7

Principles of Policy Modeling in Agriculture

Gordon C. Rausser and Richard E. Just

Introduction

The domestic and world economies of food and agriculture have become increasingly complex over the last decade due to economic instability, government administrative instability, inflation, foreign price and trade regulation, along with money supply and credit manipulation. From resource utilization at the agricultural production level, all the way to final comsumption of food, a variety of economic, political, and technological forces have continued to evolve with pronounced structural implications.

To deal with this apparent complexity of the agriculture and food sector in policy formulation, models have long been viewed as a potentially valuable aid to the evaluation and selection of policy strategies. Models can be employed to generate quantitative forecasts and to evaluate the effects of alternative decisions or strategies under the direct control of policymakers. In essence, models can offer a framework for conducting laboratory experiments.,without directly influencing the agricultural and food economy. They also potentially offer a basis for sharpening the judgments of analysts and policymakers alike.

Many models of the food and agricultural sector have been constructed. Some have been constructed for descriptive purposes, some for explanatory or causal purposes, some for exploratory purposes, some for forecasting purposes, and others for the express purpose of decision analysis. The latter group of models, of course, is of direct interest in policy formulation. Such models require at a minimum (a) the performance or target variables considered important by the policymakers, (b) the instruments or policies available to policymakers, and (c) a set of behavioral, identity, and physical relationships which link (a) and (b). This group of models is, indeed, the most demanding; the development of useful decision-making models for dynamic stochastic systems of the type represented by the agriculture and food economy requires the construction of conditional policy forecasts. In many situations, the construction of forecasting frameworks will also require the development of descriptive as well as explanatory models. To ascertain the effect of alternative policies in terms of performance measures, causal relationships between the decision variables and relevant performance measures must be captured.

An examination of the anatomy of policy models provides the basis for an assessment that the potential for such efforts is largely unrealized. By examining the elements of policy models in terms of their conceptualization, specification, estimation, and use, the unfulfilled promise of modeling as an aid in support of policy analysis begins to take shape. While the anticipated costs of policy modeling have been incurred (and often exceeded) over the past few decades, the anticipated benefits have not yet emerged. This observation is, of course, not new. Reasons such as insufficient model validation, insufficient linkage and feedback relationships, and insufficient communication between model analysts and policymakers have been advanced for the failure of quantitative models to attain their promise. This paper argues, however, that the reasons underlying this failure run deeper and span a broader set of issues.

Architects of policy models have too often followed the principles of model formulation that are generally appropriate for other purposes of models — descriptive, explanatory, ,causal, exploratory, or forecasting purposes (Rausser and Hochman). A close examination of problems arising in the use of quantitative models in policy formulation or decision analysis suggests the need for a set of principles to emphasize the tradeoffs that must be considered in the construction and use of agricultural policy models. The assessment of tradeoffs for descriptive, explanatory, or forecasting models differ measurably from such assessments for policy models. This paper attempts to develop such a set of principles or a code of conduct specifically relevant to modeling for policy decision analysis. Ten basic principles, along with a number of subprinciples, are identified. The ten basic principles and associated tradeoffs that are justified and discussed through the course of this paper are as follows:

1. The purposes and goals of policy models should be explicitly defined at the outset with a view to the policy decisions that will be evaluated.
2. The experimental role of policy models should be exploited.
3. Post-Bayesian analysis should guide the design, estimation, and use of policy models.
4. Policy models should be designed to accommodate and track structural change.
5. The degree of imposed theoretical structure in policy model specification should depend on the amount of historical information.
6. General equilibrium rather than partial equilibrium relationships should be emphasized in the structure of a policy model.
7. Policy modeling must provide for the use of intuition, both in model development and in updating; strong intuition should override causal implications of coincidental data in model development.
8. Use of greater weight on more recent data in policy model estimation should be seriously considered.
9. General purpose data sets rather than general purpose models should be emphasized.
10. Policies should be formulated with an appropriate degree of learning in mind.

Principles of Policy Model Use

Principle 1: The purposes and goals of policy models should be explicitly defined at the outset with a view to the policy decisions that will be evaluated.

What decisions or policies is the model designed to influence? Who will use the model? For whom is the output information intended? Consequently, what information must the model provide to the users? What input variables shall be used to test alternative and environmental assumptions? How often will the model be used? How timely must the input information be? The answers to these questions are crucial. They define the model operationally; in turn, they become the marching orders for the model architect to implement.

There are far too many models that have been constructed by an ambitious analyst that are well specified technically but have not addressed these questions. As a result, the models contain elaborate but irrelevant detail. Far too frequently, researchers construct policy models under the following premise: "that the goal of economic modeling is to provide ***helpful information to decisionmakers*** that will ***improve the likelihood of their making a correct choice*** when confronted with ***a set of possible actions unknown to the researcher during the construction of the model"*** (Hughes and Penson). This perspective places the researcher in a world of uncertainty, gambling with odds heavily stacked against success.

To illustrate the importance of model purpose, consider the effect or the design of policies to influence the structure and control of agricultural production. As noted by Gardner, agricultural economists have made little progress in determining the distributional effects of price support, acreage set-aside, deficiency payment, and public stockholding policies. One possible reason for this observation is that most models concentrate on output markets; and, certainly, the vast majority of agricultural sector models address only these markets. However, to measure the distributional impacts of various policies both qualitatively and quantitatively, we are forced to deal squarely with dynamic interactions, feedback, and linkage effects as well as equity and efficiency effects. This general observation leads to the following subprinciple.

Subprinciple 1.1: For multidimensional policy problems with noncomparable objectives, the analyst and policymaker should examine alternative weights or equity schemes.

In the case of many agricultural policy problems, we are faced with multiple objectives, including such loosely defined measures as increased income of farmers, increased consumer welfare, improved distribution of income, self-sufficiency; price stability, improvement in the balance of payments, decreased public expenditures, stable flow of supply, and the like. It has been recognized on both normative and positive grounds that criterion functions based only on efficiency are inappropriate in many operational applications. The work of Stigler and Peltzman highlights the growing disenchantment with the economic efficiency objective and points out that the political process is inconsistent with dichotomous treatment of resource allocation and wealth distribution.

In the face of multiple concerns, the continued use of single-attribute, objective-criterion functions will result in analyses which often fail to address actual policy problems. Hence, multiple objectives must be considered. The definition of a multidimensional objective function neither creates nor resolves conflicts associated with policy issues; instead it identifies them. The identification of conflicts is, of course, an important first step in resolution. Most of the recent advancements on the specification, identification, and assessment of multidimensional objective functions are summarized by Keeney and Raiffa.

Since unique single-attribute objective criteria are often not appropriate for policy analysis, one approach is to determine the effects of alternative policies on each objective and then allow the political process to select among the alternatives. Policy model experimentation with alternative weights can provide some important information for this process. In a "normative" or prescriptive setting, the Keeney and Raiffa multi-attribute utility function approach can be used, while, in a more "positive" setting, revealed preference has been employed to determine weights associated with various objectives. In any event, as Steiner (p. 31) argued some years ago, "we now accept in principle that the choice of the weights is itself an important dimension of the public interest."

In a revealed preference framework, Rausser and Freebairn argue that the importance of the bargaining process and the resulting compromises between different political groups, the range of preferences of these groups, and the lack of an explicitly stated, unambiguous value consensus suggest construction of several criterion functions. They argue that these functions should reflect the extreme viewpoints and preferences of various decisionmakers actively involved in the policymaking process as well as the preference sets lying between these extremes. A parametric treatment of the resulting set of preferences will provide decisionmakers with rational policy outcomes, conditional on the representation of policy preferences. Thus, the results obtained from such an approach should contribute to the efficiency of the bargaining process and in reaching a consensus, they should serve each policymaker individually, and they should serve to make quantitative analysis based on historical data effective for many policymakers even though the composition of a legislative body and/or "appointed" policymakers might change.[1]

Subprinciple 1.2: The distributional effects of agriculture and food policies can be seriously examined only through their indirect effects on asset markets.

Of course, if distributional issues are not under examination, a model need not have the complexity associated with asset markets. However, if such issues are crucial, the general equilibrium effects on these asset markets are exactly what must be examined. In three conceptual papers (Rausser, Zilberman, and Just; Just, Zilberman, and Rausser; and Hochman et al.), it has been demonstrated how input flow and asset stocks can be altered indirectly by changes in both sectoral and general economic policies. For example, a sampling of the implications of these theoretical frameworks under partial participation are as follows:

- An increase in deficiency payments and/or a reduction in acreage set-aside requirements leads to increased concentration, measured by the average land size of active farms.
- An increase in deficiency payments and/or a reduction in acreage set-aside requirements encourages the adoption of output-increasing technologies and discourages the adoption of cost-reducing technologies.
- Restrictive monetary policy tends to reduce the ratio of land prices to rental rates and to encourage participation in voluntary government programs.
- Higher rates of exemption on capital gains for tax purposes and escalations in the general tax structure increase the ratio of land prices to rental rates and encourage inflationary land price spirals.

Without the explicit consideration of the indirect effects of sec-

---

1 It should be noted that the revealed preference approach imposes rather restrictive assumptions. The mathematical form of the criterion function must be specified, the constraint structure must be empiricized, and rationality is assume. Given this structure. past policy actions can be utilized to infer the weights or tradeoffs among alternative objectives Rausser, Lichtenberg, and Lattimore have developed an integrative framework which blends a number of frameworks that have appeared in the literature This framework presumes that there is a set of relevant criteria functions. Elements of this set differ in terms of alternative weighting or equity structures. As the policymakers change over time and power shifts occur in the composition of legislative bodies, weights across various performance measures change

toral and general equilibrium policies on asset markets in agricultural systems, it would not have been possible to derive the above implications. It is, indeed, important to be alerted to such potential effects in the selection of actual policies. For example, a desire to increase farmers' income by reducing output could lead to an increase in the relative rental/land price ratio, thus reducing the shadow price of credit and making new investments more attractive. The resulting adoption of new technology, especially output-increasing technology, can make various policy mixes of target prices, loan rates, and acreage set-asides in the short run quite different from the long run.

Principle 2: The experimental role of policy models should be exploited.

In essence, policy models offer a framework for conducting laboratory experiments without directly influencing the system. Since these experiments can be conducted with a model rather than th real system, mistakes that may result in costly consequences can be avoided. This experimental perspective forces analysts or others interested in a particular system to be precise about their perceptions and to examine possible inconsistencies in those perceptions.

Experimentation with policy models has often been inhibited because of inabilities to solve complex dynamic stochastic systems. However, the development of a number of methods over the past decade facilitate the experimentation of the sort envisaged here. They can be categorized anywhere from analytical to analytical simulation to ad hoc simulation methods. All of these methods are faced with a problem of multiple local optima. Analysts frequently deal with these problems by employing incomplete or partial multiple-objective criterion functions. The limitation of such partial analysis is that superior solutions often lie in "inferior" regions. Given the limitations of operating with complete, as well as incomplete, multiple-objective criterion functions, analysts should attempt to generate alternative weightings or trade-off relationships in accordance with Subprinciple 1.1. One set of weights could reflect the power and strength of various interest groups.

Most policy models are structured to investigate specific policy instruments. The emphasis on the experimental role of policy models requires, however, more originality in the selection of policies that are evaluated. For example, the results from policy models for predetermined instruments should be used in part to gauge the design of other policies not previously considered.

To facilitate originality in the policies selected for evaluation, econometric methods, operations research, systems analysis, and simulation should not be viewed as mutually exclusive approaches. The use of multiple approaches is often more desirable (Brill) to develop, evaluate, and elaborate alternative solutions. It increases the likelihood of tailoring available algorithms to provide significant insights rather than just answers. With this perspective, policymakers and analysts are not wedded to the first design, and there are implicit incentives to pursue other distinct alternatives. In this environment, artificial intelligence and heuristic methods will prove particularly worthwhile. Thus, the answer-seeking mentality is avoided, and learning and inductive inference is highlighted.[2]

Subprinciple 2.1: Potential users must be involved in the process of model design and development.

One effective means of facilitating the effective use of policy models and the explicit definition of the goals of a policy model at the outset of the model development phase is to involve the policymakers or users of the model results in the development process from the very start. As noted in a study by McKinsey & Co., Inc., in the late 1960s, one of the principal factors explaining the failure of a large number of private corporation planning and decision models is the lack of user involvement in the development process. Of the 36 large corporations surveyed in this study, the report concluded that the neglect of user involvement is, indeed, costly.

There can be little doubt that users should play an important role in the determination of the objectives for the modeling effort. When designing the model, substantial attention should be paid to users' perceptions of the environment under examination. In general, we

2 To facilitate learning and inductive inference, analysts investigating various policy issues in agricultural systems will have to develop an expertise in experimental design and response surface procedures. Relevant experimental designs must be sequential (Anderson) and squarely address "policy improvement" algorithms. Such algorithms involving sequential designs typically begin with an extensive search via simple exploratory experiments which converge toward some peak (or valley) of the surface and then switch to an intensive search as the optimum is approached. To implement such sequential experiments and policy-improvement methods, the appropnate response surfaces must be constructed. Fortunately, an excellent survey is available for analysts to familiarize themselves with response-service investigations from the standpoint of sequential analysis and optimal designs (Chernoff).

tend to trust and use something we have had a hand in developing; it is difficult to develop confidence in something we must accept on faith. Equally important, the involvement of users during development enhances their understanding and decreases the educational effort required after the model is constructed. Obviously, involvement of the ultimate users must be managed judiciously, given their perceptions about the opportunity cost of their time. If the ultimate users cannot allocate time for such efforts, then at a minimum their trusted deputies should be assigned the task.

Subprinciple 2.2: Development of policy models must be treated as a process, as opposed to just the creation of the product.

Unfortunately, this is a subprinciple that often fails to guide the actual construction and use of policy models. The product approach is the more usual situation; its goal is to create a working model, and those involved in the construction find it difficult to see beyond that stage in their efforts. For the process approach, the creation of the model is an important step along the way toward using the model to affect policy analysis favorably. The longer run view of the process approach fosters a give-and-take relationship between the analyst and user in model design, and improvements that usually continue beyond the first implementation. It assists everyone involved in the process of model construction to behave nonmyopically and to consider how the model will be used in the future and how the organization is likely to respond to its use. The process approach anticipates the need for education and organizational change to effectively utilize the model for policy evaluations.

Principles of Policy Model Specification

Principle 3: Post-Bayesian analysis should guide the design, estimation, and use of policy models.

As argued by Faden and Rausser, neither the "Bayesian" nor the "classical" school of thought on the foundation of statistics is adequate. Thus, the nature and purpose of the current statistical foundations need to be reexamined. An adequate theory should be compatible with the way science develops. Moreover, the conceptual base should be consistent with the way in which we casually accumulate knowledge in everyday life. It should also be "axiomatically" satisfying.

The Bayesi'an approach to statistical inference and knowledge accumulation would, in fact, be correct if analysts and policymakers had unlimited and costless information-processing capacity. A rigorous Bayesian would need superhuman abilities — a perfect and infinite memory, perfect deductive powers including faultless and instantaneous calculating ability, and the wherewithal to understand questions'of arbitrary complexity. Hence, due to human limitations, more or less serious departures from the strict Bayesian approach are warranted. In particular, the cost of information collection, processing, and interpretation should be recognized.

Formally, the post-Bayesian criterion for inference is to minimize expected loss or costs. It is, there'fore, consisterit with the general framework of decision theory; inferences are "Bayes" decisions with respect to some prior distribution. However, the criterion 'stresses two major costs ca'tegories that do not appear in the early work of Wald or his successors. The first cost is associated with complexity, namely, those costs that emanate from information processing: constructing models, gathering and storing data, solving models, communicati'ng results, and the like. The second cost component is associated with inaccuracy. Hence, the approach explicitly 'evaluates the tradeoff between accuracy and complexity. In essence, the 'benefits and costs .associated with ,alternative policy models 'dictate strategy in their construction and use.

According to 'Powell, the complexity of a model is measured by such 'characteristics as 'a number of equations in a model,, the nonlinearity 'of a model, and number of "families" to which the equations belong. Similarly, *ceteris paribus*, deterministic models are simpler than stbchastic models, static models are simpler than dynamic models, and lump-parameter models are simpler than distributed-parameter models. In general, complexity rises with the number of free ,parameters.'Complexity of a policy model is not measured simply by model size or the number of endogenous variables.

To 'indicate how complexity costs can be assessed, consider the problem of alternative regression models aimed at, say, predicting a certain variable of interest. Complexity costs generally rise with the number of explanatory 'variables. Here, cost may take the form of money, time, resources, or effort used in model .development and analysis. Certain aspects of cost rise linearly with the number of variables (e.g., tabulating 'the data); some go up quadratically '(for example, printing the covariance matrix); some rise cubically (e.g., inverting the moment matrix). These are not the only costs, but they suggest that a cubic polynomial in the number of variables may be one possible representation of complexity costs.

In addition, differences in complexity costs of observation also result from sample survey design, sequential analysis, and other data selection criteria. Thus, even tractable models differ considerably in complexity. The most radical consequences of incorporating complexity costs — or, equivalently, the value of simplicity — results from evaluating the relative costs of such alternative models (Faden and Rausser).

The second important cost component is associated with inaccuracy. The more accurate a model is, the more benefit is accrued from employing it to resolve various policy issues. Or, in other words, there is a cost associated with inaccuracy. The cost of an inaccurate model depends on how it is used. That is, for models used as guides in making decisions, inaccuracy tends to degrade the quality of the decision. This implies that, to assess the cost of forecast inaccuracy, one must embed the model in a more complete policy framework. There are several ways of making this embedding, each generally leading to a different inaccuracy cost function. There is no absolute "metric" for inaccuracy.[3]

Subprinciple 3.1. Alternative model specifications for the same problem imply different decompositions of systematic and nonsystematic components.

The balancing of inaccuracy with complexity is particularly crucial in the selection of explanatory variables. Somehow, a selection of "significant" explanatory variables (or "appropriate" policy variables) must be made from a large pool of variables, and the proper estimates or settings must be made for each. The post-Bayesian approach makes this selection in a structured fashion that involves the weighting of alternative costs and avoids the inappropriate tests that are inherent from conventional statistics.

To illustrate the implementation of Subprinciple 3.1, consider the case of supply response for some of the major feed grains where weather conditions are important. Owing to complexity costs, the

3 Various metrics of Inaccuracy are outlined by Faden and Rausser Briefly, these measures are based on departures from the ideal pattern of Bayesian inference

coefficients on weather variables in an estimation context may be set to zero. For feeder calf supply, range conditions, indeed, play a role; nevertheless, they are sometimes excluded as an explanatory variable because of complexity costs associated with data acquisition, the increased ability to identify other coefficients and the inability to forecast weather. Such potential explanatory variables are subsumed in the error process. To the extent that movements in these variables can be represented by autoregressive, moving average processes, their influence on endogenous variables of interest can be ferreted out through time series representations of the error or disturbance terms. Moreover, if the purpose of constructing a policy model is to evaluate, say, alternative feed grain reserve policies vs. meat import quotas, the explanatory variable which must appear in systematic components (variables whose coefficients assume values other than zero) vs. nonsystematic components (disturbance terms) may differ among policy evaluation problems.

One of the major problems with conventional policy models that have been constructed to date emanates from their failure to recognize complexity costs and, thus, the need to balance those costs against the cost of inaccuracy resulting from abstraction. Incorporation of these costs leads to what we have characterized as the post-Bayesian approach and requires a reexamination of procedures of model construction. Admittedly, however, because accurate estimates of complexity and inaccuracy costs are not possible, post-Bayesian procedures must often be implemented with crude estimates of. such costs. Nevertheless, for a number of illustrative applications (see Faden and Rausser), it is possible to use very crude estimates of these costs to motivate procedures that should prove to be superior to conventional treatments.

Principle 4: Policy models should be designed to accommodate and track structural change.

By their very nature, models are abstractions involving simplifications imposed by available data, research time, and budget as well as by the desire to achieve tractable results. Such simplifications and abstractions often result in misspecifications which, in turn. influence the accuracy of conditional probability distributions. As demonstrated in Rausser, Mundlak, and Johnson, the effects of such misspecifications can be countered by introducing appropriate parameter-variation structures which may be theoretically or empirically based. The most important types of misspecifications that arise in the construction of policy models include omitted variables, proxy variables, aggregate data, and simplified functional forms.

In addition to the misspecification rationale for varying parameter formulations, economic theory can be advanced to justify their potential relevance. In many situations, the very nature of economic theory leads to relationships that change over time. For example, Lucas has argued that the constant parameter formulation is inconsistent with economic theory. He notes that a change in policy will cause a change in the environment facing decisionmakers; under the assumption of rational decisionmaking, this will result in shifts in the equations representing their behavior.

One of the better examples of the points raised by Lucas occurred as a result of the U.S. economic stabilization program during the period 1971-1974. Price ceilings were imposed on red meats at the end of March 1973. When combined with the biological nature of various red-meat animals, these ceilings led to distorted and clouded price signals which resulted in strategic errors on the part of numerous decisionmakers. Thus, the signals led to instability in the expectation-formation patterns of decisionmakers along the vertical commodity chain in beef, pork, and poultry. During that period, the cattle cycle, which was poised for a sizable liquidation, was substantially altered. In fact, for a short time. price ceilings appeared to become the expected prices of producers. As a result, the liquidation phase was curtailed. resulting in larger supplies, substantially lower prices, and significant negative margins. Hence, the price ceilings had the immediate effect of a substantial shift in price expectations which, in turn. had drastic implications for dynamic supply responses, ultimate market realizations, and cattle inventories. A model which includes a particular price expectation formation pattern as part of its maintained hypothesis would thus be subject to structural change.

In essence, this principle recognizes that it is important to distinguish between the "local approximation" accuracy and the "global approximation" accuracy of a model structure. In attempts to achieve global-approximation accuracy with abstract models, there is no choice but to operate with specifications that readily admit structural change. The importance of this principle has been illustrated on numerous occasions during the last decade. For example, models based on data bases up to 1972 fail to account for the significant linkages with the international economy, especially the significant movement in the exchange rates and the integration of international capital markets during the balance of the 1970s (see Schuh and Chambers and Just). Models that fail to track and accommodate these significant changes will fail to achieve sufficient credibility and thus will not be seriously entertained by policymakers. Similarly, in the late 1970s and early 1980s, linkages with the general economy (especially with interest rates reflecting monetary and fiscal policies) apparently forced a shift from one local approximation to another. During the 1980s, models which fail to accommodate structural changes that result from significant movements in interest rates (via their effect on exchange rates, export demand, stockholding behavior, and investment) will fail many credibility tests.

The issue of accuracy is particularly important when the structural model representation is nonlinear in the variable space. In agricultural systems that address dynamic, linked, and feedback relationships, model representations often involve simultaneous interactions of large systems. For nonlinear representations in these model forms, it is not possible to obtain a unique reduced form. In computing the necessary derivatives to obtain this form, issues of approximation and round-off problems naturally arise. More importantly, it is not possible to derive reliability statistics for highly nonlinear models. Analysts operating with such models often "sweep under the rug" the problem of measuring the variability (or risk) associated with the various policies that are under examination. It is shown in Rausser, Mundlak, and Johnson that these problems frequently can be avoided by specifying models that are linear in the variable space but are, in essence, nonlinear in the parameter space. This requires the specification of models in which the parameter effects are not constant but are treated as time-varying and random. The approach allows forecasts of probability distributions, conditional on alternative policy actions, to be generated for particular points in the parameter space. This approach also simplifies the validation and verification procedures, especially the derivation of dynamic properties.[4]

4 This approach is entirely consistent with post-Bayesian principle 3 From an operational standpoint, the relevant issue is whether or not the explicit recognition of varying parameters will improve accuracy and implementation benefits which outweigh their additional complexities. For most agricultural policy problems, these formulations are more likely to capture the enduring characteristics of the processes under examination.

Principle 5: The degree of imposed theoretical structure in policy model specification should depend on the amount of historical information

The proper degree of imposed structure, as well as the extent of accommodation for structural change, depends upon whether the model is used to evaluate policies for which there is much prior experience or little or no experience. The latter situation would arise in evaluating new institutional designs. In other words, a greater amount of prior experience on the effects of a particular policy allows greater accuracy in estimation with less imposed ad hoc structure. However, more specification is needed if new policy controls or instruments are under examination in order to allow parameter identification. In some instances, highly structured programming models may be the only possibility for evaluating policies for which no prior observations are available; if prior observations are available, a less structured model may be more appropriate and may provide a better level of flexibility in ascertaining from observed data the effects of alternative policy instruments.

Where sufficient data are available, reasonable fits are often obtained with the econometric approach. But, even under these circumstances, predictions often quickly go off course as explanatory forces move outside the range of data used in the sample period for estimation. Some of the main approaches to combat this problem have involved adding further structural specification such as theoretical restrictions based on consumer utility theory or producer profit maximization. Some of these approaches are based on a neoclassical theory which entails full flexibility at least as an approximation. But the cost of such flexibility can be that the numerous resulting parameters may not be identifiable when few observations on a given situation are available. This problem is mitigated to some extent by making further ad hoc assumptions with respect to functional forms of preferences and technologies; but this approach leads to costs of inaccuracy associated with erroneous ad hoc assumptions.

At the other extreme, programming models can make more efficient use of data in estimating input-output coefficients and resource availability when only one or a few observations are available, but very poor predictions of producer behavior are often obtained from programming models. This is apparently due principally to three sources of inaccuracy. First, producers' objective criteria may differ from that used in the programming model; second, farmers' subjective distribution of prices and yields may be different from that reflected in the programming model; and, third, the linearity of a programming model may be inappropriate. All three of these problems result form using extreme ad hoc assumptions rather than providing the flexibility to allow inference from observed data. The results of programming models in predicting farmer responses are often less satisfactory than those of econometric models in situations where both are applicable (that is, where sufficient historical data are available on the policy controls of interest). Thus, the appropriate degree of ad hoc structure depends crucially on the availability of data reflecting the observed effects of relevant policy controls.

Moreover, the fact that U.S. agricultural policy change is often a mixture of both institutional change and policy instrument change further suggests that policy model specification can, in some cases, be enhanced by a proper blend of the two seemingly very different approaches. An effective merger of the conventional econometric and programming approaches centers on the distinction between discrete (qualitative) and continuous (quantitative) choices. Institutional choices or selection of particular policy instruments correspond to qualitative choices, while changes in policy instruments correspond to quantitative choices. Programming formulation can easily handle the former, while conventional econometric models focus on the latter. Moreover, inequality constraints found in programming models are not admitted in conventional econometric formulations. However, both discrete and continuous choices and inequality constraints can be admitted in behavioral models estimated by qualitative econometrics methods; thus, some of the recent developments in qualitative econometrics offer promise for achieving a proper blend. Two recent papers which survey and apply these methods are Chambers and Just (1981) and Rausser and Riboud (1981).

Subprinciple 5.1: The number of variables employed to reflect policy instruments is crucial in interpreration of historical dara.

Government policies are often changed from time to time in a way that seemingly involves a switch to a new set of policy instruments. For example, U.S. wheat was regulated by price supports and strict allotments with marketing quotas in 1950 and from 1954 through 1963; by price supports alone in 1951 through 1953; by voluntary allotments, diversion requirements, and price supports in 1964 through 1970; and by set-asides with target prices and deficiency payments in the 1970s. Furthermore, the set-aside program has at times required cross-compliance and in other times not. With this frequent revision of the set of policy instruments, there has sometimes been only a very small number of years in which the effects of a given set of policy instruments could be observed. If each of these sets of policy instruments is treated as independent, then the information that can be gained through historical observation of their impacts is extremely limited.

Econometric purposes, for example, are greatly facilitated if ways can be found to represent alternative instruments as different levels of the same set of instruments. In this way, both degrees of freedom can be saved in estimation, and more information can be gained by comparison of the effects of alternative policy regimes. For example, in moving from a policy period with strict allotments to one of voluntary allotments, one would expect that those farmers that continued to participate would behave in much the same way as when allotments are strictly imposed. Similarly, one would expect those farmers who do not participate to behave much like they would when no allotment program was exercised. By making this minimal assumption, one can reduce the number of variables needed to reflect the alternative policy regimes in an econometric model (Just 1974).

Similarly, the roles of diversion requirements and set-aside requirements are quite similar as are the roles of wheat certificates and deficiency payments. By appropriately considering the similarity of these controls from one policy regime to another, one can often gain more information on the effects of policy instruments from historical data. These considerations also lead to greater simplicity in policy models and, thus, the complexity costs can be reduced accordingly. In reducing the number of variables representing policy instruments, however, one must bear in mind the approximations that are introduced. In this context, the earlier comments on the degree of imposed ad hoc structure may be reiterated.

Subprinciple 5.2: Summary variables rather than representative variables should be emphasized in policy models.

A common practice in econometric application has been to consider as many variables in model construction as may seem intuitively important but then to prune that set of variables based on their apparent econometric importance. In doing so, variables may be excluded which intuition implies should clearly play a role. A justification for this practice usually goes as follows: (1) either the variables are truly unimportant or do not play a role, or (2) they are sufficiently closely related to variables that are retained in the model that multicollinearity prevents estimating a separate coefficient. Thus, a similar multicollinearity is assumed to persist in the forecast period. When intuition is sufficient, a more appropriate practice would be to construct summary variables which include the effects of perhaps several colinear variables. This is particularly true in policy modeling where distinct changes in policy controls may cause collinearities observed in a sample period to cease.

Many models have made use of price indices along this line to represent the effects of many exogenous prices. However, relatively few models make use of price indices including several endogenous prices. Similarly, relatively few models use quantity indices which embody the effects of several quantity variables which may be too highly related to be included separately in an econometric model.

The case of estimating meat demand prior to 1970 may serve to illustrate the importance of this principle. In data generated prior to 1970, the prices of beef, pork, and poultry all tended to move together so that the resulting multicollinearity prevented estimation of commodity-specific cross-elasticities. As a result, many modelers tended to exclude all but one of the "cross" prices so that, for example, beef demand would not be sensitive to pork prices, etc. Many of these models, however, performed poorly in forecasting the events of the 1970s because the huge feed-price increases caused a change in the relationship among livestock prices. For example, hogs began to sell at a premium relative to beef cattle. These events thus led to failure of the models which had followed the practice of excluding colinear variables. Alternatively, if summary variables had been used to include the prices of all commodities which intuition clearly dictated were important. then the associated models might have been able to predict the associated consequences of high feed prices, at least to some extent. Thus, if summary variables are used rather than excluding variables which are clearly important, then a model may not flounder as soon as some existing causal multicollinearity ceases to hold. Of course, these arguments are also consistent with the need for constant consideration of model revisions and the importance of subjective information in model development and data interpretation.

Subprinciple 5.3: Functional flexibility and alternative distributed lag structures must be evaluated constantly as more information is obtained.

This subprinciple simply recognizes that all maintained hypotheses must remain tentative. In other words, various elements of conventional maintained hypotheses must be relaxed and reevaluated as the modeling process continues. The imposed structure must be constantly reassessed. In essence, to the extent possible, the imposed structure should be in a fluid state.

Subprinciple 5.4: Relative rather than absolute specifications enhance policy model longevity and degrees of freedom in estimation.

In the infancy of econometric modeling, the objective of policy modelers was to determine a linear relationship between two or more variables in nominal form. Further experience, however, particularly in inflationary times, suggested that models tended to lose their tracking ability after sufficient inflation when variables were used in nominal form. In response to this problem, prices began to be used in relative or deflated form for econometric modeling purposes. This specification was justified by the fact that economic theory under certainty implies that both producers and consumers respond directly to changes in relative prices rather than changes in nominal prices. But the imposition of such specifications is debatable since economic theory under risk implies that decisionmakers may respond to nominal prices as well as absolute prices. Nevertheless, the use of relative or deflated prices for econometric purposes has persisted because experience with deflated price models has tended to dominate nominal price models, particularly in postsample periods.

One may question, however, whether this use of relative vs. absolute specifications has been carried far enough. The practice of deflating prices by some general price index has become quite common (although it is not clear that use of a general price index in the denominator of a price relative always outperforms the use of a price of a closely related good). But the use of quantity relatives in policy models is a much less common practice. The use of quantity relatives, as well as price relatives, can often better facilitate comparisons both across time periods and economic units (decisionmakers, counties, states, countries, etc.) and often reduces the number of coefficients that must be estimated. In addition, when alternative policies are actually evaluated, relative measures ("ratios" or "differences") will simplify the comparisons.

By specification in terms of relatives, models often turn out to be independent of units of measurement and are thus formulated in terms of the basic conceptual unit of economic measurement — elasticities (quantity as well as price elasticities). In this context, the estimated structure of the model is likely to have greater longevity of application. This has been borne out by experience with respect to the use of price relatives. When all prices tend to increase together with inflation, the use of price relatives removes the effects of inflation on several prices in order to increase comparability across time periods. However, in a growing economy, all quantities also tend to increase together with the expansion of the economy. Thus, the use of quantity relatives should also tend to increase comparability of several quantities across time periods in a growing economy. The same considerations for both prices and quantities also make sense in comparing across economies (counties, states, countries, etc.) and also appear to offer even greater advantages in the context of cross-section data where units of measurement may not be comparable or where general price levels or economy sizes may greatly differ.

Experience in some preliminary work on the effects of the International Sugar Agreement may serve to illustrate this point in the context of time series data. In data over only a 10-year period from 1970 to 1980, the size of the world sugar market in terms of production and consumption increased from around 70 million metric tons to around 90 million metric tons. A change in stock levels of, for example, 5 million metric tons is often more crucial in a market with 70 million metric tons of consumption than in a market with 90 million metric tons of consumption. To reflect this difference, a model stated in terms of quantity relatives is more effective.

With this approach, we found that a model may be stated in terms of fewer estimable coefficients without losing tracking power. Furthermore, we found that postsample predictability was improved through the use of quantity as well as price relatives.[5]

As a precaution in applying this principle, however, one must bear in mind complexity costs which may be related to certain nonlinearities that may be introduced into a system (depending upon functional forms). That is, if a model is stated in terms of price and quantity relatives involving several equations, then the use of any identity relating quantity variables may make the resulting system of equations nonlinear and, thus, associated complexity costs would increase. One way to avoid this problem is to specify quantity relatives so that denominators are exogenous variables. This is essentially the traditional approach that has been used with price relatives. In addition, if general equilibrium relationships (rather than partial equilibrium relationships) are estimated, then it may not be necessary to use groups of equations together with identities for policy impact purposes (see Principle 6). In this way, some of the complexity costs associated with the use of quantity relatives may also be outweighed by the associated benefits of accuracy and model longevity.

Principle 6: General equilibrium rather than partial equilibrium relationships should be emphasized in the structure of a policy model.

In the early days of econometric modeling, researchers attempted to estimate single-equation relationships describing supply or demand in a particular market. Following a traditional Marshallian approach, the supply or demand relationship was conditioned upon all of the determinants ***(ceterus paribus*** conditions) which were econometrically discernible. The problem with such simple models is that they reflect behavior only in the market in question and ignore possible repercussions of policy changes which may take place in other markets. Also, they ignore possible feedback effects in the market in question from repercussions in other markets. For example, when a price support is increased on a feed grain, one may

5. To facilitate the merger of programming and econometric approaches, Rausser. Just, and Zilberman have presented some preliminary work on the microeconomic foundations of the merger.

obtain an estimate of the increase in feed-grain production based on a simple feed-grain supply equation. However, an increase in feed-grain prices may have substantial effects on livestock producers through higher feed prices, and the higher feed prices may lead to a reduced quantity demanded by the livestock sector. These effects, of course, could not be captured in a single-equation model.

In response to this problem, policy modelers began to add additional equations describing effects on other markets. The search for all of these effects has at times seemed endless as policy models have grown to hundreds of equations. Conceptually, these models are appealing since they allow for the feedback effects of repercussions in other markets. However, the cost has been high. Large, complex models require simultaneous solution techniques to assess the potential effects of policy changes. Also, a serious error in estimating an equation even in a market other than the one in which the policy changes are imposed can invalidate all of the results forthcoming from the model.

To exemplify the distinction between general and partial equilibrium approaches to policy modeling, consider the case where one wishes to model the beef-marketing sector to determine the effects of grain price policy and conceptualizes the problem (simplistically, for purposes of exposition) as follows. Consumers decide how much beef to consume, Q_b^d, based on the retail price of beef, P_b, and income, Y:

$$Q_b^d = Q_b^d (P_b, Y). \tag{1}$$

The beef-marketing industry (meat packers and retailers) decide how much beef to supply, Q_b^s, based on the retail price, the price they pay for fat cattle, P_f, and the wage rate of labor, P_L:

$$Q_b^s = Q_b^s (P_b, P_f, P_L). \tag{2}$$

The beef-marketing industry likewise decides how many fat cattle to buy, Q_f^d, based on the same prices:

$$Q_f^d = Q_f^d (P_f, P_b, P_L). \tag{3}$$

Feedlots decide how many fat cattle to sell, Q_f^s, and how many feeder calves to buy, Q_c^d, based on the price of fat cattle, the price of feeder calves, P_c, the price of grain, P_g, and the number of cattle placed on feed in a previous time period, N_{-1}:

$$Q_f^s = Q_f^s (P_f, P_c, P_g, N_{-1}) \tag{4}$$

$$Q_c^d = Q_c^d (P_c, P_f, P_g, N_{-1}). \tag{5}$$

Finally, cow-calf operators' supply of feeder calves, Q_c^s, depends on the price of feeder calves, P_c, and the price of hay, P_h:

$$Q_c^s = Q_c^s (P_c, P_h). \tag{6}$$

In addition, the system of supply and demand equations is closed by equilibrium relationships:

$$Q_b^d = Q_b^s, \; Q_f^d = Q_f^s, \; Q_c^d = Q_c^s.$$

Using the partial approach, the above six nonidentity equations would be estimated directly as specified. In the context of this system of equations, however, one can solve for general equilibrium specifications in each market. In doing so, one must keep clearly in mind the difference in true general equilibrium specifications and general equilibrium specifications in the context of a particular model specification. It is the latter possibility which offers advantages in policy modeling. In reality, the general equilibrium demand for beef may depend on factors underlying production conditions of many other commodities, influences on tastes and preferences for other goods, and a seemingly endless host of other factors. In the context of examining policies using the model above, however, the equilibrium effects obtained by solving the system of equations under several alternative policies (say, high grain prices and low grain prices) would not depend on such a wide array of factors; in point of fact, the effects could depend only on Y, P_L, P_g, N_{-1}, and P_h (or such changes as have well-defined effects in the context of a market model — e.g., a tax or quota) since those are the only exogenous factors in the system.

Following the abstraction of reality set forth in the above system of equations, the general equilibrium demand and supply for beef at the retail level are of the form

$$Q_b^d = \bar{Q}_b^d (P_b, Y) \tag{7}$$

$$Q_b^s = \bar{Q}_b^s (P_b, P_L, P_g, N_{-1}, P_h). \tag{8}$$

respectively; the general equilibrium demand and supply of fat cattle are of the form

$$Q_f^d = \bar{Q}_f^d (P_f, Y, P_L) \tag{9}$$

$$Q_f^s = \bar{Q}_f^s (P_f, P_g, N_{-1}, P_h). \tag{10}$$

respectively; and the general equilibrium demand and supply feeder calves are respectively of the form

$$Q_c^d = \bar{Q}_c^d (P_c, Y, P_L, P_g, N_{-1}) \tag{11}$$

$$Q_c^s = \bar{Q}_c^s (P_c, P_h). \tag{12}$$

To clarify some of the advantages of estimating equations in the general equilibrium form, suppose one is attempting to determine the effects of a grain price policy (with explicit effects on grain price) on the market transactions of consumers of beef. Using the partial approach and assuming all equations are specified linearly with constant terms (for simplicity of exposition), one must estimate 24 coefficients in six equations, whereas using the general equilibrium approach would require estimation of only nine coefficients in two equations [equations (7) and (8)]. Estimation of equations (9)-(12) would not necessarily be required. Solving for equilibrium prices and quantities is thus much simpler in the latter case because of the reduced dimensions of the problem (therefore corresponding to the guidelines of Principle 3). Finally, Just, Hueth, and Schmitz (1982) show that examining policy objectives, such as consumer and producer surplus using equilibrium supply and demand relationships in a single market, attains the same results in theory as summing results over all relationships in a system of partial specifications. Hence, policy analysis can also be simplified greatly (although with loss of distributional detail on the producer side in this case) while making the results subject to errors of estimation in fewer parameters.

Admittedly, the model specified above is quite simple but, nevertheless, illustrates the advantages of the general equilibrium approach to specification, estimation, and policy analysis. In the context of any specification of a system of equations describing a number of markets, however, one can, in principle, solve for equilibrium supply and demand equations for a particular market which describe, say, equilibrium supply price, demand price, quantity demanded, and quantity supplied as a particular policy instrument (e.g., a price support, quota, subsidy, etc.) is altered in the market. In practice, these relationships may or may not be simple to estimate as illustrated above depending on the complexity of the complete model specification. If not, however, it is often practical to estimate semiequilibrium relationships which correspond to equilibrium specifications of submodels.

For example, in the above example one may be considering effects of grain price policy in a larger model which also describes behavior in the grain market according to the equations:

$$Q_g^d = Q_g^d\ (P_g, P_c, P_f, N_{-1}). \tag{13}$$

$$Q_g^s = Q_g^s\ (P_g, A_{-1}, I_g, P_n). \tag{14}$$

$$Q_n^d = Q_n^d\ (P_n, P_g, A_{-1}, I_g). \tag{15}$$

$$Q_n^s = Q_n^s\ (P_n, P_p). \tag{16}$$

where

Q_g^d = quantity of grain demanded
Q_g^s = quantity of grain supplied
Q_n^d = quantity of nitrogen demanded for fertilizer
Q_n^s = quantity of nitrogen supplied for fertilizer
A_{-1} = acreage planted to grains in a previous time period
I_g = inventory of grain
P_n = price of nitrogen used for fertilizer

and

P_p = price of petroleum.

In this case, the general equilibrium demand and supply of beef in the context of the entire model composed of equations (1)-(6) and (13)-(16) are

$$Q_b^d = \tilde{Q}_b^d\ (P_b, Y) \tag{17}$$

$$Q_b^s = \tilde{Q}_b^s\ (P_b, P_L, N_{-1}, P_h, A_{-1}, I_g, P_p). \tag{18}$$

respectively, whereas the equilibrium specification for the beef market in equations (7) and (8) is a semiequilibrium specification which considers only equilibrium adjustments in the beef-marketing sector for given grain price. If, because of complexity (too many coefficients to estimate in a single equation) equation (18) is impractical to estimate, then the entire model in equations (1)-(6) and (13)-(16) could be replaced by one containing several semiequilibrium relationships, e.g., equations (7) and (8) plus the following semiequilibrium representation of the grain market above:

$$Q_g^d = \bar{Q}_g^d\ (P_g, P_b, P_L, N_{-1}, P_h) \tag{19}$$

$$Q_g^s = \bar{Q}_g^s\ (P_g, A_{-1}, I_g, P_p). \tag{20}$$

Thus, the model is reduced from one with 10 nonidentity equations with 42 coefficients to one of four nonidentity equations with 20 coefficients (assuming linearity with constant terms) while still reflecting the same phenomena. The complexity of the empirical model is thus greatly reduced although the underlying conceptual model does not involve any greater degree of abstraction.

Alternatively, depending on the policy objective, one could examine general equilibrium specifications for a different market. For example, the general equilibrium specification of demand and supply for the grain market in the context of the overall model in (1)-(6) and (13)-(16) is

$$Q_g^d = \tilde{Q}_g^d\ (P_g, Y, P_L, N_{-1}, P_h)$$

$$Q_g^s = \tilde{Q}_g^s\ (P_g, A_{-1}, I_g, P_p).$$

respectively, and is apparently no more complex than the semiequilibrium equations in (19) and (20). As implied by the work of Just, Hueth, and Schmitz (1982), estimates of these equations are appropriate for examining aggregate welfare effects associated with any standard intervention in the grain market for the entire group of decisionmakers whose behavior is reflected by equations (1)-(6) and (13)-(16).

Subprinciple'6.1: In policy model analysis, the emphasis should be on obtaining the most accurate conditional probability distributions for the relevant performance measures (after accounting for complexity costs).

This subprinciple is consistent with and implied by the principles of the post-Bayesian approach. The criteria used in estimating a model often do not correspond appropriately to the policy goals of interest in predicting the effects of alternative policies. For example, in an econometric model, each of the equations is usually. 'estimated with the criterion of minimizing the sum of squares of errors in a sample period. That is, in the feed grain/livestock case, one may minimize the errors in forecasting the quantity of feed grains produced given the level of a price support in one equation, minimize the errors in forecasting the quantity of feed grain consumed by livestock producers given the price of feed grains in other equations, etc. For policymaking purposes, however, one may be more concerned with the effects of the price support on the real income of feed-grain producers and livestock producers and consumers. Since the criterion in conventional estimation does not focus on accuracy in the latter forecasts, the value of the policy model may be far less than is potentially possible.

As a possible means of overcoming these problems as well, greater emphasis on estimation of general equilibrium relationships rather than partial equilibrium relationships offers promise. Simulation and forecasting in a model with many partial equilibrium relationships allow errors to propagate through a system of equations upon solution of the model, whereas the statistics of fit in the criterion of estimation of a general equilibrium relationship are more directly applicable to the forecasting mode.

Principles of Information Use

Principle 7: Policy modeling must provide for the use of intuition, both in model development and updating; strong intuition should override causal implications of coincidental data in model development.

Data use in policy models can never be allowed to become a substitute for sound, hard thinking about assumptions and alternative courses of action. To enhance the believability of policy models and their effective use by policymakers, new, potential local approximations must be continually investigated and evaluated. Prior information facilitates this investigation and evaluation. To accommodate structural change and track new and changing developments, the weighting of prior information must be revised constantly in policy models.

The relative weightings on prior information vs. sample information must depend upon the degree to which relevant policy instruments have been observed. When no prior experience (data) is available on the effects of particular policy instruments, even greater weights must be placed on intuition. New institutional designs involving discrete choices across alternative policy sets will lead to greater weight on intuition than will policy evaluations for instruments that have been applied under existing institutional designs. In this setting, the following subprinciple arises.

Subprinciple 7.1: Ample opportunities should be given for judgmental inputs, especially those provided by commodity specialists.

Subprinciple 7.1 suggests that the expertise and software must be developed for cost-effective interactions of policymakers and commodity specialists with the policy model. The basic premise for introducing information from commodity specialists into the analysis provided by policy models is given in Johnson and Rausser. To facilitate these interactions, experimentation with alternative information bases (various weightings across prior intuition and sample data) must be accomplished easily. Interactive software must be developed and maintained which allows policy scenarios to be developed both with and without the subjective input of commodity specialists. The sensitivity of such policy scenarios to the subjective input of commodity specialists should, indeed, be valuable for a number of purposes. To the extent that the information provided by commodity specialists is separable from other information sources for the constructed policy model, improved or more precise conditional policy distributions will be obtained for relevant performance measures.

Principle 8: Use of greater weight on more recent data in policy model estimation should be seriously considered.

The intuition of Principle 4 dictates that we are living in a world with constant structural change. We must accept the premise that models used for policy purposes are abstractions and approximations of reality. Thus, as the economy changes from time to time, one may find that not only should the structure used in the abstract model be changed but also, and perhaps more often, the models should be calibrated more closely to recent data. That is, to accommodate structural change and to track new and changing developments, the weighting of sample data must be revised constantly in updating policy models. In a world in which underlying forces change in an unpredictable way from time to time, this principle is formally supported by the results of Kalman filtering and adaptive stochastic control theory. In this framework, one does not view the world as having discrete structural changes between reasonably long periods of constant structure. Rather, structural change is viewed as a process which takes place constantly but with small and subjectively random increments. In this context, recent observations are far more valuable in predicting the future than are observations in the distant past although distant observations are still useful. Moreover, this consideration emphasizes the importance of continual maintenance and updating of policy models.

Principles 7 and 8, when combined with 3, 4, and 5, have some direct implications for assessment of the tradeoffs between the use of information from (1) economic theory, e.g., homogeneity, symmetry conditions, etc., (2) nonsample information, such as expert judgment, (3) recent sample data, and (4) the entire sample. The assessment of these tradeoffs must be determined in large part by the purpose for which a policy model is constructed (Principles 1 and 2). In general, however, the credibility of policy models will be enhanced by giving the most serious considerations to (1), followed by (2), (3), and (4) in that order. This ordering follows from currently available data support systems and the "local approximating" nature of quantitative models.

Subprinciple 8.1: Model maintenance and updating are continuous processes for which explicit expertise must be fostered.

Maintenance and updating must take place not only for growth and continual quality enhancement of policy models but also to avoid deterioration of the information in a policy model. Again, these arguments underscore the importance of viewing development and use of policy models as a process and not as the creation of a product.

Principle 9: General purpose data sets rather than general purpose models should be emphasized.

The use of the post-Bayesian approach, the need for constant revision of the weighting of sample information vs. intuition in model specification, the need to incorporate summary variables in policy models, and the need to evaluate new and different policy problems from time to time all dictate the need for an all-purpose data set rather than an all-purpose model. Two of the greatest problems policy modeling has faced historically have been the extreme complexity needed in a model in order to be able to address a wide set of issues unforeseen at the time of model construction and the extreme costs imposed by this complexity in model development and use. As evidenced by the experience of the Forecast Support Group in the USDA, complex models take years to build. Such models can often not be brought to fruition before some of the pressing issues have passed. Furthermore, even though a model may be made very large and complex, it may still not include the appropriate focus to evaluate some policy issue which is unforeseen at the time of the model development.

An alternative approach is to develop small policy models with specific policy focus at the time that specific policy issues surface as suggested by Principle 1. In order to pursue this approach, however, models must be developed rapidly if they are to have any bearing on the current policy considerations. Rapid model development can be facilitated by the maintenance of an all-purpose data set. That is, one of the largest costs both in terms of money and time involved in model construction is the acquisition of data and development of a data-management system and appropriate software for estimation. With the existence and maintenance of an all-purpose data set, a data-management system, appropriate estimation software, and a portfolio of previously constructed specific purpose models, a policy analyst can sit down at a computer terminal and develop a model with specific focus on the issues at hand in a matter of a few days. This has been borne out by the authors' own experience in which a model of moderate complexity (34 equations with 52 variables) was developed in less than a week through the use of a general-purpose data set.[6]

The maintenance of an all-purpose data set is also important in facilitating the use of summary variables in policy model construction. That is, with the maintenance of an all-purpose data set, the means of constructing price or quantity indices as the need arises is available. Thus, a policy analyst is less likely to be forced to use only representative variables in policy model construction.

No matter how general a general purpose model is, questions always seem to arise that are beyond the scope of the model. Moreover, what some would define as general purpose models others would argue are specific purpose. The essential point, however, is that actions which result in increasingly more general purpose models place insufficient weight on complexity costs. In this regard, the experience of the U.S. Department of Agriculture policy modeling effort speaks for itself.

6. The work by Feder, Just, and Ross on international lending policies of the World Bank also illustrates the preferred postsample predictability of a model with quantity relatives in the context of cross-section data.

Subprinciple 9.1: The principles of post-Bayesian analysis are also appropriate in governing the design and maintenance of a general purpose data set.

The design and maintenance of an all-purpose data set requires that some framework be developed to determine which variables should be initially included in such a data set and which variables should be added or deleted from a data set as additional experience is gained. Formally, these problems can be solved using the principle of preposterior analysis. That is, data base inclusions, augmentations, or deletions should be based upon intuition and judgment as well as experience in assessing the cost of maintenance vs. the potential policy modeling benefits. In the case of data set maintenance, however, these issues must be decided based on the entire collection of policy models and potential policy models rather than on the basis of a single policy model.

Principles of Policy Selection

Principle 10: Policies should be formulated with an appropriate degree of learning in mind.

If policy models are to become an important source of information in policy selection, then, in some instances, the policies should be determined so that a greater amount of information can be ascertained from observation of their effects. Principle 10 is supported formally by adaptive control theory which places some emphasis on the value of experimenting with an economy. The cost of such experimentation may be more than recovered by the benefits of setting the policy controls taking into account the potential value of improved perceptions of the system under examination.

Principle 10 is also related to the earlier discussion on the form and shape of much of governmental intervention in the agricultural economy. The form of this intervention in effect has made policy modeling difficult. Moreover, policies resulting from such intervention have placed, as expected, little value on information that might be generated from quantitative models. However, the "tidal wave" effect and the importance of path vs. magnitude emphasized by Hathaway (this volume) can be effectively managed by effective implementation of Principle 10 and the following subprinciples.

Subprinciple 10.1: Policy alterations should be imposed whenever possible by revising existing policy instruments rather than by determining a new set of policy instruments, subject to political feasibility.

Currently, historical agricultural policies generally result in instruments which are imposed only if certain fixed barriers or trigger points are reached. For example, acreage allotments and price supports represent fixed quantity and price barriers; set-aside requirements are imposed depending on whether the Secretary of Agriculture determines that some theoretical trigger point has been crossed. With such policy instruments, the effects of various policy controls may be observed in some years and not in others. Hence, less information is gained than if policy instruments were effective in varying degrees over the complete sample record. Data generated from such policy regimes call for analysis by means of qualitative econometrics thus greatly increasing the complexity costs of analysis and reducing the value of information forthcoming.

Subprinciple 10.2: Depending on administrative costs, policy instruments should be exercised in a smooth and continuous fashion conditioned on market conditions.

Greater value of feedback information from policy modeling would result from the implementation of Subprinciple 10.2. For example, government price-supporting operations for, say, wheat could be carried out by means of government purchases of 1 million bushels of wheat for every 1 cent per bushel the market price is below some target price (or, conversely, selling 1 million bushels of stock for every 1 cent per bushel the market price is above the target price). Similarly, a 1 percent set-aside could be required for every 20 million bushels of wheat in government reserves. Such policies are generally more consistent with economic efficiency in contrast to the form of existing policy instruments which are conditioned on fixed barriers and trigger points. They have the additional benefit of reducing policy risk and allowing farmers to reduce allocative inefficiencies. In other words, farmers are more able under such policies to correctly anticipate government actions based on their own assessment of market conditions. Too often, analysts concentrate on instabilities and distortions in the private sector and offer policies which, when implemented, lead to instability of the political administration system. In essence, the risk faced by individual farmers is transferred from economic markets to political markets.

As most agricultural policy instruments have been exercised historically, their effectiveness is largely dependent on market conditions. Thus, under many market regimes, no information is generated on the effects of the policy instruments. However, when policy instruments are exercised in a smooth and continuous fashion, governmental actions behave much as a demand or supply curve that can be observed at every time period. Thus, the information on the effects of policy instruments can be compiled with less empirical difficulty.'

Conclusion

We have offered a number of principles that may be interpreted as rules or a code of conduct which will allow the potential for quantitative policy models to be realized. They emphasize the tradeoffs that should be examined as we move from more conventional models (those with descriptive, explanatory, or forecasting purposes) to operational and usable policy models.

In the final analysis, of course, major benefits from modeling public policy problems depend critically upon the sound judgment and experience of public decisionmakers and the analyst involved. Only through such judgment and experience will it prove possible to balance the value of simplicity with the value of accuracy. Given the appropriate balance, the principal benefits of quantitative modeling will be achieved. These benefits include: inter *alia*, forcing the users or public decisionmakers and the analyst to be precise about perceptions of the system they are attempting to influence and testing these perceptions with available evidence, providing structure to the analysis, extending the policymakers information processing ability, facilitating concept formation, providing cues and insights to policymakers, stimulating the collection, organization, and utilization of data, freeing the decisionmaker and analyst from a rigid mental posture, and becoming an effective tool for negotiation and bargaining and as a basis for persuasion.

The above benefits can accrue to policy models provided the obstacles to achieving such potential benefits are avoided — obstacles such as timeliness, solving the wrong problem or solving the

7. For further elaboration of improved policy controls, see lust; and, for policy uncertainty, see Gardner et al., and Rausser and Stonehouse.

right problem too late, allowing improper expectations to form by not clearly delineating what the model can and cannot accomplish (the role of modeling efforts should always supplement rather than supplant the normal decision processes), and failure to differentiate the characteristics of the policymaker or user from the analyst (these are often very different types of people with different roles, responsibilities, expertise, cognitive style, etc.). The rules or principles advanced in this paper are an attempt to facilitate avoidance of the major obstacles in gaining the promised benefits of policy modeling efforts.

References

Anderson, J.R., "Simulation: Methodology and Applications in Agricultural Economics," ***Review of Marketing in Agricultural Economics,*** Vol. 42 (1974), pp. 3-55.

Brill, E.D., Jr., "The Use of Optimization Models in Public Sector Planning," ***Management Science,*** Vol. 25 (May 1979), pp. 413-22.

Chambers, Robert G., and Richard E. Just. "An Investigation of the Effect of Monetary Factors on Agriculture," *Journal of Monetary Economics* (accepted and forthcoming, 1982).

Chambers, Robert G., and Richard E. Just. "New Developments in Theory and Empirical Applications of Commodity Market Analysis: Qualitative Econometrics and Agriculture," In Cordon C. Rausser. ed., ***New Directions in Econometric Modeling and Forecasting in U.S. Agriculture.*** New York: Elsevier North-Holland, Inc., 1981.

Chernoff, H., ***Sequential Analysis and Optimal Design.*** Philadelphia: SIAM, 1972.

Faden, Arnold, and Gordon C. Rausser, "Econometric Policy Model Construction: The Post-Bayesian Approach," ***Annals of Economic and Social Measurement.*** Vol. 5 (1976), pp. 349-62.

Faden, Arnold, and Gordon C. Rausser. "Post-Bayesian Statistical Inference." unpublished manuscript, Department of Agricultural and Resource Economics, University of California. Berkeley, August 1981.

Feder, Gershon, Richard E. Just, and Knud Ross, "Projecting Debt Servicing Capacity of Developing Countries," ***Journal of Financial and Quantitative Analysis,*** December 1981.

Gardner, Bruce L., "Public Policy and the Control of Agricultural Production," ***American Journal of Agricultural Economics.*** Vol. 60 (1980). pp. 836-43.

Gardner, Bruce L., Richard E. Just, Randall Kraemer. and Rulon D. Pope, "Risk in the Structure of Agriculture," ***Risk Management in Agriculture,*** Peter J. Barry, ed., Ames: Iowa State University Press, 1982.

Hochman, Eithan, Gordon C. Rausser, Richard E. Just, and David Zilberman, "The Role of Agricultural Price Supports and Land Controls in Technological Adoption Under Uncertainty," unpublished manuscript, Department of Agricultural and Resource Economics. Unveristy of California, Berkeley, September 1981.

Hughes. D.W., and J.B. Penson, Jr., "The Value of Endogenizing Agriculture in a Multi-Sector Macroeconomic Model," Research Working Paper RWP81-07, Research Division. Federal Reserve Bank of Kansas City, August 1981.

Johnson, Stanley R., and Gordon C. Rausser, "Composite Forecasting in Commodity Systems." in Gordon C. Rausser, ed., *New Directions in Econometric Modeling and Forecasting in U.S. Agriculture,* New York: Elsevier North-Holland. Inc.. 1981.

Just, Richard E., "An Investigation of the Importance of Risk in Farmers' Decision," *American Journal of Agricultural Economics,* Vol. 56, No. 1, February 1974.

"Theoretical and Empirical Considerations in Agricultural Buffer Stock Policy Under the Food and Agriculture Act of 1977," prepared for the U.S. General Accounting Office, Volume 3, *The Farmer-Owned Grain Reserve — It has Partially Met Its Objectives, But Modifications Are Needed,* U.S. General Accounting Office, 1981.

Just, Richard E., Darrell L. Hueth, and Andrew Schmitz. *Applied Welfare Economics and Public Policy,* New York: Prentice-Hall, 1982.

Just. Richard E., David Zilberman, and Gordon C. Rausser, "The Role of Governmental Policy in Wealth Accumulation and the Appreciation of Agricultural Land Values," unpublished manuscript, Department of Agricultural and Resource Economics, University of California, Berkeley, September 1981.

Keeney, R.L., and H. Raiffa, *Decisions With Multiple Objectives: Preferences and Value Tradeoffs,* New York: John Wiley and Sons, 1976.

Lucas. R., "Econometric Policy Evaluation. A Critique," *Journal of Monetary Economics,* Vol. I, Supplement 3 (1976), pp. 19-46.

McKinsey Co., Inc., *Unlocking the Computer's Potential.* New York: McKinsey Co., Inc., 1968.

Peltzman, S., "Toward a More General Theory of Regulation," *Journal of Law and Ecotzomics.* Vol. 19 (1976). pp. 211-40.

Powell, A.A., "The Major Streams of Economy-Wide Modcling: Is Reapproachment Possible?" contribution to the Proceedings Volume of the NBER-NSF Conference on Macroeconometric Models, Ann Arbor, Michigan. October, 1978; also appears as Working Paper No. 1-09, University of Melbourne, April 1980.

Rausser. G.C., and Eithan Hochman, *Dynamic Agricultural Systems: Economic Prediction and Control,* Amsterdam: North-Holland, 1979.

Rausser, G.C., and E.P. Stonehouse, "Public Intervention and Producer Supply Response," *American Journal of Agricultural Economics,* Vol. 60 (December 1978), pp. 885-90.

Rausser, G.C., and J.W. Freebairn, "Estimation of Policy Preference Functions: An Application to U.S. Beef Import Policy." *Review of Economics and Statistics,* Vol. 56 (1974), p. 437-49.

Rausser. G.C., Y. Mundlak, and S.R. Johnson, "Structural Change, Parameter Variation, and Forecasting" in Gordon C. Rausser. ed., *New Directions in Econometric Modeling and Forecasting in U.S. Agriculture,* New York. Elsevier North-Holland. Inc.. 1981.

Rausser, Gordon C., and Chris Riboud, "Price Support and Demand in Commodity Market Modeling," in Gordon C. Rausser, ed., ***New Directions in Econometric Modeling and Forecasting in U.S. Agriculture,*** New York: Elseiver North-Holland, Inc., 1981.

Rausser, Gordon C., Erik Lichtenberg, and Ralph Lattimore, "New Developments in the Theory and Empirical Applications of Endogenous Governmental Behavior," in Gordon C. Rausser, ed., ***New Directions in Econometric Modeling and Forecasting in U.S. Agriculture,*** New York: Elseiver North-Holland, Inc.. 1981.

Rausser, Gordon C., Richard E. Just, and David Zilberman, "The Proper Mix of Econometric and Programming Formulations," unpublished manuscript. Department of Agricultural and Resource Economics, University of California, Berkeley, May 1980.

Schuh, G. Edward, "The Exchange Rate and U.S. Agriclture," ***American Journal of Agricultural Economics,*** Vol. *56* (1974), pp. 1-3.

Stigler, G.E., "The Theory of Economic Regulation," ***Bell Journal of Economics and Management Science,*** Vol. *2* (1971), pp. 3-21.