CORNELL AGRICULTURAL ECONOMICS STAFF PAPER

AN OVERVIEW OF APPROACHES TO MODELING AGRICULTURAL POLICIES AND POLICY REFORM

by

David Blandford

December 1989

No. 89-38

Department of Agricultural Economics
Cornell University. Agricultural Experiment Station
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853

It is the policy of Cornell University actively to support equality of educational and employment opportunity. No person shall be denied admission to any educational program or activity or be denied employment on the basis of any legally prohibited discrimination involving, but not limited to, such factors as race, color, creed, religion, national or ethnic origin, sex, age or handicap. The University is committed to the maintenance of affirmative action programs which will assure the continuation of such equality of opportunity.

An Overview of Approaches to Modeling Agricultural Policies and Policy Reform

by

David Blandford

Abstract

In recent years, a number of global models have been developed and used to analyze the domestic and international implications of agricultural policies. In developing countries, the introduction of reforms under structural adjustment programs, and pressures for broader multilateral trade policy reform under the General Agreement on Tariffs and Trade, have contributed to growing interest in such models. This paper reviews the types of approaches used in constructing global agricultural trade models, and their advantages and disadvantages. The major advantage of partial equilibrium models is their simplicity; they are both easy to construct and to understand. However partial models are limited technically by their neglect of important feedback effects of policy reform in the economies of developing countries. General equilibrium models can incorporate these feedback effects, but are more complicated to construct and to communicate to policymakers. Unlike the partial models, there is substantial disagreement on model structure among general equilibrium modelers, and this can have significant implications for the policy implications of results. In the future, both types of models will need to be improved in order to capture more accurately the effects of policies, and the dynamic implications of policy reform.

An Overview of Approaches to Modeling Agricultural Policies and Policy Reform[1]

David Blandford[2]

In recent years, there has been growing interest in both developed and developing countries about the effects of agricultural policies and policy reform. Developed countries, which typically subsidize agricultural producers and tax consumers, have become increasingly aware of the high costs of their programs. Developing countries are concerned about the impact on their economies of current or alternative agricultural programs in the developed countries, particularly since agricultural policy reform is a major item on the agenda of the current round of negotiations under the General Agreement on Tariffs and Trade. In addition, developing countries have experienced substantial economic stress under the global economic environment of the 1980s. Debt servicing problems, created by high interest rates and depressed export prices, have revealed weaknesses in domestic economic structures and policies. Many countries have embarked upon economic stabilization and structural adjustment programs, which frequently have significant implications for the agricultural sector.

The Need for Measurement

Faced with the prospect of both internally and externally generated change, developing countries need access to information on how their policies, and the policies of others, affect agriculture. The contribution that agriculture and related industries frequently makes to income, employment, and foreign exchange earnings in developing countries means that agricultural and trade policies can have a significant impact on national economic well-being. Insight is needed into the costs and benefits of alternative policies, in order to guide policy choice at both the national and multilateral levels.

The most important information which countries need is the effect of changes in policy on national economic welfare. Frequently, such change has distributional implications, and the welfare calculation may need to be sufficiently disaggregated to determine impacts on key groups within the economy, identified by functional type (e.g., producers or taxpayers), location (geographic region or urban-rural), or by levels of income or wealth. Additional economic indicators are often required, for example, changes in absolute or relative prices, levels of consumption and employment, and effects on the

---

[1] Prepared for the UNCTAD seminar on *Agricultural Modelling for Analysts from Developing Countries* held in Geneva, November 23-24, 1989. This paper draws in part on an earlier paper entitled "Global Partial Equilibrium Models and the Analysis of Agricultural Trade Liberalization" prepared for the joint OECD/World Bank Symposium on *Agricultural Trade Liberalization and the Developing Countries* in Paris, October 5-6, 1989.

[2] Professor in the Department of Agricultural Economics, Cornell University, Ithaca NY 14853, USA.

government budget and the balance of payments. These indicators enable policymakers to determine the effects of policy change on economic objectives, such as the rate of economic growth and development, and "non-economic" objectives, such as social stability and food security. In the context of the latter, information on both the level and variance of key indicators, such as food prices, is desirable.

The need for these types of information has stimulated the development of quantitative models which allow the effects of policies on key economic indicators to be calculated. The impact of policies can be complex. It is frequently difficult to determine the implications of a change in policy without the use of systems of equations which capture major behavioral relationships governing production, consumption and price formation. This is especially true at the international level, where changes in the policies of one country may affect the agricultural sector in another country through trade and price linkages.

For policymakers in developing countries, the relevant calculus of benefits and costs is a national calculus. Policymakers need to be able to determine the implications for their country of their own policies, or the policies of others. When a change in national policies alone is envisaged, it may be sufficient to construct a national model which assumes that international prices will be unaffected. When the trade of the country is a small proportion of world trade, this may be a realistic assumption. However, if a country accounts for a significant proportion of trade, or if other countries are implementing policy reforms, some consideration of world market effects will be required. For this reason, substantial effort has been directed in recent years towards the construction of multi-country models. These models differ in country and commodity coverage, in the detail with which they treat individual countries, whether they are static or dynamic, the way in which they represent agricultural policies, and whether they are partial or general equilibrium in nature. National agricultural models form the components of global models, and many basic features and problems are common to both. For these reasons, this paper focuses primarily on the global models.[3]

Partial Equilibrium Models

A number of global partial equilibrium models have been constructed to provide insight into the implications for domestic and international agricultural markets of existing and alternative agricultural policies. The models generate information on the effects of such policies on domestic supply, demand, and prices, the volume of international trade and "world market" prices. This information if often used to compute partial equilibrium welfare measures such as producers' and consumers' surplus. An important characteristic of the models is their ability to capture the price effects of policy changes across related

[3] For a comparative analysis of the results obtained by some of these models for trade liberalization in the developed countries, see Blandford (1988).

commodities, through substitution in supply and demand, and among countries through the trade linkage. The models do not typically analyze the effects of policies on trade flows between individual countries, but on aggregate net imports or exports. The information which different models provide on these factors is determined largely by their structure and the way in which agricultural policies are incorporated.

Major structural differences between models exist because of commodity coverage; country coverage; temporal properties; and the "partiality" of their partial equilibria. In many cases, commodity coverage is related to country coverage. Models which have been built primarily to analyze the effects of agricultural policies in industrial countries tend to neglect "minor" commodities; those with negligible production in these countries or which are not subject to significant government intervention. Only when such commodities are significant substitutes in consumption for those produced in industrial countries (e.g., the fats and oils group, or manioc in the EEC) are they usually included. Consequently, many commodities of interest to developing country exporters receive cursory treatment.

The models typically treat commodities as being homogeneous. For an importer, wheat from Canada, for example, is considered to be a perfect substitute for wheat from the EEC. This simplification implies that only the behavior of net trade can be analyzed, even though many countries have both imports and exports of a commodity group, and imports from different suppliers may not be perfect substitutes. An empirical evaluation of individual variation in a country's imports and exports is only possible if similar commodities are treated as imperfect substitutes. Interrelationships between commodities are reflected by cross price elasticities, but these do not always meet theoretical restrictions, such as symmetry and homogeneity. One area in which this may be particularly significant is in the relationship between livestock production and the production and use of grains and livestock feeds. Few models capture the complex and highly elastic economic linkages in this area, and yet in many countries the behavior of the livestock-feed complex is one of the most significant determinants of the effects of domestic agricultural policies on trade and prices. In general, differences in the assumed values of elasticities between models can be an important determinant of differences in results.

Country coverage is often related to commodity coverage. Where the focus is primarily on industrial countries, developing and centrally planned economies often receive cursory treatment. One of the major reasons for this is the difficulty of obtaining information on market parameters and policies in such countries. Work to rectify this problem should be a high priority for the future.

A further important structural characteristic is the temporal property of the models. Many are static with "medium term" elasticities. Only a few are dynamic. There may be substantial differences between the effects of changes in policy in the short term and their impacts in the longer term. Comparative static models can reflect these differences only through changing the values of elasticities, but this does not provide a complete picture of the process of change. The lack of dynamism means that the models as a whole also

provide limited information on stability, frequently an important concern of developing countries. They cannot determine the time path of the effects of changes in policy or evaluate the phasing of policy reform. Frequently, it is not only important to know the end result of a particular change in policy, but also what might happen along the way. The phasing of policy change and the implications of alternative policies for domestic and international market stability are important issues for both developed and developing countries.

Finally, there is the issue of how partial are the partial equilibrium assumptions in the models. Static models do not incorporate the effects of changes in such factors as income, except through comparative statics. Dynamic models have to deal with changes in income and other shift factors, but these are typically treated as exogenous. Changes in input prices are typically excluded, although there is some on-going work in this area. All models incorporate exchange rates which can be varied exogenously. One particularly important issue in the context of developing countries, is that changes in the agricultural sector may themselves have implications for income and the economy as a whole and hence further second-round implications for agriculture. Also macroeconomic policies, particularly exchange rate regimes, have a major influence on agriculture and agricultural trade in many developing countries.

General Equilibrium Models

The partial equilibrium models typically ignore the linkages between agriculture and the rest of the economy. If a change in agricultural production causes a change in the price of industrial inputs, such as fertilizer, this will not be reflected. If wage or interest rates are affected by changes in the demand for labor and capital, then these will not be captured. Such changes may not only have implications for the agricultural sector but will also influence activity in the rest of the economy. Changes in the balance of trade may affect the exchange rate and hence the competitive position of all export or import-competing industries. The price of non-traded goods and services may also be influenced by the change in economic activity brought about by agricultural policy reform. Computable general equilibrium (CGE) models explicitly recognize linkages between agriculture and the rest of the economy and try to quantify these.

Many of the CGE models developed to analyze trade and domestic policy issues have been national models. Unlike partial equilibrium models, there is substantial variability in the structure of CGE models and in their assumptions. This is not surprising given the complex economic relationships which they attempt to capture. Most models reflect supply through the use of production functions in which primary factors (for example, labor and capital) or classes of factors (skilled and unskilled labor) are combined to produce particular commodities or commodity aggregates. The demand side of the model typically includes households, the government, the capital account, and the rest of the world. Household income is derived from wages, profits, rents and transfers. Household consumption is typically reflected through an expenditure system. Several types of

households may be defined, for example, by income level. Government income is included through direct and indirect taxes, its expenditures on purchases of goods, and its transfers (e.g. between household types). The government surplus or deficit is the residual between inflows and outflows. The capital account deals with the flow of savings (private, government and foreign) which are used to purchase investment goods. In contrast to partial equilibrium models, the assumption is usually made in general equilibrium models that domestic and imported goods are imperfect substitutes in consumption.[4] CGE models solve for real prices and contain no assets or money. There have been some attempts to bring macroeconomic features into such models, but this typically involves the incorporation of exogenously-specified macro scenarios into the model.[5]

One of the major sources of difference between CGE models is their degree of neo-classicism. Some models assume that all prices are fully flexible, which implies that there will be full employment. Other models, particularly those for developing countries, incorporate structural rigidities, including administered prices and wages, and constraints on the movement of factors between sectors. These assumptions can lead to substantial differences in the predicted effects of policies.[6]

In many general equilibrium models, the agricultural sector is dealt with in a fairly aggregated way. Commodities are typically grouped together, for example, into classes such as "all grains" or "all export commodities". One reason for this is that it is difficult to derive the parameters for disaggregated models, particularly where there are important complementarity or substitution relationships in production. Many models treat the supply of each agricultural commodity as being determined by independent production functions of Cobb-Douglas or Constant Elasticity of Substitution forms. With these functions, substitution between commodities is only reflected through their competition for factors, e.g. labor. Some, such as the IIASA model, have adopted a more disaggregated approach to agricultural production (Parikh et al., 1988) and have attempted to improve the treatment of the substitution in production (e.g., Sadoulet and de Janvry, 1989).

Because of the complexity involved in their construction, there are relatively few multi-country CGE models with a detailed treatment of the agricultural sector or agricultural policies. The data requirements for such models are formidable. Some countries do not even have an input-output table, which forms the basic building block for the Social

---

[4] There has also been some work on this subject in partial equilibrium models through the use of the Armington model and its derivatives (Armington, 1969), but this has been limited in the context of multi-commodity global models.

[5] For a description and critique of the approaches used, see Robinson (1989).

[6] De Janvry and Sadoulet (1987) demonstrate the importance of the wage process for the predicted effects of agricultural pricing policies on the level and distribution of real income by using a number of national CGE models of developing countries.

Accounting Matrix (SAM), used in the construction of most CGE models. Therefore, it is not surprising that there are few models which are comprehensive in their treatment of agriculture and agricultural policies, and are able to capture the time path of the adjustment to policy change. The Basic Linked System model of IIASA is a notable exception which incorporates both of these features (Parikh et al., 1988). However, this model has a fairly simplistic treatment of the non-agricultural sector.

The Treatment of Policy

One of the crucial characteristics of both partial and general equilibrium models is the way in which they represent domestic agricultural and trade policies. The most popular approach has been to express the aggregate effect of policy as a tariff-equivalent or wedge between domestic and world prices. One of the simplest approaches is to compute the difference between a domestic price and an international reference price, possibly adjusting for transportation costs and marketing margins, and attribute this difference to the effects of domestic policies. A slightly less crude approach is to estimate the value of producer support (or consumer tax) per unit of output using a combination of domestic/international price comparisons and government expenditure data, and express these as a Producer Subsidy Equivalent (PSE) and Consumer Subsidy Equivalent (CSE). These can handle instruments whose effects are not reflected directly in market prices, such as input subsidies, but a decision must be made as to how such subsidies actually influence incentive prices. Models differ (and are often obscure) as to how they treat margins between domestic and international reference prices. This is not a trivial issue, since the structure of margins and the level to which model elasticities correspond (retail, wholesale, farm level) can affect substantially the potential response of production, consumption and trade to changes in policy.

All models make explicit or implicit assumptions about the degree to which changes in international prices are transmitted to domestic prices. Such assumptions can have a major impact on the results obtained. The only way to deal effectively with this price transmission question, and the differential effects of policies on incentive prices is to incorporate specific policy instruments into the models. This is time consuming, requires substantial detailed knowledge about the way in which policies operate in individual countries, and can often lead to models which are computationally difficult to solve. It is, therefore, not surprising that progress on the more accurate representation of policies in global models has been limited.

Future Modeling Priorities

It is easy to be critical of existing models. However, these models take a substantial amount of time and effort to construct. Even in their simplest forms they are extremely information intensive. Despite their limitations, the models have made a major contribution to increasing understanding of the domestic and international implications of agricultural policies. Important cross-commodity and transnational effects of agricultural programs can

be highlighted by such models. The inefficiency of many existing programs is made clear. The particular empirical results obtained differ for numerous reasons, including variations in structure and base period, and in assumptions about the effects of national policies. It is important to examine why such divergences arise, particularly when these are in key areas, such as the direction of price changes. Whether it is possible to resolve differences typically depends on the ability of analysts to agree on assumptions. Sometimes such agreement is difficult to achieve.

There are two areas to which both partial and general equilibrium modelers need to devote more effort in order the improve the usefulness of their analysis for policy purposes. The first of these is in the improved representation of policies. The use of price wedges or PSE/CSEs in models are simply not enough. These do not capture important discontinuities in the effects of policies nor the differing effects of alternative policies on the linkage between domestic and international markets. Measures of support, such as PSEs, will continue to be useful in their own right, but it is time for modelers to move on to the complicated but potentially rewarding area of incorporating individual policy instruments and instrument combinations in their models. For many of the general equilibrium models, this will inevitably mean that greater commodity disaggregation will be required. It is difficult to reflect the impact of complex combinations of policy instruments with the level of commodity aggregation used in many of these models. The improved representation of policy will represent a major challenge for modeling developing countries. It is often extremely difficult to obtain the necessary information to be able to model commodity markets and policies in non-industrial countries, but it is necessary to tackle this problem if we are to be able to provide more accurate and realistic assessments of the implications of changes in domestic policies.

The second priority area is the treatment of dynamics in the models. Many of the models can only be used for comparative static analysis. As indicated earlier, the short- and long-run effects of policy change may differ significantly. It is necessary to have information on the time path of change and adjustment in order to aid policymakers in making decisions. Furthermore, a number of authors have demonstrated that alternative policies can have substantially different implications for domestic and international stability of prices and trade volumes (e.g. Zwart and Blandford, 1989). For developing countries, stability is a fundamental issue, and yet few models provide much insight into this.[7] Dynamic models are needed to address the adjustment and stability issues.

[7] One notable exception is the Tyers and Anderson model (Tyers and Anderson, 1986), although the fairly simple treatment of policies in this model limits its ability to evaluate the complex issues involved.

Issues in the Choice of Approach

It is probably fair to say that there is a high degree of consensus among partial equilibrium modelers on model structure, assumptions, and priorities for the future. There is a high degree of consistency among the models in terms of the qualitative implications of their output (Blandford, 1988). Quantitative differences can frequently be explained in terms of the levels of agricultural protection in different base periods (Magiera and Herlihy, 1988). There appears to be a substantial consensus as to how the partial models might be improved, for example, through making them dynamic, improving the theoretical properties of their parameters, and deepening their treatment of policy. The partial equilibrium models are relatively simple in structure and can be explained fairly easily to non-specialists, for example, policymakers. Despite their limitations, it seems likely that partial equilibrium models will continue to play a substantial role in the analysis of agricultural policy options.

Less consensus on structure, assumptions, and priorities for the future appears to exist among general equilibrium modelers. There are significant differences between the neoclassical and structural schools of thought in terms of assumptions about the way in which factor markets function. There are several competing theoretical forms for production and demand systems; some of which have substantial differences in their properties. Because general equilibrium models are less transparent than partial models, it is often difficult to determine why models generate significantly different results. It is, therefore, not surprising that it can be difficult to communicate the logic of the models and their results to non-specialists, such as policymakers. These comments may sound unduly negative, but they are not intended to be so. There seems little doubt that in the future, the general equilibrium approach will be the principal means through which we will model agricultural policy. The long-run advantages of the approach far outweigh its costs, but these costs must be recognized. It will be a lengthy process to achieve the necessary consensus on structure, and to develop the communication between modelers and users, to make general equilibrium models the principal vehicle for policy analysis.

Empirical models can make a substantial contribution to improving understanding of the implications of agricultural policies. The debate between modelers on the most "appropriate" modeling approach will inevitably continue. But for the users of models, it is benefit-cost analysis which should determine what type of approach is adopted. If information is scarce and costly to obtain, and the benefits to be gained from *any* analysis of policy options are high, it is likely that simple approaches are likely to be preferable. As the information needed to construct more complex models becomes available, and modelers and model-users progress to higher points on the learning curve of model development, more complex forms will become appropriate. Choice of technique must be sensitive to both needs and capacities if models are to make a sustained and meaningful contribution to agricultural policy analysis.

References

Armington, P. S. "A Theory of Demand for Products Distinguished by Place of Production". **IMF Staff Papers**. 16, 1969, pp. 159-176.

Blandford, D. "The Impact of Freer Agricultural Trade: A Review of the Empirical Evidence." Background paper prepared for the International Agricultural Trade Research Consortium Symposium entitled ***Bringing Agriculture into the GATT*** held in Annapolis, Maryland, August 1988.

de Janvry, A. and Sadoulet. "Agricultural Price Policy in General Equilibrium Models: Results and Comparisons". **American Journal of Agricultural Economics**. 69, 1987, pp. 230-246.

Magiera, S. and M. Herlihy. "Comparing World Price Changes for Trade Liberalization Models". Background paper prepared for the International Agricultural Trade Research Consortium Symposium entitled ***Bringing Agriculture into the GATT*** held in Annapolis, Maryland, August 1988.

Parikh, K. S., G. Fischer, K. Frohberg, and O. Gulbrandsen. **Towards Free Trade in Agriculture**. Mortimers Nijhoff. Amsterdam. 1988.

Robinson, S. "Computable General Equilibrium Models of Developing Countries: Stretching the Neoclassical Paradigm". Paper presented at the joint OECD/World Bank Symposium entitled ***Agricultural Trade Liberalization and the Developing Countries*** held in Paris, October 1989.

Sadoulet, E. and A. de Janvry, "Growth and Welfare Effects of a GATT Agreement in Agriculture on the Developing Countries; A General Equilibrium Analysis". Paper presented at the joint OECD/World Bank Symposium entitled ***Agricultural Trade Liberalization and the Developing Countries*** held in Paris, October 1989.

Tyers, R. and K. Anderson. "Distortions in World Food Markets: A Quantitative Assessment". National Center for Development Studies, Australian National University, Canberra, January 1986.

Zwart, A. C. and D. Blandford. "Market Intervention and International Price Stability". **American Journal of Agricultural Economics**. 71, 1989, pp. 379-388.

Other Agricultural Economics Staff Papers

No. 89-26	Economic Dimensions of CO_2 Treaty Proposals	D. Chapman T. Drennen
No. 89-27	A Conceptual and Operational Framework for Teaching Management to Farm Managers	R. Milligan G. Hutt
No. 89-28	Human Resource Management: Program Needs in Organizing Farm Businesses	R. Milligan
No. 89-29	Policy Education to Build Local Capacity to Manage the Risk of Groundwater Contamination	D. J. Allee C. W. Abdalla
No. 89-30	Hunger or Plenty? The Food/Population Prospect Two Centuries After Malthus	T. T. Poleman
No. 89-31	Statement for the Subcommittee on Courts, Civil Liberties and the Administration of Justice for Hearings on H.R. 1556 the Transgenic Animal Patent Reform Act, Washington, D.C.	W. Lesser
No. 89-32	Does a New Technology's Profitability Affect Its Diffusion?	J. M. Love
No. 89-33	Honey Industry Survey: Summary of Pretest Response	L. S. Willett
No. 89-34	Generic Dairy Promotion Economic Research: Past, Present, and Future	O. D. Forker D. J. Liu
No. 89-35	Income Tax Management and Reporting for Christmas Tree Growers	S. F. Smith
No. 89-36	Equitable Patent Protection for the Developing World	W. Lesser J. Straus W. Duffey R. Vellve
No. 89-37	Farm Policy and Income-Enhancement Opportunities	O. D. Forker