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RESEARCH AND EXTENSION ISSUES IN PRODUCTION ECONOMICS

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INTRODUCTION

The role of the economist in agriculture has increased in significance in the 1970s and 80s. A review of the recent history of agriculture begins with the period of stability and relative certainty of agricultural input and product prices in the 1950s. But by the 1970s, the economic impacts of the oil crisis, inflation, and orientation to free market prices of agricultural products necessitated a transition in the role and importance of the agricultural economist. Economists became vital to farmers who had to make economic decisions on appropriate cropping patterns, when and how to market products, and how to invest wisely.

A discussion of the future role of the agricultural economist requires some examination of the development of the agricultural scientific community. Production economics is now viewed as an integral part of agricultural research. Further, the agricultural economist is expected to be competent in the on-farm use of computers. Many far-reaching governmental policies require sophisticated economic analysis. The agricultural community now expects economists to meet its increasingly complex needs. This paper addresses production economics and farm management specifically, although there are many interrelationships of production economics with marketing, policy, international trade, and finance.

ERA OF STABILITY

Input prices, relative to product prices, were lower in the 1950s and 60s than they are today. For example, in the 1960s farmers paid $0.32/mcf for natural gas, $0.195/gal. for gasoline, $0.13/gal. for diesel, and $.061/lb. for nitrogen in anhydrous ammonia. They received $1.80/cwt. for sorghum, $0.27/lb. for lint cotton, $2.50/bu. for soybeans, and $1.80/bu. for wheat (Grubb, et al.). A less specific example is provided by comparing the ratio of prices received to prices paid by U.S. farmers using 1910–14=100. The average ratio for 1965–73 was 91, compared to 84 for 1974–80 (USDA). In 1980, the ratio was 77.

Before 1970, the profit level was near maximum yield level, i.e., the maximum yield was about equal to maximum profit. Take, for example, a production function for corn response to irrigation on the Texas High Plains (Petty et al.). The estimated function is as follows:

$$Y = 15.2 + 9.48W - .16W^2$$

where

Y = bushels of corn per acre, and
W = acre inches of irrigation per acre.

Based on this function and a corn price of $1.20/bu., with a water price (cost to pump) of $0.30/acre inch, profit maximization would be at an irrigation level of 28.8 acre inches, or a yield of 155.5 bu./acre. Maximum yield is at 155.6 bu./acre, or 29.6 acre inches of water. But at current corn prices of near $3.00/bu., with a water pumping cost of about $3.00/acre inch, the profit maximizing level of irrigation water declines to 26.5 acre inches. Where water costs are approaching $4.00/acre inch, the profit maximizing irrigation rate is reduced to 25.5 acre inches.[1] This example can be extrapolated generally across the country and to practically every input. The concept of maximum profit being approximately at maximum yield set the stage for progress in production agriculture up to the early 1970s.

Livestock production developed in a manner analogous to crop production. Trends in beef cattle breeding and feeding concentrated on the use of low-cost feed grains and highly finished cattle in the 1950s and 1960s.

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[1] There are many issues not addressed in this rather simple illustration: for example, critical water periods for plants, opportunities to improve irrigation distribution efficiency, and possible temporal implications of groundwater withdrawal, to name a few.

The goal was to achieve high yields, which was economically rational. Lending institutions evaluated producers on the basis of average crop yields. Economic thresholds were the points at which yields would be reduced, and insecticide recommendations were established with that in mind. Production agriculture evolved to produce relatively high yields with large inputs of energy and chemicals.

This thinking affected the education of agriculturists. Although the role of the production economist was important during the rather stable period of crop and input prices, physical production of crops and livestock was emphasized much more than economic analysis. After all, the goal was to produce more by increasing yields or conversion efficiencies. Farm fundamentalism prevailed in the agricultural research and educational institutions, and the objective of growing two blades of grass where one grew before (Tweeten) did not require an economist. Throughout the United States, research and extension centered on the physical sciences.

AGRICULTURE IN TRANSITION

The early 1970s saw an end to the relative stability of earlier decades. No more was the major unknown the yield of a crop. The cost to produce the crop and price of the crop became the crucial unknowns. For example, the standard error of the prices-paid index by U.S. farmers is 17.5 for 1950–70, compared to 152.2 for 1970–80, with the coefficient of variation 6.4 and 28.2 for the same periods, respectively. Interestingly, the same statistics for the prices-received index are very similar (USDA).

Conservation of energy became an issue, and rising exports of agricultural products began to alter markets in the 1970s. The role of and need for the production economist was demonstrated in all states.

Yet the United States had few economists in county agent or regional specialist positions. Furthermore, the rather limited input of economists to past efforts of research and extension institutions left serious gaps that could not be rectified quickly.

The agricultural infrastructure still reflects biases of the decades of development through the 1950s and 60s. Curiosity about the role of economists is expressed by some county agents and physical scientists. The concept of maximizing yields is far from gone. The attitude that any technology which increases yield is beneficial to the farmer and needs to be immediately adopted is often voiced in agricultural institutions. The past role of production economics was a passive one, but questions being asked by agricultural producers now force the production economist to take a major and very active role in U.S. agriculture.

Foreign Agricultural Sales

The United States became increasingly dependent on export markets for major commodities in the 1970s, as shown in Table 1. In recent years, the United States has also held more than a third of the world's grain carryover stocks. The value of U.S. agricultural exports increased from $6.7 billion in 1970 to $40.5 billion in 1980 (Wisner and Denbaly).

TABLE 1. Share of Major U.S. Crops Exported

Commodity	Domestic Use 1969–70	Domestic Use 1979–80	Exports 1969–70	Exports 1979–80
	percent			
Wheat	56	36	44	64
Cotton	74	41	26	59
Soybeans	51	42	49	58
Corn	87	68	13	32

Source: Wisner and Denbaly

Greater dependence on foreign markets and governmental use of agricultural exports as a tool of foreign policy has increased the instability of the demand for major commodities. Producers can now see more variation in commodity prices in a week than they experienced in a year during the 1960s. Export instability, combined with much greater free market domestic policy, has added a large source of risk for agricultural producers. The dependence on foreign markets and associated instability caused by this dependence has forced producers to shift management strategies to adjust to economic factors, rather than simply to maximize production.

Impacts of Energy and Water

Naturally, anything that affects the price of an input, price of a product, or yield, has an impact on production agriculture. Some factors help to illustrate the new economic environment of production agriculture.

Energy is often seen as the villain in the rapid increase in production costs for agriculture. Natural gas is used to produce nitrogen fertilizer. Many agricultural inputs such as insecticides and herbicides are directly linked to petroleum. However, much of the increased cost for pesticides is attributable to research and development expenditures.

Rapidly rising energy prices affected energy-intensive agricultural regions strongly. For example, in the Trans Pecos region of Texas, natural gas prices rose 450 percent from 1972 to 1975. Irrigated cotton production in the region declined from 200,000 acres to less than 20,000 acres (Lacewell et al.). Acreage went uncropped in an area with less than nine inches of rainfall annually.

Texas producers used large amounts of fertilizer, water, and chemicals. When these inputs were inexpensive, the system was economically viable. However, rapid energy price rises left producers using the same production criteria (maximize yield) at a time when they could not cover their variable costs. Agricultural advisors were not prepared to indicate the appropriate adjustments in levels of input and yield, including the possibility of ceasing production, given significant rises in input prices. There was little data on yield response to reduced levels of input; i.e., no production function.

For another example, cotton producers in the Lower Rio Grande Valley used intensive inputs. Insect pests were controlled with insecticides; quantities of insecticides used per acre on cotton in this area were among the highest in the nation. Farmers, in their eagerness to control all insect pests, found that they were unable to control late season tobacco budworm infestation. This was because the budworm had developed resistance to insecticides, and early season control of boll weevils destroyed the beneficials (Namken and Heilman). Cotton producers were faced with increasing costs of insecticides as well as declining yields. The result was a severe economic problem for cotton producers. Again, no economist had been involved in research for the area, and no extension program based on economic criteria could be readily implemented.

Obviously, if crop prices rose at a similar rate or faster than input prices, then the objective of maximizing yield might not be so ill founded. However, one need only review 1980 and the current crop prices to get a dramatic view of their highly variable nature: this points to the importance of well-planned marketing.

Currently in irrigated regions of Texas, producers can only hope to cover their variable costs of production. This means their strategies are for short-run survival. Furthermore, many of these same producers are seeing the price of natural gas (used to power irrigation wells) increase, topping $4.00/mcf. Producers faced with these situations need and are most anxious to accept guidance in making farm management decisions.

Those regions that must be most careful about farm management and marketing decisions are those that are energy intensive and feature high costs per unit of output. This involves much of the South, Southwest, West, and Great Plains. In these areas, there is little room for errors in judgment. Furthermore, the impact of an error in judgment for areas of high production cost is often swift. Many producers no longer have sufficient economic resources to recover after a drouth such as that of 1980, or low crop prices as those of 1981. Clearly, adjustments in production are needed for these regions. The needs and demands of these producers are becoming much more sophisticated and challenging.

PRODUCTION ECONOMICS NEEDS

The current research and extension complex for agriculture can be modified to react better to the challenges of the 1980s and beyond. To effect needed modifications, current weaknesses or limitations must be examined.

Separation of research and extension in production economics is constantly becoming more difficult. However, the activities of the production economist and the uses of production economics can be divided into several categories. These include, but are not limited to, the following: training; on-farm computers; rapport with agribusiness community; production function analysis; integration of economics with physical sciences; feasibility analysis; inflation, risk, and structural adjustments; marketing, production, and finance; and aggregate issues. The remainder of this paper covers each activity in turn and ends by drawing some conclusions. Many of the specific topics are closely interrelated. For example, the introduction of on-farm computers has significant implications for training and types of analysis to be included.

Training

The cooperative extension service has had a long history of commitment to farm management education. Today there is a need to train county agents, other extension staff, and involve agribusiness people and lenders in the delivery systems. Computer technology can facilitate the use of improved analytical tools and can hasten delivery of information to decision makers.

However, many extension staff members are not trained in economics, much less in computer technology. For example, much of the expansion of the cow-calf activity in East Texas and the South has been supported by pasture improvement through the use of nitrogen fertilizer. Now alternative production systems need to be developed and disseminated to help producers cope with rising input costs and variable product prices. Extension agents recommend the following relative to the amount of fertilizer needed for forage production. It depends primarily on three factors: "(1) the amount of and quality of forage to be produced, (2) the supply of plant nutrients in the soil, and (3) the seasonal distribution and amount of water (Gray)."

The Texas Extension Service identifies four forage production systems, with fertilizer costs ranging from $98 to $170 per cow unit or equivalent to 160 to 280 pounds of calf at $60 per cwt. per cow unit (an 85 percent calf crop weaning 450 pound calves will produce 380 pounds per cow unit). The recommendations, although noting the high cost of fertilizer and anticipated increases, do not include partial budget analysis of the alternative forage systems nor do they identify systems that have a potential to be profitable with reduced fertilizer use.

Agricultural economists are being asked to work with animal scientists and forage production specialists to identify alternative production systems or perhaps alternative land uses for these areas. Producers need information on alternative production systems that identify adjustment possibilities as input and product prices change. Recommendations that do not include economic implications have limited usefulness in today's decision environment.

Most county agents have very little training in economics. They studied animal science, agronomy, or other production fields or agricultural education. These curricula have limited economics training. This training of county agents reflects the needs of production agriculture in the 1950s and 60s. Most county agents do not have the training to deal effectively with the increased need to help producers with financial, economic, and marketing problems. Furthermore, economic decision assistance needs to be individualized, and, hence, does not lend itself to mass media approaches traditionally used by extension.

Thus, the economic training of county agents is a major function for production economists. To meet the increased clientele need for extension programs that focus on economics, finance, and marketing, the extension staff must be offered the opportunity for education and be given positive professional rewards for participation. If not trained in economics, the county agent will be increasingly unable to meet a critical need of extension clientele.

In addition to training county agents, economists can increase training and support of professionals in the private sector to meet the needs of commercial agricultural producers. This involvement can be as direct as supporting the sort of farm business association that exists in the Midwest, or supporting specialized agribusiness services, banking, and private consultants.

A major issue is the training in production economics of sufficient people so that they are qualified to work with farmers on cropping patterns, input levels, marketing decisions, and equipment investment strategies. Some of this responsibility is going to shift to private consultants, because only private consultants are going to have the time to become deeply involved in a farm's operations and provide continuing assistance over a long period of time.

Nevertheless, county agents must recognize the concept of economic efficiency and marginal analysis. They need to know how to apply economic principles to plan for maximum profit. Today, there simply is not a sufficient number of trained people to provide detailed assistance to the large numbers of individual farmers who are demanding these services.

On-Farm Computers. An example of an important training need for production economists is application of on-farm computers. The microcomputer has put the power of the computer on the farm and in the hands of the decision maker. Economists now have the opportunity to make computerized management information systems available to farmers and ranchers. Extension workshops across the country which involve applications, education, and demonstration of microcomputer hardware and software are usually well-attended.

Hildreth suggests that the role of extension in the 1980s should be to respond to felt needs of clientele and also to help them recognize their needs. Computer application falls into this category of activity. Agricultural economists have been leaders in developing on-farm computer use and are also involved in finding applications for microcomputers. However, as the technology develops, the opportunity exists to involve more researchers in development of analytical tools for decision makers. Presently, there are few incentives for the researcher to use the extra time and effort to make computer tools available for use by producers in their decision making. Opportunity exists for the agricultural economics profession to devise means to give professional recognition for creative activity in computer application.

The computer will be the primary source of access to producers in the future. Extension staff are approaching the situation in which the commercial agricultural producer will require that analytical tools be provided in the form of computer software. Agricultural economists who cannot use computer technology will be severely restricted in their work with progressive farmers and ranchers.

With the expansion of the use of computerized information networks, cable television, and satellite communication, the means to deliver data and information is changing. Economists are beginning to use these technologies. In the near future, much of the information delivered by both research and extension economists will pass directly to producers through their on-farm computers.

Computer use will increase the demand for economics education. The computer and its software are only tools, and users must learn how to utilize them. The expanded agricultural economics education of extension staff, agribusiness people, and lenders will facilitate the successful application of computer technology in farm and ranch management.

An effective computer application program for farmers and ranchers includes: (1) user education, (2) software development, (3) a software distribution and maintenance system, and (4) a strong interdisciplinary research-extension working relationship.

Appropriate software has been a primary limitation on the effective use of microcomputers in agriculture. Private software developers of the "cottage industry" type have sprung up to meet record-keeping and accounting needs. The decision tool development that requires interdisciplinary professional involvement is mainly taking place in the land-grant institutions. Credibility and low cost to clientele favors developing software or decision tools in the public sector.

Successful development of software for farmers and ranchers requires interdisciplinary involvement. Problems faced by producers do not conveniently break down on a discipline basis. Most useful software will combine technical agriculture with economic and finance components. It is also important to involve extension staff and researchers in software design and field testing to insure that the product is user oriented.

It is necessary to have a support unit between the software developers and the users. If this support does not exist, software developers may develop only a few programs and spend the rest of their time servicing software, leading to severe restrictions on new program development.

Support of regional centers for coordination of computer applications by the Kellogg Foundation and land-grant universities will provide for more efficient exchange of educational information and software, and will also provide for professional recognition. Using computer technology to enhance extension delivery offers a significant opportunity to meet the increased needs for economics education, analytical tools, and information to improve decision making by farmers and ranchers.

Rapport with Agribusiness Community

In many cases, the rapport is excellent among production economists and bankers, suppliers, and dealers. However, this is not always the case. A new low-input cotton production system was designed for the Trans Pecos area of Texas after most of the acreage went idle. Unfortunately, the finance community resisted the new system and were only willing to assist a farmer using conventional production strategies. The finance community still relied more on conventional wisdom than enterprise budgets. Thus, many agribusiness people need to be apprised of advances in farm economic analysis.

Another example of an important role of the production economist is in enhancing interaction between growers and buyers. Cost-of-production estimates are increasingly used by producers to negotiate contract prices with packers and processors for perishable and specialty crops. Inadequate data have often placed producers at a disadvantage when negotiating prices, especially considering high rates of inflation and rising input costs. One of the most successful contributions that farm-management extension economists have made in Texas is assisting producers in predicting costs, to negotiate contracts with processors. The economist knows how to use the data to develop an objective analysis that can be useful to both parties. In one experience, spinach prices received by producers increased gross revenues by $2 million for one small production area solely because the producers, working with the extension economist, used revised cost-of-production estimates. The success of this effort was demonstrated when both the packers and producers asked the economist the following year to work with them in revising cost estimates. A similar experience resulted from economists' assisting producers of a specialty crop called guar. Guar is processed into a number of products, one of which is used in the oil industry. The extension economist is able objectively to help both producers and processors by contributing to their decision-making framework.

Production Function Analysis

Crop enterprise budgets are most useful in production economics. However, production functions are a valuable tool when prices are highly variable. For many crops in many regions, there are no reliable functions of yield response to selected inputs. Many producers need advice on input substitution and tradeoffs.

In developing data for production functions and, of course, in estimating a crop response function, there are exciting new discoveries to be made. An example helps to demonstrate the potential. Stoecker and Onken have been working on grain sorghum response to applied and residual nitrogen. In a draft of their report, they indicate preliminary findings that may dramatically affect farm management decisions. Their data suggest that grain sorghum shows a greater yield response to residual nitrogen (soil nitrates from nitrogen applied in previous years) than to nitrogen applied to a growing crop. As Stoecker and Onken show, this means long-term production decisions need to be made, and nitrogen needs to be applied years in advance of its expected utilization. Furthermore, their results indicate that with no soil nitrates, a producer would apply nitrogen to the point of being in Stage III of production in year 1: this is to build soil nitrates for year 2 when expected yield increases.

Valid production functions require consistent and statistically relevant data from the physical sciences over several years. Too often, yield data from physical scientists' research has serious limitations. Test plot data too seldom provide the opportunity to estimate production functions. Clearly, the economist must cooperate with the physical scientist in planning research.

Beyond traditional production functions, plant growth simulation models provide an excellent analytical tool, but are often quite simplified and include only one or two inputs. In addition, simulation and activity analysis offer alternative methods for defining production functions.

Integration of Economics with Physical Sciences

We have alluded to the need for economists to work closely with physical scientists. There are many opportunities to develop production recommendations on fertilization, planting date, irrigation, tillage, and pest control, which coordinate efforts of economists and physical scientists. An example of a production system that incorporates expertise from several disciplines and includes economic criteria is cotton production in the Coastal Bend Region of Texas. Increasing insect and weather damages had caused per-acre yields to decline appreciably. A new integrated crop production system was developed that included a change in plant variety, shift from spindle picker to stripper for harvest, reduced fertilization, and integrated pest management for insect control. The new production system was developed jointly by agriculturists from several disciplines. This new system is documented as increasing yield two-fold and increasing profit beyond two-fold. Efforts of extension staff combined with economists resulted in total conversion of the region to the new cotton production system (Clarke). Further, acreage of cotton increased from about 55,000 to more than 300,000 from 1975 to 1980 with the new crop production system.

The need for including economic criteria in evaluation biological systems is increasingly recognized. The sharp rise in feed grain price relative to beef in the early 1970s, increased competition of poultry and pork, and present consumer demand for lean beef means alternative production systems must be used to produce beef at competitive prices. Byers points out that smaller cattle are favored on forage systems, while grain feeding programs favor large cattle. He adds that the goal is to match feed resources with physiological potential of cattle being fed and include economic criteria in evaluating the marketing-feeding production system. Accurate monitoring, together with objective and precise evaluation of the animals' degree of finish are necessary to implement these ideas in the feedlot. Feedlot models presently used to project animal performance should more fully incorporate degree of finish information and economic criteria on market demand. This, in turn, will assist producers in making marketing decisions. Economic models could also be useful in matching the feeding program to the physiology of the animal to meet product demand.

The economist can help to provide direction in developing new production systems. Also, the economist can do price sensitivity analysis to assess changes in relative input prices and how these might affect profitability of new crop or livestock production systems.

Feasibility Analysis

The production economist can provide a rather general economic feasibility study of various producer options. Such options include (1) new crops or crop varieties for a region and their possible product price effects; (2) alternative energy sources for agriculture such as wind, solar, alcohol, biomass and so on; (3) use of saline water for irrigation; (4) alternative tillage systems and implications of each; and (5) innovative equipment.

Analysis of any of these options can range from casual to very detailed. Considering new equipment, in one instance described by Petty et al., a low-pressure irrigation system that reduced irrigation water use and requires less fuel was evaluated by a recursive linear program. The irrigation system affected costs and returns. Less fuel was required for distributing irrigation water and more acres could be covered, permitting better timing of irrigations. Also, water was drawn from the Ogallala aquifer. This aquifer, a stock resource, does not recharge. The temporal analysis indicated that this irrigation system would increase the present value of groundwater by about $1 billion during a 20 year period if adopted on 1.6 million acres of sprinkler-irrigated land. For the individual farmer, the investment was shown to be profitable. Such an analysis is needed to quantify all factors. Simply to view the reduction in irrigation fuel use as a benefit of the new system is to miss one of the more important contributions, that of increased groundwater value.

Many issues relevant to economic feasibility studies are controversial. The gasohol fever of two years ago is a case in point. Farmers were anxious to invest, and, apparently, there was a fuel-hungry country. However, production economists' feasibility studies did not support investment in small-scale alcohol plants. There was even a comparative disadvantage on costs of producing alcohol in Texas compared to most other states (Avant et al.). Such results are not popular with state legislators, state agency officials, farm organizations, and lay public. Other similar issues abound and include water transfer, new crops, plant oils as a fuel substitute, energy farms, wind-driven irrigation wells, and more.

Inflation, Risk, and Structural Adjustments

Production economists in research and extension must adequately incorporate risk, inflation, and structural adjustments into their analyses. Selected crop data are presented in Table 2 to provide an indication of variation in net returns, as well as impact of inflation, on production costs. Currently for the Texas High Plains, given late 1981 crop prices, the only profitable crop is wheat. Irrigated cropland may not produce returns sufficient to cover variable costs in 1982.

TABLE 2. Estimated Per Acre Total Costs of Production and Net Returns for Selected Crops on the Texas High Plains 1978, 1981[a]

Crop	1978	1981
Corn		
TC	262	466
NR	44	-115
Sorghum		
TC	205	323
NR	24	- 80
Cotton		
TC	270	361
NR	24	- 79

Source: Extension Economists-Management

[a] Based on a per acre yield of 120 bu. corn, 60 cwt. sorghum and 500 lbs. lint cotton. Prices per acre were $2.45 in 1978 and $2.65 @ bu. in 1981, for sorghum $3.82 in 1978 and $4.05 @ cwt. in 1981 and for cotton $0.537 in 1978 and $0.514 @ lb. in 1981.

Some very basic structural changes in production agriculture for the region are needed if crop and livestock prices remain at December, 1981, levels. If crop prices decline, dryland production may cease to be feasible; if crop prices increase, irrigation may continue to be profitable, unless input prices rise faster than product prices.

Thus, the producer faces both significant yield risk as well as product price risk throughout much of the South. The 1980 drouth reduced yields to very low levels, yet product price was relatively high. In 1981, yield levels were relatively high, but crop prices were low. This has placed many producers in a vulnerable position, and 1982 is a critical year for reestablishing economic viability. Production economists have not adequately considered risk, inflation, nor structural adjustment in work with producers.

The quantitative tools are certainly available to incorporate risk and inflation into our analyses. There are many studies dealing with risk using quadratic programming, Motad models, and so on. However, very little of this work has been delivered to producers.

Additionally, there is little support for producers on impacts of inflation and how to cope with inflation in making farm management decisions. Simply to continue advising producers to hedge and contract is inadequate. Using computer technology to enhance extension delivery offers a significant opportunity to meet the increased needs for economics education, analytical tools, and information to improve decision making by farmers and ranchers.

Marketing, Production, and Finance

Much of the focus of this paper is on production economics. However, in developing a farm or ranch management program, farm policy, marketing, and finance are equal concerns. Often, producers feel quite comfortable with their ability to produce a crop; it is how and when to market and how to finance that are the major issues. The production economist must blend in a marketing strategy and be able to construct a cash flow analysis for a production plan. Thus, just as many of the specific needs in production economics as discussed herein imply many facets of integration and joint consideration, marketing and finance are two more factors to be considered conjunctively with all others.

Aggregate Issues

The production economist is increasingly involved in many issues and questions that require aggregate analysis for regional, U.S., or even world consideration. Thus, training in theory and quantitative techniques is paramount. Most agricultural economists have studied macroeconomics, but few use it. Credit, general money markets, and broad U.S. economic policy are key issues facing farmers today.

At the macro level, types of analysis have been conveniently separated into policy issues, production factors, and planning. A few examples in each of these three classifications are provided next, to indicate the nature of increasing future involvement by production economists.

Policy Issues. The U.S. Department of Agriculture farm program is in a periodic state of evolution. Often, the components of the farm program must be included in other analyses, such as on-farm studies.

A very large list of macroeconomic policy issues exists. For illustrative purposes, a few studies will be discussed, along with some of the kinds of issues that arise.

A study of alternative boll weevil control strategies in response to a USDA proposal to eradicate the boll weevil required an aggregate analysis (Taylor and Lacewell). In this case, an L.P. model of the U.S. was used. The model maximized producers' surplus plus consumers' surplus. The analysis included boll weevil eradication and two integrated pest management (IPM) alternatives. The results of the analysis indicated that producers' surplus would decline $44.0 million with IPM, and $100 million with eradication. The present value of social net benefits was $1.3 billion with IPM, and $923 million with eradication. This study is currently being updated, using an econometric model and data from field tests in North Carolina and Mississippi.

Controversial issues such as this are often brought to the economist for input. The economic study can be expected to draw heavy criticism from that group for which the results are least attractive.

Water issues are providing the incentive for economic studies on a regional basis. One example is a new ruling that permits farmers to accumulate in a reservoir a part of their annual water allocation for use in future years; i.e., conserve water this year to increase the amount available in a future dry period. This refers to Bureau of Reclamation water only and to farmers in an approved water district.

An analysis of the potential effect of the water accumulation policy for the El Paso County Water Improvement District, which draws water from Elephant Butte Reservoir in New Mexico, has just been completed (Cornforth and Lacewell). Currently, farmers receive three feet of water per acre, given an adequate reservoir level. A farm that elects to use less than 3 feet per irrigated acre can save or accumulate the water in his name in Elephant Butte Reservoir. However, the farmer must incur evaporation losses on his accumulated water. The results of the analysis suggest an optimal annual rate of water use in the study area is between 2.5 and 3 feet. The increase in present value of producers' profit for the optimal allocation as compared to a 3-foot annual use rate was an increase of less than 2 percent. Thus, since the farmer must incur evaporation losses, there is little incentive to save water for drier years. Furthermore, the 3-foot annual allocation is an estimated sustained annual allocation rate, hence is very close to any optimum temporal use rate.

A study such as this is of considerable interest to the farmers and water management people of a region, since all have vested interests. However, the objective is to develop an optimal allocation of a scarce resource. Other similar issues abound in water resources.

There is much discussion of water banking, salinity control, acreage limitations, and water planning outside the market mechanisms. These issues are now moving into the South as the need for irrigation increases and non-agricultural impacts occur.

The entire area of energy issues as they affect agriculture must be explored. Presently, major questions surround the agricultural production aspect of natural gas deregulation (a national study). Not only is natural gas used for drying and powering irrigation wells, but natural gas is the major feedstock for producing nitrogen fertilizer. Certainly some comparative advantages will be affected. Again, we foresee the production economist drawn much more into these major issues.

Production Factors. The effect of a change in the price of inputs and/or products overlaps with policy issues. However, the impact of percentage increases in input prices as compared to alternative percentage price changes for agricultural products can be analyzed. It is useful to identify regions of comparative advantage and expected adjustments in cropping patterns across regions.

Another major role of the economist is to help evaluate new technology. For example, there is a new irrigation distribution system that uses very low pressure yet achieves about 99 percent distribution efficiency. For non-irrigated agriculture, or very limited agriculture, furrow diking (row damming) has been shown to increase average cotton yields between 11 and 25 percent, and sorghum yields between 25 and 40 percent in Texas and Oklahoma (Clarke). This translates into an $87.6 million-increase in rent to farmers in Texas and Oklahoma. These estimates were made by applying a national econometric model of agriculture developed at Texas A&M.

New technology in most cases can be represented by changes in production costs and/or yield. Most models are applicable to these changes, i.e., LP, econometric, simulation. However, it is necessary that both costs of production and yield changes can be incorporated in the same model. Econometric models often do not include costs of production, which is a major factor in shifting supply curves.

A last example related to resource scarcity, particularly over time. The Ogallala aquifer in many areas has little to no recharge; hence, its water is an exhaustible resource. In other cases, water withdrawals exceed recharge, which means that the water is being "mined." Temporal implications of structural adjustments are important considerations. Also, analysis of an optimal temporal allocation of an exhaustible resource must consider attitude to risk, financial situation, and size of operation. Further, the expected impact of new technology can be superimposed on conventional (analysis) methods for added insight.

Planning. Naturally, much of the type of work outlined in all of the above sections is used for planning. In this case, we refer more to emergency activities. For example, planning for drouth, a reduction resource availability, or conflicting resource uses.

At the time of a drouth, there seems to be always a major void in planning for both the agricultural and non-agricultural sectors. During a drouth, there is a flurry of activity that abruptly ceases when the drouth ceases.

There are other similar issues evolving in which we visualize the production economist playing a major role, for example, fuel allocation to agriculture in a time of shortages. Many issues are important in analyzing fuel allocation to agriculture, including sensitivity of yield to timing of operations and appropriateness of using renewable resources, such as plant oils as a diesel fuel substitute. Furthermore, if fuel is not diverted to agriculture, what are the expected consequences?

Conflicting resource uses can become controversial. Cases in point include land use (for agriculture or urban development), water use (for coal slurry or irrigation), strip mining of coal vs. production agriculture, use of water for irrigation or for non-agricultural uses (energy development, cities, industry), and so forth. Many propose that uses of resources must be carefully planned. Once again, we see the production economist playing an important role in sorting out the issues and providing economic implications or alternative scenarios.

For the most part, each production economist will span the range of research from on-farm studies to aggregate studies. In extension activities, more specialization may be possible, but the range of activities will still be much broader than it has been. For example, the production economist working with software for on-farm computers must be familiar with different farming areas and detailed characteristics of each; that same economist must also continually broaden software packages to suit a wider range of uses and users.

CONCLUSIONS

The production economist will be doing much the same thing over the next few decades as he has done through the 1970s. But today, economists are on center stage, and people are listening. Before, when maximum yield equalled maximum profit, the production economist was not as influential as today. Changing economic conditions have favored the production economist, and his work is now crucial to the agricultural complex.

Agricultural clientele are much more sophisticated than they once were, and their questions are much more complex. Growth of the use of computers in farm management will continue to accelerate, far outstripping resources now available from either extension or research. Thus, a significant need for production economists in the private sector is anticipated so that they can serve as consultants to individual farmers. Training of these consultants is of top priority. There is also a need to provide a significant amount of economic (farm management) instruction to people in extension positions. Currently, they offer the farmer little or no help in the area of farm management economics.

The production economist needs to coordinate research efforts with physical scientists, so that the economist can be assured of data that can be analyzed in an economic framework.

Involvement in physical science research programs, aggregate analyses that affect policy decisions, and computer application for the farm or ranch all demand timeliness. Economic results, models, software packages, and so on, must be delivered in a timely manner to be of value. Too often in the past, economic analyses have been completed after all decisions were made and were simply academic exercises. Now, economic analyses must precede decision-making.

Last, it is important to reaffirm that production economics must be closely integrated with marketing, finance, and policy. Indeed, many farmers view the marketing of their crops as the number-one area in which they need help.

The issues facing production economists are as broad as the imagination. No more are economists primarily observers; they are active participants. Whether by choice or default, the production economist is going to be involved far beyond interaction with the farmer. His work now carries considerably more weight, and reliance on economic input will accelerate in all phases discussed in this paper.

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