Miscellaneous Publication 8--1981
Minnesota Agricultural Experiment Station
University of Minnesota

Evaluation of Agricultural Research

Proceedings of a Workshop Sponsored by NC-148
Minneapolis, Minnesota May 12-13, 1980

TECHNOLOGY ASSESSMENT AND THE NATIONAL MODEL

Klaus Alt, Earl Heady, and Burton English*

We present possibilities for generating economic intelligence by use of a national model to aid in the assessment of technological changes and research returns. At the outset, we want to differentiate two types of technology assessment: _ex post_ and _ex ante_. The _ex post_ assessment measures what has happened in the past; a national programming model is not an efficient tool to measure this type of change. The _ex ante_ assessment suggests which types of technological change could occur in the future and/or which types of change should occur to satisfy future demands. It is the latter assessment for which a national programming model is uniquely qualified. We will restrict this paper only to the _ex ante_ assessment.

The objective of this type of analysis is to generate information on the possible impacts of technology changes. There are several alternative ways of meeting this global objective. One can look at technology changes which are either presently underway or imminent and assess their impacts on methods and location of agricultural production, levels of output, resource returns, shadow prices, consumer and producer surpluses, and other target variables. Alternatively, one can use such a model to identify the priority areas for research and extension, either on a regional, crop, or production process basis. Finally, one could "solve the equation backwards" by specifying future demand levels and solving for the technology changes required to meet those levels.

The traditional studies estimating returns to research are on an aggregative basis for all of agriculture, although there are a few for individual commodities such as poultry and hybrid corn. The aggregate estimates tell nothing about where the marginal returns from research expenditures are greatest. Neither do they tell us whether marginal returns from research investments are constant, increasing or decreasing. Also, those which estimate returns for an individual commodity do not allow us to make comparisons of marginal research returns for other commodities.

Our programming models could be used for such purposes. We could go to the extreme and use linked linear programming - recursive simulation models to trace out these possibilities over time. We could use a quadratic separable programming model to estimate these details at a point in time. Or, we could use a simpler linear programming model for this purpose. We suppose that such a model incorporates a sufficient number of regions to express regional differentials in climate, natural resources and income conditions of agriculture.

Agricultural scientists could (1) list each possible new innovation in agriculture which is known and/or (2) list each potential innovation possible. Even for the latter case, they also could quantify estimated yield effects and required inputs. (Scientists should do this anyway as they go about their research, as a manner of giving it intellectual ordering.) Then these estimates of yield effects and input requirements can be incorporated in the model. The results of each innovation, by crop, cropping practice, and region, could then be traced. Under this detail, the marginal return of each practice, or of practices in combination, could be estimated in terms of either (1) resources saved to attain given demand levels, (2) producers' and consumers' surplus, (3) income increases or declines to agriculture, (4) the distribution of these economic impacts by land class, by producing area, or by agricultural commodity, (5) the shifts in production by crops and regions, (6) changes in supply prices of crops--nationally or by regions, (7) etc.

There are many alternative national program-

---

*Klaus Alt is a Project Leader, Natural Resource Economics Division, Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture and Assistant Professor, Department of Economics, Iowa State University. Earl Heady is a Distinguished Professor, Department of Economics, Iowa State University and Director of the Center for Agricultural and Rural Development, Iowa State University. Burton English is a Research Economist of the Center for Agricultural and Rural Development.

ming models available to researchers; these range from the very aggregated to the very complex. On the aggregate end of the spectrum, one can find demand-and-supply-function models for a single commodity with no regional detail. On the complex end, one finds multi-region models with many commodities and thousands or tens of thousands of alternative production processes. We are involved in the latter type of programming models. Some of these programming models are linked recursively with econometric simulation programming models so that endogenously determined prices are fed back to determined output and resource use--which again impact through the model on prices. Other models incorporate demand functions and in quadratic form determine prices, production, and resource use endogenously. They have been used on a separable basis to estimate consumer and producer surplus from various types of change in agriculture.

There is not time (nor reason) to explain in detail the features and capabilities of the several ISU models; each has its own merits, drawbacks, and peculiarities. For the purpose of this discussion, it suffices to describe these models as having many production regions (most models have 105 producing regions to cover the 48 contiguous states) and a large number (now about 40,000) of crop production possibilities, differentiated by 330 crop rotations, four tillage methods, three soil conservation methods, and five land classes. This massive amount of detail makes it feasible to use these models to generate information on, for example, the regional change in crop production levels and methods induced by a certain type of technological change in a comparative static analysis.1/

We will describe some of these possibilities in a bit more detail. A first type of analysis deals with the effects of technological change which increases the yield of specific crops. This yield increase may occur at differential rates in different regions of the country. It is then a relatively simple task to change the crop yields in the model and solve for the new regional distribution of crop production. Intuitively, we would expect to find a relative concentration of this crop in those regions of highest yield increase; a national model of sufficient regional detail will show such a result as a comparison of "before" and "after" runs.

A second type of analysis deals with technological change which is cost changing, either cost-decreasing or increasing. Again, it is relatively simple to adjust the crop production costs in the model, solve the revised model, and compare the results to a base model solution to identify the changes induced by the technological change.

The third type of analysis is probably the most common, namely a technological change which changes yields, costs, and other production input requirements. Again, the approach will be to compare two "with" and "without" model solutions to identify the induced changes. Despite its apparent simplicity, this method is very powerful. It allows us to point out potential regional shifts of production; it can indicate whether an economically marginal region may drop out of production or whether it will gain by the technological change. This method allows us to identify shifts in crop production that might be missed by other analysis methods.2/

Each of the previous types of analysis is based on what might be called a "limited" kind of technological change, either changing yields, costs, or both. There are broader types of technological change which may change basic crop production processes, introduce totally new crops, or some other major change. Can a national model handle those changes also? Certainly it can, with the proper data and skillful programming.

A change in technical crop production processes may be induced by outside pressure, as, for example, a ban on specific tillage practices imposed by environmental legislation. Alternatively, such a change may come from economic pressures, such as a reduction in tillage operations induced by higher energy costs. In either case, a national model can determine the end results of such a change if enough production alternatives are specified in the model. Clearly, this method may require us to specify budgets for production processes which are not presently used or which are only experimental. It becomes a challenging task in itself for the researcher to determine these relevant alternatives and to generate the model budgets. If the researcher is successful in this specification,3/ the model will point out some directions of change and the magnitude of changes on a regional and national level.

The same argument applies for other major technological changes, such as introductions of new crops. Again it is up to the researcher to exercise his expertise in developing the production budgets to include in the model. But note that a national model is a uniquely well qualified method to trace through the regional and national impacts of such potential technological changes.

One can use a national model to help determine priority for research and extension expenditures. This method would use a series of "what if" model runs to solve for the effects of several alternative R & E expenditure targets. A comparison of the results of the several model runs against the decisionmaker's list of priorities should help him/her to choose the most desireable policy, or the research and development investment which gives the greatest return. This use of the national model as a decisionmaking tool has in the past perhaps not received the attention it deserves.

We mentioned a final type of analysis in the introduction, namely to solve from the desired future output levels backwards to the required rates of technological change. In one sense this is the most difficult analysis, because even if we know the future goal, there may be a large number of alternative means to achieve that goal. In this analysis, a national model also can serve a useful function as a decisionmaking tool, because it allows us to estimate the regional and national effects of alternative paths of technological change.

In summary, we have suggested several alternative methods of using national programming models to generate intelligence on the assessment of technological change. Such programming models can be a useful tool in the research or decisionmaking process. They can show expected returns from alternative research investments in different crops or livestock, in different management practices, in different land classes, and in different regions. Thus, they could provide a fairly detailed analysis of the expected marginal return from research in different commodities, regions, etc. However, they also can have importance in indicating which regions, crop groups, and farmers may gain or lose from particular innovations.

Footnotes

1/Full details and documentations on the several ISU models have been published. The publications also include many research reports with national results and regional implications under a variety of assumptions, time horizons, level of detail, and other variables. A full list of completed reports and information on models in progress are available from the authors.

2/ISU models had forecast an increase in soybeans in the Southeast long before that became an acceptable prognosis.

3/If he is not successful, he will succumb to the GIGO syndrome (Garbage In-Garbage Out).