evaluations and several suggestions for improvement.

About half of the representative sources listed in this category are written from the standpoint of information producers (engaging in self-criticism or intramural criticism) and about half from the standpoint of information users. Sometimes the two groups seem to "talk past" each other because they tend to focus on relatively narrow aspects of an information system, not the system as a whole. Nevertheless, nearly every aspect of information has received its share of critical review, and many evaluations offer critiques and suggestions in several areas.

Sources. ASA, Advisory Committee [1948]; Bachman [1958]; Barlowe and Vlasin [1974]; Bawden and Kershaw [1973]; Beck [1955]; Becker [1951]; Becker and Harlan [1939]; Benedict [1939]; Benedict and Kuznets [1958]; Benedict, Tolley, et al. [1944]; Bhatia [1971]; Bodin [1955]; Boger [1961, 1966]; Breimyer [1968]; Burroughs [1950]; Clawson [1966]; Clough [1951]; W. W. Cochrane [1966]; Daly [1963, 1966, 1969]; Denison [1969];

Dyer [1975]; Ebling [1939]; Eisgruber [1973]; Erickson [1971]; Ferris [1962]; Fox [1953]; S. J. Gilbert [1955]; Griliches [1960]; Grove [1967]; Gunnelson, Dobson, and Pamperin [1972]; Halcrow and Hieronymus [1959]; Hale [1939]; Hardin [1946]; Haren [1975]; Harris [1962]; Hathaway [1959, 1963]; Hayenga [1971]; Heflebower [1951]; Hendricks [1955]; Hoffman [1966]; Houk [1957]; Houseman [1955]; Howe and Handy [1975]; Hurley [1965]; Hurley, Jabine, and Larson [1963]; Hurwitz [1962]; Ives [1957]; Jessen [1939, 1942]; D. G. Johnson and Nottenburg [1951]; Jorgenson and Griliches [1967, 1972a, 1972b]; Keith and Purcell [1976]; Kizer [1967]; Koffsky [1947]; Kottke [1964]; Krueger [1963]; Kutish [1955]; I. M. Lee [1952]; Loomis [1957]; Lowenstein [1954]; Luby [1957]; McAllister [1950]; McCormick [1955]; W. K. McPherson [1956]; McVay and Tucker [1950]; Murray [1939]; National Advisory Commission on Food and Fiber [1967]; T. R. Nelson [1967]; Newell [1953, 1957, 1958a, 1958b]; Nordquist [1956]; Paarlberg [1950]; Pearson and Brandow [1939]; Ramsey [1959]; Riley [1956]; Ruttan [1954, 1963]; Sarle [1939]; Sarle, Heimberger, et al. [1953]; Schrader [1951]; Scoville [1959]; Sherr [1960]; Shiskin [1960]; Sinclair [1951]; R. H. Smith [1954]; R. K. Smith [1955]; Snedecor [1939]; Spielman and Weeks [1975]; Stapp [1958]; Stauber [1959b, 1964]; H. C. Taylor [1939]; H. M. Taylor [1950]; Teper [1956]; Timm [1966]; Todd and Ziricle [1952]; Trelogan [1972]; U.S. Congress [1952, 1957, 1960, 1967b, 1971, 1972]; U.S. Congress, Office of Technology Assessment [1976a]; U.S. Department of Commerce, Intensive Review Committee [1954]; U.S. Government [1971]; Upchurch [1974]; W. F. Williams, Bowen, and Genovese [1959]; Woytinsky and Woytinsky [1939]; Wright and Torgerson [1975].

Information and Data Needs

A large and diverse body of literature is devoted to the data and information needed by analysts and decision makers. Some of the suggestions come from data or information users, some from data or information producers. The suggestions range from demands for narrow bands of data to well-thought-out suggestions for large additions to existing information systems.

Sources. Borum [1955]; Bottum and Ackerman [1958]; Bryant [1973]; Budd [1971]; Butz [1966]; Daft [1973]; David [1976]; Ebling and Ahlgren [1954, 1959]; C. Edwards [1969, 1973]; Ewing [1956]; Gardner [1973, 1975]; Gillett [1948]; Grove [1969]; Hathaway [1972]; Houseman [1964]; Hurley [1949, 1954, 1958]; Madden [1970, 1973]; Mayer and Ahalt [1974]; Mendelowitz [1971]; Raup [1959]; Schaars [1955]; Schultze [undated];

J. T. Scott and Heady [1969]; Sturt [1972]; Sundquist [1970]; Thomas [1956]; Vlasin [1973]; Vlasin, Libby, and Shelton [1975]; Webb [1956]; Westcott [1956]; White [1964]; Wilcox [1956].

Reports of Advisory Committees

Sources. AFEA, Agricultural Data Committee [1957]; ASA, Advisory Committee on Statistical Policy [1953]; ASA, Census Advisory Committee [1951]; ASA, Committee on Census Enumeration Areas [1954, 1955]; Fuller, Gillett, et al. [1953]; Rathbun [1972].

Relationship between Agricultural Economic Data and National Economic Data

With the increased interest in aggregate models—including input-output models and econometric models—more attention has been given to the compatibility of agricultural economic data and concepts with the data and concepts used to describe the complete economic system. Similar concern has been focused on income generation and capital formation for the farm and nonfarm sectors. All these forms of interdependence bid fair to occupy a good deal of the time of agricultural economists and macroeconomic model builders.

Sources. Brake [1974]; Brake and Barry [1971]; Christensen and Jorgenson [1973]; de Leeuw [1962]; Denison [1969]; Ducoff and Hagood [1946]; Dunn [1971]; Fabricant [1959]; V. Fuller and Van Vuuren [undated]; Haavelmo [1947]; Jorgenson and Griliches [1967, 1972a,b]; Kendrick [1961, 1972, 1973]; Penson and Baker [1978]; Rice, Hinrichs, Tolley and Hauser [1945]; Robbins [1963]; Ruggles and Ruggles [1971]; UN [1968]; UN, FAO [1973]; UN, FAO [1971]; Wells [1961].

Explanations and Illustrations of Data Series

A considerable body of literature is devoted to explanatory materials on data series (especially on changes therein) and on data systems. Most of the publications reflect the viewpoint of data producers. The explanations usually include data collection procedures as well as information processing procedures.

Sources. Allison, Zwick, and Brinser [1958]; Banks and Shapiro [1971]; Barton and Durost [1960]; Bayton [1950]; Borum [1951]; Bosecker and Ford [1976]; Bowman and Martin [1962]; Boxley [1971]; E. M. Brooks [1949]; Burk [1959]; Burk and Lanahan [1958]; Callander and Sarle [1947]; Caudill [1965]; Cavin [1952]; Ciancio and Tortora [1976]; Eckler and Taeuber [1954]; Grove [1954]; Hansen [1965]; Harlan [1947]; Hendricks [1947,

1963]; Hendricks and Huddleston [1955]; Jacobs [1975]; Knutson [1949]; Koffsky [1958, 1966]; Landau and Brandt [1966]; A. T. M. Lee and Bachman [1953]; Marsh and Conklin [1953]; Morton [1969, 1972]; Nordquist [1952]; Ogren [1956]; Parker [1951]; Parker and Holmes [1958]; Peterson [1947, 1950]; Purcell and Raunika [1971]; Quackenbush [1954]; Quackenbush and Shaffer [1960]; Randall [1968]; Robinson and Wallrabenstein [1949]; F. S. Scott, Jr. [1955]; Sells [1975]; Senf [1949]; Simon [1958]; Stauber [1950, 1959]; Taeuber [1947, 1957, 1971]; USDA [1958, 1959]; USDA, AMS [1957]; USDA, ERS [1975]; USDA, FCA [1968]; USDA, SRS [1967]; U.S. Department of Labor, BLS [1974]; Wells [1950, 1958].

Evaluative Techniques

The publications in this category are concerned with the development or use of evaluative techniques on different aspects of information.

Sources. Bullock [1976]; Fellegi and Krotki [1968]; Ferber [1955]; Ingram and Prochaska [1972]; Marks, Mauldin, and Nisselson [1953]; H. T. Shapiro [1973].

Economic Forecasting Models

Sources. Barr and Gale [1973]; Crom [1972]; Cromarty [1959]; Daly [1963]; K. A. Fox [1953]; Kuznets and Harvey [1953]; Leuthold et al. [1970]; Palmer and Schlotzhauer [1950]; Parr and Calvin [1956]; Theil [1958].

Foreign Agricultural Economic Information

Sources. Ball and Gardella [1967]; CIDA [1963]; Hirsch [1947]; Koenig [1951]; United Nations [annual], *Statistical Yearbook*; United Nations, FAO [annual], *Yearbook of Food and Agriculture Statistics*.

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Epilogue

Epilogue

The chapters in this volume emphasize the importance of more fully integrating the array of various quantitative approaches to problem solving and to the testing of theoretical constructs. Whether approached from an econometric, optimization, systems and simulation standpoint, or from a more pragmatic data-dredging standpoint, the applied problems of agricultural economics require specialized analysis if they are to be handled effectively. Accordingly, the authors of each of the chapters look toward the day when the apparently separate tasks associated with problem-oriented research will be more fully and effectively integrated. The compartmentalization typical in the profession and emphasized by the organization of the volume seems more and more artificial as the quantitative methods and approaches to data generation are viewed in their modern and/or generalized forms.

The review of econometric methods by Judge concludes with an evaluation of estimation techniques which support the theme of integration. The various forms of preliminary testing and Stein-rules, Bayesian estimation and inference, adaptive estimation, updating, and variational parameter procedures are all econometric techniques which recognize and emphasize the specialization of method to the problem at hand. Moreover, they point toward a need for the integration of research tasks associated with data gathering, model revision, and applications in policy or optimizing contexts. For example, variational parameter estimation methods are consistent with evolutionary problem specifications and a variety of schemes for obtaining data. Similarly,

the comparatively recent results on preliminary tests and adaptive model construction have done much to formalize and lend scientific content to methods of analysis long practiced by applied researchers. Although the results in this instance are somewhat discouraging regarding the information content of the adaptively or sequentially constructed models, they do underline the value of optimizing methods for model revision, the collection of additional data, and policy applications. These methods are at present somewhat demanding computationally and even conceptually, but they indicate the direction in which the modern developments in econometrics are moving.

Day's chapter on the conceptual background of economic optimization is on the surface somewhat less suggestive of the integration theme. Technical aspects of modern optimization methods and problems or structures are surveyed in an expository manner. The connection of these models or methods with economic systems such as market processes and their extensions to dynamic frameworks are key features which support the general theme. Throughout the chapter the reader is reminded that the model, however elegant, is not an end in itself; rather, it is formulated for a specific purpose—to study an economic system. Correspondingly, as perceptions of the economic system being modeled change, perhaps through use of the model itself, the optimizing models can be altered in such a fashion as to capture more accurately or economically those aspects of the problem of interest to the researcher.

Day's chapter also delineates several types of dynamic optimizing models. With command of these formal dynamic optimizing structures, it is natural to initiate the process of formalizing the procedures for model revision to comply with added or developed perspective on the economic system in question. Potential variables for broadly conceived optimizing models are designs for data generation and estimation methods and again must incorporate in an integral fashion the other quantitative approaches and/or problems considered in this volume.

The review of applications of optimizing methods by Day and Sparling surveys past studies and presents a few speculations on directions for future research. The studies are categorized by food and diet, farm and business management, farm development, production response, spatial economies, natural resources, and development. The chapter highlights original contributions or studies which represent the first attempt at the systematic application of optimizing techniques to the selected problem areas. As in the preceding chapters, several methods applied to complex problems which are demanding from a computational viewpoint are identified as important milestones in the evolution of results on optimization methods. Of the applications reviewed, the resource models possibly come the closest to achieving an integra-

tion of quantitative techniques along the data-estimation-optimization focus of the present discussion. Attempts to cope with uncertainty about the initial conditions and the economic structure, along with the intrinsic dynamic nature of these problems, place this work in the forefront of advanced modeling applications. Similar problems arise in the construction of models for farm growth management. Largely because of the readily available traditional linear programming methods, however, generalization to an integrated approach was limited by the failure early in the research efforts to formulate the problem in a truly dynamic context.

Woodworth's chapter reviews the extensive theoretical and applied work on production functions. The chapter thus concentrates more on an area of economic substance than on analytical methods or data. For this reason the review is less integrated into the present discussion than are the other chapters. The research on production functions is, however, an area in which theory, data, and estimation methods have been effectively combined. The evolution of specifications to more generalized forms, allowing for variation in the elasticity of substitution, linkages of these models to input-output relationships in fixed coefficient forms, questions of appropriate levels and methods of aggregation, and the estimation of parameters incorporating firm equilibrium conditions are identified as important developments and avenues for further study. As shown by the review, much of the original work in applying and estimating production functions has been done in agricultural economics. For the United States applied activity in this area peaked in the late 1950s and early 1960s, owing in some respects to the adoption of the major concepts in production theory by the technical scientists generating the data (a factor useful in explaining the continued work on estimating production functions in developing economies) and perhaps because the specifications of the models and uses have focused on comparative statics. Following the theme of the earlier comments on adaptive modeling, it would seem apparent that interest in production functions will be renewed when dynamic models of firm behavior are made more complete and accompanying evolutionary specifications for the associated technical relationships are required.

The review of systems and simulation procedures and analyses by Johnson and Rausser focuses on the importance of systematizing the processes of model development, estimation, and application and choice. The initial sections of the chapter provide a framework for integrating these processes and identify their connection with the modern work on adaptive control. Systems and simulation are shown to have been useful in stimulating more general approaches to methods of model construction and application. It is also shown that the implicit optimizing context in which purposeful model development and application are viewed calls for much more structured approaches to the

problems of verification, validation, estimation, operation, and revision. A major limitation of the applied work in systems and simulation has been the highly personalized nature of the models. The chapter concludes with a survey of applications, concentrating on those which have been innovative in method and in the formalization of model construction and application processes.

The remaining chapters are a collection of essays on data systems, including their history and implications for future research. Upchurch provides a fairly complete survey of sectorwide data systems. He emphasizes that the various data systems have been typically initiated in response to particular economic problems. Farm surveys and commodity statistics which arose from policy problems faced during the depression years, costs and returns studies to support parity programs, and the more recent concerns with rural development are examples of instances in which data systems have been initiated or greatly expanded in response to an agricultural problem requiring centralized policy action.

From the present perspective this unstructured approach to data collection and the development of an information base for the agricultural sector may seem unfortunate. But is it reasonable to expect anything else? Data and information are expensive, so choices must be made on the bits of information to be included in the system. Current policy problems dictate the relevance of the various existent and possible data systems. These problems tend to change in unpredictable ways. This being the case, it is likely that researchers will continually be dissatisfied with the existing base. What will happen is largely what has happened in the past. The information system will continue to evolve very slowly and adapt to the information needs of the data users, with some improvement in the communication between the people who collect the data and those who use it for research or decision-making purposes.

Trelogan and his associates chronicle the history, evolution, and present status of the Statistical Reporting Service of the USDA. Again the emphasis is on the development and extension of the SRS data system in response to perceived policy problems at the national level. More specifically, the extensions have occurred largely in response to administrative and governmental program needs—for example, the need for data to monitor and implement the various types of governmental programs for agriculture which have been applied over the years.

Of particular interest in this chapter are the observations made on new technologies for data gathering and handling. Advances in multiframe sampling theory, along with the accumulated knowledge on the population, have made possible the development of more reliable estimates for the recorded features of the sector of the economy and the units within it. Similarly, tech-

nological advances in data processing have resulted in the cost feasibility of handling and maintaining a much more ambitious data base. Many important possibilities associated with linking data systems on a real-time basis are still to be explored. As these possibilities are recognized and exploited, data systems may begin to focus more on the information content and the economic and social returns of having the information and less on the costs of collection. Finally, remote sensing holds great potential for reducing costs of data gathering. For example, worldwide crop acreage inventories obtained on essentially a real-time basis seem at present almost within our technological grasp. It is interesting to note that remote sensing as applied in modeling has also developed just as the need for policies more effectively linking the agricultural sector to world food and fiber markets has emerged as a major concern in the efficient and purposeful functioning of the sector. Although of course dependent on space technology, the process of obtaining information for more accurately modeling world food production, stocks, and consumption patterns can be viewed as a response of the data system to recent major policy issues involving population dynamics and economic development.

Bonnen explicitly treats the data gathering, storage, and discrimination processes as an evolving system. Problems with the data base, Bonnen argues, are best approached by recognizing that the essential features of the process can be viewed in an information systems context. He stresses that data systems involve management and operationalization of economic concepts, along with institutional and statistical theory. Moreover, data systems feed into a larger structure termed an inquiry system. The scope and content of the inquiry system is to a large extent defined by the informational needs and requirements of the various agricultural decision makers. Within this process we can readily envisage changes in data-gathering techniques, in data base management, and in the focuses for the basic sampling or recording endeavors. It is important that the information system serve current policy needs. Various hallowed data series or concepts on which data gathering has been focused should not be automatically perpetuated. The costs and benefits of the different types of information which can be obtained—not tradition and vested interest—should guide the system. For agriculture, Bonnen argues that vested interest groups have made the data system less flexible than it might otherwise have become. The optimal economic framework for positioning the data or information system must balance benefits and costs on a continual basis, emphasizing the advantages of more accurate or more complete information in existing and contemplated research activities.

The observations made by Bryant in the essay on economic and social statistics for rural people are quite consistent with our general theme and with the chapter on data systems by Bonnen. Specialized experiments on a grand

scale are strongly suggested as useful approaches to the generation of data needed for fruitful studies of rural development. Moreover, Bryant recommends the collection of more secondary data on rural populations and economies to support the research suggested by modern development policies. Thus, Bryant's remarks, in the context of the general theme and Bonnen's comments on information systems, are easily understood, given the recent attention of the profession to rural development problems. Bryant's chapter provides a good example of how the process of reorienting and expanding data or information systems occurs in response to changing theoretical concepts with respect to human capital, household production theories, and so on and in response to changing economic problems and policy questions. It is unfortunate that this response cannot be more timely and less costly, but these characteristics are symptomatic of the major decisions on information trade-offs that such changes imply.

Since the systems and simulation chapter necessarily addresses the gamut of activities associated with model development, specialization for applied problems and use, it has anticipated a number of our overall concluding comments. Systems concepts have proved very useful in understanding and modeling highly complex structures. Johnson and Rausser emphasize what has been implicit in all of the chapters—namely, the importance of clearly identifying the purposeful intent of research in developing models and of corroborating the models with the system vis-à-vis data collection and information processing and applying this acquired knowledge in a descriptive, behavioral, forecasting, or decision context. In this regard, it has been illustrated that the theory of adaptive or dual control provides a framework sufficiently general to unify the modeling and research process. With systems concepts and the adaptive control framework, the compartmentalization of quantitative research and teaching processes such as estimation, data gathering, and optimization can be discarded.

Modeling activities and, in fact, research in general involve implicit optimizing processes. Models are constructed and research is conducted with implicit or explicit purposeful intent. Moreover, there are natural and identifiable constraints associated with the modeling process itself and of course with the system under study. Thus, research efforts, whether related to model formulation or to application in a policy context, have identifiable objectives which are approached by strategies for allocating scarce resources. Users of this framework view choices of estimation method, data collection, verification and validation procedures, and analytical construct as potential control variables in a general optimizing process.

The evolutionary nature of the research process underscores the importance and use of the adaptive control framework in guiding and specializing

research, which is by design a search and discovery process. Consequently, at various points in the research process increased knowledge of the system in question puts the decision maker in an improved position for identifying the relevant instrument variables and setting optimizing levels of controlled activities. This together with the observation that the agricultural sector and the subunits within it are in a state of continual change further underscores the importance of electing an approach to research activities which can accommodate and adapt to evolutionary processes. Changes in the system, perceived problems, data systems, methods of analysis, and the like are more the rule than the exception and thus require an adaptive mode for decisions regarding research activities.

Agricultural economics has been heavily influenced by the neoclassical paradigm in economics and classical statistical decision theory. Both are constructs which abstract from the evolutionary nature of the processes, economies, agents, and managerial participants interacting with the system under examination. Perhaps this has caused the profession to look too much for "the" optimal data systems and has led to inflexible models and optimization methods which in many cases require perfect knowledge and foresight. Developments in systems and simulation and within the statistical and optimization methods and information processing areas have shown the frailty of these concepts. Such developments argue for a more realistic characterization of the present state of knowledge and for more adaptive research strategies. The world is changing and our perceptions of it are being revised as a result of passive and manipulative intervention in the various subsystems.

The reviews in this volume have stressed that data systems, methods of model construction, model use, and research strategies which do not recognize the integrative features of the information generation process are often ineffective and inefficient. Nevertheless, the progress toward estimation and optimization methods and data generation systems which are more attuned to the evolutionary nature of research problems and activities is reflected in each review.

