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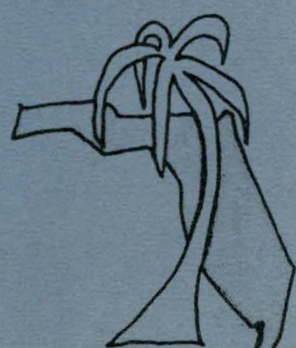

AGRICULTURAL PRODUCTIVITY, TECHNOLOGY AND ENVIRONMENTAL QUALITY*

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Providing for human needs with limited resources requires the efficient organization of production and a equitable system of distribution. These issues have been the central concern of economics. In the early history of economics the scholars concerned themselves with trade, the organization of markets and the development of a political system compatible with a world of merchantilism and men with new found freedom. For neoclassical economists faced with industrialization, the answer to problems of distribution seemed to be efficient production and Pareto optimality. In other words more for everyone. As material living standards and population densities increased the problem of pollution or garbage management emerged. There is still the problem of providing for the world's population through increased production of goods and services and at the same time there is much concern that our production will generate waste products in such abundance that the quality of life and maybe even life itself may be diminished. Thus Ruttan [21] noted two challenges to man: (a) provision of adequate sustenance and (b) managing the production and distribution of garbage. It is not my purpose to show that agriculture is ecologically sick. However, there are it seems a number of environmental problems that are related to the pressure for productivity and the resulting adoption of industrial products and techniques that require our attention as agricultural economists.

I have characterized these problems as (a) technical externalities, (b) estimation of the costs and benefits of technology, (c) economic growth, and (d) property rights each of which will be discussed in turn.

We need not review the dramatic increases that have been made in increasing the output of American agriculture. Nor is there any need to develop a long theoretical explanation for the phenomenon of technological advance that has made this increased output possible, while using fewer market valued resources per unit of output. We are concerned here with the

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unresolved relationships between technology, productivity, and quality of life. We can and should be concerned because agriculture continues to be plagued with excess capacity to produce, low prices, and for many, inadequate incomes. In addition, the appropriate use of technology to deal with the price and income problem has come under criticism of late. Fertilizer use has become suspect as a possible source of nitrates in streams and underground water supplies. Concentrated animal fattening plants have been charged with pollution of water and air. Intensive cultivation has been criticized for its contribution to sedimentation problems as well as the alteration of landscape through removal of natural vegetation. Finally, chemical pesticide use has been seriously attacked for the discharge of toxic chemicals into the environment allegedly damaging wildlife, fish, domestic animals and humans. So, while providing an adequate supply of food and maintaining the income of farmers have been challenging enough for as long as I can remember, there is now the additional challenge of finding and maintaining the right relationship between agriculture and the natural environment.

TECHNICAL EXTERNALITIES AND RESOURCE USE

The study of environmental quality and its relationship to technology and productivity brings us face to face with the issues and problems of economic welfare theory. Even if the problems of wealth and output distribution, which loom quite large, are assumed away the problem of technical externalities remains. The interdependency of production functions and the spillovers from consumption activities are physical realities that confront us in almost any economic problem we can imagine. However, it is only since the increase in the furor over environmental quality that economists have given much thought to this phenomenon.[1]

With respect to agriculture and its role in environmental problems there seems to be at least three main questions of interest to economists. First, are the demands that modern agriculture places on environmental resources in excess of what is in the public interest? Second, does the total bundle of resources now used by agriculture represent the least social cost use of national resources? Third, is increased productivity in agriculture and the associated economic growth consistent with improved welfare?

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[1] Good expositions of the concept of externalities are found in Meade [16], Castle [8] and Buchanan and Stubblebine [6].

If the answers to the previous questions are in the negative, there is reason to believe that the external costs of agriculture are much larger than we had thought since most of our statistics and research results show that the public, through the market, has faired reasonably well under policies stressing technology, increased productivity and growth. For instance the real (market) price of food, excluding marketing services, is now estimated to be about one third of its level in 1929 [11]. These studies conclude that the consumer has benefited from increased productivity in agriculture through low cost food and fiber.

Paraphrasing Barry Commoner and his colleagues [2], agriculture has not been using the least cost bundle of resources, but rather has been tricked into believing in a statistical measure of efficiency that leaves unaccounted resources that many believe are of great value. The consumer's price does not reflect the opportunity costs of the environmental resources incorporated in food production. This line of argument suggests that the resource savings we believe to have achieved have not been savings at all but substitution; that inputs such as fertilizer are underpriced because the external costs of use, such as possible nitrate pollution, are not accounted or that the external costs of nitrogen production are not accounted, since nitrogen output is a byproduct of petroleum production, which is itself not being used at an optimal rate. To summarize, Commoner would seem to argue that a proper accounting system including the external cost of environmental resources would show agriculture to be less efficient than we believe it to be. If these observations accurately reflect the scientific facts and our values, our agricultural strategy with respect to growth and development will need to be rethought.

Of course the painful truth is that no one knows whether Commoner is right or wrong. This statement in itself tells us something about ourselves and about the kind of economic policy we have been using in agriculture. There was a reason why we were not required to understand technical externalities in graduate school. They were not important! When operating under a philosophy of expansion by exploitation, the use of the environment as a disposal medium for the residuals of production and consumption is not important because, for a time at least, the quantity of environmental resource services demanded exceeds the quantity available. It appears now that the demand for the services of the environment has expanded both for use in disposal of production residuals and for consumption as amenities, the latter believed to be quite income elastic, such that the distribution of common property resources has become a problem.

The questions posed earlier in this section concerning whether agriculture's use of the environment is in the public interest and whether output was being produced at the lowest social cost are difficult questions to answer. The difficulty arises because of a lack of information relative to the demands agriculture is placing on environmental services as well as a lack of definition of what constitutes the public interest and, therefore, lowest social cost. This information is not available because of gaps in physical, biological and social information. Many of the processes allegedly at work are not well understood and the proper measurements have not been made to allow estimation of environmental parameters. In addition, we are poorly informed about the optimal levels of certain technical inputs such as pesticides, partly because their use has been so obviously profitable to the firm in the short run [10]. Thus, little attention has been paid to their use rates and we have no objective way of knowing whether farmers are applying equilibrium amounts[2] or, whether the same or better results might be achieved with less input of pesticides or, whether there may in fact be better methods of dealing with the problem.

With regard to use rates of insecticides some interesting research is under way by entomologists to see if chemical insecticides integrated with biological and cultural controls and good farm management can profitably reduce (not necessarily eliminate) the use of insecticides. Adkisson [1] reports that in west Texas, with supervised insect control procedures, cotton was produced on the Pecos Experiment Station 1968-1970 with only one insecticide treatment providing yields of lint cotton comparable to farms adjoining the station and throughout the county where 8 to 10 treatments per year were used. Adkisson also reported that farmers were using much too much insecticide for treatment of greenbugs on grain sorghum near Lubbock. They found that 0.1 pounds of parathion per acre gave 98 percent control after 3 days compared to 100 percent control with 0.5 pounds per acre.[3] After 7 days the percent control was 93 and 97 respectively. In Adkisson's opinion insecticide control on cotton in most areas of the U.S. might be reduced by as much as 50 percent without reduction in yields.[4] This

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[2]Recent research by Ogut [18] has concluded that Missouri farmers are not overapplying nitrogen fertilizer to corn in relation to the prices of corn and fertilizer. This study was not able to judge the social optimality of nitrogen use due to the reasons mentioned above.

[3]In a personal conversation Adkisson stated that the extension service was having difficulty convincing farmers of this fact.

[4]This opinion is consistent with the opinion of the President's Science Advisory Committee [19] in 1965.

particular example points up the need to provide the users of technology with better information than they now have and the need to effectively communicate with them.

Where nitrate pollution of water supplies is a problem it is evident that experiment station scientists are not well informed concerning the fate of nitrates in the soil. It has been estimated that 50 percent of the nitrates in Lake Decutur in Illinois were from farm fertilizer sources [14]. Agronomists to my knowledge don't know how general that result might be. We don't know how soil type, type of farming, time of application and other variables might effect the amount of nitrate that reaches streams and underground water supplies from a given application. Until this kind of information is available policies to control nitrogen use will be made under a considerable amount of uncertainty.

The challenge presented to agricultural economics research, teaching and extension with regard to the allocation and distribution of environmental resources is indeed large. We have not developed our research to deal with these kinds of questions. Our students are painfully ignorant of the theoretical concepts of public goods, common property resources, collective goods, option demand and the general theory of welfare economics. Our extension work has tended to focus too much until recently on the economics of the firm with the tacit assumption that interdependencies of all kinds including third party effects were either non-existent or unimportant. Much relevant work therefore remains to be done. It seems clear to me that agricultural economists must become involved in research designed to provide answers to these questions.

ESTIMATION OF THE BENEFITS AND COSTS OF TECHNOLOGY

Benefits from technology arise in principally two forms; either the new state of the arts saves resources or it provides a larger output from a given resource commitment. In principle it seems rather straightforward to estimate the total resource costs before the infusion of new knowledge and then estimate the resource costs given an output level after the innovation with the difference representing the resource saving. Or, alternatively one can estimate the equilibrium output prior to the new knowledge and again after with the incremental increase in output representing the output gain made possible by the advance.

While the above procedure is straightforward, it is also oversimplified. The infusion of new knowledge into the economic system is a dynamic process. Change, rather than being an instantaneous transformation, is a series of events and developments with linkages through time. Therefore there are difficulties in classifying benefits and costs. We are all familiar with the transformation of the benefits for one generation into the costs of the following generation. Similarly, one change in the state of the arts occasions another and the individual benefits are not additive lest multiple counting occur. Therefore, the evaluation of technology must consider more than the instantaneous effects. Cotton entomologists are convinced that our chemical solutions to boll weevil control have induced the bollworm problem. With the development of insecticide resistance by the weevil, cotton growers today have two problems.

We are now more than ever faced with a holistic approach to analysis of our activities. We are thus interested in all benefits and costs, that is, the social costs and benefits of our activities. This is the essence of economics applied to environmental problems. All resources employed must be accounted and all of the benefits must be estimated; hence, the problem of defining the resources to be saved and the outputs to be increased. For most significant developments this requires considerable understanding of the system before, during and after the infusion of new knowledge.

If you will pardon a Corn Belt example, the culture of continuous corn will serve to illustrate the evaluation problems. The advent of commercial nitrogen made it possible to produce continuous corn without reductions in yield. Farmers then began to produce corn without benefits of legumes in the rotation, but problems began to appear. Continuous corn production developed disease, weed and soil insect problems requiring the application of various chemicals as complements to commercial nitrogen. To assess the contribution of commercial nitrogen to corn production, we must be sure to measure the net contribution and not the gross. That is, net not only of the factor cost of the nitrogen, but net also of the other inputs that are required along with nitrogen. While I am neither an entomologist not a plant pathologist, I feel certain that most of the current disease and insect problems of corn culture have been induced by the practice of continuous corn. Thus, the cost of developing new control devices is a cost of continuous corn.

The evaluation process can be taken further. Changes in corn production may have also precipitated some of our nitrate problems as well as pollution problems from mercuric fungicides and chlorinated hydrocarbon insecticides. These are costs if proven to be serious--and I believe this to be an open question--that must also be netted out of the contribution of commercial nitrogen to corn production.

Of course, the process is also capable of branching, since one can separate the pest control aspects of corn production and evaluate them as well. Taking as given that continuous corn production is the optimal practice, we can ask what the contribution of insect control is to farm income. If one cultural practice induces another problem then clearly the cost of solving the induced problem is a cost of the prior practice. Prevention of damage from soil insects induced by continuous corn is a non-trivial problem and a benefit to be compared with the cost of insect control only so long as the practice of continuous corn is clearly superior to other methods of corn production. The approach is partial or incremental and the quality of the result is only as good as the choice of the values from which the partial analysis proceeds. If the givens are not correctly chosen we can become guilty of what Boulding [5] has characterized as doing a very good job on things that should not be done at all.

There are in my view many developments that need to be made in the evaluation of our technological strategies throughout society. Our methods are myopic and so is our advice. There are great challenges for the young in our profession to develop the analytical skills that will provide alternative technological strategies for agriculture that are not the product of Topsy like processes, but rather contribute by design to the fulfillment of the aspirations of society.

ECONOMIC GROWTH, TECHNOLOGY AND ENVIRONMENTAL QUALITY

It has been suggested that in order to combat the current and prospective environmental quality problems there must be more economic growth. The argument goes on to assert that there is no way to marshal the resources necessary to correct pollution and other forms of degradation with a static GNP, since environmental improvement is analogous to and competitive with activities such as health and education and must find the needed capital in some sort of surplus over and above current patterns of consumption and investment.

E. J. Mishan [17] in an exhortative article, rather out of character for most professional economists, suggests five reasons why this argument is wrong. First, Mishan argues that the industrial growth of the last twenty years creates much more pollution than is eliminated by private and public spending and more of the same appears to be in store. Second, pollution abatement increases rather than diminishes real GNP. Third, too little of the annual increment to GNP is committed to combating pollution. Fourth, the need for more GNP to accomplish environmental improvement is fantasy because each year more and more GNP goes toward items that are, in Mishan's language, "near garbage" and "positively inimical". Fifth, expenditure is not the real need. Rather, what is needed is effective legislation to put the burden on the polluter and reallocate resources away from pollution creating goods.

While the arguments of Mishan along with those of Scitovsky [23], Boulding [4] and Galbraith [9] smell strongly of value superimposition they point to a question we are not prepared to answer. Can the quality of life be improved given a static metric such as GNP? Or is a rising GNP necessary for improvement of the quality of life? Or should we find another measure? Staffan Linder [15], in his economic analysis of time as a resource, provides some intriguing ideas. His thesis is that economic growth increases productivity thereby increasing the yield on time. When this occurs, there is a disruption of the time-return equilibrium existing under the previous income level and all uses of time must be adjusted to bring the time yield on all activities up to that of working time. Linder, therefore, concludes that economic growth leads to a general scarcity of time. Moreover, as growth of goods increases and time becomes even more valuable the resulting affluence is only partial and life becomes harried.

Resource allocation in agriculture has been considered an important variable in the strategy for economic growth. The conventional wisdom has been that only when productivity in food production was high enough to release agricultural labor for other tasks could real growth take place. Naturally the term growth is usually synonymous with industrual growth and is also value laden. Industrialization leads to mechanization, more consumption of goods and a general substitution of capital for labor. But consumption requires time and must be at least as rewarding as production. Consequently, following Linder, society moves toward ways of increasing the yield on consumption time by finding quicker ways to eat, exercise, be entertained, etc., all of which can lead to an overwhelmed kind of life in the midst of material affluence.

Agriculture is certainly not responsible for increasing the tempo of life under a policy of growth, but the agriculture we know is the result of growth stimulating policies. However, agriculture has not shared in the product of growth on a par with other sectors. Farm incomes continue to lag, rural poverty continues and rural communities have fallen behind in community services in spite of higher taxes. As the population becomes well fed income elasticities of demand for food decline. Consumers are willing to spend relatively more on marketing services to save time than on the basic food itself. Finally, we find that agriculture is expected to provide food at a price which will leave the largest residual to indulge in demands for the luxuries of modern life.

The adoption of industrialized technology is the method we have chosen to minimize the market value of resources devoted to agriculture. In that regard we have been effective.

But the extra-market values sacrificed for cheap food and economic growth have not been as consciously economized, if at all. Our streams and lakes are muddy and contain a variety of man made chemicals. Our groundwater is suspect and the disposal of animal and processing wastes in certain localities impinges upon the natural environment in an unsatisfying way. Communities have been depleted of their people as economic growth has spurred urbanization. At least part of our economic growth has been provided by living off the depreciation of both the countryside and the cities. Yet due to our method of measuring our material well being, the maintenance activities required to correct the former short sightedness result in increasing GNP [5].

Political candidates speak of attacking these problems and many ask the source of the resources to replace the depreciation. The easy answer is continued economic growth because it holds the promise of no apparent material sacrifice. But, that is an empty promise for growth of the type we have known. It seems clear that the twentieth century brand of economic growth based on technology and industrialization is, if not the cause, at least central to the issues of the quality of the environment. The political or idealogical base is not easily indicted, since the countries of the Soviet Bloc are also experiencing similar problems. The resources to replace our natural and social depreciation will come at least in part from our present and future consumption if the problem is to be resolved.[5] Making this a reality will require some very far reaching change in our attitudes and our basic philosophy involving patterns of consumption, the institution of property and taxation. Therefore, I agree with Ruttan [21] concerning the sociopolitical aspects of the environmental controversy. There is much work to be done in our nation. Yet, unemployment is a perennial problem. It is a problem of equity and distribution. Who will sacrifice? Who counts?

PROPERTY RIGHTS AND THE ENVIRONMENT

Various authors have cited the importance of property rights in matters of environmental degradation and improvement.[6]

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[5]This obviously represents a deep commitment on my part to an old economic adage supported by a basic teutonic outlook that there is no such thing as a free lunch.

[6]See Allen Schmid [22] for a fine discussion of property rights and environmental quality issues.

Many of our environmental conflicts arise as a result of increased demands for common property resources. When the assimilative capacity of the resources has been reached congestion (pollution) sets in and the resource is no longer free. Rationing then becomes necessary and/or decisions must be made regarding expansion of capacity.

Solutions to this kind of problem would seem to be forthcoming from analysis by standard resource allocation techniques. Hence, the various articles and books on taxes and subsidies as a means of restoring efficient resource allocation where common property resources are concerned [13]. Without intending to be hypercritical this work, while interesting and capably done, misses the point. For it is one thing to determine the damage from animal wastes discharged into a stream and yet another to decide who should pay. Should the feeder pay to discharge or should the public pay the feeder to refrain from discharging. For questions such as this, efficiency analysis is premature, since in many cases the property rights have not been defined and we can not determine who is imposing on whom.

The first question to be answered in this case is the one that indicates who counts, the feeder or the public stream users. That decision should, under our form of government, be a collective decision since it vests some group with property rights. Once that decision has been made, following Buchanan and Stubblebine [6] the relevant externalities can be identified and economically efficient means found to internalize them.

Granting of property rights is a serious business, with far reaching welfare implications, for the granting determines who can buy and sell, what markets will exist and how the product of the system will be distributed. The most important consideration in granting property rights is the determination of the kind of performance that is expected of the economy.

Therefore, some of the questions we need to be asking are: what form of property rights will provide us with the kind of use of our natural resources most consistent with our social goals? How will changes in property rights affect various groups within society? What effect will different kinds of property rights have on technology? How will markets be affected? Will indemnification be required?

It seems these are relevant questions that, when answered, will eliminate much of the confusion that surrounds the use of the natural environment, the choice of technology and the brand of economic growth. The collective decision to vest in certain groups the right to prescribe and apply pest control methods in agriculture can remove considerable controversy and uncertainty and, in addition, lead to better results. As long as each producer is given the right to buy and use whatever is for sale, the available methods should be restricted to those that can be safely used by non-experts. It is clear from historical experience that a market solution within our present institutional setting will not provide a desirable solution for pest control. If it is decided that the public holds all the property rights to navigable streams and that the public value of these streams will be maximized by multiple uses including recreation, water supply, navigation and waste disposal then the public can exchange the rights for money through use permits for the various activities. At this point the water pollution is amenable to economic analysis of the kind with which we are most familiar. I am not, nor do I intend to suggest that market solutions have no place in environmental quality problems. Rather, I am convinced that given present institutions, attitudes, the vagueness of certain property rights and high transaction costs, market solutions will never be effective since there are too many barriers to trade. Therefore, policy makers will resort to the one method that is most available--standards and regulation--unless they are provided with superior workable alternatives [20].

FUTURE DIRECTIONS

Having outlined what I feel are the major problems we face as we try to maintain agricultural productivity, use technology to expand our resources and provide a fulfilling environmental dimension to life in our society, it is appropriate to speculate on the directions we may take in our attempts to serve the public as researchers and educators. It is my personal view that we, as professional economists, are fortunate to have before us the challenge to assist in the development of strategies for moving our society into a new era. There is no shortage of work to do.

We have turned the corner so to speak in our search for a place for the applied talents of agricultural economists in dealing with the problems of contemporary society. Now these talents must be organized to press on with the work [12]. Gone or at least weakened are the kind of frustrations that gave rise to Bonnen's [3] concern for the decadence of the Agricultural Establishment and the restrictions it placed on the experiment station. We can now and in the future work with problems outside the usual definition of commercial agriculture without apology or fear of reprisal.

I have already indicated some of the tasks that lie before us: (a) the development of our understanding of externalities and the assessment of the set of coefficients that relate agriculture to the natural resource base, (b) the improvement in our methods of estimating the benefits and costs of technological change using a holistic or systems approach, (c) the need to develop a more complete explanation of economic growth and its relation to use of environmental resources, and (d) the need to explore the consequences of alternative sets of property rights and accompanying institutions to make the problem of defining goals and analyzing alternative methods of attaining objectives manageable. There is also the need to become more closely related with other disciplines that are likewise concerned with the two challenges mentioned at the outset.

Having broken away from the confinement to problems of commercial agriculture and the declining constituency it represents we are now in a position to focus on problems of the rural or at least non-urban community. These are problems that do not fall neatly into our usual boxes of academic interest [24]. Problems of the disposal of human and animal waste require the cooperation of several areas of expertise to develop solutions that are acceptable and workable. The working out of strategies for pest control will require the biological, chemical, engineering and social science resources of our experiment stations and government agencies. Adaptation of agriculture and our entire system to the ever increasing pressure on energy sources will demand the concerted skill and imagination of us all as we try to find ways to bring about social and technical change to adapt to new resource problems.

What of the future of the discipline and the core of economic theory and methods that bind us together? There is the fear that our engagement in multi-disciplinary endeavors will weaken our need for and command of our basic discipline. Johnson [12] very skillfully dealt with this question and argued that such activities will show the need for more rather than less disciplinary training.

One fairly common complaint is that the questions addressed here are very messy and of the type that welfare economics has addressed, but has been unsuccessful in answering. It is then easy to say that welfare economics is useless and return to work on problems we can solve. This is not the appropriate response in my view for we must admit that welfare theory at least lets us ask some of the right questions. When compared with other disciplines we are considerably advanced in our approach to these problems. Economists should not shrink from the challenge. We have a history of at least 200 years that documents the thoughts of people wrestling with the problems of equity and distribution from Adam Smith to Kenneth Arrow. Because the theory of welfare economics and its empirical application is not up to our standards of neatness indicates that it should receive more emphasis rather than less.

Whether all of our present academic baggage will remain as we relate to other disciplines is of course another question, but my experience in working with another discipline on pest control problems supports Johnson's thesis. I have found optimization concepts, capital theory and other concepts that are a part of the way economists think, to be highly useful in trying to make sense out of pest control problems and have found the problems demanding of economic skills. It seems certain that the working out of a nitrogen policy, the development of methods of dealing with animal wastes and their evaluation, for instance, will require the best in theoretical and quantitative skills if we are to do more than just "wool" the problems around. The work of Burt and Cummings [7] for example has demonstrated the complexity of dynamic investment processes that are most assuredly a part of the intertemporal allocation of resources.

Finally, I believe that the future holds some exciting prospects for agricultural policy. Now that we have acknowledged the pervasive interdependencies that exist between agriculture and the rest of the economy, I believe we can look for a movement away from what has been, for me at least, a dreary patchwork of commodity programs and marketing schemes that has turned the study of economic policy for agriculture into an intellectual wasteland. A holistic approach to meeting the agricultural needs of a society that is keenly aware of a complex set of resources constraints will and must lead to more recognition of the relationship between institutions and technology and the recognition that programs alter production functions as well as reallocate along existing ones. What we are learning as we attempt, through simulation, to build holistic models that incorporate large numbers of technical and behavioral relations in addition to our increasing multidisciplinary experience should be helpful in the planning of agricultural activities to indicate the direction of various kinds of policy decisions.

These are exciting times. I believe that we will witness, before the end of this century, some of the most dramatic changes in the organization of resources to meet the needs of man since the beginning of the industrial revolution. Agricultural economists can be a part of shaping that change if we develop our intellectual curiosity and renew our dedication to the solution of the problems of people.

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