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Author

Rausser, Gordon C.

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FOR MODELING THE U. S. AGRICULTURAL SECTOR

by

Gordon C. Rausser

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NEW CONCEPTUAL DEVELOPMENTS AND MEASUREMENTS
FOR MODELING THE U. S. AGRICULTURAL SECTOR*

Gordon C. Raussert†

The use of economic models to represent various components of the U. S. agricultural sector has a long and rich history. This history has been eloquently documented by Leontif in his 1971 Presidential Address to the American Economic Association:

"An exceptional example of a healthy balance between theoretical and empirical analysis and of the readiness of professional economists to cooperate with experts in the neighboring disciplines is offered by agricultural economics as it developed in this country over the last 50 years. . . . While centering their interest on only one part of the economic system, agricultural economists demonstrated the effectiveness of a systematic combination of theoretical approach with detailed factual analysis. They also were the first among economists to make use of advanced methods of mathematical statistics. However, in their hands, statistical inference became a complement to, not a substitute for, empirical research."

Shortly after World War II, the systematic combination of theory with empirical analysis began in earnest at the U. S. Department of Agriculture (USDA). These early efforts were made by Frederick Waugh and Karl Fox along with numerous others and typically concentrated on demand and/or supply estimation for a particular commodity. Over the years, these single-equation representations were expanded to include simultaneous interactions between supply and demand to determine market price as well as links between one commodity system and another, e.g., feed grains and livestock. The vast majority of these models were partial equilibrium frameworks involving the straightforward empirical application of conventional microeconomic theory.

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†Chairman and Professor of Agricultural and Resource Economics, University of California, Berkeley.

Throughout the 1950s and 1960s, the constructed empirical models were used as an aid to the evaluation of alternative policy strategies. In addition, the models were often used to generate conditional forecasts of various elements of the U. S. agricultural sector concentrating on different types of exogenous shocks. In effect, the models provided a means of conducting laboratory experiments without directly influencing the U. S. agricultural and food economy. The development of models by experienced analysts during this period frequently involved the combination of theory and empirical facts to sharpen judgments and perceptions of policymakers (Brandow).

The above developments, however, came to a screeching halt during 1972-73. The magnitude of increases in farm product and food prices surprised almost everyone within the public as well as the private sectors. To the U. S. government officials who were struggling to contain inflation, especially in the administered price sectors of the economy, the tremendous increase in food prices was indeed a bitter disappointment. At this juncture, it became crystal clear that the constructed models of the USDA were no longer viable. The forecasts generated by these models appeared to be outliers in comparison to the actual behavior of the system.

After much academic debate and the preparation of numerous reports, the profession came to the conclusion that the models constructed prior to 1972 could no longer serve as useful aids for evaluations of alternative policies or to forecast with any degree of accuracy the future behavior of the U. S. agricultural sector. This conclusion was based on the simple observation that the U. S. agricultural sector was no longer a closed system. The move to flexible exchange rates; the rapid expansion of international markets; the decreasing barriers between the agricultural economy and other domestic economic sectors; and, perhaps most importantly, the rapid change in the implementation of U. S. agricultural sectoral policies all pointed in the direction of an open system modeling approach. Up until the early 1970s, U. S. sector policies in effect isolated the agricultural sector from the world economy as well as the general domestic economy. The major sector policies that led to this insulation included, inter alia, farm credit, land diversions, domestic price supports, subsidies offered to exporters who bought at domestic price supports and sold at the lower world prices, and the active accumulation of public stocks which were released when market prices were above support prices and were augmented when market prices were

at the price support or below. With the rapid explosion in prices during 1972-73, the sector policies became temporarily unnecessary. This, combined with the significant depreciation in the value of the dollar and the huge increases in world money supplies, provided an opportunity for a significant increase in the links between the U. S. agricultural sector and the international economy.

In the face of the above events, a number of serious questions arose with regard to the specification, estimation, validation, and effective use of economic models of the U. S. agricultural sector. In early 1975, the Forecasts Support Group of the USDA called together a number of agricultural economists for their counsel and advice. At the Chicago meeting, Wayne Boutwell and Richard Haidacher of the Forecast Support Group, USDA, outlined proposed revisions in their model specifications and their plans for the future. After much free advice from the academic contingent at this meeting, it was decided to hold a series of annual conferences sponsored by the USDA and the Farm Foundation. Each of these conferences were to focus on modeling the U. S. agricultural sector. A total of five formal conferences were held over the years 1976 through 1980. Except for the conference held in Ottawa, Canada, in 1980, all took place in Washington, D. C. The first formal conference was organized by George Judge, University of Illinois; the second, by Stanley Johnson, University of Missouri, Columbia; the third, by Richard E. Just, University of California, Berkeley; the fourth, by Gordon C. Rausser, University of California, Berkeley; and the fifth, by Oscar R. Burt, Montana State University.

The participants of each conference included representatives from the Forecast Support Group of the USDA, academic representatives from U. S. and Canadian universities, representatives of the Economics Branch of Agriculture Canada, and model analysts from a number of commercial vendors of large-scale agricultural sector econometric models. As a result of the special blend of practitioners, applied research economists, and econometric theorists, a cross-fertilization occurred at these various conferences which, at times, was insightful and, at other times, meaningless. On the whole, however, the benefits to most participants at these conferences far outweighed the associated costs.

During the period that these conferences were held, the commercial vendors made major advancements in the construction and effective use of

~~Large-scale agricultural sector econometric models.~~ The Forecast Support Group of the USDA, however, achieved far less success due, in part, to personnel turnover and uncertain funding commitments. Nevertheless, each of these two efforts provided an empirical background for the debate and discussion that took place at each conference. This empirical perspective imposed a degree of practicality that otherwise would not have existed.

Across the various conferences, the same issues continued to arise. As one would expect, these issues related to the entire process of model construction and use. Some agreement was achieved while many differences remained. For example, it was agreed at the first conference that the model purpose, whether forecasting, policy impact analysis, explanatory analysis, or simply descriptive analysis, was crucial in structuring the research strategy for model construction and use. Formally, the research strategy is determined by the model architect's view of the trade-off between complexity and inaccuracy or, equivalently, simplicity versus accuracy.

In terms of model specification, views of the simplicity-accuracy trade-off can result in widely different treatments of the U. S. agricultural sector. Only by defining the model purpose is it possible to evaluate quantitatively the trade-off between accuracy and complexity (Faden and Rausser). Many conference participants argued for all-purpose models or at least models that were able to forecast with accuracy and could also be used simultaneously for policy impact analysis. Other participants argued that it was only possible to construct single-purpose models, i.e., forecasting models or policy impact models but not both could be simultaneously embedded in the same representation. Of course, it was readily accepted by all participants that the ultimate model of the U. S. agricultural sector should be able to perform satisfactorily as both a forecasting tool and as a tool for evaluating alternative policies.

In determining the appropriate model specification, the major issues that arose related to the appropriate level of aggregation, the selection of endogenous and explanatory variables, and the distinguishing features of model representations for U. S. agriculture. The issue of aggregation assumed many different forms. For example, how many commodities should be included in the representation, which links must be treated with tender loving care (e.g., feed grain-livestock links), and which links can be treated superficially (fruits and vegetables-food grains)?

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Each commodity system comprising the agricultural sector is composed of a number of components. These components include the input suppliers, the producers, the assemblers, the processors, the wholesalers, the distributors, and the ultimate consumers of the commodity in question. The treatment of each of these components must reflect a view about the appropriate level of aggregation and the selection of endogenous and explanatory variables. For example, can an appropriate degree of accuracy be achieved by endogenizing prices only at the farm level? Must we also endogenize prices at the retail and wholesale level? Should margin relationships be estimated along the vertical marketing chain from producer to ultimate consumer? The answers to these questions imply a particular specification of the endogenous variables as well as the level of aggregation. The vertical marketing chain for each commodity system can be represented by a single price point or be disaggregated across various components and, thus, be represented by numerous price points.

Spatial and temporal levels of aggregation also assume much importance in the U. S. agricultural sector. In terms of supply response, a spatial disaggregation is presumed to achieve greater accuracy in forecasting and policy impact analysis. Land allocated to soybeans in the Midwest faces different opportunity costs than land allocated to soybeans in the Southeast. On the food consumption side, the demographics and tastes in the Southeast may be quite different for some commodities than in, say, the West. In terms of temporal aggregation, a number of specifications are possible including annual, semiannual, quarterly, monthly, and, in some instances, even weekly time periods. Originally the forecast support group of the USDA specified an annual time period for their agricultural sector model. As a result, they were unable to model, with any degree of reliability, the stockholding behavior in the food and feed grain sector or the behavior of breeding stocks in the livestock sector.

The distinguishing features of model representations for the agricultural sector pertain to its stochastic/nonstochastic, dynamic/static, recursive/interdependent, decomposable/nondecomposable, linear/nonlinear, and interactive/noninteractive dimensions. In the case of agricultural and food commodity systems, uncertainty and large fluctuations are the rule rather than the exception. Hence, it is not expected that the U. S. agricultural sector could be represented by nonstochastic or deterministic models.

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The model representation should also be dynamic including time in an integral fashion. This may require the specification of feedback relationships; that is, information flows among variables over time. The model specification could also be recursive or interdependent across its various components. In recursive models, feedback or information flows between one variable and another are temporally lagged, whereas the flows in interdependent components are presumed to occur instantaneously. For some commodity systems, the model specification must be recursive, while for others an interdependent specification is appropriate.

Given the scale of the U. S. agricultural sector, another feature relates to its decomposability. The complete model representation should be decomposable into various components thus allowing submodels representing these components to be operated autonomously. The degree of nonlinearity of the model representation is of much importance. Nonlinear specifications depend principally on the nature of the underlining relationship (demand, supply, margins, etc.) and the degree of approximation deemed appropriate. Finally, the interactive feature of the model specification should be taken into account. This feature depends upon the association between the agricultural sector and its model representation. For example, information obtained by simulating the model may be used to develop more realistic relationships among the components and, in fact, to specialize submodel representations of individual components. This information may result from comparing the outcomes of the simulations to the observed system or from more implicit comparisons of outcomes with preconceived ideas as to the behavior of the agricultural sector.

In addition to issues of specification, the conferences also focused on alternative estimation methods. Here, the common debate between classical statisticians and Bayesians naturally arose. The most interesting insights, however, resulted from the effective utilization of alternative sources of information for estimating a complete representation of the U. S. agricultural sector. The alternative information sources included traditional sample data (time series and cross section), the use of future markets as surrogates for expectations, judgmental inputs especially those of USDA commodity specialists, and the use of prior probabilistic distributions based on previous empirical work. Much of the discussion also focused on the role of qualitative econometrics in estimating various

relationships and how econometric techniques might be combined with programming methods to achieve a greater degree of disaggregation and, hopefully, more accuracy in forecasting and policy-impact analysis.

The effective utilization of model representations was examined at some length. Here, the concern focused on the desire of the USDA for a rapid response to congressional and/or executive branch requests for forecast and/or policy-impact scenarios. This, of course, led to an investigation of how model representations should be maintained and effectively utilized. Perhaps, more importantly, it also led to an examination of the institutionalization of large-scale agricultural sector models.

The appropriate calibration of a model which has multiple uses was debated. Most participants frowned on the procedure followed by commercial vendors of calibrating their models by revising intercept terms in accordance with the degree of error of the most recent one-period ahead forecast. Internally consistent calibration methods were reported at a number of the individual conferences.

However, the major focus of all conferences was not on the above issues but instead on new conceptual and econometric developments that might prove valuable in constructing and effectively utilizing model representations of the U. S. agricultural sector. Most of these developments were and continue to be in an embryonic stage. University researchers were asked to evaluate these new developments and their potential cost and benefits of implementation by the Forecast Support Group of the USDA. The new developments evaluated by university participants covered the full gamut. For example, what role should product characteristics and/or the household production function approach play in this specification of consumer demand relationships? Should quality of various products be recognized explicitly or should we continue to operate with only a single measure of quality focusing only on quantity flows? What role should imperfect competition play in the specification of marginal relationships between the retail and farm levels?

In supply-response specifications, what insights are offered by the notions of duality and generalized cost structures? Are multiple-product or single-product supply response specifications appropriate? What is gained by formally incorporating risk and uncertainty in specified behavioral

equations for supply response? What type of improvements can be achieved by operating with flexible functional forms rather than prespecified relationships?

Most representations of the U. S. agricultural sector are based on expectation formation patterns that can be characterized as adaptive or extrapolative. Will the performance of the models be improved by replacing these expectation patterns with rational expectations? Observable data are available from future markets that relates to market expectations. Will the use of such observations as surrogates for price expectation variables result in an improved forecasting performance?

In context of market analysis, is qualitative econometrics simply another esoteric technique or does it improve the accuracy of forecast and policy impact scenarios? Does a formal recognition of price supports alter the measured elasticity of demand for various products? How sensitive are the forecasts that are generated to these new measures of elasticity? What insights have been gained from previous attempts to model agricultural trade? Is it possible, with any degree of accuracy, to endogenize the export demand facing the United States? Can the distortions that are introduced via import quotas, export quotas, tariffs, and the like be effectively incorporated in the specification of the trade component of the sector representation? What is the complexity-accuracy trade-off in modeling the rest of the world as one single aggregate or as a number of individual countries?

Many of the papers presented at the various conferences focused on policy impact analysis. The standard procedure of the forecast support group was to perform policy impact analysis by simulating the effects of various policies on selected endogenous variables. This approach was compared and contrasted with the specification of a formal criterion function and the derivation of optimal policies. For both the food-grain and feed-grain sectors, the effectiveness of these two approaches depends on the treatment of a number of influences. The first influence is the specification of two major uncertainties, weather and export demand. The second relates to the specification of private stockholding behavior, vis-a-vis, the behavior of government in its holding of public stocks. The third depends upon the commodity-specific policies that are pursued by the

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U. S. government, particularly their price stabilizing or destabilizing effects. Fourth, in recent years, the effectiveness of sector policies were shown to depend critically upon the general economic forms of governmental intervention, namely, fiscal, monetary, and exchange rate policies.

If our purpose is to forecast the future behavior of the U. S. agricultural sector for one to four quarters ahead, an exogenous specification of U. S. agricultural policy is often appropriate. Longer forecast horizons, however, require that the levels of various policy instruments must be assumed. Given the importance of governmental intervention in U. S. agriculture, this results in conditional forecasts which often vary widely as the conditioning levels of the policy instruments are changed. An alternative to this approach is to attempt to endogenize governmental settings on the policy instruments. On this issue, the theory of political economic markets and some empirical applications were presented at two of the conferences.

A number of papers focused also on various statistical methods for evaluating the accuracy of model representations. Clearly, the methods of evaluations depend upon the purposes for which the model was constructed. Various principles were outlined for the construction and evaluation of models constructed only for forecasting purposes as well as for models constructed for policy analysis purposes. The updating and maintenance of models and the recognition that structural change is often a fact of life in the U. S. agricultural sector were also examined. The conferences, in fact, motivated the development of a new methodological framework for specifying and estimating models which accommodate structural change.

The USDA, in the preparation of its short and longer term outlooks for the U. S. agricultural sector, combines a number of different information sources to generate forecasts. This is also true of Agriculture Canada. Some papers focused on how various information sources including the forecasts generated from econometric models might be optimally combined. Some attention was also paid to the institutionalization of large-scale econometric models, in particular, how the information generated from such models might be combined with more traditional sources of information. Here, a case study of Agriculture Canada proved particularly valuable.

This book is an outgrowth of the above papers. It includes a selected subset of the papers presented at the various conferences. The subset is sufficiently representative in its coverage of potentially promising developments. It represents an extensive assessment of the state of the art in econometric modeling and forecasting for U. S. agriculture.

Many of the papers presented in this volume are an appraisal of theoretical and applied research that is currently underway. Assessments of principal obstacles and problems of implementing new developments are provided. In the context of both forecasting and policy impact analysis, most papers treat analytical devices and their practical applications with an emphasis on what future directions modeling of the U. S. agricultural sector might profitably take.

The papers selected for this volume are categorized into one of six major phases of economic model construction and use:

1. New developments in supply response and demand analysis
2. New developments in expectation formation patterns
3. Market analysis and qualitative econometrics
4. New developments in agricultural trade analysis
5. New developments in government policy analysis
6. New developments in forecasting methods, evaluations, and model use.

Part I is devoted to new developments in demand and supply response analysis, the pivotal elements in any analysis of agricultural markets. This section contains five chapters. It begins with a chapter by George W. Ladd which surveys promising developments in demand analysis. The purpose of this chapter is to show how product characteristics can be incorporated into model representations in the hopes of improving the accuracy of demand forecasts. Chapter 3, by W. Michael Hanemann, also focuses on demand analysis with explicit attention given to the quality dimension. The framework advanced is theoretical, but it extends the earlier work of Waugh who studied the relationship between prices of various agricultural commodities and their quality. Chapter 4, by Peter Berck and Gordon Rausser, investigates the margin relationships between the farm and retail level introducing a number of new developments. These new developments are based on the formal recognition of grading and branding in the U. S. food

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sector, consumer uncertainty with respect to the quality dimension, and how econometric tests can be conducted to determine whether the structure between the farm and retail level for particular commodity systems is purely or imperfectly competitive.

In Chapter 5, Robert D. Weaver turns to issues of supply response. After presenting general duality theory, an interesting empirical application is presented along with some useful econometric methods for model simplification. The final chapter of Part I, by J. Arne Hallam, Richard E. Just, and Rulon D. Pope, focuses on the important choices that must be made in the specification of positive models which incorporate risk and uncertainty in agricultural production. Risk preferences and the evolution of subjective information play a crucial role in this chapter.

Part II is devoted to new developments in expectation-formation patterns. In dynamic representations of the U. S. agricultural sector, the specification of expectation patterns assumes a crucial role. It has long been recognized by agricultural economists that the major impediment to the development of successful forecasting models may result from misspecified expectation-formation patterns. Chapter 7, by Jean-Paul Chavas and S. R. Johnson, treats one expectation formation pattern, namely, rational expectations. The treatment is largely methodological focusing on the implications of the rational expectation hypothesis for the specification and estimation of econometric models. In Chapter 8, by Abraham Subotnik and James P. Houck, a specific empirical application is presented which utilizes the futures market as a vehicle for generating price expectations. The application integrates future market institutions with spot markets in the context of a quarterly econometric model for the corn commodity system. In Chapter 9 by Melvin H. Jameson, another empirical application is presented. Here, a formal test of the hypothesis that hog producers use rational expectations in making breeding decisions is conducted. The implications of this test for the frequently observed hog cycle are noted.

Part III on market analysis and qualitative econometrics contains two chapters. The first chapter, by Robert G. Chambers and Richard E. Just, recognizes that many of the previously constructed models of the U. S. agricultural sector failed to account for the discontinuous or discrete nature of observed data. A number of methods are surveyed, including

qualitative and limited dependent variable analysis, switching regression regimes, and disequilibrium models. The authors argue that the characteristics of the U. S. agricultural sector provide one of the most fertile areas for the application of qualitative econometrics. The use of qualitative econometrics is investigated for both U. S. wheat and corn demand by Gordon Rausser and Chris Riboud in Chapter 11. The qualitative feature of the model results from governmental price supports (loan rates) for both corn and wheat. An assessment is made of differences in estimates of demand elasticities resulting from the use of conventional procedures versus the use of qualitative econometric methods.

Part IV examines new developments in agricultural trade analysis. This section begins with a survey of recent developments in agricultural trade modeling and forecasting by Robert L. Thompson and Philip C. Abbott (Chapter 12). As the U. S. agricultural sector has become increasingly more dependent on international trade, the models surveyed in this chapter assume particular importance. The second chapter in this section, by Robert G. Chambers, Richard E. Just, L. Joe Moffitt, and Andrew Schmitz, examines the use of qualitative econometrics, namely, a disequilibrium model to investigate U. S. beef import quotas. A comparison of the welfare effects with and without the quota is provided.

Part V contains five chapters which focus on various issues associated with the use of econometric models for policy analysis. Chapter 14 by Oscar R. Burt, Won W. Koo, and Norman J. Dudley investigates the use of a stochastic dynamic optimization model to determine the optimal level of the U. S. wheat stocks. An interesting feature of this empirical application is the use of information beyond that represented by the estimated econometric model. Chapter 15 by Bruce Gardner explicitly recognizes the important distinction between private stockholding behavior and government holding of stocks. Emphasis is given to the effects of government commodity storage policy regimes on stockholding behavior in the private sector. Chapter 16 by Richard E. Just and J. Arne Hallam examines price stabilization policies. Previous theoretical work strongly suggests that alternative functional forms can drastically change the qualitative welfare implications of price stabilization. In the case of the U. S. wheat market, the authors find that the gains for both consumers and producers are quite stable in the neighborhood of the functional flexibility suggested by their statistical

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estimates. In Chapter 17, John W. Freebairn, Gordon C. Rausser, and Harry de Gorter specify a model composed of an international component, a domestic macro component, and an agricultural sector component to investigate (i) whether sector policies in agriculture should be designed to deal with specific shocks on the agricultural sector; (ii) whether the sector policies are more or less important than macroeconomic policies in terms of their effects on the performance of the U. S. agricultural sector; and (iii) what role macroeconomic policies might play in normative evaluations of agricultural sector policies. The presented analysis is based on an incomplete set of simulation experiments conducted with the estimated model.

Chapters 14 through 18 are searches for prescriptive or normative policy solutions based on an improved positive analysis of the private sector. In Chapter 18, the focus on policy analysis shifts from prescriptive to behavioral treatments of governmental intervention. This chapter, by Gordon Rausser, Erik Lichtenberg, and Ralph Lattimore, begins with the notion of political economic markets and their role in the redistribution of wealth from one economic interest group to another. After a complete survey of theoretical paradigms, empirical formulations are outlined for specifying and estimating behavioral equations for governmental policy. A review of recent efforts to endogenize governmental policy is also provided.

Finally, Part VI examines new developments in forecasting methods, evaluations, and model use. It begins with a chapter by Arnold Zellner (Chapter 19) which investigates how current statistical analyses of econometric models can be improved so as to achieve better forecasting and policy-analysis performance. The emphasis is on discovering and repairing defects of model representations, and methods are recommended which are likely to prove helpful in improving the quality of econometric models. Chapter 20, by Gordon Rausser, Yair Mundlak, and S. R. Johnson, argues that it is overly optimistic to presume that parameters summarizing the effects of economic variables will be identical over the complete sample record regardless of whether the model is linear or nonlinear. On the basis of this motivation, the authors develop a new methodology for formally incorporating structural change in model representations of the U. S. agricultural sector. The following chapter, by S. R. Johnson and Gordon Rausser, is devoted to composite forecasting, namely, a method for transforming a group of forecasts into a single probabilistic prediction.

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This chapter is based on the premise that it is unwise to discover which of a number of alternative forecasts is "best." In the case of the U. S. agricultural sector, the authors develop the methodology for combining forecast from econometric models, future markets, time series representations, and the expert opinion of commodity specialists.

In Chapter 22, Gordon Rausser and Richard E. Just turn to the design of model representations for policy analysis. A set of principles is developed which emphasizes the trade-offs that must be considered in the construction and use of agricultural policy models. It is argued that the assessment of trade-offs for descriptive, explanatory, or forecasting models differ measurably from such assessments for policy models. Part VI concludes with Chapter 23 by S. R. Johnson, H. Bruce Huff, and Gordon Rausser, which evaluates the experience of Agriculture Canada in assembling and integrating a large-scale econometric model into outlook and policy analysis systems. Based on this experience and similar observations for Australia and the United States, a number of generalizations are offered for how a large-scale econometric model might be effectively institutionalized.

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