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Agricultural Energy Modeling For Policy Purposes

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Major economic problems of rural areas over the last three decades stemmed importantly from the large supply and low real price for energy and energy-related inputs. These problems were not analyzed and modeled as specific energy problems because the energy component was a small part of a broader economic and social system. It was impossible to isolate and quantitatively identify the impact of energy supplies and prices per se. It also is likely that high energy prices in the future will have economic impacts which are so broad that quantification of energy effects will be difficult.

There are, however, energy problems which can be modeled to supply important policy information. Those of the individual farm are rather obvious. The level of energy prices to cause pump irrigation to be unprofitable or grain drying from crop residues to be profitable can be analyzed readily with programming, simulation or budgeting models. Hence, we turn to broader problem sets. Major future problems will relate especially to energy prices. Prices will be high because supply is short relative to demand or institutional measures are used to encourage energy conservation, production or substitution.

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Price Related Problems

Energy price uncertainty is a problem encountered by all types of modeling approaches. Between 1965 and 1972, the farm index of energy prices rose 1.5 percent per year (Statistical Reporting Service, 1977). Over the period 1972-76, it rose at an annual rate of 15 percent. Conventionally, we expect econometric models to be built to predict the structure of supply and demand for a resource, and thus to forecast prices. But we doubt that data exist for doing so in face of changes in the energy market which has broken from its past structure. While econometric models may not provide price forecasts, potentials for analysis under uncertain prices exist. Price uncertainty itself presents interesting modeling opportunities. For farms, various decision models under uncertainty might apply. Programming models with parameterized energy price might be used to evaluate prospects in pump irrigation, substitute energy sources, etc.. For more macro aspects of agriculture, different pricing environments provide alternative scenarios in evaluating impacts of varied prices for energy. Contrasting results from these scenarios can be communicated to administrators faced with decisions on energy price, conservation, production, and distribution policies. Alternative price scenarios seem particularly relevant for simulation and programming models developed to trace the impacts of changing energy prices through the agricultural systems.

With major impacts through energy prices, the supply prices of agricultural commodities might be expected to increase and bring forth a second problem set. With the supply function shifting to the left, gross revenue of agriculture should increase under inelastic food demands. If

revenue effects override cost effects, net income of agriculture also would increase at sufficiently high energy prices. While these results of new energy price structures theoretically would prevail, we know nothing of the price levels needed to bring them about. Neither do we know the time lag which might cause output to decline under sustained high energy prices. Higher food prices augment problems of inflation, low income families and export goals. Tracing quantitatively the impact of high energy prices on food supplies and prices would have considerable potential utility for policy makers. These relationships are difficult to model. Because time series observations under the new energy environment are few, it is unlikely that econometrically-based models can allow prediction of the effect of higher energy prices on food supplies and prices. Alternatively, simulation and programming models might serve as imperfect substitutes in evaluating certain price impacts. For example, the commodity shadow prices generated under various energy price levels in a national programming model could suggest how supply prices of commodities may be affected. The normative nature of the estimates would, of course, need to be recognized. No model can answer policy questions of whether energy in agriculture should be subsidized to prevent negative impacts on inflation and low income consumers, but results of the model could suggest indirectly how serious these impacts might be.

As a third major problem set, higher energy prices will spawn inequitable income redistributions. While restrained commodity supply functions for agriculture could increase the sector's aggregate revenue, producers of some commodities and locations will gain at the expense of

others. Shifts in income generally will parallel interregional redistributions in crop production and land and water use. Regions with chemicals or groundwater irrigation as dominant inputs can suffer large declines in net income. The decline in resource values can be drastic in areas where irrigation ceases. Linear programming models provide a capability for identifying these interregional shifts. Through shadow price analysis, they also may suggest magnitudes of compensation relevant for sacrificing farm groups. However, income equity problems extend beyond agriculture. Rural communities with an economic base linked to irrigation also may have a sharp decline in income and employment. Input-output models might capture some of the resulting impacts on other rural community sectors as the structure of agriculture shifts due to high energy prices.

The fourth major problem set relating to higher petroleum prices is that of substitution. With price increases for one energy form, other forms will be substituted for it under favorable substitution rates and relative prices. Policy increasingly will be directed at substitution of other energy sources for petroleum. Attention already is being directed to solar grain drying, solar-powered irrigation, anaerobic digestion of manure, harvesting agriculture's biomass for conversion to electricity and production of energy crops. The feasibility of some of these conversions can best be tested by farm level models. Harvesting and transporting biomass to a generating plant implies a model with spatial and allocative features such as linear programming. On a larger scale where biomass harvesting and energy plant production compete with food production in a national context, both simulation and programming could be model candidates.

A nod seems to go to programming in its ability to incorporate more detail by location and to allocate resources and regions to energy or food crops relative to energy processing centers. Such models can provide information, although not on a predictive basis as in a statistical model, on levels of petroleum prices necessary to cause either source of substitution to be economic, the number and location of generating plants needed, the land and crops best allocated to energy production, and similar items. Coupled with an input-output component, they could indicate requirements and impacts on other sectors of agricultural communities.

Opportunities and Limitations in Modeling

We designated four broad problem areas related to higher energy prices; namely, price uncertainty, supply prices for agricultural commodities and food, changes in income and its distribution, and the substitution of energy forms. Most specific energy problems fall in these categories. These problem sets vary so much in nature that a single overall model cannot be specified which will provide a quantitative base for policy decisions in all of them. Aside from firm models, some of them will need to be on the scale of a small region; e.g., the supply area of a generating plant. In other cases, they will need to be on the scale of a large region; e.g., an entire region of groundwater irrigation. Some problems require a national model with interregional linkages to indicate pricing and income distribution effects.

Four categories of models are candidates for evaluating impacts under rising energy prices or energy shortages and include: econometric

models for estimating behavioral responses with respect to changing energy prices, simulation models to trace impacts through a system with synthesized or statistical estimates of parameters, input-output models to describe interrelationships between energy and other subsectors under specified changes in demands, and mathematical programming which provides a normative approach in describing potential response, alternative allocations, resource values, and related quantities. Each approach has advantages and disadvantages relative to different problems to be analyzed. Potentials for statistical models are limited because of restricted time series observations in an economic environment where energy prices are high. They are even more limited for analysis of problems such as biomass utilization or energy crop production in agriculture. Similarly, input-output models can describe interrelationships in use of energy and other inputs or outputs but are restricted importantly by the amount of data available or a complete lack of historic data relating to nonconventional energy forms or utilization methods. Simulation models are more flexible in the sense that parameter estimates can be synthesized for new alternatives. Yet building up data sets can be burdensome for this method and for programming models. Programming has the potential of providing great detail of energy pricing or supply impacts on land and water use or the environment, resource values, interregional redistributions in production, farm income, and related quantities. Yet the results are generated in a normative framework and thus are somewhat qualitative characterizations of behavior expected under future "real world" conditions.

Data paucity and validation

Data for programming and simulation models also are scarce. However, opportunity to generate coefficients for them does exist in engineering approaches. The estimates can be improved over time through engaging physical scientists in the process and in more detailed specifications of the models and their parameters. Initiation of federal projects for specific purposes of estimating basic quantities can help. An example is the SRI project to provide county estimates of biomass availability from crop residues (Alich et al., 1976). Data will be improved as more people work on the problem set for a longer time period. Cooperation among different groups working on energy models can be helpful.

Validation problems exist both for estimates of parameters to be used in models and for the models themselves. Difficulty in validation of parameter estimates prevail especially where the coefficients must be generated by engineering processes. Perhaps validation is best approximated in breaking a process into its components and estimating the energy quantities separately. Checking parameter estimates with scientists experienced in particular fields could be useful. After an initial set of coefficients has been estimated, a Delphi survey could even be conducted among scientists experienced in the area. Problems of model validation prevail especially for simulations or analyses of situations which have not previously prevailed. As a substitute, validation is best accomplished through use of careful logic in specifying the model, a detailed a priori representation of the system being modeled and careful gauging of empirical results against general knowledge of the real world.

Improving the effort

Modeling efforts will be improved as we have more experience. One seldom develops the all time model on first effort. Instead, he builds several generations of models, each being a step to subsequent generations. While early generations may be incomplete, they can provide information which allows more efficient policies than if decisions were "made in the dark." They improve as subsequent generations are more completely specified, include greater detail and use improved data. Improvement can come as more persons work on problems of energy and models adapted to it.

A National Programming Model

Our modeling has been by means of a national programming model (Dvoskin and Heady, 1976; Dvoskin, Heady and English, 1977). It is specified for the analysis of the relationships of energy prices and supplies with land use, water use and supply sources, fertilizer use, tillage practices, commodity supply prices, and interregional shifts in resource use, production, resource values, and farm income. We developed this model because it allows analysis of problems of importance to the whole of agriculture and its regions.

The current model has land restraints for 105 producing regions, 938 restraints overall, and 12,000 real activities. It provides regional detail on land and water use, crops grown, tillage practices, energy and fertilizer use, and shadow prices for resources and commodities. Activities in the model simluate crop rotations, water transfer and distribution, commodity transportation, chemical nitrogen supplies, manure nitrogen

supplies, and energy supplies. Point commodity demands and a transportation submodel are defined for the model's 28 market regions. The model allows replacement of nitrogen fertilizers by animal wastes and nitrogen fixation. It allows interregional shifts in crop mixes and substitution among minimum and conventional tillage practices. It allows different levels of nitrogen and water use on crops as energy prices vary.

Major scenarios analyzed include higher prices and reduced supplies of energy. One modification minimized national energy use in crop production (Dvoskin and Heady, 1976). Another examined policies of natural gas deregulation and curtailment for irrigation (Dvoskin, Heady and English, 1977). A new version of the model evaluates potentials in harvesting crop residues and producing energy crops. Model solutions suggest important adjustments and regional redistributions under various energy situations. High energy prices cause important interregional shifts in resource use, crop production and income. Impacts are greatest in the energy-intensive irrigated regions. The model identifies the regions shifting to dryland agriculture. It also shows dryland regions which would gain in producing crops formerly grown in irrigated areas. It indicates the extent by which land might be substituted for energy through interregional land use shifts. Future solutions may show whether this type of adjustment is more efficient than harvesting biomass, producing energy crops, or other energy adjustments. Since it generates shadow prices for land, water, and commodities in each region, the model provides normative indication within agriculture of the distribution of income sacrifices and benefits as energy prices and supplies are varied.

Footnotes

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References

Alich, J. A., R. E. Inman, and K. Ernest. An Evaluation of the Use of Agricultural Residues as an Energy Feedstock, Volumes I, II. Stanford Research Institute. PB 260 763 National Technical Information Service, July 1976.

Dvoskin, Dan and Earl O. Heady. U.S. Agricultural Production Under Limited Energy Supplies, High Energy Prices, and Expanding Agricultural Exports. CARD Report 69. Center for Agricultural and Rural Development, Iowa State University, Ames. November 1976.

Dvoskin, Dan, Earl O. Heady, and Burton English. National and Regional Impacts of the Natural Gas Crisis, and Increased Energy Prices for U.S. Agricultural Production. CARD Report. Center for Agricultural and Rural Development, Iowa State University, Ames (forthcoming 1977).

Statistical Reporting Service. Agricultural Prices Annual Summary 1976. U.S. Dept. of Agr. PR 1-3(77). June 1977.