



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

*Models for Decision-making in Agricultural Marketing**

This is an age when scientific methodology and technology have achieved a number of towering successes after centuries of uneven yet persistent development. For example, man's safe journey to and from the moon bears valid testimony to his conquest of outer space. Few would disagree that this remarkable achievement epitomizes the totality of science that has so far been evolved by man. Already, in many branches of science, concepts and tools such as the mathematical model, information feed back, simulation, decision theory, stochastic process and the digital computer have come into common usage. The computer is now standard equipment in many institutions, where masses of data are to be processed. Agricultural economists have provided leadership in the application and use of these concepts and tools in quantitative research.

This session of the Conference focuses on the function of models for decision-making in agriculture. This paper attempts an appraisal of models for decision-making in agricultural marketing. It will offer some reflections on the results of research using these models, and will evaluate the models used at the different levels (i.e., micro, macro, regional and interregional interdependencies). This paper will also consider the need for coordination of the different model approaches, and the role of these models in the formulation of agricultural marketing policy.

1. CONCEPT OF AND PROBLEMS INVOLVED IN
THE DECISION-MAKING PROCESS

A pre-requisite to appraising the models for decision-making in agricultural marketing would involve formulating some concept of the decision-making

† Executive Director, National Farm Products Marketing Council, Ottawa, Ontario, Canada.

* The author wishes to acknowledge the useful comments and suggestions of Dr. W. J. Anderson, Associate Director General, Agriculture Canada. These were helpful in the final preparation of this paper.

process, and an appreciation of the specific kinds of problems which the decision-maker needs to resolve in agricultural marketing. The literature on this subject abounds neither with clues about the "hard kernels" of the details of the decision-making process, nor with criteria used in balancing, comparing or choosing among alternative courses of action. Yet, these constitute the very core of the decision-making process. More attention needs to be focused on this key link in the chain of knowledge. In-depth analytical studies of the decision-making process either by participants actually involved in the process, and/or by adequately trained perceptive outsiders would make a definite contribution to knowledge. Much of the published material tends to gloss over, or to ignore the difficult decisions that have to be made in the development of programs and policies for agricultural marketing. Difficulties arise because decisions are normally made in an environment that is shrouded in uncertainties.

Nowhere does this problem of uncertainty seem to be more true than within the complex world of agricultural marketing. Few, who are intimately involved in this discipline to the extent that I am, would seriously question the assertion that the need for improved techniques of agricultural decision-making is already great, and shows signs of increasing. In fact, the growth of the marketing research and planning function attests to the concern for more systematic and better informed approaches to the problems of agricultural marketing.

No longer does the decision-making process merely involve a "collection of projects", or an investment program for the agricultural sector. It now involves the development of more integrated policies and programs of resource allocation to achieve clearly defined goals. This paper will indicate that over the past three decades, a body of tools, techniques and analytical models, that have been developed outside the field of agricultural marketing, shows promise of providing a framework within the functions of market planning and research can more closely be linked to the central decision-making process.

The development of effective public policies and programs to achieve certain strategic goals is a complex process involving a number of difficult decisions. For example, improving farm incomes and prices, reducing economic instability in agriculture, providing farmers with a greater measure of economic security, improving the bargaining position of farmers in the market place, providing the farm sector with a greater relative share of the national prosperity, and shifting more in farmers' favour the terms at which agricultural products are traded in the market place — are all typical issues facing most countries today. The decision-making process adopted by public and private planners to develop programs and policies to have a significant effect on these areas is complex.

What is the decision-making process? What are the fundamental steps in this process? What criteria are used in making a rational choice among alternatives? Petit, in his paper presented earlier, has suggested that "any decision process is a link between thinking and doing, between reflection and action".¹ Simon has also indicated that the decision-making process involves the following fundamental steps, viz: firstly, *problem finding*, which entails searching

the environment for conditions calling for decisions to be made and new policies developed; secondly, *design*, that is inventing, developing and analyzing alternative courses of action; and thirdly, *choice*, which entails the selection of a particular course of action from among available alternatives.² In practice, a number of criteria may be used in the selection of a choice. The economic criteria may involve "cost-benefit" analyses of the alternative courses of action. This decision-making process presupposes that there is a clear statement of strategic objectives, which serve as criteria for balancing and evaluating alternative courses of action. However, the development of effective policies and programs to achieve these clearly defined strategic objectives is a complex and difficult task, which involves making critical decisions on problems as they emerge in the process.

Decision-makers are faced with an array of problems on which decisions must be made in the process of formulating and implementing policies and programs designed to affect agricultural marketing. The problems differ as between commodities, programs, sectors, institutions, regions and countries. For example, Canada has adopted a supply management approach to the problems of economic instability and economic insecurity in the poultry industry. In the case of eggs, decision-makers, who are responsible for the administration of the egg program, are confronted with a number of difficult problems on both the demand and supply sides of the market.

On the demand side, eggs have revealed three important characteristics, viz: firstly, a declining per capita consumption for table eggs, secondly, inelastic demand for table eggs, but elastic demand for processing eggs; and decline in consumption as disposable incomes rise. In full awareness of these characteristics, decision-makers are confronted with the problems of establishing the national quota, its apportionment among the provinces, and then its distribution among Canada's 5000 egg producers who are registered under the National Supply Management Program. In setting the national quota, decision-makers have to resolve the problem of determining the requirements of the components of the national market, viz: requirements for table stock, processing, hatching and export.

On the supply side, decision-makers have to resolve the problem of stipulating the number of layers, based on some acceptable rate of lay, to produce the national quota. In addition thereto, decision-makers must take into specific account imports and the production of the large number of unregistered producers who are exempt from the National Supply Management Program in order to avoid unmanageable surpluses. Moreover, decision-makers are faced with the additional problem of establishing producer prices for eggs at a level that would allow producers to recover their production costs, take into account the interests of consumers, and at the same time, not induce larger than normal in-flows of eggs from abroad.

2. CONCEPT AND ROLE OF ANALYTICAL MODELS

The literature on economics abounds with references about reality. Yet, there exists no universally acceptable proposition of what constitutes reality. Is it a

mythical "will-o-the-wisp" concept that man forever pursues, yet never fully attains? Is there any other reality than man's concept, his perceptions of reality? Models are man's perceptions, his representations of reality. In a sense, they are his perceptions of himself in relation to his environment. They do not constitute a retreat from reality, but "stepping-stones" to reality. Hence, models – formally or informally – are an important part of, and play a crucial role in all decision-making processes. In fact, formally constructed models perform the function of refining these processes, thereby making them more systematic, and more scientific. Models enable man to think systematically and logically about reality. Therefore, the practice of building abstract models sharpens identification and analysis of problems. In themselves, such models aid in improving the logic of the decision-making process. The "acid test" arises when the model-builder attempts to convert an abstract model into an operational form by fitting it to the real world, thereby removing the model-builder from his "Ivory Tower". The link in this regard is to be found in observation and measurement. Models serve to apply the measuring instruments to those dimensions that are relevant in this exercise. They force both the builder and the decision-maker to set out their objectives more precisely, and so sharpen the analytical tools.

Models have often been evaluated either in terms of the reasonableness of their approximations to reality, or in terms of their predictive capability. However, the real purpose in building models goes well beyond these attributes. In fact, "the reasonableness of a model's approximation to reality may indeed be merely an academic quality, that is of little relevance to the pragmatic decision-maker". Furthermore, prediction is only a means to an end. The ultimate purpose of models is to aid decision-makers in answering the complex problems that emerge in the planning or policy formulation processes, thereby influencing the policies and plans of decision-makers in a manner that makes the outcome of decisions fall more in tune with the overall goals of society. Hence, models and model-building are not ends in themselves, and should not be viewed as such. They are means to achieve other ends. That is to say, they are tools or aids to decision-makers. As such, they provide inputs or aids to decision-makers in dealing with the complex problems encountered in the decision-making process. Models should therefore be problem oriented rather than be a mere academic exercise. Their real test relates neither to the reasonableness or their approximation to reality nor to their predictive capability, but to their appropriateness, relevance and capability in aiding human judgement in the decision-making process. Models are no substitutes for human judgement. They should, therefore, solve tomorrow's problems today, rather than resolve yesterday's problems tomorrow.

Thus, models assume a particularly crucial role in the decision-making process. It would seem appropriate, therefore, that the interrelations between the model-builder, the model and the decision-maker should be reviewed. The model-builder should ensure that the decision-maker is involved as intimately as possible in the model-building process, if the latter's confidence in the capability of the model is to be gained. The decision-maker should be involved in the conceptualization, formalization and specifications of the model, in the

identification of the assumptions upon which the model rests, as well as in the review of the limitations of the model. There needs to be a meeting of minds in these areas. This may be accomplished in a variety of ways, the most effective of which could be a matter of mutual arrangement between the model-builder and the decision-maker. Moreover, the model-builder must be credible, that is to say, he must be able to communicate with the decision-maker.

However, there are many reasons, particularly from government's point of view, as to why models of systems such as the food system or the marketing system are needed. Such models aid comprehension of how the system operates, and assist in the identification, behaviour and interrelationships of variables within the system. They assist in sorting out significant variables in the system, thereby facilitating greater efficiency in studying and managing the entire system or any component thereof. In addition, models are useful in projecting the behaviour of the system, and in the identification and evaluation of alternative solutions. They are useful in the continuous monitoring of the system so as to identify changes that are necessary or that are likely to occur.

It does seem that some of the skepticism which decision-makers have revealed with respect to models arise from the fact, not that decision-makers are dull of comprehension, but that model-builders have isolated themselves from decision-makers, who ultimately bear responsibility for the decisions made. It is in the interest of acceptability of their models, that model-builders should ensure that decision-makers are more intimately involved in the model-building process. Decision-makers are shrewd and selective in their choice and judgement. Why should they not be? It is they who ultimately bear responsibility for the decision made.

3. PROBLEMS OF MODEL CONSTRUCTION

The practice of building models is an integral part of the scientific method in agricultural economics. Scientific classifications in the natural sciences have been found to be particularly useful, because they provide the basis for predicting the essential elements of behaviour. Human society, however, is the exception, yet it is with this behaviour that marketing is concerned. The needs and responses of human behaviour are neither uniform nor constant. In fact, if invariance is characteristic of the physical world, certainly variance is characteristic of the human world. The variability of human behaviour has often been used to defend inaction in the mathematical treatment of economic and social problems. The usual defence has been that human behaviour is not predictable.

The "new physics" have shown that the behaviour of atomic sub-structures are also individually unpredictable, but that the behaviour of masses of such particles are predictable by means of stochastic process methods. Does this notion not have some relevance to human behaviour? Certainly, what a single individual will do with his disposable income is not predictable. However, the prospects of predicting mass spending or mass savings seem pretty good. In

any valid comparison of the problems encountered in the natural sciences and the social sciences, three important characteristics of the social sciences should be borne in mind. These are: the relatively many factors to be dealt with, their high variability, and their statistical instability.

Methodological developments in the natural sciences have had important implications for the social sciences in that they offer a methodology to smooth the path of the science of human affairs. They do nothing, however, to change the "state of turbulence" and variability of these affairs. Moreover, in the perspective of time, the physical world is a static world. This simplifies the accumulation of knowledge — a factor that is important in the development of a science. The variability and instability of the parameters of the human world are restraining factors that interfere with the development of empirical social science in that measurements become obsolete and inaccurate even though relevant for the analysis of the dynamic system. Furthermore, in the natural sciences the degree of accuracy of measurement is affordable, since the investment necessary for obtaining it could be spread as a social cost over all of perpetuity. The fact that measurement in the social sciences is perishable inversely effects the investment that can economically be made to obtain precision. Even if affordable, there could be no absolute precision of measurement.

However, agricultural economists need not be unduly overwhelmed by the towering successes achieved in the physical scientists' deterministic world. Current successes in the physical sciences have been achieved after centuries of uneven but persistent forward development. The foundations for this development were first laid by Claudius Ptolemy³ in the second (2nd) century, and also by Nicholas Copernicus⁴ in the sixteenth (16th) century. It may be noted that there were fourteen (14) centuries between Ptolemy and Copernicus, following whom new developments came in relatively rapid succession through the contributions of Johannes Kepler, Galileo, Isaac Newton, and more recently Albert Einstein.⁵ It was through the cumulative efforts of these scientists that we have today a general model of the universe, which explains more satisfactorily the behaviour of cosmic phenomena. Surely, it is only time that will tell whether Einstein is to have the final say in the development of a grand model of the physical universe.

In contrast, economics had its birth as a science with the publication in 1776 of Adam Smith's "The Wealth of Nations". In the development of the science of economics, many lessons could be learnt from the experiences in the physical sciences. An important one is that the "coupling of models and measurement is a continuing process in science. Observation leads to the improvement or rejection of models and the progressive leap-frogging of theory and measurement goes on".⁶ Moreover, although immediately inappropriate the methodology, a significant proportion of the technology and the attitudes of the physical sciences are transferable to the science of economics.

Marketing economists now need to focus on the uniqueness of economic and social phenomena, and so re-orient their models as to take into account the multi-dimensional aspect of human behaviour. A reason that some

economic models have not received the accolades expected lies in the fact that their builders attempt to solve yesterday's problems tomorrow rather than resolve tomorrow's problems today. To be relevant, economic models should anticipate rather than follow problem development.⁷ They should be more prescriptive and less descriptive.

4. PROSPECTS IN AGRICULTURAL MARKETING

The outlook for further progress in agricultural marketing must, therefore, be seen in the light of the model-builder's appreciation of the complex problems encountered in the decision-making process, the availability of tools for measurement, the complexity of the system that model-builders attempt to construct, and the availability of data to be used in making measurements. The promise of science hovering over agricultural marketing has certainly been illuminated in recent times by the advent of the electronic computer during the past decade. Concurrent with this invention, changes have also taken place in the physical structure of its marketing management, in the theories of economic activity, as well as the method of accumulating, organizing, processing, and utilizing information. The electronic computer has the incredible capability to extend and enlarge man's mental processes. Its future greatest contribution is likely to be in simulating systems or processes for scientific and experimental purposes.

In the construction and development of models intended to serve as decision-making aids in agricultural marketing, economists are still confronted with a number of conceptual, analytical and operational problems. Some of the more difficult of these involve those of perception, specification and measurement of reality; validation of models, procurement of reliable and up-to-date information to be used in measurements; perception and construction of relationships that depict the real world; the versatility of models as aids to the decision-making process, and the more intimate involvement of decision-makers in the model-building process.

Agricultural economists have used several classifications to categorize the various types of models which have been developed and used in agricultural marketing problems. Some authorities have distinguished between positive and normative models. Another classification is based on criteria relating to the mathematical model, or to the source of data used in estimating their parameters. However, in this paper three classifications will be used so as to facilitate presentation. These are: the analytical models based on statistical inference, mathematical programming models and simulation models. In this connection, I should like to point out that the research studies already completed, or underway in many world institutions and countries, are impressive. They bear unquestionable testimony to the dedication of agricultural economists in resolving a wide array of man's economic problems. Unfortunately, in view of the time constraint, it will only be possible to touch on a limited number of studies. This is, in no way, an attempt to attach labels of importance to particular studies, or to scale down the relative importance of others. Studies are cited only insofar as they illustrate a point being made.

5. ANALYTICAL MODELS BASED ON STATISTICAL INFERENCE

Many problems in agricultural economics deal with universes that are subject to human influence, and so change at least gradually over time. Reference has already been made to the particularly difficult problem that confronts decision-makers in Canada's supply management program in their attempt to maintain market balance in the poultry industry. A number of these problems involves estimation of the demand for and the supply of poultry products. An analytical tool, that is useful in providing an input into resolving such problems, is regression analysis.

Regression analysis, which provides a tool for testing empirically some hypotheses of classical economic theory, was the first type of alternative analytical technique that appeared in quantitative research in agricultural economics (1920's). Firmly based upon the relevant variables affecting market supply and demand as stipulated in the classical economic model, the application of the technique has focused, among other things, on problems of developing supply response functions, and of estimating demand relationships for a number of farm commodities using time series or cross-sectional data. The technique involves the development of an economic model, which is the theoretical stage; acquisition of adequate data; and the marriage of economic theory to the available data through the use of appropriate mathematical and statistical tools. This synthesis of economic theory, data, mathematical and statistical tools provides the analytical model, which is the operational version of the economic model.

In cases where the concern is with linear phenomena, adequately specified regression models are fairly realistic and computations are also easily handled, especially with the aid of the electronic computer. The performance of the statistical tests associated with the least-squares method are valid on the assumption that the samples are drawn from a normal population. It also gives good results even when the parent population is not normal.

5.1. *Time series models*

Historically, supply analysis has been based on single equation regression models using time series data. There have been a number of minor refinements over time in the application of such models. For example, Murray⁸ used a lagged deflated price in estimating pig supply. Together with Cohen,⁹ he used acreage planted in the United Kingdom to indicate the intended supply of wheat. Johnson¹⁰ showed that in some circumstances, supply might be determined by external factors such as weather, rather than farmers' response to price. He also applied a number of statistical techniques to supply analysis: e.g., confluence analysis and first differences.

Some advancements have also been achieved over the simple correlation of supply with price (lagged). More varied developments in the use of time series data have been made in recent years, particularly in the United States. These have focused on the various deficiencies of simple time series models. However, they have been sporadic rather than cumulative in nature. First was the important development of simultaneous equation estimation model, whose

importance lies in the fact that with a single equation model, in which one or more of the explanatory variables cannot be considered endogenous, the parameter estimates will be biased.

A single equation model is not appropriate when one hypothesizes that current supply of a product is a function of the current price of that product. In such a case, price is an endogenous variable, and a two equation model is required in order to obtain biased-free estimates. Girschick and Haavelmo¹¹ used this technique in determining the structural parameters of a system including a demand and supply equation for food in aggregate. This was followed by Foote¹² who developed in 1953 a more detailed model of the U.S. feed-livestock economy; and later by Cromarty's comprehensive model¹³ of the agricultural sector in 1959.

The usefulness of simultaneous equation estimation models should be considered in the light of the fact that (1) parameter estimates from least-squares single equation models have generally been found to be very similar to estimates from simultaneous systems, and (2) within the agricultural sector, supply cannot readily be adjusted in the short-run period. Consequently, demand and supply responses are readily identifiable separately.

A more recent development in time series analysis may be ascribed to Nerlove¹⁴ whose innovation, based on the much earlier work of Fisher and Koyck, is that of distributed lag models. This type of model focuses on the dynamic problems of supply. Other innovations include Griliches' attempt to derive supply relations from estimated demand for inputs — given a technical relationship, the inputs indicate intended supply in response to relevant stimuli; Suits and Kiozumi's¹⁵ use of "dummy variables" in regression models for handling non-quantifiable factors such as policy, and the explicit inclusion of weather variables by Candler¹⁶ and Johnson.¹⁷

Projection of the demand for food is one area of investigation where there is an immense and competent volume of theory and empirical research that is relevant to the planning and decision-making process in agriculture, particularly in the low-income countries. Indication of its usefulness can be gained from a review of the Food and Agricultural Organization bibliography.¹⁸ The extent of interest is evident from the number of surveys cited by Houthakker,¹⁹ and by the number of agencies in different countries that have been working on this problem as documented in the FAO list.²⁰

In spite of the extensive theory and empirical research on demand projection, the scanty information available in case studies and plan documents indicates that to date agricultural planning in many low-income countries is still based on rather simple projections of recent trends or on simple expansions based on population growth. Although a significant attempt to use demand projections was made in the Economic Commission for Latin America (ECLA) Studies, the projections, however, have had little real impact on national plans.²¹

Projection of export demand is a critical and difficult problem for agricultural planning. It is one for which there is only an inadequate solution. This is certainly one area where international agencies and institutions have taken a great interest with substantial results, and can continue to make a special

contribution. The most significant result to date from the point of view of agricultural planning and decision-making are the FAO commodity projections.

These represent major steps in the right direction. However, a serious limitation is that the projections are simply for high, medium or low estimates with no particular attention being given to price trends. This limits the direct usefulness to agricultural planning since, in projecting the contributions of the export sector to real national income and foreign exchange, exports should be measured in the prices expected to prevail during the projection period.

5.2. *Cross-section models*

Analysis of market supply need not be confined exclusively to time series data. Their combination with cross-section data has been reviewed by Hildreth.²² Holme²³ developed a supply function for milk using survey data. However, the bulk of research on analysis of supply has, at least until recent years, been based on time series data at the market level.

Schaller and Dean²⁴ tested the recursive programming model against conventional regression analysis of time series data. They observed that regression analysis would provide better estimates during periods of smaller changes and relatively stable structure, and that the recursive programming would be more effective for prediction purposes under situations of sharp structural changes in technological, managerial skills, etc. However, conclusions based on predictive tests indicated that neither model does a particularly outstanding job of real prediction as opposed to explanation, though the regression analysis would still appear slightly superior.

A regression model may primarily be useful for short-run forecasting. The use of such models in forecasting calls for a statement of desired results in terms of a range of probabilities rather than in terms of exact predictions. Thus, the concept of statistical control makes the decision-maker more conscious of the limitations of his value judgement. An important aspect of the application of such models is concerned with the level of aggregation at which they may be used. For example, most regression models of supply response have so far been developed for individual commodities, thus providing little basis for inference about aggregate agricultural output.

In many respects, regression analysis would appear more directly useful for predicting farmers' response than conventional linear programming. Because regression results are based on actual past changes in production, they are more likely to take into account farmers' likes and dislikes and other considerations which are omitted in the usual programming model. Further advantages of regression are: (a) the relative accessibility of aggregate data compared with the difficulty of obtaining more detailed input, output and resource data required in linear programming; (b) relatively low cost and quick aggregative results; (c) the ability, given the satisfaction of certain statistical assumptions underlying the model, to make probability and confidence statements around the results.

6. MATHEMATICAL PROGRAMMING MODELS USED IN AGRICULTURE

Decision-makers are often confronted with problems of making decisions on questions of the most rational organization and use of resources in agriculture. The problems may also involve: forecasting the optimal organization of agriculture in some future time period; forecasting the effects of technological change on the optimum production pattern for agriculture; determining the effect on agriculture of changes in the domestic and export requirements for agricultural products; and determining the effect of different agricultural policies and programs on the optimal organization of agricultural production. Linear programming models of agriculture are useful aids to decision-makers in resolving these problems.

Following World War II, new methods of analysis have been developed that depend in large measure on the linear characteristics of economic problems, and which focus on the optimizing problem that is familiar to the science of economics. The most familiar of these are: game theory, input-output analysis and linear programming. Although John von Neumann enunciated the main theorem of game theory in 1928,²⁵ it was not until 1944 that its implications for economics were revealed.

Von Neumann's achievement lies in his demonstrating that something definite can be said about the array of cross-purposes and psychological interactions characteristic of human affairs. He demonstrated that under certain assumptions, each participant can act so as to be guaranteed at least a certain minimum gain (or maximum loss). Thus, each participant prevents his opponents from attaining any more than their minimum guaranteeable gains. The implications of this theory for economics are that it holds out hope of banishing oligopolistic indeterminacy where such economic situations exist.

Input-output analysis was the second of the three branches of linear economics to appear. Leontief²⁶ published the final clear statement of the method in 1936. The technique is based on the idea that a considerable proportion of the effort of a modern economy is devoted to the production of intermediate goods, and that the output of intermediate goods is closely linked to the output of any final products. A change in the output of any final product implies a change in the outputs of intermediate goods used in producing that final product and indeed, in producing goods used in producing that final product and so on.

In its original version, input-output analysis dealt with an entirely closed economic system — one in which all goods were intermediate goods. Equilibrium in a system exists when output of the various products are in balance in the sense that just enough of each is produced to meet input requirements of all the others. The specifications of this balance and its pricing implications was Leontief's first objective. Beginning with World War II, interest has shifted to a different view of the Leontief model. In this view, final demand is regarded as exogenously determined, and input-output analysis is used to find levels of activity in the various sectors of the economy consistent with the specified pattern of final demand. For example, Cornfield, Evans and

Hoffenbay²⁷ have computed employment levels in the various sectors and hence total employment consequent upon a presumed pattern of final demand. Leontief has also estimated the extent to which fluctuations in foreign trade influenced activity of the various domestic sectors.

Difficulties with studies based on input-output models relate to linearity in the technical coefficients. Gittinger²⁸ has suggested that although these models can be modified to minimize some of these difficulties, such as assuming a lag linear function, such devices do not really overcome the difficulties. He has pointed out that this type of planning model does not cope well with such problems as: the form that technological changes will assume, how these are to be incorporated in the models, and the institutional constraints on agricultural development, etc. Yet, these are precisely the kinds of considerations with which decision-makers are concerned.

In this regard, Bishop²⁹ has contended that the fixed coefficient assumption is untenable in agriculture because of enterprise combination flexibility on farms, the new technology available to farmers for producing the same products, and the problem of capital formation, where input-output theory assumes capital formation to occur in a sector other than the one where it is used. He concluded, however, that "input-output work is unrealistic concerning the conditions of growth in agriculture itself, but it may be helpful in estimating the availability of commodities entering into agricultural production and for commodities produced by agriculture which are generated in other sectors of the economy".³⁰ In addition, Seers has suggested that he has found input-output models useful as a "working sheet for gathering together statistical information", and as a device for helping "the economist gain insight into the working of the economy, especially its future potentialities".³¹

7. LINEAR PROGRAMMING MODELS

The last of the three branches of linear economics to originate was linear programming. It was developed by George B. Dantzig in 1947 as a technique for planning the diversified activities for the U.S. Air Force. Application of the linear programming model to economic problems in agriculture appeared in the 1950's. The model involves a computational method to determine the best plan or course of action from among several possible alternatives when a specific or numerical objective exists for it and the resources available are limited.

Linear programming is only one of several techniques available among the general set known as mathematical programming. The other techniques in this family are: non-linear programming, and dynamic programming. In special situations and under given conditions, techniques of recursive, stochastic and parametric programming or other variants thereof have also been developed. The technique has experienced vigorous growth since the conclusion of World War II, and has widely been used in agriculture, transportation and other industries. In agriculture, it has been used as aids in problems relating to: shipping of a product from several points of supply to various destinations; optimal marketing facilities; solution of profit-minimizing product flows;

interregional and national planning and optimal organization of agriculture; and models for the economic development of agriculture and other economic studies.

Pioneering work with the application of these models under the direction of Professor E. O. Heady at Iowa State has been underway on a progressive basis over a period of some twenty (20) years.³² The initial models were simplified representations of U.S. agriculture, in which some rather gross assumptions were adopted primarily because of the limited computational facilities available in the mid-1950's, and the associated small size of the analytical models adopted. The progressive development of the Iowa State models could be traced from: (1) the Egbert-Heady model, (2) the Egbert-Heady-Brokken model, (3) the Heady-Whittlessey-Skold model, (4) the Brokken-Heady model and the Eyvindson-Heady model.

As is normal in the development of scientific methodology, the realism of these models grew and matured with time. Their development was enhanced by the electronic computer, more refined data and greater experience and facility in model-building by research workers.

These linear models used in forecasting, in policy development and evaluation relate to: (1) forecasting the optimal organization of agriculture in some future time period; (2) forecasting the effects of technological change on the optimal production pattern for agriculture; (3) determining the effect on agriculture of changes in the domestic and export requirements for agricultural products; and (4) determining the effect of different agricultural policies on the optimal organization of agricultural production.

The real test for these models lies in the extent to which the production patterns generated by the model approximate those that have occurred in reality. Although, no model can be expected to duplicate reality, it should at least be possible to explain most of the differences between what has, in fact, occurred and the results generated by the model. In general, the Iowa State models, particularly those that were earlier and less detailed, yielded production patterns that were fairly reasonable. The results generated by the earlier models indicated sufficient reasonableness to justify some confidence being placed in the results obtained when the models were used to project the effects of changes in economic conditions. Three main reasons explain the differences between the actual production and that generated in the optimal solution, viz: (a) the fact that the pattern generated by the model is an optimal solution which cannot be duplicated in reality because of the various restrictions which are not, and in some cases could not, have been incorporated in the model; (b) other limitations or errors in the model and data; (c) differences between actual conditions and those postulated in the model.

The models contain two types of limitations, viz: firstly, those that are inherent in all models of this type; and secondly, those that are specific to a particular model. The latter is usually the result of compromises (or errors) that were made in formulating the model and/or in collecting the data. Since most factors of production are considered variable, the optimal production patterns computed in the Iowa State models are valid only for the long-run. This limitation was especially true in the earlier models in which land is the

only restraint on production. However, even in the latest model which includes labour and capital restraints, there was no differentiation between different types of capital and labour so that, in effect, the model assumes that one type of labour can readily be substituted for another. This may be possible in the long-run, but such is not possible in the short. As such, the Iowa models can say little about short-run changes resulting from changes in economic conditions or policies. This limitation may be remedied by including more realistic restraints in the model; but it may be more advantageous to use an alternative approach when short-run implications are of more interest than those of a longer-run nature.

Another limitation in these models is the timelessness of the analysis. That is to say, the models can identify changes in the optimal production pattern associated with changes in economic conditions, but they tell us nothing about the time required for this adjustment, or about the path that this adjustment might assume. In organizational planning in agriculture, information on the time requirement for adjustment and the path of such adjustment may at least be as valuable as information about the resulting optimal production pattern. A pitfall in these models, as is the case with all linear programming models, is the inherent assumption of constant input-output coefficients over the entire range of output possible for a producing unit. It is unlikely that this assumption is exactly satisfied in reality.

Another difficulty with these models relates to the problem of "aggregation bias"³³ which arises from the fact that all production units within either a given size group or a region are treated as a single production unit.

A final major limitation in the models is that requirement levels must be taken as given. That is to say, the models determine the production pattern that will satisfy a given level of product requirements at minimum costs or maximum returns. However, they do not allow for any inter-action between supply and demand. In this connection, Heady, Hall and Plessner³⁴ have developed "quadratic programming" models similar to linear programming models that incorporate demand functions thereby allowing demand and supply to be determined simultaneously.

A special case of linear programming that is of particular interest to agricultural marketing problems involves the application of the transportation model. This is appropriate to the determination of optimum shipping routes in the distribution of a product from several sources of supply to numerous destinations. This model has been found to be very useful in determining the least-cost routes in shipping feed grains from some sixteen (16) sources of supplies to eleven hundred (1100) destinations in Eastern Canada following the close of the St. Lawrence Seaway to shipping during the winter.³⁵ This model has also been found to be useful in several other economic and business management problems. Its appeal lies in its economic implications and its computational simplicity. The transportation model has obvious relevance to problems relating to the principle of comparative advantage and interregional trade.

In summary, the application of linear programming models to economic problems in agriculture have proven to be very useful tools of analysis to

industry problems at the micro level, macro level, interregional interdependencies and even at the national level. The principal benefit of these models is also shared by other approaches to national problems in that it allows many segments of the industry and their inter-action to be considered simultaneously, thereby avoiding problems of approaches that consider each sector separately and so ignore the inter-actions between sectors.

An important aspect of the appeal that these models have is that they facilitate testing the effects of changes in conditions on the sector of the economy under review. Moreover, these models have some robustness and flexibility. The latest one developed at Iowa is quite large and contains considerable detail. It seems likely that even larger and more detailed models are possible in the future. It is also evident that smaller models could be developed that may focus on analysis of a specific region, a specific product or a specific problem. For example, Wilson and Wood³⁶ used a linear programming model in analyzing the effects of Canada's feed freight assistance on the regional distribution of livestock production. Linear programming models have proved to be flexible and powerful tools of economic analysis; and as such, they provide one of the valid approaches to micro problems and in developing regional or national models of agriculture.

8. RECURSIVE PROGRAMMING MODELS

In the attempt to develop rational policies and programs, decision-makers often require short-term quantitative estimates of production and resource adjustment by regions and for the country under alternative prices, subsidies, quotas, exports and resource inputs. Problems to be resolved in the decision-making process involve such considerations as: How will production change in the following year? What changes will occur in the pattern of land use as a result of program or policy changes? How will a reduction in subsidies affect supply of particular commodities? What effect will a change in prices paid to producers have on a supply management program? Recursive programming models are useful aids in dealing with problems involving considerations of supply response.

Recursive programming models are useful in analyzing a variety of problems in agriculture. In terms of solution procedures, recursive programming is similar to linear programming in that both are mathematical techniques employed to optimize a linear objective function subject to linear constraints. However, recursive programming is useful in predicting the actual behaviour of firms, whereas linear programming is designed to estimate optimal behaviour patterns.

This special characteristic of the recursive programming model is possible through the use of "flexibility constraints" in addition to the conventional linear programming constraints. The recursive programming model may be used to make either short-run or intermediate-run predictions. In making short-run predictions for only one year ahead, a programming problem may be developed using the preceding year's prices and costs and the current year's flexibility constraints and resource supply constraints.

Research work done in Canada and the United States has demonstrated the flexibility of the recursive programming models. These models have some merits over linear programming in estimating supply response. Linear programming models provide optimal solutions which may be good predictions in the long-run. However, they do not estimate short-run or intermediate-run supply response, nor do they map out the actual process of adjustment. With recursive programming models, risk and uncertainty, norms other than short-run optimal positions and non-economic considerations are recognized through the use of both "flexibility" and "capacity" constraints.

Another important feature of recursive programming is that confidence intervals around forecasts of supply response may be estimated from the standard errors of estimates computed in the regression analysis of the flexibility coefficients. By contrast, in linear programming confidence intervals cannot be so estimated. An additional merit of recursive programming, as compared to linear programming, is that it provides a framework for analyzing the rates of adoption of new technologies and the abandonment of old ones.

Regression models provide positive tools of analysis. However, they have four major limitations relative to recursive programming, viz: (1) in the light of any recent or unexpected sharp structural changes, regression models cannot be used to predict production response because equations are fitted to historical data. However, by changing net income coefficients and/or restraints, recursive programming can be made to estimate the impact of new structures on production response; (2) in regression analysis supply functions are estimated without explicit reference to the technical structure of production, whereas in recursive programming the technical structure is first estimated and the supply function is then derived from it; (3) a simple time trend is introduced in regression models as a proxy for technological changes. In recursive programming technological change is analyzed in a much more precise way; (4) with regression models, statistical problems occur when the number of time series observations are limited, the independent variables are highly correlated. These problems do not occur in recursive programming.

There are two major limitations of recursive programming, viz: (1) research resources required to estimate a supply function are considerably greater for the recursive model than the regression approach; (2) when structural changes occur, the adequacy of the flexibility restraints to product supply response is greatly reduced because they are usually estimates from historical data.

9. SIMULATION MODELS

An alternative type of analytical model which has been acquiring substantial appeal among model-builders and decision-makers is simulation models or management information systems. These models have proven to be useful aids in facilitating integration of our knowledge of an economic system, thereby assisting in resolving complex problems such as some of those that confront decision-makers in Canada's supply management program for eggs as outlined earlier in this paper. Simulation is really the operation of an abstract model or

the proto-type of a real system designed to trace out the dynamic inter-actions in order to answer specific questions about the system. Computer simulation is the operation of an abstract model or a real system on a computer. The simulation approach organizes the inter-actions between the parts of an economic system and the dynamic processes into a computer model. The model incorporates the theory of the system's structure and internal relationships. In turn, computer simulation reveals the dynamic characteristics of the system that is described within the computer program. Thus, by changing the guiding policies within the system, one can readily show how the behaviour of the actual system might be modified.

Based on this view of simulation, the methodology for the study of complex systems involves the formulation of a conceptual framework of the system to be followed by the simulation processes. The development of the conceptual framework involves the following: firstly, delineation of the problem, establishment of objectives, hypothesis, etc.; secondly, analyzing the inter-relationships of the system and sub-systems; thirdly, the analytical and empirical modelling of the real system in mathematical format, specifying parameters to be estimated and the classification of variables; fourthly, translation of the model of the real system into a computerized system which involves many sub-systems and corresponding linkages between the systems. This also involves the collection of data and their organization for initial input into the system; fifthly, testing the validity of the sub-systems and the entire system in terms of simulators of the real system.

Simulation of the system involves firstly, performing experiments which provide insight into the validity of the hypotheses generated earlier; and secondly, performing additional experiments as inferences from previous results are used to develop new hypotheses to be tested.

Construction of a mathematical model of the real world forces the model-builder to put together the knowledge that he has about the separate components and their interactions. By simulating the model on a computer, the model-builder may reveal the consequences, the contradictions and/or internal inconsistencies and the assumptions of fragmentary knowledge about the system. From such an estimation, a vastly improved understanding of the real system can be gained. If such a model is representative of reality, then the output of the simulation should also indicate the kinds of consequences that are likely to be forthcoming from the real system, if it is operated, in fact, like a simulated model.

Research efforts have been undertaken at a number of institutions and countries, in developing systems simulation to deal with a wide array of problems. For example, a joint effort to generate more information on South Korea's agricultural sector was undertaken between Michigan State University in the United States, and the National Agricultural Economics Research Institute in South Korea. The problem, as envisaged in the Korean Agricultural Sector Model (KASM), involved the major concerns of Korean decision-makers such as: increasing farm income, achieving self-sufficiency in the important food grains; improving agriculture's trade balance and decreasing the contributions made by food prices to the country's inflation. A major problem,

which the model-builders face in the development of this model, as well as in the Nigerian and the Venezuelan models, relate to the procurement of data of sufficiently good quality to measure the economic and behavioral variables associated with agriculture. Other limitations of the systems simulation approach are the high initial costs, a long period of model development, and the availability of qualified personnel with adequate background in the economic, technical and social features of the agricultural sector under study.

An important merit of the systems simulation approach is that it is comprehensive in scope, and versatile in its use of other conventional analytical tools and data, thereby providing model-builders and decision-makers with the flexibility of accommodating the diverse components of the system. Hence, the approach provides greater insights into the complexities and functioning of the economic system. Another positive feature of this approach is the scope that it offers for a reasonable degree of cooperation between economists, agronomists, extension workers, soil scientists, animal husbandrymen, farmers and policy-makers in generating data for the model. Certainly, the development of these models has benefited substantially from this interdisciplinary approach to model simulation.

This particular type of model is considered appropriate to the commodity systems approach to Canadian agriculture. Canada is among those countries with current experience in the use of a supply management program as a marketing approach to the low farm-income problem. In fact, Canada has gone the furthest along the road in giving farmers legislative authority to implement supply management programs.

A focus of Canada's national supply management programs is on the poultry sector, where consumption is more seasonal than most agricultural commodities, and where production is cyclical. These factors, coupled with change in consumption patterns, have led to difficulties in balancing supply with demand. In addition, the production of an egg, a broiler or a turkey involves several separate stages. Consequently, they are several key points in the decision-making process relating to the production and disposition of these commodities. The success of this process is dependent upon the level of managerial capability within the industry to coordinate the activities of each stage, particularly in regard to geographical movement and timing. The logical sequence of events in production and distribution may best be understood using a systems' approach.

Current information relating to the production and disposition of eggs and egg products is acknowledged to be imprecise by most industry participants. Demand characteristics derived are at best indicative. There is a lack of information about demand forces and, to a lesser extent, product flows. The major pre-requisite of a responsive supply management program is a sound understanding of market forces. This understanding provides the means to forecast demand more accurately, and to predict the quantity required at a given location in a given time period. This can be accomplished by determining end-product use and the factors which influence this use.

Once future market needs have been established, and this has proven to be a difficult problem, it is then possible to schedule production to fill these

needs. The technical coefficients of egg production are fairly standard, and consequently, hatchery egg and pullet placements can be directed to ensure adequate supply. For the optimum coordination of production activities, market requirements must be established a minimum of six months in advance. This approach also allows for monitoring of production. Since certain placement numbers are necessary to meet demand, high placements, or low fowl slaughterings, would signal a possible over-supply, whereas low placements or high fowl slaughterings, would signal a possible shortage. These indicators would become more precise as better information becomes available on hen numbers, placements, and fowl slaughterings.

Problems have been encountered in the broiler industry since early 1974 in producing and distributing broilers and broiler meat. Shortages and over-supplies have developed, exports have virtually disappeared, imports are reaching unprecedented amounts, and consumption is relatively stagnant. The trade situation in broilers is largely the result of sustained high price differentials between Canadian and world markets, particularly the U.S. market. The imbalances of supply and demand appear to be due to incorrect demand determination, while the reasons for depressed consumption have not been fully identified. There also seems to be some concern over the willingness of producers to respond to processing requirements.

In light of this situation, it is necessary that some research efforts focus on determining:

- (1) Those factors influencing supply and demand for broiler meat.
- (2) How to optimize use of resources within the industry to restimulate growth and competitiveness.
- (3) How to best coordinate production and marketing to ensure adequate response to market requirements.
- (4) The most useful method of communicating relevant market information among the various sectors involved in production, processing and distribution.

The use of a simulation model may be appropriate to determine optimum use of resources, the coordination of production and marketing, and to simulate product flow, financial flows, and the input-output relationships of each major decision-making unit. This model would not be based on expected theoretical relationships, but on actual, observable operating characteristics. The purpose of a representative working model of the industry would be to study realistically the inter-actions of each sector with the aim of improving over-all performance.

A simulation model would have the following characteristics: location of production, and flow of product through processing and marketing channels would be detailed; product flow would be outlined by kind of product, i.e., light or heavy birds, eviscerated whole or cut-up meat, further processed products, etc.; financial transactions would be categorized and their location indicated; critical decision-making points and the information required to evaluate alternative decisions would also be included; performance criterion for each point would be developed to assist in planning; the relevance and

impact of imports and exports would be shown to provide a means of assessing alternative trade practices.

The success of the production and marketing process in poultry is closely related to the coordination of each activity in this process. Having a model which incorporates future market demand, productive and processing capabilities on a geographical basis, would provide decision-makers with a useful technique to assist in planning and scheduling. It would also help to identify those areas where improvement is needed in order to increase efficiency and competitiveness.

The technical coefficients for production and processing are fairly standard for broilers, and once market requirements are determined, supply can be geared to meet these demands. The results of this process can be optimized using the model outlined above. The success of this approach would depend on the willingness of decision-makers in each sector of the industry to co-operate and to carry out their respective responsibilities in relation to other industry participants.

A simulation model would be of benefit to decision-makers and others with an interest in the planning and coordination of the system. Regional capabilities and constraints would be better pinpointed and ways to capitalize on the capabilities and surmount the constraints could be more effectively evaluated. The effect of different policy alternatives could more efficiently be measured also due to the input-output relationships which would be incorporated in the model.

Present domestic disappearance statistics for poultry products are too general to provide the information necessary for proper scheduling of production and product movement. This is a particularly acute problem in the turkey sector, where demand is highly seasonal, product type diverse and length of production greater than for broilers and eggs. Due to the small market size for turkeys, fluctuations in demand have a greater impact on the industry than in other sectors.

One of the major concerns currently facing decision-makers is what amount of each bird size is needed to satisfy market requirements in a given location and at a given time. Little information exists as to regional consumption patterns, apart from holiday influences, and to the factors which affect this consumption. Because of this, market shortages and over-supplies have recently occurred, and concerns over imports have been expressed.

The development of a relevant demand system for turkey meat would assist greatly in alleviating the short-term problems of the industry. In order to develop a more effective long-term strategy, it is proposed that the demand system be incorporated into a larger sectoral model, similar to that considered for broilers.

Preliminary investigation of the market for turkeys indicates that most product is consumed over a relatively short time-span. Most of this consumption can be attributed to holidays. However, there appears to be a trend towards increased further processing of turkey products. The determination of regional consumption patterns and trends, and the factors responsible for these, would assist in stabilizing production and fluctuations in returns. This

approach would allow for more efficient use to be made of production facilities through improved timing and routing of product flow.

Establishment of a model simulating the industry would aid in policy and decision-making. The model would include product flows, the resultant financial flows, and input-output relationships for each major transformation unit. Such a model would provide information relating to regional capabilities, flow capacities, and alternative possibilities. Performance criterion would be developed to assist in evaluation and planning. Major decision-making points would be outlined and the type of information required for assessment of alternatives.

Isolating decision-making points and determination of the information required by each, provide the foundation for the establishment of a modern market information system. Some progress along these lines has occurred in Canada, but many proven techniques have not made significant in-roads at the present time. As the complexities of the Canadian market for poultry products increases, and as competition between various products increases, a modern simulation computerized information system will become vital.

10. SUMMARY AND CONCLUSION

Models play an important role in the decision-making process, in the sense that they provide useful aids to human judgement. However, they are no substitutes for human judgement. Decision-makers are normally faced with an array of current economic problems in respect of which decisions must be taken. These decisions are intended to influence the performance of the system, such that its performance will be more in tune with the over-all economic and social objectives of society. If models are to make meaningful contributions in this regard, they must focus on the important economic problems of the day. Models should solve tomorrow's problems today, rather than resolve yesterday's problems tomorrow. Hence, they should be more prescriptive, and less descriptive.

If model-builders are to obtain decision-makers' confidence in these models, they must be credible. The decision-makers ought to be involved more actively in the model-building process. Moreover, in the specification and description of the models, and in the interpretation of the results generated by them, model-builders must speak less to themselves, and more to their clients, whose decisions they hope to influence.

An impressive array of analytical hardware has already been developed to deal with a wide variety of problems in agricultural marketing. It would seem that concerted efforts should now be made to coordinate the different model approaches. The merit in this is that such coordination will facilitate assessment of the relevance of the various techniques to the complex of problems in agricultural marketing. The several analytical techniques available for model-building may be combined in various ways when developing econometric models. For example, other techniques such as recursive linear programming, or other recursive models might be incorporated, as needed, within

an over-all systems simulation approach to optimize certain components of the model.

Input-output analysis may constitute one phase of a model, which otherwise has the feature of a simulation model. What determines the analytic techniques appropriate for a particular model is the particular problem under study, and the over-all objectives to which the model is directed. I find myself at variance with those who would suggest that national economic models should be capable of solving a wide variety of problems, without first specifying precisely what those problems are. It would seem that one cannot expect a particular model to be appropriate for solving any more than a few of the major problems of agricultural marketing. Specification of a problem should precede the development of a model. The model is then developed to answer these questions. Some issues which would require the development of regional or national agricultural models are of a normative nature, while others may be of a predictive nature. For this reason alone, it cannot be expected that one model will be appropriate for analyzing a wide array of problems. This does not mean, however, that the research input to build two types of research models should be built in isolation.

The major research activity in working with regional and the national economic models is the synthesis of appropriate data. Model conceptualization may not be the major ingredient. However simple a model may appear to be, there is no question that considerable research resources are required in its development. I would expect that a large part of the research is for the generation of appropriate quality data. National economic models are highly dependent upon basic data which are consistent, and uniformly developed for all components of the model. The large data requirements for national and regional model development, and limited research resources make it essential for some over-all coordination of this type of research, as well as for the developed model approaches.

The diffusion of research results into the decision-making process suggests that models be problem oriented. The reason for this is that it is often necessary for decision-makers to be involved in the research process from its inception, if they are to make use of its findings. This presents a rather difficult problem, when one considers that considerable lead time is necessary in such projects, so that the research results may be timely. Part of the researcher's job is to develop an awareness on the part of the decision-maker as to the need for answers to forthcoming problems. There are various ways to involve the decision-maker in the research process, so that the findings do have credibility, and are understood when they become available.

One method being used in Manitoba, Canada, is that of an advisory committee of staff from the various provincial government departments, which might utilize the results of the study when completed. The purpose of this committee is to create an awareness on the part of the decision-maker as to the usefulness of the study to their supportive decision-making role; and to provide continuing insight into the type of problems which the model is capable of answering. In that way researchers are kept up-to-date with the

dynamic and changing nature of the research problem. This also provides a means whereby greater realism is built into the model.³⁷

There are important implications from the analysis of the various analytical models that have been reviewed in the previous section of this paper. In addition, it is quite evident that the application of a particular model must be related to the problem to be resolved. The problems which confront those concerned with agricultural marketing are complex and diverse. Consequently, there is a particular role that each model can assume, but this role must be consistent with the problem under review.

Each analytic model is constructed so as to test or to project the effects or outcome of different economic conditions and/or policies on agriculture, as well as other sectors of the economy. Linear programming models attempt to project the long-term effects of changes in domestic and foreign demand, in technological conditions, and in supply management programs on the optimal organization of agriculture. Recursive programming models test the short-run and intermediate-run effects of changes in prices, subsidies, production quotas, exports, and resource adjustments.

Analytical models based on statistical inference attempt to explain the interrelationships between independent variables, and also attempt to explain the association between independent and dependent variables in the short-run. Input-output models attempt to measure the effects of changes in domestic and export demand, productivity, prices and taxes on output, employment and income in agriculture as well as the rest of the economy. Simulation models attempt to test the effects of changes and prices, commodity systems production research extension efforts, private and public investment on farm income, national income, export earnings, the level of demand, and the level of employment.

With respect to the role of linear programming models in the decision-making process in agricultural marketing, it is evident that the models used by Professor Heady and his associates at Iowa State represent a continuous research input over a period of over 20 years or more. The initial models are very simple representations of American agriculture adopting very gross assumptions because of the limited computational facilities available in the mid-1950's, and considerable research input to generate data was also a contributing factor. However, the refinement of the Iowa models grew with time, associated development of the computer facilities, more refined data and even greater facility in model-building by research workers. In the Eyvindson-Heady model which was completed in 1970 there were 6800 rows and more than 40 000 columns, yet I am sure that these research workers would agree that considerable aggregation and some lack of realism still exist in the model. Overall, the Iowa State models are limited primarily to normative applications because of their reliance on the ordinary linear programming techniques. There is no predictive element to these models although there can be time based in the future.³⁸

Recursive linear programming is identical with ordinary linear programming in terms of solution procedures, the difference being primarily of a conceptual nature with respect to the Manitoba model developed by Dr. Sahi.

The inclusion of flexibility constraints in the recursive model gives it some predictive capability than rather being strictly normative. The United States Department of Agriculture (USDA) production supply response model and the Sahi model for prairie agriculture are both capable of predicting acreage for the future years. However, like Iowa State models, these models consist of regional components. In the ordinary linear programming models, the solution for one region is dependent upon the solution for any other region.³⁹

The simulation models developed at the Michigan State University particularly the Korean Grain Market Management Model, the Nigerian Model, and the Venezuelan Model could be identified as taking a more systems approach. These types of models do not necessarily start off with any given structure, but are rather based on what the research workers know about the system. The structure of such models becomes evident through branches and loops as included in the computer program. It may not be possible to describe the total structure in terms of a complete set of mathematical equations.

Simulation models may also be based strictly on econometric analysis. A computer program, however, will still be used to solve such models but the entire structure of the model can be described by mathematical equations. Most simulation models either follow a systems approach or are econometric in nature and are predictive rather than normative in terms of the specific type of solutions derived.

Input-output analysis in its most limited form is a means of describing an economic system. The various inter-dependencies in the economy are reflected through coefficients which indicate the sector requirements of every sector on every other one.

The experience in terms of analytical model-building thus far has tended to be rather institutionalized in terms of a particular model, for example, the Iowa State linear models and the Michigan State simulation models. This is not necessarily bad in that the research input into developing and perfecting these models has saved other research workers considerable time by way of not duplicating, but drawing upon the knowledge and experience gained in experimentation with these models.

It would seem that research effort should now focus on the coordination of the different model approaches, in order that the whole spectrum of analytical models could be brought together thereby facilitating assessment of their appropriateness to the diverse and complex problems confronting agricultural marketing. What is being suggested here is that research workers in the field of agricultural marketing should now take an inventory of the various analytic models available with a view to coordinating the various approaches. I say this because this has not yet been done with the same rigour that has applied to the development of these models.

Obviously, analytic models have a very distinct role to play in the formation and the development of agricultural marketing policy. In fact, the development of effective government policy programs in any complex is at best a difficult task. The decision-making process by which planners, model-builders, policy builders, and elected officials develop processes and programs to deal with these arrays of problems is in itself a complex process involving three

fundamental steps: problem finding (searching the environment for conditions calling for decisions to be made and new policies developed), design (inventing, developing, and analyzing alternative courses of action), and choice (selecting a particular course of action from alternatives available).

The decision-making process presupposes that the planner has been given a clear statement of strategic objectives. When considered, these would serve as the criteria for developing alternative courses of action. The several economic techniques available for model-building can be combined in various ways when developing econometric models. For example, linear programming might be embedded within an overall simulation model to optimize certain facets of the model.

A major research input in the development of analytic economic models is obtaining appropriate data. However, data suitable for one economic model can often be used in the construction of other types of models. For example, the synthesis of enterprise budgets is a major research activity in the development of national economic models. Yet, it is quite conceivable that these same budgets could comprise appropriate data for some parts of a supply response model. Therefore, rather than initiating a major research activity to estimate these costs quite independently of other research, it is possible to use the same basic data as developed for an interregional model.⁴⁰

Simulation models either with an econometric base or systems approach are probably much less costly. However, it must be recognized that they are not necessarily applicable to all types of problems, such as those that may better be resolved by linear programming models, or by mathematical models based on statistical inference. Familiarity with economic systems on the part of the research workers is probably required more in the case of mathematical programming models.

In closing, I would like to repeat the caution given by W. Craddock in his summary statement at a Canadian seminar on "national and regional economic models of agriculture". He cautioned that "Model-building can be a very fascinating and challenging type of research activity. As one becomes involved in the beauty of his model, he must not lose sight of the fact that: firstly, the model is being developed to deal with real world problems and secondly, no matter how much research input extended, the model contains many limiting assumptions and is based upon historical data, and as such it is, therefore, only a crude approximation of the economic system that it attempts to portray. Models can sometimes give the wrong answer due to the inability to describe adequately the various aspects of the social, political, and economic behaviour of individuals".⁴¹

NOTES

¹ Michel Petit (1976), *The Role of Models in the Decision-Making Process in Agriculture*, a paper presented at the XVI International Conference of the International Association of Agricultural Economists, Nairobi, Kenya, July 26–August 4, Page 1.

² Herbert A. Simon, *The New Science of Management Decisions*, Harper and Row, Page 2.

³ Ptolemy was among the ancients who sought to unravel the mysteries of the physical

universe by constructing models to describe the movement of the planets. In the 2nd century Alexandria, Claudius Ptolemy formulated a model of the solar system which recognized that the world was round or spherical and that the planets had circular motion. See Peter Langhoff (1965), 'The Setting: Some Non-metric Observations', in *Models, Measurements and Marketing*, Englewood Cliff, N.J., Prentice Hall Inc., Pages 9–12.

⁴ Copernicus was a Polish model maker, who near the beginning of the 16th century, stuck upon the radical idea that the earth and the other planets revolved around the sun. This was such a novel notion that nobody, including dignitaries of the church, took him too seriously. *Ibid.*

⁵ Johannes Kepler improved on the graphic model of Copernicus by describing it in terms of a series of mathematical expressions. Galileo pushed Copernicus' theory so hard that he found himself in trouble with the Roman Catholic Church. When some Dutch lens makers developed the principles of the telescope, Galileo seized the opportunity to develop it and to use it in astronomy. Issac Newton was born in the year of Galileo's death. Newton built a new model of the solar system and removed some of the slight defects noted in Kepler's model. Later, Albert Einstein improved upon the Newtonian model which had served so well for such a long time.

⁶ Peter Langhoff (1965), 'The Setting: Some Non-metric Observations', in *Models, Measurements and Marketing*, Englewood Cliff, N.J., Prentice Hall Inc., Page 11.

⁷ See Hosan Ozbekham (1971), 'Planning and Human Action', in Weiss, P. A., *Hierarchically Organized Systems*, New York, Hafner Publishing Co., Pages 123–230.

⁸ Murray, K. A. H. (1933), 'The Future Development of the Pig Industry in Great Britain'. *Empire Journal of Experimental Agriculture*, Volume 1, Number 3, September.

⁹ Murray, K. A. H. and Cohen, R. (1935), 'Wheat Prices and the Acreage of Wheat in Great Britain', *Scottish Journal of Agriculture*, Volume XVIII, Number 4, October.

¹⁰ Johnson, R. W. M. (1955), 'The Aggregate Supply of New Zealand Farm Products', *Economic Record*, Volume XXXI, Numbers 60–61.

¹¹ Girschick, M. A. and Haavelmo, T. (1953), 'Statistical Analysis of the Demand for Food: Examples of Simultaneous Estimation of Structural Relations', In *Studies in Econometric Methods* (Edition Hood, W. C. and Koopmans, T. C.) Wiley, New York, Pages 92–111.

¹² Foote, R. J. (1953), 'A Four Equation Model of the Feed and Livestock Economy and its Endogeneous Mechanism', *Journal of Farm Economics*, Volume XXXV, Number 1, February, Pages 44–61.

¹³ Cromarty, W. A. (1959), 'An Econometric Model for U.S. Agriculture', *Journal of American Statistical Association*, Volume 54, Pages 556–574.

¹⁴ Nerlove, M. (1958), 'The Dynamics of Supply: An Estimation of Farmers' Response to Price'. *John Hopkins Press*, Baltimore.

¹⁵ Suits, D. B. and Kiozumi, S. (1956), 'The Dynamics of the Onion Market', *Journal of Farm Economics*, Volume XXXVIII, Pages 457–484.

¹⁶ Candler, W., 'An Aggregate Supply Function for New Zealand Wheat', *Journal of Farm Economics*, Volume XXXIX, 1957, Pages 1732–1741.

¹⁷ Johnson, R. W. M. (1955), 'The Aggregate Supply of New Zealand Farm Products', *Economic Record*, Volume XXXI, Numbers 60–61, May.

¹⁸ Food and Agricultural Organization (FAO) of the United Nations, Bibliography on the Analysis and Projection of Demand and Production, 1963 (Commodity Reference Series Number 2) Rome: FAO, 1963, Page 273.

¹⁹ Houthakker, H. S. (1957), 'The International Comparison and Household Expenditure Patterns, commemorating the Century of Engel's Law', *Econometrica* 25: 532–551, October.

²⁰ Goreux, L. M. (1960), Institutions Dealing with Demand Analysis and Projections. Rome: FAO, Page 30 (mimeo).

²¹ United Nations (UN), Economic Commission for Latin America (ECLA). Analysis and Projections of Economic Developments.

²² Hildreth, C. (1960), 'Combining Cross-Section Data and Time Series, Cowles Commission Discussion Paper', Statistics Number 347, May 15.

²³ Holme, F. (1958), 'Estimating a Supply Curve', *Journal of Agricultural Economics*, Volume XIII, Number 1, June, Pages 67–71.

²⁴ Schaller and Dean, *Predicting Regional Crop Production: An Application of Recursive Programming*.

²⁵ Game theory is based on the proposition that there is a close relationship between parlor games of skill and conflict situations in economics. The theory suggests that in each situation, there are a number of participants with incompatible objectives. The extent to which each participant attains his particular objective depends upon what all other participants do. Each participant has, therefore, to formulate his plans so as to take into account the actions of his opponents, each of whom is so laying his plans as to take specific account of the first participant's actions. Hence, each participant must surmise what each of his opponents will expect him to do, and how they will react to these expectations.

²⁶ Leontief, W. W. (1936), 'Quantitative Input and Output Relations in the Economic System of the United States', *Review of Economic Study* 18: 105–25, August. And a full exposition in 1941, 'The Structure of the American Economy, 1919–1929', *Harvard University Press*, Cambridge, Mass., 1941.

²⁷ Cornfield, Evans and Hoffenbay, 'Full Employment Patterns, 1950', *Monthly Labour Review* 64: 163–190, February, 1948.

²⁸ Gittinger, J. Price (1966), *The Literature of Agricultural Planning*, Planning Method Series Number 4, National Planning Association, Page 63.

²⁹ Bishop, R. A. (1956), 'Input–Output Work as a Basis for Development Planning', *Monthly Bulletin of Agricultural Economics and Statistics* 5: 1–10, May.

³⁰ *Ibid*, Page 10.

³¹ Seers, D., 'The Use of Simple Input–Output Model for Drawing Up a Development Program', In I. Adelman and E. Thorbecke, editors, *Theory and Design of Economic Development*, Baltimore, John Hopkins Press, Pages 9 f.

³² Cited below are some of the linear programming models developed under the direction of Professor E. O. Heady at Iowa State:

Brokken, Ray F. (1965), 'Interregional Competition in Livestock and Crop Production in the United States: An Application of Spatial Linear Programming', unpublished Ph.D. thesis, Iowa State University.

Brokken, Ray F. and Heady, Earl O. (1968), 'Interregional Adjustments in Crop and Livestock Production, a Linear Programming Analysis', USDA, ERS Technical Bulletin 1936.

Day, Richard H. (1963), 'On Aggregating Linear Programming Models of Production', *Journal of Farm Economics* 45: 797–813.

Egbert, Alvin C. and Heady, Earl O. (1961), 'Regional Adjustments in Grain Production: A Linear Programming Analysis', USDA, Ag. Res. Service Technical Bulletin 1241 and supplement.

Egbert, Alvin C. and Heady, Earl O. (1963), 'Regional Analysis of Production Adjustments in the Major Field Crops: Historical and Prospective', USDA, ERS Technical Bulletin 1294.

Egbert, Alvin C., Heady, Earl O. and Brokken, Ray F. (1964), 'Regional Changes in Grain Production, an Application of Spatial Linear Programming', *Iowa Agric. and Home Econ. Expt. Stat. Research Bulletin* 521.

Eyvindson, Roger K. (1970), 'A Model of Interregional Competition in Agriculture Incorporating Consuming Regions, Producing Areas, Farm Size Groups and Land Classes', unpublished Ph.D. thesis, Iowa State University.

Heady, Earl O. and Skold, Melvin (1965), 'Projections of U.S. Agricultural Capacity and Interregional Adjustments in Production and Land Use with Spatial Programming Models', *Iowa Ag. and Home Econ. Expt. Station Research Bulletin* 539.

Heady, Earl O. and Whittlesay, Norman K. (1965), 'A Programming Analysis of Interregional Competition and Surplus Capacity of American Agriculture', *Iowa Ag. and Home Econ. Expt. Station Research Bulletin* 538.

Madsen, Howard C., Heady, Earl O., and Nicol, Kenneth J. (1970), 'Trade-offs in Farm Policy: Prices, Incomes, Costs, Interregional Payment Distribution and Patterns of

Land Retirement', Center for Agricultural and Economic Development, Iowa State University, CAED Report 36.

Mayer, Leo V. and Heady, Earl O. (1969), 'Projected State and Regional Resource Requirements for Agriculture in the United States in 1980', *Iowa Ag. and Home Econ. Expt. Station Research Bulletin* 568.

Miller, Thomas A. (1966), 'Sufficient Conditions for Exact Aggregation in Linear Programming Models', *Agricultural Economic Research* XVIII: 52-57.

³³ Such a procedure is satisfactory only if it is true that the homogeneity of producing units in the group is such that the results so obtained will be identical with those that would be obtained if each production unit were treated individually and the results summed. If this is not the case, then the difference between the results so obtained with two procedures is referred to as "aggregation bias". It does seem unlikely that this problem could satisfactorily be resolved without a very detailed model.

³⁴ Hall, Harry H., Heady, Earl O., and Plessner, Yakir (1968), 'Quadratic Programming Solution of Competitive Equilibrium for U.S. Agriculture', *American Journal of Agricultural Economics* 50: 536-555.

³⁵ Walker, Hugh V. (1967), *The Transportation of Feed Grains in Eastern Canada*, Ottawa, Canada. The Agricultural Economics Research Council of Canada, Number 8.

³⁶ Wilson, A. G. and Wood, A. W. (1969), 'Regional Livestock Production and Feed Freight Assistance', *Canadian Journal of Agricultural Economics*, Number 17, Pages 77-90.

³⁷ *Loc. cit.*

³⁸ See W. Craddock (1972), 'Summary on National and Regional Models of Agriculture' in Agriculture Canada - *National and Regional Models of Agriculture*, Ottawa: Economics Branch, Agriculture Canada, Number 7219.

³⁹ *Op. cit.*

⁴⁰ *Loc. cit.*

⁴¹ *Loc. cit.*

BIBLIOGRAPHY

- Agrawal, R. and Heady, E. O. (1972), *Operations Research Methods for Agricultural Decisions*, The Iowa State University Press/Ames, Iowa, U.S.A.
- Anderson, J. R. (1972), 'An Overview of Modelling in Agricultural Management', Sydney, Australia, *Review of Marketing and Agricultural Economics* 40(3), 111-122.
- Baritelle, J. L. and Price, D. W. (1974), 'Supply Response and Marketing Strategies for Deciduous Crops', *American Journal of Agricultural Economics* 56(2).
- Bass, Frank M. King, Charles W., and Pessemier, Edgar A. (1968), *Application of the Sciences in Marketing Management*, J. Wiley, New York.
- Beneke, R. R. and Winterboer, R. (1973), *Linear Programming Applications to Agriculture*, Iowa State University Press, Ames.
- Bishay, F. K. (1974), *Model for Spatial Agricultural Development Planning*, Rotterdam University Press.
- Bishop, Charles E. and Toussaint, W. D. (1958), *Introduction to Agricultural Economic Analysis*, J. Wiley, New York.
- Black, J. D. (1933), *Research in Agricultural Policy Scope and Methods*, J. D. Black editor, New York, Bulletin No. 21.
- Bromely, David W. and Beatlie, Bruce R. (1973), 'A Short-Run Price Prediction Model for Eggs', *American Journal of Agricultural Economics* 55(3).
- Bullock, J. B. and Logan, S. H. (1972), 'Cattle Feedlot Marketing Decisions Under Uncertainty'. Berkley, California, U.S.A. Giannini Foundation Monograph; California Agricultural Experimental Station, No. 28.
- Burt, Oscar R. (1971), 'A Dynamic Model of Pasture and Range Investments', *American Journal of Agricultural Economics* 53(2).
- Byerbee, Dereck and Halter, A. N. (1974) 'A Macroeconomic Model for Agricultural Sector Analysis', *American Journal of Agricultural Economics* 56(3).

- Clark, G. B. and Simpson, I. G. (1959), 'A Theoretical Approach to Profit Maximisation Problems in Farm Management', *Journal of Agricultural Economics*, Volume 13, No. 3.
- Cromarty, William A and Myers, Walter M. (1975), 'Needed Improvements in Application of Models for Agricultural Commodity Price Forecasting', *American Journal of Agricultural Economics* 57(2).
- Crowder, R. T. (1972), 'Statistical Versus Judgment and Audience Considerations in the Formulation and Use of Econometric Models', *American Journal of Agricultural Economics* 54(5).
- Review of Marketing and Agricultural Economics*, Volume 40, No. 3, September 1972. Department of Agriculture, New South Wales, Australia.
- Eyvindson, R. K. (1972), 'National and Regional Economic Models of Agriculture', Regina, Saskatchewan. Processed Report, Economic Branch, Canada Department of Agriculture, No. 72/9.
- Footte, R. J., Craven, J. A., and Williams, R. R. (1972), 'Quarterly Models to Predict Cash Prices of Pork Bellies', *American Journal of Agricultural Economics* 54(4).
- Fuchs, H. W., Farrish, R. O. P., and Bohall, R. N. (1974), 'A Model of the U.S. Apple Industry: A Quadratic Interregional Intertemporal Activity Analysis Formulation', *American Journal of Agricultural Economics* 56(4).
- Gadner, Bruce L., 'The Farm Retail Price in a Competitive Food Industry', *American Journal of Agricultural Economics* 57(3).
- Halter, A. N. and Dean, G. N. (1965), 'Simulation of a California Range-Feedlot Operation', Giannini Foundation Research. Report No. 282, University of California.
- Handy, C. R. and Padberg, D. I. 'A Model of Competitive Behaviour in Food Industries', *American Journal of Agricultural Economics* 53(2).
- Hayenga, M. L., Manetsch, T. J., Halter, A. N., Carroll, T. W., Byerlee, D. R., Abkin, M. H., Chong, K. Y., and Johnson, G. L., Michigan State University Simulation Team (1971). 'Comparing Agricultural Adjustments and Policies via an Agricultural Sector Simulation Model'. Proceedings of the A.A.E.A. Annual Meeting. Southern Illinois University, Carbondale, Illinois. August 15-18.
- Heady, Earl O. (edit) (1971), 'Economic Models and Quantitative Methods for Decisions and Planning in Agriculture', Proceeding of an East-West Seminar, edited by Earl O. Heady. The Iowa State University Press/Ames, Iowa, U.S.A.
- Heady, Earl O. (1961), *Agricultural Supply Functions*, Iowa State University Press, Ames, Iowa, U.S.A.
- Hockman, E., Regev, U., and Ward, R. W. (1974), 'Optimal Advertising Signals in the Florida Citrus Industry: A Research Application', *American Journal of Agricultural Economics* 56(4).
- Hutton, Robert F. (1961), 'Operations Research Techniques in Farm Management: Survey and Appraisal', *Journal of Farm Economics*, Volume 43, No. 2.
- 'Farmers in the Market Economy', Iowa State University Center for Agricultural and Economic Development. Iowa State University Press. Iowa, U.S.A., 1964.
- King, Gordon A. (1975), 'Econometric Models of the Agricultural Sector', *American Journal of Agricultural Economics* 57(2).
- Kost, W. E., 'Trade Flow in the Grain-Livestock Economy of the European Economic Community', Ann Arbor, Michigan, U.S.A. Dissertation Abstracts International (1972), 32(12) 6639. Michigan State University, East Lansing, U.S.A.
- Kottke, Marvin W. (1961), 'Budgeting and Linear Programming can Give Identical Solutions', *Journal of Farm Economics*, Volume 43, No. 2.
- Kulshreshtha, S. N. and Wilson, A. G. 'An Open Econometric Model of the Canadian Beef Cattle Sector', *American Journal of Agricultural Economics* 54(1).
- Langhoff, Peter (edit) (1965), *Models, Measurement and Marketing* Marketing Research Council, Prentice Hall, Englewood Cliffs, N.J.
- Martin, Larry and Zwart, Anthony C. (1975), 'A Spatial and Temporal Model of the North American Pork Sector for the Evaluation of Policy Alternatives', *American Journal of Agricultural Economics* 57(1).
- Martin, William E. (1972), 'More Sophisticated Tools for Less Important Problems: The

- History of Range Improvement Research: Comment', *American Journal of Agricultural Economics* 54(1).
- 'Systems simulation of Agricultural Development. Some Nigerian Policy Comparisons', Michigan State University Agricultural Sector Simulation Team. *American Journal of Agricultural Economics* 55(3), 1973.
- 'A generalized Simulation Approach to Agricultural Sector Analysis with Special Reference to Nigeria', Michigan State University, East Lansing, Michigan, U.S.A. (1971).
- Mighell, Ronald L. and Black, John D. (1951), 'Interregional Competition in Agriculture with Special Reference to Dairy Farming in the Lake States and New England', Cambridge, Harvard University Press.
- Miller, S. F. and Halter, A. N. (1973), 'Systems Simulation in a Practical Policy-Making Setting: The Venezuelan Cattle Industry', *American Journal of Agricultural Economics* 55(3).
- Myers, W. M. (1972), 'Combining Statistical Techniques with Economy Theory for Commodity Forecasting', *American Journal of Agricultural Economics* 54(5).
- Naylor, T. H. (1971), *Computer Simulation Experiments with Models of Economic Systems*, J. Wiley, New York.
- 'Agricultural Production Systems Simulation', Proceedings of a Workshop, May 4-8, 1970. Oklahoma State University, Stillwater, Oklahoma.
- 'Marketing and Purchasing Strategies', West Lafayette, Ind.; Purdue University. Department of Agricultural Economics 59-63, January 1974.
- Rosine, J. and Helmsberger, P. (1974), 'A Neoclassical Analysis of the U.S. Farm Sector, 1948-1970', *American Journal of Agricultural Economics* 56(4).
- Roy, J. K. and Johnson, Phillip N. (1973), 'Econometric Models for Quarterly Shell Eggs Prices', *American Journal of Agricultural Economics* 55(2).
- Scoville, Orlin J. (1973), 'The Agri-business Sector: An Important Link in Economic Growth Models', *American Journal of Agricultural Economics* 55(3).
- Shepherd, Geoffrey S. (1969), *Marketing Farm Products; Economic Analysis*, 6th Edition. Iowa State University Press, Ames, Iowa, U.S.A.
- Smith, Eldon D. (1972), 'Agricultural Marketing Research for Less Developed Areas', *American Journal of Agricultural Economics* 54(4).

DISCUSSION OPENING — A. Weber, Kenya/Fed. Rep. of Germany

The increasing maturity of agricultural marketing as a subdiscipline of agricultural economics has been subject to several systematic reviews in Germany by G. Schmitt¹ 1968, in the United States of America by H. Breimyer² with a very useful extended international coverage and just recently by Bateman³ 1976 for the U.K. Reviewing the existing literature was also done in 1973 at the Sao Paulo Conference for Farm Management.⁴

The report presented by Dr. Walker gives an immediate access to the most recent development of models in agricultural marketing. The concept of marketing used by the speaker is necessarily a little more narrowly defined than that used by the above quoted general reviews. The presentation gains, however, by concentrating on newly emerging types of models.

(a) *Type of decision-making and decision-makers*

Dr. Walker is not analyzing the various elements of the decision-making process itself, but investigates which models are available for specific purposes of policy decisions in marketing. He conceives, therefore, the task of model-builders as a contribution to marketing policy related to the public or to supply management schemes directed to an industry or a commodity market.

As a consequence of this limitation, the decision-making on farms or of large firms in the food distribution system is not dealt with specifically, because public policy-makers normally use only a small part of the whole marketing mix: namely quantities and prices. Another element which has to be kept in mind is that the models of consumer behaviour are strictly based on the lines of neo-classical theory. There might be some new insights in the policy variables at hand if consumers reactions to changing conditions were not excluded.

b. Class of Models

Dr. Walker considers among verbal, graphical and mathematical models only the last ones and distinguishes three types:

- (i) econometric models,
- (ii) mathematical programming models,
- (iii) simulation models.

His view of the three types of models follows the general professional discussion, but he observes that a certain sequence of econometric, programming and simulation models were the consequence of increasing computing facilities. This would imply that the progress made has not been dictated by the problem orientation of agricultural marketing economists as such. The progress has rather been the consequence of handling more data and testing more complex theories by applying computer programmes from other fields of science. In other words: Learning by doing paved the way to progress.

Another matter for remark is related to the interaction of increasing computer facilities and the intellectual advancement of policy-makers and agricultural economists. Does the increasing use of computer facilities bring better policies or do they inspire policy-makers to invent new areas of intervention with probably doubtful consequences?

It would be easy to argue that certain subtypes of models are not covered by Dr. Walker's review; lack of space obviously limited his selection. However, which type of models would Dr. Walker have excluded if he had to deal with decision-making in production economics. Let us assume the result of reviewing models of production economics would not have been very different from those in a marketing review. In that case we have to ask: are the models from production economics merely superimposed on marketing? Certainly very few marketing economists would agree that the same kind of problems occur in production economics and in marketing. Elaborating this question brings us probably a little nearer to the empirical relevance of the various types of models. If strict maximizing and minimizing rules in marketing cannot be followed the simulation approach seems to be more appealing than the strict linear programming type of model.

(c) Further developments

Since developing countries have to put a high emphasis on earning foreign exchange by exporting agricultural products, two other types of models might

usefully be investigated further in agricultural marketing to suit the following problem areas:

- (i) Commodity modelling and supply management schemes at an international level have to be pursued in future. However, difficult aggregation and disaggregation procedures are a practical barrier to move faster ahead. They have to be overcome by marketing economists who involve themselves in this, much needed, research area.
- (ii) Models are needed which describe the framework of international marketing of agricultural products and processed food in a more comprehensive way. These models have to stress a little more deeply traditional functions and institutions in an international setting without excluding the whole marketing mix.

REFERENCES

- [1] Schmitt, G. (1968) *Landwirtschaftliche Marktforschung in Deutschland* Munchen. Bayerischer Landwirtschaftsverlag.
- [2] Breimyer, H. F. (1973) The economics of agricultural marketing: a survey. *Review of Marketing and Agricultural Economics* 41, (4) 115-165.
- [3] Bateman, D. I. (1976) Agricultural marketing: a review of the literature of marketing theory and of selected applications. *Journal of Agricultural Economics* 27 (2) 171-225.
- [4] Throsby, C. D. (1974) New methodologies in agricultural production economics in *The future of agriculture. Technology, Policies and Adjustment*. Oxford: Agricultural Economics Institute.

RAPPORTEUR'S REPORT — M. Hawkins, Canada

The nature of this session was to share experiences. The opening paper by Walker did an outstanding job of presenting specific economic models with their strengths and limitations. Therefore, the consensus of the group was to proceed from the paper into the broader issues which exist in market analysis.

The discussion reflected the varying philosophies and approaches to models utilized within marketing theory, yet it remained tolerant of ideological differences among the discussants. It appears that marketing is becoming increasingly concerned with group arrangements. This is in direct contrast to production economics which is primarily concerned with individual farm units. Vertically integrated systems, marketing boards and co-operatives are of increasing importance. Marketing issues have become more involved with equity and marketing has become a more integral part of development plans.

Models must involve many non-mathematical concerns. The conceptual framework of a market must be enlarged to consider institutional factors that is, government, agribusiness, human behavior, etc. Agricultural economists must become more adventurous in exploring other models and approaches which should appear as a result of problem-solving in the marketplace.

As we develop our models and concepts, marketing economists must prepare the strategy for policy-makers. We must deal with market imperfections. A consideration of the triangle involving commercial farms, government and a

concentrated market place entails careful consideration of market structures, conduct and performance, while preparing our models and policy strategies. Here the theories of effective or workable competition deserve considerable attention as they blend with tenure systems, welfare considerations and social structures.

The challenge is pragmatically to structure a market system in order to get performance. In this regard there are many applied experiments in new systems throughout the world from which there are now applied research results which should be seriously examined.

The history and evolution of marketing events is largely ignored by model-builders as they work and thus they continue to lose contact with the core of basic economic thought. The construction of models that lack sensitivity to basic economic and policy criteria often leads to a large waste of resources.

As a final comment, the discussion showed an interest and maturity that was not apparent at previous conferences. Perhaps this illustrates the growth, maturity and concern of the profession of agricultural economists, in the discipline of marketing and its important role in economic and social development.