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ASSESSING THE IMPACTS OF TECHNOLOGY ON SOUTHERN AGRICULTURE AND RURAL COMMUNITIES

Tesfa G. Ghebremedhin

Technology has made U.S. agriculture one of the world's most productive and competitive industries. Farmers have already witnessed the dramatic results of two major technological eras in agriculture. The mechanical era from 1920 to 1950 allowed farmers to make the transition from animal-powered agriculture to engine-powered commercial agriculture. Notable features included electrification, universal education, revolutionized transportation and communication, and the application of science through research. Application of science and industry to agriculture resulted in massive substitution of capital for labor and increased the productive capacity of U.S. agriculture (Tweeten). The chemical era from 1950 to 1980 further increased agricultural productivity by increasing farmers' ability to control weeds, pests, and diseases and by increasing the use of chemical fertilizers. Now, in the 1980s, U.S. agricultural production is being propelled by a new major technological thrust characterized as the biotechnology and information technology era. Biotechnology includes any technique that uses living organisms or processes to make or modify products, to improve plants or animals, or to develop microorganisms for specific uses. Information technology is the use of computer and electronic technologies for the automated collection, manipulation, and processing of information for control and management of agricultural production and marketing. The effects of this new era on agricultural productivity may be more profound than those experienced in either the mechanical or chemical eras (U.S. Congress).

The biotechnology and information technology era has generated marked changes in the structure of the agricultural sector of the rural communities that support farming. The effects of these technologies are represented

by new products and services, which have led to new businesses, expansions, and improved productivity and efficiency, new production processes, and new management skills and methods. Government support for agricultural research and development is the main source of technologies that have stimulated agricultural productivity. Thousands of publicly funded discoveries and innovations have resulted from the research at centralized, federally funded agricultural experiment stations and university-based cooperative extension programs (Southern Growth Policies Board).

Today, the nation has an agricultural system in which three percent of the work force can produce more than enough food for an entire nation. Fifty years ago there were 6.5 million farms in the United States; the average size farm was 145 acres; and there were 13 million farmers and farm workers, each of whom, on the average, produced enough food and fiber for eleven persons. Today there are about 2.4 million farms; the average size farm is 450 acres; and there are 3.7 million farmers and farm workers, each of whom, on the average, produces enough food and fiber for 80 persons. One hour of farm labor now produces 14 times as much food and fiber as it did 60 years ago. In the last 20 years, agricultural productivity per hour worked on the farm has increased more than three times faster than industrial productivity per hour worked. One farm worker creates jobs for 5.2 nonfarm persons who produce the things farmers need and who process, transport, and merchandise the things farmers produce (U.S. Department of Agriculture).

The agricultural sector in the South has experienced similar developments and technological changes. Agriculture has been and continues to be the backbone of the South's

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economy, providing the major employment base and source of capital. There is an increasing reliance on information and knowledge, and thus, education, for economic growth as one of the major trends in the South and in the rest of the nation. Technological developments in the agricultural sector have been crucial for the improvement of the economic and social well being of the South, but not without costs. Technological change is a powerful force for long-term growth and prosperity, but it also brings short-term disruptions that must be addressed. Technology has increased agricultural productivity and created new jobs, but it has also displaced persons from their occupations and livelihood. Farming is becoming more centralized and more vertically integrated. Farms have become larger and more capital-intensive, and produce specialized commodities. Large farms, though small in number, now produce most of the agricultural output. Operators of small and medium-sized farms are becoming increasingly less able to compete, and many are giving up farming altogether. The disappearance of these farms is causing repercussions for other businesses in the rural community and for the labor pool in general, which must absorb all those whose livelihood once depended on agricultural production (U.S. Congress). Rural communities which depend on agriculture face special problems in this changing environment. This paper will, therefore, assess the role of technological changes in both agriculture and rural areas in the South by addressing the impacts on small versus large farms, public costs in rural communities, and the future direction of research needs.

STRUCTURAL CHANGES IN AGRICULTURE

The history of U.S. agriculture as well as southern agriculture is one of continual response to economic and technological forces. That is, agriculture is a highly diversified industry that is continually changing. The general trend in the structural change of production agriculture has been of major interest to agricultural researchers and public policy makers. Much of the interest is centered around (1) the increasing rate at which the number of small to medium-sized farms has been declining over the years; (2) the disproportionate percentage of total agricultural production now generated by a relatively small percentage of farms in the large size

category; and (3) the rising percentage of farm family income derived from off-farm sources. The shifting structure in production agriculture which is characterized by technological change has important implications for resource use and enterprises combinations; the development and effectiveness of desirable public policy; the future survival of small scale agriculture as a viable economic unit and as a "way of life"; population distribution and labor mobility; local economic and social growth; and the general well being of farm families in rural communities (Ghebremedhin and Johnson; Heady and Sonka).

Farm Size and Numbers

The shifting structure of production agriculture is characterized by an increasing average farm size and declining farm numbers. At the national level, average farm size increased from 242 acres in 1954 to 433 acres in 1982. In the South, average farm size increased from 167 acres in 1954 to 305 acres in 1982. Nationally, the number of farms decreased from 4.78 million in 1954 to 2.37 million in 1982. In the South, the number of farms decreased from 2.31 million in 1954 to 1.02 million in 1982 (U.S. Department of Commerce, 1984). If these trends continue, national farm numbers are projected to decline to 2.10 million in 1990 and to 1.80 million by the year 2000 (Lin et al.). A 1986 study by the Office of Technology Assessment (U.S. Congress) suggests that the number of farms will decline to slightly more than one million by the year 2000. Most of the change is taking place in the South followed by the North Central Region. The problem of declining numbers of farms and increasing average farm size is forcing many farmers either to enlarge their farms, get out of farming, or stay in farming and get off-farm work to survive (Gladwin and Zabawa).

An important observation is that U.S. agriculture is moving toward a bimodel system, with increasing numbers of large farms at one end of the spectrum and increasing numbers of part-time small-scale farms at the other end. One result of this trend is the possible emergence of large commercial farms in traditionally strong agricultural areas and part-time farm operations near certain employment centers. The traditional family farms or medium-sized farms with gross annual farm earnings in the range of \$40,000 to \$250,000 will experience the greatest decline in numbers as they either scale up to become large commercial farms or reduce the volume

of business to become smaller, part-time farms with greater dependence on off-farm earnings (Schertz et al.; Kohl et al.).

The concept of economy of size and increased efficiency through specialization has led agricultural policy makers, the private sector, and the land grant system to focus on increasing agricultural production through large-scale, mechanized, capital-intensive, specialized commercial farms. Scientists who participated in the development of technology which accounted for the escalating productivity on commercial farms felt that larger farmers are more productive than small-scale farms. The larger a farm, and, hence, the more input and output to influence, the more high technology can potentially contribute to its efficiency (Tweeten). However, increasing farm size does not necessarily increase farm efficiency or productivity. In fact, small-scale farms in many field crop regions are nearly as technically efficient as large farms. The results of empirical studies (Ghatak and Ingersent) support the hypothesis that agricultural output per unit of land area does tend to be inversely correlated with farm size. Thus, the small-scale farms produce more per unit of scarce resources than large ones. The small-scale farmers are poor, not because they utilize their resources inefficiently, but because of restrictions in the kinds and quantities of productive resources they command. Net farm income on small-scale farms is limited by low volume production, not by reduced cost efficiencies. Small-scale farms generate low incomes and these low incomes cause such farms to exit, become part-time units, or expand to increase income whether or not economies of size exist. Hence, farmers of all sizes tend to enlarge their farms in search of higher income rather than to increase per unit cost efficiencies (Miller). Thus, the only feasible means of enabling small scale farmers to materially increase their output through technical innovation is by equipping them with more appropriate productive resources.

Farm Population and Rural Communities

The mechanization of the agricultural industry in the South within the past 50 years has produced many major societal changes which can be vividly seen in rural areas. Higher urban wages and salaries, more attractive jobs, and better educational opportunities and other social services in contrast to relatively lower farm wages, limited employment opportunities, and low or negative in-

come in agriculture have combined to produce a large exodus of the farm population from rural agricultural communities to urban centers. For instance, the population of the rural South has decreased from about 26.12 million in 1950 to 24.96 million in 1980, and the farm population decreased from 11.90 million in 1950 to about 2.63 million in 1980 and to 2.60 million in 1984. However, the population of the urban South has increased from 22.96 million in 1950 to 50.42 million in 1980 (U.S. Department of Commerce, 1983). The negative growth in the rural population can be attributed to the balance of natural increase and net out-migration to urban centers.

Technological change has adversely affected the human resource infrastructure. It has created considerable mechanization, growing farm size, and rising incomes for some rural residents, but lower incomes and underemployment for many others, particularly those with low levels of education and technical skills. Consequently, there has been a growing number of displaced farm workers with limited employment skills for absorption into the nonagricultural job market. With better training, educated workers migrated to urban centers, leaving rural areas characterized by severe unemployment, underemployment, and poverty. Those persons who remained in rural areas tended to be economically and politically disadvantaged, powerless, and disadvantaged for human resource development purposes (Marshall).

Technological development in agriculture has affected the economic status of the rural South. The declines in farm numbers in the agricultural sector have been transmitted to the public sector and, thus, hindered local economic growth and development. Local officials have often been faced with a declining number of taxpayers and shrinking public revenues at the same time that the costs of running local governments have increased. These localities have therefore been forced to cut back on social services, often when such services are most in demand (Mazie). Rural towns in the South which depend on agriculture face special problems in this changing environment. More than 70 percent of the income of farm families in the South came from non-farm sources in 1982 as low income families responded to their inability to effectively support their families from farm product sales by seeking off-farm jobs. But, despite these income supplements, 24.9 percent of the total farm population is considered

below the poverty line as opposed to 16.6 percent of the non-farm population (Southern Growth Policies Board).

Implications for Black-Operated Farms

The changing structure of production agriculture has also adversely affected the economic well being of black-operated farms. The number of black-operated farms dropped from a 1920 peak of about 926,000 to 33,250 by 1982, of which more than 93 percent are located in the southern states. The growth rate in size of black-operated farms was negative over the years. Almost half of all black-operated farms are less than 50 acres and have farm product sales under \$2,500 annually, with more than 92 percent having sales of less than \$20,000 (Banks). In general, the rural black population, although closely attached to the land, has worked in an environment that has been almost impervious to technological change and public policies. This, coupled with distorted racial attitudes, has kept black farmers in a disadvantaged position relative to the more well-to-do members of American society (U.S. Commission on Civil Rights). Black farmers did not develop the necessary technical and managerial skills to operate successful farming businesses, partially because of discrimination in the quality and quantity of formal and practical educational opportunities (Huffman). Most black farmers are educationally disadvantaged and economically poor, and they may face barriers to institutional services. Most of these operators do not have adequate amounts of land, capital, management, and/or financial resources to increase production and expand the farm base and avail themselves of new technology, which leads them to a poverty cycle (Banks). The lack of sufficient technical and managerial training has caused black farmers to be less able to acquire and interpret information on the latest technological developments, sort out relevant facts, or make modifications to their farming operations. All these technological developments will continue to speed up resource concentration and further force black farmers out of agriculture.

ADVERSE EFFECTS OF INNOVATIONS

Resources Endowment

Specialization and increased uniformity of farming resulting from adoption of the techniques of regional monocultural production have increased the vulnerability and reduced the adaptability of small-scale farm opera-

tions. Small-scale farm operators are unable to keep pace with sweeping scientific, technological, and social changes because they lack access to the productive resources necessary for adopting improved technologies. The large farms adopt new technology and better cultural practices. Small-scale farmers who control limited quantities of land, capital, and skilled labor often do not take advantage of improved technology, new managerial practices, intensive cultivation, and more profitable enterprise combinations. If they try to imitate the large farmers, who usually are the ones who have the resources to adapt the technology, the small-scale farmers may end up further in debt. Factors inhibiting adoption of technology on small-scale farms include lack of knowledge, limited resources, fear of risk, and limited managerial ability, as well as inability to justify economically the adoption of certain types of technology on small farm units (West). Thus, in this competitive market economy, low productivity and low income earnings often lead small-scale farm operators to a long-run situation of disinvestment and eventual relocation in other economic sectors.

Credit Financing

The capital investment possibility has become a question of survival for many small-scale farms. Most small-scale farmers, because of the small size of their farms and the high cost of borrowing, have traditionally financed the major share of capital requirements for farming operations from internal savings (equity capital) and/or minimized credit requirements by reducing input use and selecting low cash cost enterprises. Some farmers have also cut production and sold land to handle huge debts when no other alternatives were available. Others have become financially stressed from borrowing and are in jeopardy of losing their farms because they cannot make payments on their huge debts. This has placed them in situations where the risk of bankruptcy and farm foreclosures is high. Some farmers may wish to remain debt-free, because of risk considerations (Huffman and Donald).

Small-scale farmers are constantly plagued by credit problems. Without an adequate source of credit they cannot invest in production inputs, land, and modern machinery to increase production and expand the farm base. However, small-scale farmers still continue to have problems getting credit from conventional lending institutions. Major sources of

farm credit have often failed to extend credit to small-scale farmers because of the high risks of these farms, their low equity positions, and the general conservative lending practices of the financial institutions (Marshall and Thompson). The lending institutions impose rigid rules on credit lending in order to fully protect the loan capital, which limits the access of small-scale farm operations to the capital market (Ghebremedhin et al.).

Pricing Systems

Small-scale farms are confronted with many problems since they produce in an industry geared toward serving large-scale production units. One of the problems facing small-scale farms is the increase in input prices. Large farmers typically can buy farm inputs in bulk at lower prices than small-scale farm operators. Their advantage may be due to simple market power from their size in relation to the supplier's market or to actual lower cost for suppliers moving a volume to an individual producer. Changes in input prices are the result of change in basic supply and demand conditions for inputs, as well as changes in competitive conditions in the input market. As input prices vary among firms or change over time, the relative competitive positions of farm firms are affected. Consequently, many small-scale farmers have turned to production activities that do not require significant levels of capital and rely heavily on family labor resources (West).

Marketing Practices

General developments in marketing services, which include developments in transportation and storage, the advent of mass retailing patterns, the accompanying volume specification and grade standardization requirements, integration of segments in the production and marketing system, and public regulation of marketing activities, have all created serious problems for small-scale farm operators. These technological developments and changes in the marketing structure have significant impacts upon the survival of small-scale farm operations. Changes in the marketing practices influence the structure of the assembly and processing systems and thus influence access to markets for both inputs and outputs. Small-scale farms are seldom in a position to benefit directly from higher product prices and expanding markets. New methods of marketing have replaced organized open markets and set volume requirements so high

that small-scale producers are often excluded from the marketing process. Small-scale farm operators do not produce enough output to influence price, and they have usually incurred high input costs relative to large farmers because they do not buy bulk amounts. The effect of mass retailing, product standardization, and volume specification are often such that small-scale farmers cannot penetrate and compete. Marketing firms have turned to larger farms or developed an integrated system which bypasses small-scale farms. Small-scale farms, with their relatively low volumes and bargaining powers, have found it difficult to gain access to this centralized system on an individual basis. Therefore, they have been forced to seek other means of gaining access to this system, such as producing commodities different from those to which the marketing system in the region is geared, pooling their production through cooperatives to gain the advantage of a high volume, or using other market outlets (West). In general, small-scale farms are not in a position to benefit directly or indirectly from modern technological developments in marketing practices and pricing systems.

Government Policies

Government policies directly influence the structure of agricultural production and marketing. The goals of agricultural policies have not held the maintenance of a competitive production and market structure for agriculture as high priorities. Even though there were more than \$26 billion in agricultural income support, \$4 billion in subsidized loan programs and some additional rural development program dollars that went to America's farmers in fiscal year 1986, farm problems have not yet been solved (Lawrence). Commodity programs have often benefited to a much greater extent those farms that were in the strongest position from the standpoint of assets or volume of production. Commodity programs for the most part benefited large farmers who already had the land and capital to take advantage of the provisions of the program (Marable; Schultze). U.S. tax policies also give tax breaks to large farmers which represent subsidies to land and capital as opposed to labor, the one resource small-scale farmers have in relative abundance. Tax policies permit large farmers to acquire expensive agricultural inputs by bidding up the prices and shifting the cost to the government. Small-scale farmers have the same op-

tions but cannot afford the new agricultural inputs (Marshall and Thompson).

Current government policies have not and will not preserve all family farms (Tweeten). National agricultural programs are not necessarily applicable to all small-scale farms. Larger farmers were able to adopt output increasing technology because of a high level of government support, while small-scale farms represent an enterprise which has been largely ignored by public policy, both agricultural and economic. The long-run effect of public policies is price and income stability, which tends to reduce risk and uncertainty, facilitate adoption of new technology, and augment bankers' confidence in cash flow projections on farm loan applications. All of these factors strengthen the competitive position of large over small-scale farms. These policies have resulted in increased purchase of machinery inputs and land which have led to farm consolidation, expansion of farm units, and reduced farm numbers (Spitze et al.).

Research and Extension Programs

Technological research is one of the most powerful forces shaping production agriculture. By shaping technology and considering societal goals, research ultimately has great influence over the economic and social structure and the natural environment of rural communities. Thus, agricultural research and cooperative extension services have provided the basis for highly innovative agriculture. However, these innovations have displaced many farm workers, eliminated many small family farms, and diminished the quality of many rural lives. Today, there is no forum to aggressively articulate or advance the unique concerns and interests of the small-scale family farm. A concerted effort has not been made to solve problems impeding the economic improvement of small-scale agriculture. Oftentimes, the objective of research and extension programs has been to enable a small-scale farmer to become a big producer, and many who could not make the transition left farming for non-agricultural jobs (Wilson).

The adaptive approach of modern technology and structural change in agriculture has gone so far as to employ the power and influence of government and educational institutions, mainly the land grant universities, and has allowed the harsh forces of uncontrolled competition to drive less prosperous farmers out of agriculture and accelerated the migration of farm families from the land. Most of the

agricultural research by USDA and the 1862 land grant institutions is geared towards capital-intensive, large-scale farming. Large-scale enterprises have been the principal beneficiaries of agricultural research and extension in the farm sector (U.S. General Accounting Office). Many small-scale operators who cannot afford new large-scale technology to increase their output on small acreage fall behind and have to leave agriculture in the long run. Many others have been undoubtedly made worse off by the new technology that reduced the demand for farm labor and crop share tenants (Huffman). The historically black land grant institutions have played a vital role in helping the small, low-skilled, and limited resources farmers; however, limited federal funding has stifled the potential of these institutions for assisting in the survival of small-scale agriculture.

CONCLUDING REMARKS

The changing agricultural structure, as a response to ongoing economic adjustments, is not a temporary phenomenon. It is a situation in which the economic and natural resource base of farming and rural communities will be changing constantly. Emerging modern agricultural technology will move and change the structure of agriculture in the same profound ways and directions in the future as before—toward more sophisticated and challenging management and marketing, toward larger and fewer commercial farms, toward greater capital intensity, and toward greater separation of management from ownership (Tweeten). Agricultural research which is linked to biotechnology and information technology will result in a far more rapid turnover of technologies affecting input use rates and output levels than was the case with past research efforts. New biotechnologies will continue to emerge and will have the greatest impact because they will enable traditional crop and livestock enterprises to become increasingly specialized, centralized, and vertically integrated under corporate ownership. However, questions about socio-economic impacts and safety implications of new biotechnologies have to be addressed. Likewise, information technology is going to be a major tool in integrating decision-making involving financial management, planning and budgeting, optimal resource allocation, the use of production records, and a host of other management-related skills. Future commercial agricultural producers must be better

trained in economics, finance, business management practices, and computer assisted decision-making skills, to rapidly relate to real-life problems, to put in place technologies promising increased profit, and to take advantage of market demand and price opportunities (Kohl et al.).

The severe financial stress of a large proportion of farmers and the recent regulatory and competitive changes in financial markets have combined to change significantly the financial framework of farming. The farm of the future will be treated financially like any other business. Managing a farm efficiently and profitably will mean keeping up-to-date with technological developments and changing financial markets. The combination of future yield increases from new technology and current economies of size in many commodities may mean that there will be substantial incentives for farms to grow in size (U.S. Congress). However, maximizing farm yields through modern intensive technologies usually requires expensive purchased capital. When small-scale farmers are left with no choice but to invest in heavy machinery and equipment which are unsuitable for their small-scale farms, fixed production costs become excessively high, leading to negative net farm income and high debt/asset ratios. Relying on expensive technologies makes it likely that production will be used to pay the bills, thereby giving rise to a vicious cycle of dependence resulting in many leaving agriculture. Eventually the process leads to the absolute decline in the welfare of the majority of farm families and loss of jobs, revenue, and agricultural businesses in the rural communities.

There are many critical needs at different levels in agricultural development and human growth in the rural communities. Farm

families and rural communities need access to information and assistance to help in this changing economic environment. The land grant universities and USDA need to do research and disseminate appropriate information on low-cost farming technologies, community resource management techniques, and economic and social impacts of production efficiency. An integrated rural development program must include a broad range of public service programs from off-farm job creation and human resources development to community development programs such as improving community infrastructure and energy efficiency, development of businesses that can complement a more diverse agriculture base, efficient land use systems, water and soil conservation, efficient production management practices and marketing systems, and the provision of appropriate technology. All these need to be initiated to generate income and employment opportunities in rural communities. Thus, policies and development programs should be developed to solve the problems of rural poverty and unemployment. However, a well-designed national plan for rural socioeconomic development cannot fit each community. Each rural community needs a custom-designed development plan for its heterogeneous societal groups, and no one is better able to create the perfect fit than the community itself. In addition, no public agency working alone can do what needs to be done to revitalize rural communities. What is needed is a functioning coalition of federal, state, and local governments, rural residents, and land grant universities working with the ingenuity of the private sector towards increased productive capacity, job creation, and rural community development.

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