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ABSTRACT

The purpose of this paper is to identify the role of high technology in rural-to-urban and urban-to-rural movement and the implications of this technology for agriculture and rural areas. The first section of the paper considers the impact of technology on agriculture in the United States over the past 50 years. Because U.S. agriculture has undergone unprecedented technological change since the 1930s, this provides an excellent case study of the effects of technology. Section 2 examines the potential impact of high technology on rural people and areas and concludes that high technology will influence rural areas more as users than as producers of such technology. The next two sections focus on two major high technology users--the farming industry and local rural government and schools. Applications of computers in agriculture and telecommunications in marketing are described, forecasts of future microcomputer uses on farms are made, and selected applications by the public sector are considered. The final section addresses some underlying issues (posed as questions with brief answers and supporting arguments) about high technology's effect on economic efficiency and equity, educational needs, and philosophical concerns. (YLB)

High Technology in Rural Settings

STATE-OF-THE-ART PAPERS

OFFICE FOR RESEARCH IN HIGH TECHNOLOGY EDUCATION
The University of Tennessee College of Education

High Technology in Rural Settings

by

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FOREWORD

The Office for Research in High Technology Education at the University of Tennessee, Knoxville, is conducting a program of work on high technology and its implications for education. Funded by the U.S. Department of Education's Office of Vocational and Adult Education, the program addresses the skill requirements and social implications of a technology-oriented society. Issues concerning computer literacy and computer applications are a focus of the program. The balance between the liberal arts and technological skills and the complementary roles they play in enabling people to function in and derive satisfaction from today's high-technology era are also addressed. The program's efforts are targeted at secondary schools, two-year post-secondary institutions, community colleges, universities, industrial training personnel, and other education and training groups.

The program consists of three major components:

At Home In the Office Study - At Home In the Office is an experiment that has placed office workers and equipment in the workers' homes to determine (1) what types of office work can effectively be done at home and (2) the advantages and disadvantages of home work-stations. The implications for educators, employers, and employees will be significant, as work at home offers a possible avenue of employment for people living in rural areas, parents of pre-school children, handicapped individuals, and others.

COMTASK Database - COMTASK is a model of a computerized task inventory for high-technology occupations. The outcomes of the COMTASK system include a sampling of task analyses, the demonstration of how these task analyses can be rapidly updated, a manual for conducting task analyses to provide data for the system, and a guide to using the system.

State-of-the-Art Papers - A series of nine papers is being developed to address high technology and economic issues that are of major concern to education. Nine working titles have been selected:

- The Changing Business Environment: Implications for Vocational Curricula
- Computer Literacy in Vocational Education: Perspectives and Directions
- Computer Software for Vocational Education: Development and Evaluation
- Educating for the Future: The Effects of Some Recent Legislation on Secondary Vocational Education
- The Electronic Cottage
- High Technology in Rural Settings
- (Re)Training Adults for New Office and Business Technologies
- Robots, Jobs, and Education
- Work in a World of High Technology: Problems and Prospects for Disadvantaged Workers

Abstract

This study's purpose is to identify the role and implications of high technology, in the form of microcomputers and telecommunications, for agriculture and rural areas. The study concludes that rural people will be influenced by high technology much more as its consumers than as its producers. The best judgment is that the number of jobs in rural areas directly or indirectly related to producing high technology will be small compared with the total numbers of rural people who are employed, unemployed, or underemployed.

High technology's principal impact on production in rural areas will be through traditional industries such as manufacturing, services, and agriculture. To some extent, high technology will displace workers who have performed the low-wage, routine assembly work in which rural areas have had a comparative advantage. On the other hand, high technology will help keep in efficient operation and thus retain some rural industries that otherwise would have been closed down or moved to low-wage locations overseas. In addition, many workers in service and other industries will find more dispersed rural locations feasible because high technology will enable effective communication with home offices in urban areas or elsewhere.

Adult education in high technology, especially in the use of microcomputers, is deficient. Many family farms, small rural firms, and local governments cannot afford the start-up time and expense entailed for microcomputer operators to become proficient. This paper advances some proposals to remedy that situation.

About the Authors

Luther Tweeten has written numerous books and articles, perhaps the best known being Foundations of Farm Policy and Micropolitan Development (the latter coauthored with George Brinkman). His research emphasis has been on problems of regional and national economic development, the economics of human resources, and public policy for agriculture.

About the Editors

This paper has been prepared as part of a series of state-of-the-art papers edited by Lillian A. Clinard, an associate director of The University of Tennessee's Energy, Environment, and Resources Center (EERC), and Mary R. English, a research associate at EERC. The editors, who have been on assignment to the Office for Research in High Technology Education, were responsible for selecting the series' authors, reviewing and coordinating external reviews of the papers, and preparing the papers for release.

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CONTENTS

INTRODUCTION

Broadly speaking, technology is the means used to convert resources into things needed or desired. Rural people hold ambivalent attitudes toward technology. Through it, the United States, with less than 3 percent of the nation's work force on farms, feeds itself plus millions of people in other countries. Technology's blessing is that the nation enjoys a higher quality, variety, and abundance of food at lower real cost than ever before; its curse is that many traditional family farms have been sacrificed in the process.

After decades of increasing concentration of the nation's population in metropolitan areas, a turnaround took place in the 1970s. The population and employment levels of nonmetropolitan counties grew at faster rates than did those of metropolitan counties. The rural turnaround of the 1970s has turned around again in the 1980s. From 1980 to 1982, the metropolitan population grew 2.4 percent while the nonmetropolitan population grew only 1.9 percent (U.S. Bureau of the Census, 1984, p. 4). The recent, more rapid population and employment growth rates in metropolitan counties may come from the changing preferences and values deemphasizing "natural" rural amenities, the return of middle-class residents to the inner city, the more rapid recovery from economic recession in metropolitan areas, and the completion of the shake-out from internalizing environmental costs in large cities. But high technology has also played a significant role, and it will continue to do so. The purpose of this paper is to identify that role and its implications for agriculture and rural areas.

Definitions

Before proceeding, several terms should be defined. Unless otherwise indicated, urban is defined here as nonrural, and rural is defined as open country and places of up to 50,000 in population (a rural definition called "micropolitan" developed by Tweeten and Brinkman [1976, p. 5]). This micropolitan definition includes (a) people residing within Standard Metropolitan Statistical Areas (SMSAs -- i.e., counties with at least one city of 50,000 or more inhabitants plus the counties socially and economically integrated therewith) who live in open country or in small towns of fewer than 2,500 inhabitants, and (b) all people residing outside of SMSAs. This definition of rural combines geographic areas with similar problems and opportunities -- notably, problems and opportunities associated with low population density. By this definition, nearly 40 percent of the nation's people reside in rural areas.

High technology today may be defined as a conglomeration of computer electronics, software, robotics, communications equipment, computer-assisted designing and manufacturing, fiber optics, optical instruments, vapor/phase technology, medical instruments, and biogenetics that stands at the frontier of innovation (Karmin et al., 1984, p. 38). The focus here is on computers, especially microcomputers, and on telecommunications. Occupations influenced by such technology, as either users or producers are emphasized, with particular emphasis on farmers as users of computers and telecommunications. (Biotechnology is not omitted from this paper because it is deemed unimportant -- it may do more to change the food, agriculture, and rural sectors than will microcomputers [see, e.g., Butler, 1984].

Biotechnology is omitted here because of space limits and because its forms and products are yet too little known to trace future socioeconomic trajectories.)

The new socioeconomic environment of microcomputers and telecommunications has been called the information society. The two most important features of the information society are (a) the increasing importance of information as a component in the production of goods and services (Dillman, 1983, p. 345), and (b) the low cost and high speed of processing and communicating information electronically.

Objectives and Scope

The high technology of computers and telecommunication holds the potential to revolutionize the world in which we live. But in what ways? How will agriculture and rural areas be influenced, and will that influence be different from that experienced in other sectors? Will high technology increase or decrease comparative advantage in rural areas relative to urban areas? Will high technology cause a higher or lower proportion of the nation's people and jobs to be in rural areas? Will high technology increase or decrease the quality of rural life? These are some of the questions this report attempts to answer. Many of the answers must be tentative, however, because the socioeconomic study of high technology is a dynamic, emerging field in which journal articles and scholarly books often are obsolete before they are published.

The first section of this paper considers the impact of technology on agriculture in the United States over the past fifty years. Because U.S.

agriculture has undergone unprecedented technological change since the 1930s, it provides an excellent case study of the effects of technology. The paper then turns to the potential impact of high technology on rural people and areas, concluding that high technology will influence rural areas more as users than as producers of such technology. The next two sections focus on two major high technology users -- the farming industry and local rural government. The final section suggests some of the implications of high technology and draws conclusions on issues important to the future of rural America.

TECHNOLOGY'S IMPACT -- A CASE STUDY OF AGRICULTURE

Agriculture illustrates the effects of rapid technological change. Technological change as measured by output per unit of labor or per unit of all production inputs has been much more rapid in the farming industry than in other industries as a whole. The result is that agriculture can serve as a laboratory revealing costs and benefits from technological change. Of course, each technology is unique; the current and future socioeconomic impacts of microprocessors and telecommunication technologies are not directly comparable to the past impacts of hybrid seed or internal combustion engine technologies. But all adopted technology changes the way people live and work.

Some of the benefits from technological change in agriculture include the following:

- Overall economic gains have been vast, with calculated rates of return on investment in agricultural research and extension averaging approximately 50 percent since the 1930s (Ruttan, 1979). This means that the total resource costs for developing agricultural technology would have just equaled economic benefits if 5C-percent interest had paid by society on all funds used for agricultural research. Benefits have been especially large relative to taxes paid by low-income consumers.

- In the 1930s, when the U.S.'s agriculture began to undergo massive technological change, the per capita income of people in farming in the U.S. averaged only about one-third of that of nonfarm people. But over the past decade, the U.S. farm population's average per capita income, wealth, and rates of return on resources were at least as high as those of nonfarm people (Council of Economic Advisors, 1984, p. 112).

- It now takes only 3 percent of the civilian labor force to meet domestic food needs and still have sizable agricultural exports -- exports which earn 20 percent of the total U.S. export revenue (Council of Economic Advisors, 1984, p. 112).

- Americans pay a lower percentage of their income for food than do persons in any other nation (U.S. Department of Agriculture, November, 1982, p. 31). The U.S.'s efficient agriculture production is one reason for this; another reason is the U.S.'s high per capita income.

- Technological change has conserved soil. Millions of acres today are in pasture, forest, and other extensive uses that, in the absence of such technological change, would have been in erosion-inducing crops. Technological change has also made conservation tillage profitable and widely used.

- Labor-saving technology and improved transportation and communication have made part-time farming feasible. Off-farm income has substantially leveled family income among different classes of farms as measured by sales.*

Not all aspects of technological change in agriculture have been favorable:

- Farm population fell from 30.5 million in 1940 to 5.6 million in 1982 (U.S. Department of Agriculture, October, 1983, p. 81). Many of the millions who left the farm experienced difficult economic and sociopsychological adjustment problems. On the whole, however, it is not possible to conclude that those who left the farm generally were worse off; most were better off. (Tweeten, March 4, 1983, p. 1039; Tweeten & Brinkman, 1976, pp. 88-92).

- Many small towns lost population or disappeared as technological change eroded their socioeconomic base of farm families. Improved rural transportation and communications enabled the remaining potential customers to shop elsewhere, further diminishing these towns' economic vitality.

- Some technologies cause environmental problems: some chemical pesticides are carcinogenic; tractors compact the soil; fertilizer runoff may entrophy lakes; seepage of nitrogen fertilizer sometimes toxifies groundwater; continuous row-cropping increases soil erosion; monoculture increases the seriousness of disease epidemics.

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*Unless otherwise indicated, the farm classifications used in this paper refer to size categories by annual crop and livestock receipts. For 1982, these were as follows:

Farm Size	Receipts	Number of Farms (1,000)	Share of All Receipts (%)
Small	Less than $40,000	1,710	12
Medium	$40,000 to $200,000	578	39
Large	Over $200,000	112	49

For farmers in particular, the benefits of agricultural technology have been mixed. Except for early innovators, producers initially were made worse off by output-increasing technological change, which drove down real farm commodity prices and encouraged substitution of improved purchased inputs for farm labor. However, by the late 1970s, the farm labor supply had adjusted and farmers' per capita incomes had caught up with those of nonfarmers. Society as a whole has become better off, although economic setbacks such as those experienced by farmers in the early 1980s have obscured progress. The American standard of living would be much lower today, both on farms and in cities, without the technological change that has taken place in agriculture. Apocalyptic predictions of mass unemployment, chronic poverty, and social unrest arising from technological change have been unrealized.

Unemployment has numerous causes; the displacement of workers by technology is only one. America has undergone several technological revolutions since its origin. If each revolution had caused significant unemployment and if that unemployment was cumulative, unemployment rates would be massive indeed today! In recent decades, income has not become significantly more unequal, either in the nation or among classes and farms. In fact, income has become more equally distributed among farm classes as measured by crop and livestock receipts. Income distributions have remained remarkably stable within and among nations in recent decades, with the bottom quintile of population typically receiving 5 to 10 percent of the total personal income and the top quintile receiving 40 to 60 percent (see Campo & Norrlof, 1982, Annex).

THE IMPACT OF TECHNOLOGY ON RURAL AREAS

In analyzing the possible future impacts of high technology on farmers and rural areas, it is useful to distinguish between producers and users of high technology. Users can be further divided into those who use high technology to produce (e.g., in traditional manufacturing industries) and those who use it to consume (e.g., in the home). The conclusion of this section is that rural areas will be influenced by high technology more as users than as producers. And users probably will be influenced more in their consumption than in their production activities, although this section -- and this paper -- more extensively treat production activities.

Rural Areas as Producers of High Technology

Armington et al. (1983, pp. 62-72), using data for 1976 and 1980, found that the formation of high technology firms was positively correlated with city size and the presence of technical skills, factors that work against rural areas. But business formations were also positively correlated with low wages and low taxes, factors that favor rural areas. The same study found that the growth of high technology firms was not influenced directly by city size but favored low wages, low taxes, and low initial sector share of high technology employment -- all factors favoring rural areas. The computer industry is markedly distinct spatially between (a) research and development (R&D), new products, and administration in California and in the Boston area; and (b) standardized production in the Southeast and elsewhere (Malecki, 1983, p. 102).

R&D. The R&D phase is not labor intensive but is highly capital intensive -- human capital intensive. It requires major inputs of scientists, engineers, and skilled technicians (SET). For several reasons, the development phase is likely to be centered in urban rather than in rural areas:

- SET personnel frequently wish to be near major universities having strong science and engineering departments (Karmin, 1984, p. 43). Of such universities, the strongest are in metropolitan areas, where SET personnel can most easily interface between academe and industry. Of course, many large land-grant universities and other higher education institutions with strong science and engineering programs are located in nonmetropolitan communities, and these communities may also grow rapidly because they provide a favorable environment for high-technology industries.

- Major agglomeration economies accrue in R&D lowering unit costs for a firm located near to other R&D firms. Such economies arise from being able to draw from a large pool of SET personnel and a strong supporting infrastructure, including transportation (e.g., the presence of a major airport), communications, finance, advertising, and the like. Rural areas offer fewer agglomeration economies than do urban areas.

- SET personnel are highly paid, in short supply, and often prefer areas with amenities and high-quality community services. Firms must respect such preferences. The quality of rural schools is not necessarily low, but few rural schools offer the breadth and depth of curriculum found in the best urban or suburban schools. SET personnel also frequently wish to be near to cultural attractions and comprehensive medical facilities -- both frequently unavailable in rural areas. Of course, some rural areas on the urban fringe offer SET personnel the best of both worlds -- the amenities of open space traditionally associated with rural areas, but the easy access to high-quality merchandise, medical services, and cultural attractions traditionally associated with urban areas.

But even if rural areas were to share fully in high technology's R&D, the resulting employment would comprise only a small proportion of the rural work force. National projections for average annual openings for engineering and science technicians for the 1980s range from 168,000 to 183,000 (Galambos, 1983, p. 13). If 72,000 (about 40 percent) of these jobs were in rural areas, they would comprise well under 1 percent of the rural work force.

Production facilities. For most rural communities, high technology's most promising economic opportunities lie in attracting production facilities rather than R&D facilities. High technological production is not confined to Boston's Route 128, California's Silicon Valley, or North Carolina's Research Triangle. The Midwest, Southeast, Southwest, and mountain and plains states are potential gainers from future expansion of high-technology industries because such industries are new and relatively small. They do not have transportation or raw material costs that would tie locations close to markets or raw materials. Much of the labor force employed by high-technology industries is nonprofessional and nontechnical. Mature high-technology firms frequently establish production facilities away from their urban R&D and administrative headquarters.

Like other manufacturing industries, the production facilities of high-technology firms have fled older industrial areas in search of cheaper production costs and have found them in areas of low wages, low unionization, low taxes, and less stringent environmental laws (Tomashovic-Devey & Miller, 1983, p. 62). Because rural areas can offer the ample low-wage labor desired by firms for high-technology production facilities, rural areas can be expected to attract such facilities and jobs.

But employment gains are likely to be partially offset by high-technology robotics and automation, not only in industries producing high technology but in other industries as well. Computer-aided designing and manufacturing technology and mechanical robots will displace some of the lower wage, routine jobs in which rural labor has a comparative advantage. However, the low-skill, production-line jobs of urban areas will also be affected: most robots are now used in five metal-working industries, including steel and automobile manufacturing, and these industries tend to be unionized, high-wage, urban-located, and facing stiff competition from abroad. Robotics and automation technology will continue to displace labor in these industries to reduce costs.

According to Hogue (1983, p. 2) the simplest first-generation robots now in use have the potential to replace about one million of the nine million operating manufacturing workers currently employed in rural and urban areas. He adds that as new, more advanced generations of robots are introduced, an additional three million jobs will be at risk in the areas of assembling, packaging, grinding, electroplating, and inspecting. Similar estimates are reported by Ayres and Miller (1982, p. 42), but they add that the displacement of workers will take at least twenty years. (However, these figures fail to account for jobs gained or retained in the United States through automating manufacturing plants that otherwise would have been relocated to the third world [Karmin, 1984, p. 43]).

Estimates from the Bureau of Labor Statistics (BLS), Tomashovic-Devey and Miller (1983, p. 58), and Galambos (1983, p. 3) indicate that from 2 to 9 percent of total wage and salary employment is in high-technology industry, with such industry defined in various ways, including R&D expenditure relative to sales. The estimates indicate that either (a) high technology, narrowly defined, composes a small proportion of all jobs but is growing rapidly; or (b) high technology, more broadly defined, composes a much higher proportion of all jobs but is growing little or is declining. To be sure, the demand for some high technology is mushrooming. But labor productivity is also growing very rapidly; hence, increased sales do not translate into proportional increases in employment.

Malecki (1983, p. 101) reports that one result of the separation of R&D from production is that control over the production plant's processes and decisions becomes separated regionally or sectorally. The regions or sectors with production facilities lose the ability to innovate or to generate new firms. This effect is due partly to "de-skilling," a reduction in the skills required at the plant level which reduces the number of SET personnel at the plant -- the personnel most likely to venture out on their own to begin new firms. Rural areas do not have concentrations of existing high technology firms, and these firms, as they generate spinoff firms, have been a major source of new high-technology employment for many areas.

There is some fear that emphasizing production plants rather than administrative and R&D facilities in rural areas increases the chances of plant closures. However, studies reveal that branch plants in rural areas do not have unusually high closure rates (Malecki, 1983, p. 101). This may not be surprising, because in most cases branch plants are not speculative ventures but are carefully planned expansions by established firms seeking low-cost production.

Software production. Computer software sales, $2.7 billion in 1981, mushroomed to an estimated $10 billion in 1984. Sales will total a projected $30 billion in 1988 — an impressive 32 percent annual rate of growth (Software: The new driving force, 1984, pp. 74-75). Because software production requires fewer fixed assets and entails fewer economies of size than does hardware production, software production might be better suited to rural areas than hardware production is.

However, the software industry is moving out of the "cottage industry" phase. Future success will require massive marketing and distribution skills, ties with computer manufacturers, and close touch with the market. Because many of these requirements are best met in urban areas, rural areas will find it difficult to compete. Nonetheless, modern communication and coordination technology will allow a mix of rural-urban locations. An individual programmer can operate as a "cottage industry" in a location of choice, communicating with the main office by computer. The best rural locations will probably be within commuting distance of metropolitan centers.

High technology production in rural areas — A summary. In short, based on the above and other considerations, the best judgment is that, in rural areas, the number of new jobs related directly and indirectly to the production of high technology will have only a small impact. One reason is that the total number of jobs in high-technology industries will not be very large. A second reason is that even if rural areas got their full share of high-technology employment and experienced no displacement of labor, the number of new jobs in rural high-technology industries would make only a small dent in the estimated 3 million full-time equivalent jobs now needed for full employment by a rural work force of approximately 35 million (see Tweeten & Brinkman, 1976, p. 94 and Blakely & Bradshaw, 1983, p. 70 for unemployment and underemployment estimates).

High Technology Supporting Traditional Industries

Table 1 shows the employment in computer occupations in agriculture, forestry, and fisheries and in all industries for 1978 and as projected for 1990. Data broken out by rural and urban areas are unavailable, but it is well known that agriculture, forestry, and fisheries are especially prominent in rural areas. The data in Table 1 show that employment in computer occupations in these extractive industries is currently modest but that rapid growth rates are expected in most fields.

However, the principal means by which high technology will add or retain jobs in rural areas is by helping traditional industries to meet metropolitan and foreign competition. Today's microcomputers and telecommunications reduce the costs of distance and information transfer that have historically placed rural areas in comparative disadvantage (Blakely & Bradshaw, 1983, p. 67; Dillman, 1983, p. 351). In this and the following section, the emphasis is on high technology within traditional industries rather than as an industry itself.

Manufacturing industries. Jobs in manufacturing have increased in rural areas in recent decades, but rural areas rely only slightly more than do urban areas on manufacturing jobs. Production workers in

Table 1. Employment in Computer Occupations by Industry Division, 1978 and Projected to 1990

Occupation	Agriculture, Forestry, and Fisheries			All Industries		
	1978	1990	% Change	1978	1990	% Change
All computer occupations	1,079	1,785	65	1,157,983	2,140,000	85
Systems analysts	45	200	344	181,998	400,000	120
Computer programmers	269	600	123	246,998	500,000	102
Computer service technicians	5	10	100	63,001	160,000	154
Computer and peripheral equipment operators	337	625	86	392,993	850,000	116
Keypunch operators	423	350	-17	272,993	230,000	-16

Source: From "Employment Trends in Computer Occupations," Bureau of Labor Statistics Bulletin 2101, by the U.S. Department of Labor, October, 1981, Washington, DC: U.S. Government Printing Office.

manufacturing receive lower wages in rural areas than in urban areas -- for example, in Alabama in 1977, production workers in manufacturing averaged $4.20 per hour in nonmetropolitan counties and $5.85 per hour in metropolitan counties (U.S. Bureau of the Census, 1981). Although metropolitan and nonmetropolitan counties each had 20 percent of their work forces in manufacturing in 1979, metropolitan counties derived 26 percent of their income from manufacturing while nonmetropolitan counties derived only 18 percent of their income from manufacturing (Tweeten, October, 1983, pp. 176-77).

SET employment in manufacturing industries in 1980 totaled 1,345,100. This represents about 7 percent of all manufacturing employment in that year. SET workers were often critical to the viability of industry and hence to all manufacturing workers.

Private industry employs more than one-half of the nation's science and engineering work force (National Science Foundation, 1982, p. vi). In 1980, manufacturing industries, although employing less than 30 percent of all workers in private industry, employed 40 percent of all scientists, 60 percent of all engineers, and 45 percent of all science and engineering technicians in private industry. By 1984, computer systems analysts probably exceeded chemists as the largest science occupation in manufacturing industries (National Science Foundation, 1982, p. 2).

It is notable that SET employment in manufacturing was concentrated in durable goods industries -- these industries accounted for four-fifths of all SET employment in manufacturing. Rural areas have a disproportionately small share of durable relative to nondurable manufacturing employment, a factor which works against high proportions of SET employment in rural areas. Nonetheless, high technology can help "smokestack" and other manufacturing industries compete more successfully by cutting the costs of energy and materials needed to build superior-quality products, by more efficiently controlling inventories, and by preventing production bottlenecks through improved coordination.

The structure of the U.S labor force is changing. On the average it is becoming older, with relatively more experienced workers and with fewer new, unskilled workers. The result is likely to be lower unemployment and more competition for workers in the future and hence more opportunity to utilize underemployed rural workers than in the last decade. Many of these adult workers will require vocational-technical training. Some with inadequate schooling will need remedial general education before obtaining gainful employment.

Service industries. In rural and urban areas, most new jobs are in service industries rather than in traditional manufacturing industries. Service industries are highly diverse and include (a) trade, finance, insurance, and real estate industries with high proportions of low-wage clerical, secretarial, sales, and nonsupervisory workers; and (b) industries such as computer and data processing services, legal services, and other categories with high proportions of high-wage technical and professional workers.

According to Hogue (1983, p. 1), 90 percent of all new jobs added to the economy from 1969 to 1976 were in service occupations. By 1990, 72 percent of the labor force is expected to be employed in service industries. Up to 55 percent of all workers in 1980 were engaged in some kind of information-related occupation, including generating, storing, transmitting, or otherwise manipulating information.

Service occupations have traditionally located disproportionately in metropolitan areas. Service industries mostly have entailed low raw material costs but high costs for human capital, transportation, and communications. Service industries have tended to locate in urban areas, near their markets.

Advances in the information sector offer some hope for more service-industry jobs in rural areas. Decentralization made possible by microcomputers, word processors, cables, and satellites make small businesses and support businesses (such as software development or editing) possible even at some distance from clients. Furthermore, in contrast to current service industries in rural areas, which mostly serve their localities and hence do not draw outside dollars, advanced telecommunications and computers enhance opportunities for basic service industries in rural areas that serve state, national, or international markets. However, basic service businesses are likely to settle in "choice" rural locations with tourist attractions and good schools, rather than in poor areas where much of the manufacturing and agricultural job displacement is occurring (see Rosenfeld, 1983, p. 3).

In conclusion, it is impossible to predict whether high technology will enhance the comparative advantage of the service and manufacturing industries that currently dominate employment in rural areas. Employment gains through reduced costs of information processing and transfer are likely to be offset at least partially by the displacement of low-skill workers through robotics and automation. No signs of major new trends in service and manufacturing industries among sectors are apparent or expected.

AGRICULTURE AS A USER OF HIGH TECHNOLOGY

This may be viewed as a continuation of the previous section examining the impact of high technology on established industries. High technology on the farm is highlighted here because agriculture is an important, basic rural industry, and because computer and telecommunication applications in agriculture are so varied and pervasive that hardly any realm of farm life is left untouched. The high-technology revolution on the farm is more a quiet infiltration than a blitzkrieg, however.

Computer Applications

Table 2 lists some of the applications of computers in agriculture. (Computer applications for the farm household are similar to those for other households and are not considered here.) The list was compiled from a survey which revealed nearly 1,500 software packages (Strain & Fieser, March, 1982). Although many of these packages perform similar tasks and are merely variants of similar programs developed by different software makers and tailored to different microcomputers, it is still clear that farmers and those who work with farmers have a variety of software from which to choose.

The farmer has an increased need for sophisticated information, much of which can be supplied by computer applications. Integrated pest management; moisture sensors that promote high crop yields while using fewer pesticides and less irrigated water; delivery of The Wall Street Journal on rural mail routes across the United States on the day of publication; cable televideo information systems; satellite downlink discs

Table 2. Description of Computer Programs for Agriculture Reported by Land-Grant Universities, Fall, 1981

Program Category	Description
Farm business management records	Farm enterprise record systems, single and double entry accounting systems, profitability/cash flow analysis, balance sheets.
Farm business management/ budgets and planning	Budget generator systems for calculating impact of changing yields, prices, etc. on enterprise costs, returns, and net returns; computation of income-maximizing farm enterprise mix; optimal depreciation schedules.
Farmland investment analysis	Calculates maximum bid price for land, years to recover land investment, mortgage payments, investment profitabiltiy and feasibility, discounted cash flow, net present value, benefit cost ratio, internal rate of return, compound interest, repayment schedules.
Farm equipment and machinery business analysis	Calculates machinery/equipment ownership and operating costs; calculates custom rates, optimal tractor and other implement size, owning versus leasing machines.
Technical analysis for farm facilities and buildings	Estimates farm building material needs/costs, single-span minimum beam size, grain and livestock ventilating needs, building energy requirements, water pipe friction loss, livestock waste lagoon design.
Government commodity programs	Calculates cost and benefits of government crop program participation
Taxes, tax management	Estimates individual federal-state tax, joint/corporate income tax, alternative tax management strategies; shows federal income tax schedules.
Estates, estate planning	Analyzes estate/gift/property taxes, calculates tax due for specified estates.

(table continues)

Program Category	Description
Labor management	Estimates farm labor needs for livestock/crops; calculates social security/witholding/net pay, optimal labor job assignments.
Marketing	Electronic listing of cash and futures market quotes, displays USDA agricultural outlook, plots market price data, charts future prices, analyzes market prices for trend/prediction, compares grain selling/storing alternatives, analyzes grain crop marketing/hedging/storing alternatives.
Chemicals, soils, and fertilizer	Calculates crop fertilizer requirements/costs, least-cost fertilizer mix; accesses soil test data files; uses soil test results for fertilizer recommendations; makes soil loss predictions from erosion; designs drainage systems.
Irrigation	Estimates irrigation system feasibility, costs/returns; evaluates irrigation pump performance; estimates irrigation pumping costs; analyzes soil moisture for irrigation schedule.
Grain storage, drying, and handling	Analyzes farm grain handling facility, calculates monthly grain storage costs, estimates corn drying breakeven cost/price, calculates grain-drying fan size/HP needed, estimates natural air grain-drying time, compares alternative fuel costs for drying.
Pest management	Accesses state Integrated Pest Management data base and management system, reports on crop pest infestations, identifies plant disease from symptoms, accesses pesticide recommendations, calculates amount of pesticide application, calibrates pesticide sprayers, predicts insect development from weather.

Source: Adapted from "Updated Inventory of Agricultural Computer Programs," Circular 531 (Tables 1, 2, and 3), by R. Strain and S. Feiser, March, 1982, Gainesville, FL: Food and Resource Economics Department, University of Florida.

providing the potential for as many as 100 video channels, ranging from home entertainment to constant weather and market information to the sale of new products; electronic spreadsheets . . . these are becoming as important to some farmers as their disks and plows (Dillman, 1983, pp. 349-50).

Some futurists foresee 21st-century cropland traversed by giant horizontal beams, riding perpendicular to tracks at each end of the beam (Twist, 1982, pp. 457). These robots would make passes as necessary over fields to perform planting, growing, and harvesting operations with minimal labor. Of course, operations would be automated and controlled by computer. However, such capital-intensive, labor-extensive operations would be confined mostly to high-value horticultural crops for the foreseeable future.

In the next decade, computers probably will replace labor and increase output to only a modest degree. They will replace many pencils, notebooks, livestock performance and account record books, calculators, and typewriters, and they will provide more precise control of machinery and irrigation systems. However, for the foreseeable future, they will not replace tractor or combine operators. They will save time and energy and will reduce harvesting waste, but they will not substantially increase the output of crops and livestock.

Across the nation small groups of farmers, usually 10 to 30 in numbers, have formed into computer clubs. These clubs survey, appraise the suitability of, and exchange software and hardware; they conduct educational programs to improve computer skills; and they evaluate specific measures such as whether to participate in the payment-in-kind crop diversion program. These are not just social or "hobby" clubs joining persons of shared interests; the clubs have enhanced farm management and marketing expertise.

Not much is yet known about these clubs, but they probably contain disproportionate numbers of middle-scale commercial family farmers. Larger farms can afford paid consultants. Many smaller, part-time operators cannot justify the expense of consultants and cannot spare the time for computer clubs. But such clubs offer potential networks to facilitate communication and adult vocational training in agriculture. In this, a critical role can be played by the Cooperative Extension Service.*

Telecommunications In Marketing

Some of the most interesting applications of high technology in agriculture are in marketing. Telecommunications have proven especially beneficial for markets that previously were "thin" because buyers and sellers (and their merchandise) were too few and dispersed to meet face-to-face without undue travel time and expense. Organized electronic markets have in common the use of electronic communications equipment. They differ in methods of operation and degree of complexity. The five basic types of electronic markets (Ethridge, 1978, p. 178) are described

*The Cooperative Extension Service is an educational arm of states and land-grant universities which originated under the Smith-Lever Act of 1914; is supported by federal, state, and local funds; and provides noncredit, nonresident student outreach to farmers and rural communities.

below.

(1) Manually operated telephone clearinghouses. Offers to buy and sell a commodity of well-defined quality and quantity are made by telephone to the clearinghouse, where offers are manually matched. Since 1971, telephone clearinghouses have been used to market eggs.

(2) Telephone auctions. A commodity is traded by a conference telephone call between an auctioneer and a group of geographically dispersed bidders. Since 1962, this procedure has been used to trade slaughter hogs, feeder pigs, slaughter and feed cattle, and market and feeder lambs (see Ward, 1983).

(3) Teletype auctions. Sellers' consignments of a commodity are listed on a teletype network of potential buyers, and bids are received by teletype. Teletype auctions have been used to market butcher hogs in Canada since 1961.

(4) Computerized trading. Sellers' consignments are offered for sale to potential buyers on a network of remote terminals connected to a central computer. The computer receives, compiles, and stores bids and offers; it completes transaction and keeps records. A key element in the electronic market is a standardized grading system which is accepted by buyers and sellers (Ethridge, December, 1978). The Haymarket and TELCOT systems are described below to provide insights into the operation of computerized trading.

The Haymarket system in Oklahoma potentially benefits both buyers and sellers while increasing the efficiency of hay marketing. Previously, hay sellers and buyers had no satisfactory means to communicate. With

Haymarket, growers can receive information about potential buyers, their hay needs, and how much they are willing to pay, while buyers can receive information about where and how much hay is for sale, what its quality is, and how much growers want for it. Growers pay a fee to the system for listing and grading. Timely information on hay for sale is relayed quickly by computer from growers to buyers, and buyers then contact growers directly. The two parties negotiate price, payment method and time, delivery date, and trucking arrangements (Cuperus, Rommann, & Ward, 1983). Growers report sales immediately to the market coordinator so that the listing can be removed from Haymarket.

TELCOT, which markets cotton and is operated by Plains Cotton Cooperative Association (PCCA) in Lubbock, Texas, is one of the most successful computerized spot markets and one of the few outside of livestock. TELCOT operates with a network of remote terminals connected to the PCCA central computer. Terminals are in offices of subscribing cotton merchants, gins, and the central office of PCCA. Price, quality, and sale information is stored on disks by the computer.

Producers from any of 190 participating cooperative gins can use TELCOT to sell cotton. After the producer's cotton has been harvested, ginned, and classed, data on quantity and quality are coded and stored in the PCCA central computer under the producer's identification number. The producer can offer the cotton for sale at any time. The bidding on the lot is open for 15 minutes; if the highest bid is within at least 25 cents per pound of the asking price, the cotton automatically is sold to the highest bidder. Under an alternative system, a producer can specify the acceptable price for a lot of cotton, and the lot will be sold to the first buyer willing to meet the price. Computerized trading has been used for cotton since 1975.

(5) Video auctions. The first video auction was conducted in 1975 in Oregon for feeder cattle. In video auctions, the cattle or other livestock remain on the owner's farm or ranch during the sale. Buyers see a video tape of the cattle for sale; the cattle are then sold to the highest bidder. After the video auction, the cattle are moved from the seller's ranch to the buyer's location. Video auctions have been conducted commercially in a number of states and in Canada. Video auctions have been used most extensively for feeder cattle but have also been used for slaughter and breeding cattle, feeder lambs, and breeding sheep (Ward, 1982).

In video cattle marketing, producers inform the video auction sponsor that they have cattle for sale. A cameraman and someone from the sponsoring firm visit each consignor's ranch. A crew tapes about 10 minutes of video while the cattle are on the ranch, usually in a pasture. As the cattle are videotaped, the market agent describes their number, sex, grade, genetic background, condition, the owner's health and feeding programs, and their estimated weights at the time they will be delivered. Buyers may assemble in a motel conference room, where the sale often originates. Buyers also may be scattered all over the country; those not at the auction location phone in their bids to the auctioneer.

In short, telemarketing is especially attractive to widely scattered small and medium-sized farms which cannot market in large lots. While telemarketing may preserve or extend markets to farmers, it may displace some existing conventional markets, especially marginal markets in small towns. Whatever the microcomputer's impacts on conventional markets, it is a tool that is used increasingly in the marketing system. Vocational-technical education can help farmers develop the microcomputer operating skills needed to function effectively in the new marketing world.

Institutions Promoting High Technology For Agriculture

Nearly every land-grant university in the United States offers programs in computer applications to agriculture. Some have special programs. Texas A & M University has launched a "Year 2000 Computerized Farm" whose purpose is to demonstrate how computer technology can be applied to all aspects of a commercial-sized farming operation.

Chartrand, Carr, and Miller (1982, pp. 34-40) provide an excellent review of operating videotext systems used in various states to provide farmers with electronic mail, to analyze farm management problems, and to receive information on markets and weather. The federal Extension Service, the W. K. Kellogg Foundation, and other organizations have helped to form a number of such computer-support systems -- e.g., AGNET out of the University of Nebraska, TELPLAN out of Michigan State University, FACTS out of Purdue University, CMN out of Virginia Polytechnic Insitute and State University, and ANSER out of the University of Kentucky (Congressional Research Service, 1982, p. 147). Of course, private firms and farm organizations such as the American Farm Bureau Federation also offer excellent videotext services to farmers.

In some instances, cooperating universities have formed centers. For example, the North Central Computer Institute (NCCI), formed in 1981 at the University of Wisconsin, is supported by twelve land-grant universities and is supplemented by grant funds from the W. K. Kellogg Foundation. The programmatic unit of NCCI supports the extension, research, and resident instruction functions of the twelve universities' agriculture and home economics programs by facilitating the development and dissemination of software and data bases.

Future Use Of High Technology On Farms

A lack of primary data on the current levels and trends of farm high technology use makes future use especially difficult to forecast. It thus is necessary to rely here mainly on informed judgments. Although the computer may be the most significant technological innovation on the family farm in the next decade, not all agree on the probable extent of its use.

Robert Kramer, Program Director of the W. K. Kellogg Foundation, which has supported extensive computer applications in agriculture, predicts that the following will have occurred by 1990 (NCCI, 1981):

- Nearly three-fourths of the commercial farmers in the United States will use computers or programmable calculators in making management decisions.
- Many farming operations will be computerized and will be automated by electronic controls.
- Ninety percent of the nation's county extension offices will have "intelligent" terminals.
- Virtually all departments in colleges of agriculture and home economics will have intelligent terminals or small computers.

A more conservative forecast comes from a market research firm survey which estimates that only 94,330 microcomputer systems will be sold to farmers between 1983 and 1987 (<u>Small talk on big issues</u>, 1983, p. 4). During this period, an additional 36,090 farms, representing only 1.5 percent of the 2.4 million U.S. farms, are expected to become new users of agricultural data-processing services. An estimated 300 companies are producing software for agriculture; serious questions are being raised about whether the market can support such activity (<u>Small talk on big issues</u>, p. 4).

The opinions of 535 farmers, ranchers, lenders, and consultants formed the basis of another investigation, reported in 1983, of farmers' and ranchers' future information needs (Carlson et al., 1983). The 250 farmers and ranchers in the study were selected because they were regarded as <u>innovative producers</u>. Their responses thus represent only innovative farmers and ranchers such as themselves. In contrast, the lender and consultant respondents were asked to consider the practices of all commercial farmers and ranchers. It is felt that, in the years ahead, the majority of commercial farmers and ranchers are likely to implement the procedures of today's innovative producers.

The study's conclusions were as follows (Carlson et al., 1983, pp. 2-3):

- Innovative producers use information-related services, especially small business computers, more extensively than do all commercial farmers and ranchers. Although an estimated 3 percent of all commercial producers own a computer, 22 percent of the innovative producer respondents reported owning one.

- One-sixth of all commercial producers (excluding small farms) are expected to acquire computers within five years, and nearly all innovative producers are expected to acquire them. This estimate suggests that 50,000 computer units will be acquired by the 300,000 largest commercial farms and ranches. Respondents estimated that computer workshops are desired by 25 percent of all farmers and ranchers.

- Consultants will play an increasingly important role in the management of farms, especially larger farms. Considerable dissatisfaction exists, however, with the present availability and quality of assistance in some important management areas. In the areas of marketing, financial analysis, and computer use, one-half of the respondents believed that the present availability and quality of assistance will continue to be a problem.

Satellite-linked proprietary systems are a partial remedy to this problem. These are now in place and can provide market, statistical, and managerial information to farmers who use microcomputers to receive and process the information. Bonnen (1983, p. 963) raises a noteworthy issue: "Whoever controls the dissemination of the farm decision models is likely to control the dissemination of future research knowledge and the analytical capacity needed for farmer decisions."

In concluding this section, it is noted that forecasts of future microcomputer uses on farms are only conjecture. The potential for innovative computer applications is large, and farmers are receiving help and encouragement from numerous sources. But farmers need more depth in computer use and application — something that will require more formal training in vocational-technical schools and elsewhere. At present, resources are inadequate for such training. Operators of medium-sized farms are prime candidates for training programs, but operators of all sizes of farms could benefit.

LOCAL RURAL GOVERNMENTS AND SCHOOLS AS USERS OF HIGH TECHNOLOGY

High-technology applications by the private sector in rural areas were discussed earlier. Here we examine selected applications by the public sector.

Lack of fiscal capacity to support planning and evaluation staffs has long characterized rural communities. In some cases this has made it difficult for rural communities to compete for grants with metropolitan centers and their sophisticated planning departments. In other cases it has resulted in inefficient spending because decisionmakers lack the necessary information to make critical choices.

Low-cost computer technology has placed sophisticated management techniques in the hands of local rural governments. Most of the software described in Table 3 was developed at land-grant universities to assist local governments, but some of the programs such as "apartment projects" also can be used by private firms to evaluate alternatives. As illustrated in Table 3, this software deals with a wide variety of community services as well as with simulating the impact of industrial development, public works projects, and other investments on the public and private sectors. Technical assistance provided by Cooperative Extension Service personnel is widely used and continually improved.

Other innovative uses of computers by local governments have been proposed -- for example, microcomputer programs to record land use inventories and developments. By using extensive stored information along with appropriate computer software, analysts could perform sophisticated analysis of land-use impacts previously affordable only by large

Table 3. Computerized Models for Economic Evaluation, Impact Analysis, and Simulation, by State

Model	Description	States Listing Program
Community services		
Apartment projects, mobile home parks	Estimates the total annual cost and breakeven monthly rental rates for rental apartment projects in rural areas, feasibility (costs/returns) analysis of rural mobile home park projects.	MO, NV, OK
Clinics	Generates budgets of costs and returns for rural medical clinics; estimates number of calls, annual capital and operating expenses, revenue, and net revenue.	MS, MO, NV, OK, TX
Emergency medical systems	Generates budgets for emergency medical services; estimates num- of calls, annual operating and capital costs, revenue, and net revenue; calculates optimal ambulance location(s) among cities in a rural area to minimize response time, cost, or other objective.	IN, NV, OK TX
Fire protection	Generates budgets for rural fire stations; estimates number of calls, annual operating and capital costs, revenue, net revenue.	MO, OK
Nursing homes	Provides estimates of capital and operating costs for alternative sizes of nursing homes based on various occupancy rates and other factors.	MO
Sewer facilities	Provides projections of capital and operating costs for alternative types of sewer collection/treatment facilities.	OK, TX

(table continues)

Model	Description	States Listing Program
Solid waste management	Feasibility analysis of rural solid waste management systems; estimates budgets for collection transfer stations, and landfills.	AL, MS, OH, OK
Swimming pools	Economic feasibility; shows estimated costs, returns, and net revenue.	AP
Transportation system	Projects number of riders for minibus system under given population density patterns; estimates, annual capital and operating costs.	MO, NV, OK TX
Water	Projects annual capital and operating costs for rural water system; projects growth and net revenue.	OK, TX
Population projections	Projects the population of a given area based on birth, death, and migration rates.	OK
Rate structure analyses	Projects revenues for alternative community service rate structures based on estimated demand and other conditions.	OK
Routing	Calculates minimum distance or least-cost route for school bus, solid waste pickup, milk route, elderly transportation, etc.	OK
Carpool analyses	In terms of cost and time, determines optimal routes and riding arrangements for commuters traveling to a single point.	OK, NC

(table continues)

Model	Description	States Listing Program
Impact analyses and simulations	A family of related models showing net fiscal impacts of new industry on city government, county government, school district, and private sector; projects population, income, employment, and community service needs; evaluates new residential subdivision proposals for fiscal impact; analyzes benefits and costs for multi-year projects, including net present values, cash flow, benefit/cost ratio, internal rate of return, and breakeven point.	ID, IN, KY, MO, NV, OH, OK, SC, TX, VA

Source: Adapted from "Computer Programs Available to Measure Growth and Decline" (Tables 1 and 2) by M. Woods, G. Docksen, and V. Lenard, October, 1983, Stillwater, OK: Cooperative Extension Service and Department of Agricultural Economics, Oklahoma State University.

governments and corporations (McKenzie, 1982, p. 18).

One reason that people in rural areas often lag behind their urban counterparts in income is that they frequently lag in both vocational-technical and general education (see Tweeten & Brinkman, 1976, chapters 4 and 5; see also Appendices A and B). The effective use of high technology to "skill" rural students can in part offset the "de-skilling" taking place in industry.

By sharing services electronically, some rural schools are reducing the need for consolidation and attendant transportation costs. Rural communities that cannot afford teachers to serve small classes of students with specialized needs can benefit especially from the use of telecommunications and microcomputers for computer-assisted instruction (CAI) or computer-managed instruction (CMI). CAI has been used cost-effectively in many rural areas where sparse populations preclude conventional instruction to provide individualized instruction, in either basic skills or highly specialized subjects (see Ball & Jamison, 1972; Joiner, Silverstein, & Clay, 1981). (For example, in rural northern Minnesota -- an area where too few students, too little money, and a scarcity of skilled staff ruled out conventional instruction -- students pursued independent study using Control Data Corporation's PLATO system on microcomputers [Joiner et al., 1981, p. 579]). However, despite numerous innovative CAI and CMI efforts in rural areas ranging from remote regions of Alaska to the mountains of West Virginia, rural schools have for the most part been slower to apply high technology to the classroom than have been urban schools.

In rural areas, according to Rosenfeld (1983) "a skilled work force, strong schools, and extensive communications links have been added to the list of factors needed to sustain growth" (p. 4). Rural communities can improve their economic prospects by (a) developing human resources through improved education and skill training; (b) improving infrastructure that supports the small-service businesses, specialty manufacturing and crafts, agribusiness, and tourism which rural areas are likely to attract; (c) assembling private risk or venture capital, supplemented in some cases by public financial assistance, to help entrepreneurs test their ideas and turn them into businesses; and (d) providing increased technical assistance in planning and assessing the feasibility of proposed projects, perhaps partially through cooperative extension activity from land-grant universities.

In some cases, communities can profit from a combination of all the above activities, most of which can benefit from high technology. Control Data Corporation, in its Rural Ventures program, makes extensive use of its own computer-based PLATO education and training programs along with a host of other planning and management software to improve community services and economic vitality (including the economic vitality of small farms) in depressed rural areas (Rural Ventures, Inc., 1983, p. 3).

CONCLUSION

In this concluding section, the paper's findings are coupled with other analyses and judgments to address some underlying issues (posed as questions with brief answers and supporting arguments) about high technology's impact on rural areas and people.

Summary of Findings

In the past, technology has affected rural areas in important ways, contributing to demographic turnarounds and other socioeconomic changes. Today's high technology -- especially the microcomputers and telecommunications emphasized in this study -- will continue to play a role. Identifying that role and its implications for agriculture and rural areas in the United States has been the purpose of this paper.

U.S. agriculture provides an excellent case study to assess the impact of rapid technological change. When measured by the proportion of income spent by consumers for food, the high exports relative to domestic use of farm products, and other economic yardsticks, the technological revolution in agriculture has been a major success. The social impact of this revolution is much more difficult to measure, but available evidence on persons displaced from agriculture indicates that, on the whole, they improved their socioeconomic circumstances, based on either subjective or objective measures.

More central to this paper is the prospective impact of today's high technology on rural industries and agriculture. This study finds that in rural areas the number of jobs related directly or indirectly to the production of high technology will be small compared with the total numbers currently employed, unemployed, or underemployed. Instead, the principal impact of high technology on production in rural areas will be through traditional industries such as manufacturing, services, and agriculture.

In manufacturing, high technology will displace some low-wage workers performing routine assembly work. Rural areas will then lose some jobs but will be better able to retain their comparative advantage in this type of production by keeping in efficient operation some industries that otherwise would have closed down or moved to low-wage locations in other countries. In service and other industries, dispersed rural locations will become increasingly feasible as high technology enables effective communication with home offices in urban areas or elsewhere. In agriculture, extensive use of high technology is already being made, especially by innovative producers and larger farms in their management and marketing operations. Telecommunication in marketing is, perhaps, especially significant: it has made the production of commodities at scattered points more economically feasible.

The public sector in rural areas is also beginning to take advantage of high technology. With help from universities and agencies such as the Cooperative Extension Service, local rural governments have adopted many innovative computer applications to facilitate planning and decisionmaking in areas such as transportation, prospective population and land use, and the provision of community services.

Underlying Issues

The first three questions posed below center on high technology's effect on economic efficiency and equity. The answers and arguments given are not conclusive but must be viewed as informed hypotheses, subject to further testing. The fourth question addresses the educational needs implied by this paper's analysis; in response, a few proposals are advanced about ways to help meet those needs. The last three questions are more philosophical, but they may be the issues that most profoundly concern us all.

Will high technology give a comparative advantage to one size farm over another? . . . Yes, high technology will advantage large farms more than small- and medium-sized farms, but the resulting changes in comparative advantage will not cause major structural changes.

Computer and telecommunication technologies for business applications are best suited to large farms, where they are being adopted first. A personal computer, with its required software, costs less than half as much as an automobile and hence is well within the means of the vast majority of farm families. But the continuing costs for a cable or telephone hookup to teletext information systems and for software to manage and operate the farm are by no means inconsequential.

The high technology of computers and telecommunications does not increase farm output directly. Rather, it is an intermediate input, providing information which operates through other inputs to increase efficiency by using less aggregate input or producing more input. The larger the farm and hence the more input and output to influence, the more high technology can contribute to efficiency. Start-up time and labor requirements to operate computers can be substantial. Large farms have an advantage in being able to afford hired, specialized skills and to spread their costs over many units of output. Their chances to use microcomputers profitably are greater than the smaller farms' chances, since their overall costs for this technology are much less per unit of output. Thus, a higher proportion of large farms than of small farms will use microcomputer and telecommunication technology, and they will use it more intensively in their managing and marketing operations.

Both part-time small farms and full-time family farms may be unable to spare family labor time or to afford hired labor to operate computers. However, some part-time farm operators may have considerable off-farm discretionary income to purchase microcomputers, may have been exposed to computers in their off-farm work, and may have the multiple-use potential to justify buying a computer. Thus, large and part-time small farms have some advantages over medium-sized farms in adopting high technology. The medium-sized family farm is shrinking as a proportion of all farms and needs to exploit every opportunity, including high technology, to regain comparative advantage. A case can be made for a greater public role in providing training for such farmers.

The advantage to large farms is unlikely to be decisive, however. High technology will not save poor managers and profligate spenders from financial ruin. Personal performance -- especially in terms of the capacity of operators and their families to mentally process information and reach sound decisions, but also in terms of dedication, initiative, and fortuitous circumstances -- will far outweigh high technology in determining the success or failure of a farm, whether it is large or small.

Family-owned farms have been efficient because the owner/operator has had a stake in the business. The result has been a high level of operational management apparent in getting the crop planted and harvested on time, being on hand when sows farrow at midnight, and so forth. However, organizational management entails acquiring assets, managing investment portfolios, managing risk, choosing enterprises based on careful forecasts, and so forth. The latter type of management requires sophisticated information systems, special expertise, and an adequate scale for success. In modern agriculture, organizational management is becoming important relative to operational management. The family farm whose traditional strength has been operational management will have to use high technology to compete efficiently with large, industrial-type farms that are able to purchase or hire organizational management. Other things being equal, however, the farms able to apply high technology at a low cost per unit of output will have the advantage. But the advantage offered by high technology to large farms at this time is less than that offered by mechanization. The computer is likely to have much less impact on farm size and numbers than does the tractor.

Will high technology change the comparative advantage of rural versus urban areas? . . . No,, high technology will not decisively change the existing comparative advantage.

High technology reduces the friction of rural space to an extent unparalleled since the advent of the automobile and telephone. Reduced costs of communications enhance the comparative advantage of rural areas, other things being equal. But other things are not equal, as noted earlier. Conglomeration economies are evident in the production of high technology. High technology in the form of robotics and automation may replace many unskilled jobs in which low-wage rural workers have had a comparative advantage. On the other hand, the innovative use of high technology will improve efficiency, helping to keep some manufacturing plants and jobs in rural communities that otherwise might be driven out by foreign competition. The net impact of these forces on rural areas is impossible to judge, but the best guess is that high technology will not be decisive in giving comparative advantage to rural versus urban areas.

Will high technology bring about a more unequal distribution of benefits, including income? . . . No, it is premature to contend that high technology will give rise to a notably more unequal distribution of income and other benefits.

High technology allows society to have more output from given resources. For example, when abundant elements such as silicon are substituted for labor and are used to generate high-value products, the nation's standard of living is enhanced. Many of the benefits of high technology accrue to consumers in the form of lower cost, higher quality products. These benefits will be widely shared, approximately in proportion to the consumption of products that are made cheaper and more accessible by high technology.

More middle-class than other people are involved in producing and consuming high technology. High technology creates large numbers of jobs in marketing, management, and other areas that pay more than routine assembly jobs but less than the best paid scientific and engineering jobs.

Regarding income from production, high-technology industry will make rural incomes (from all sources) more equally distributed if it raises below-average incomes, reduces above-average incomes, or induces net inmigration that shifts the population profile toward average income. Unlike the case of auto and steel workers in urban areas, relatively few high-paid production workers are expected to be displaced by high technology in rural areas. Rather, production jobs may be created which are likely to be filled by workers improving their relatively low earnings. Reducing the friction of space may distribute the employment of scientists, engineers, and skilled technicians (SET) more evenly, but much of the high-income, high-technology employment will continue to be in urban areas.

In sum, high-technology production could cause incomes to become slightly but not notably more equally distributed between rural and urban areas. However, factors such as luck, education, and individual and community initiative will continue to be more important in influencing income distribution.

What kinds of high-technology education are needed in agriculture and in rural America? . . . Surveys indicate that adult education in high technology, especially in the use of microcomputers, is deficient. Some proposals are advanced below to remedy this problem.

The major impediment to extending high technology to agriculture and rural areas is the high start-up cost in becoming a proficient computer user. This is not an overriding problem for consumers for whom microcomputers are hobbies or for large firms that can afford extended professional instruction. But for those who have limited time and resources — e.g., family farms and local rural governments — the time and money required to develop computer operating skills may be significant obstacles.

On college campuses across the country, the computer skills training of resident students is becoming more widespread, comprehensive, and effective. Many students will return to rural areas to form a nucleus of personnel skilled in high technology. Computer skills are also being taught in many elementary and secondary schools, although rural areas frequently lag behind in this regard. When the students so trained become adults, they can expect to be comfortable in the use of high technology.

Much of the current problem concerns adults who wish to use high technology but lack the requisite skills and are constrained by limited resources or educational opportunities. Private firms selling computer hardware and software are increasingly likely to provide education because this will complement sales, but public agencies will also need to play a role.

Several options are available to public agencies to help rectify this problem:

- Make greater use of computer clubs providing intensive training in word processing, spreadsheet analysis, investment analysis, and other specialized skills. Provide intensive training to one computer club member at a vocational school, regional extension workshop, university, or elsewhere; that member could then provide one-on-one and group assistance to fellow club members.

- Make greater use of local institutions such as banks and private and cooperative input supply firms (e.g., fertilizer-feed stores) to provide specialized instruction to farmers in operating computers. Again, public agencies can help by training the local institutions' instructors.

- Intensify extension service activities and adult vocational programs providing computer training. In some instances, this will mean having more rotating workshops around the state. In other instances, it might require that educational personnel work more closely with computer clubs and local institutions which will then work with others.

Will high technology depersonalize rural society? . . . No, on balance, high technology will not depersonalize rural society.

Rural areas have long prized such amenities as a friendly, neighborly social atmosphere. The small rural store, church, and bank contribute to this favorable social atmosphere. High technology has the potential to leapfrog local institutions by electronic "shopping" using video catalogues, by religious broadcasts on television, and by electronic money transfers. But these are unlikely to replace the local store, church, and bank to the extent that the automobile (or mail-order catalogues, in the case of shopping) has caused these rural institutions to be bypassed. The "electronic cottage," with people working in their rural homes while telecommunicating with urban offices, offers promise for economic opportunity in rural areas. While such telecommunication is in itself a poor social substitute for personal contact, those who use computers often form clubs that provide lively social interaction grounded in shared interests.

Should we stop the high-technology revolution? . . . No, it is neither desirable nor possible to stop the high-technology revolution.

The market generally operates effectively in allocating resources to improve the well-being of both individuals and society if price signals reflect true social costs (benefits) at the margin (Tweeten, 1983). In high technology, there are no large discrepancies between incremental social and private costs (benefits). Under such circumstances, the market can be expected to bring outcomes that improve the standard of living and quality of life for rural and urban Americans.

For the most part, people and firms are adopting high technology because they want to. For many firms, however, the choice about whether to adopt is narrowed, because economic survival requires it. As long as competitors are adopting high technology, a firm must respond in kind to remain competitive. This is, then, largely a rhetorical question, for the high-technology revolution is worldwide, and there is no stopping it.

Why is high technology likely to be so pervasive? . . . A major reason is that high technology, especially the microcomputer, is a consumption good as well as a factor of production.

The high technology of computers and telecommunications is improving economic efficiency in rural and urban areas. In agriculture, for example, high technology -- although it will increase output far less than does hybrid corn and will save much less labor than does the tractor -- will improve farm management and marketing. And in the industrial sector, high technology -- although its production will have only a moderate impact on rural areas -- will make traditional manufacturing and service industries more efficient in terms of their production and communication costs.

But to examine only changes in production or communication costs misses much of the point of high technology. The personal computer is to a large extent a consumption good which people purchase and enjoy, much as they would a boat or a sports car. People will experience high technology more as consumers than as producers. And in production, rural areas will experience high technology more through changes in occupations than as a new industry. Most farmers, for example, will experience the impact of high technology in some form each day in their farm production and consumption activities, although relatively few will own or operate a microcomputer and fewer indeed will engage directly in producing high technology.

APPENDIX A

Median School Years Completed by Employed Persons 25 to 64 Years Old, Selected Categories, 1970 and 1975

	Median School Years Completed			
	1970		1975	
Age and Occupation Group	Male	Female	Male	Female
25 to 44 years old:				
Professional and technical	16.6	16.3	16.8	16.4
Managers and administrators, excluding farm	12.9	12.6	14.4	12.9
Sales workers	13.4	12.4	14.2	12.6
Clerical workers	12.7	12.5	13.0	12.7
Craft workers	12.2	12.2	12.4	12.4
Operatives	11.8	11.1	12.2	12.0
Laborers, excluding farm	10.7	a	12.1	12.2
Service workers	12.3	12.0	12.5	12.2
Farmers and farm managers	12.2	a	12.5	a
Farm laborers and supervisors	8.5	11.5	9.1	12.3
45 to 64 years old:				
Professional and technical	16.4	16.2	16.5	16.2
Managers and administrators, excluding farm	12.7	12.5	12.9	12.6
Sales workers	12.6	12.3	12.9	12.4
Clerical workers	12.5	12.5	12.5	12.6
Craft workers	11.3	12.0	12.1	12.2
Operatives	9.7	9.9	10.6	10.2
Laborers, excluding farm	8.5	a	9.1	11.9
Service workers	9.8	10.0	11.2	11.1
Farmers and farm managers	9.0	a	10.9	a
Farm laborers and supervisors	7.4	8.9	7.6	12.0

[a]Data base of fewer than 75,000 persons.

Source: Data compiled from the U.S. Bureau of the Census, Current Population Reports, by F. Fratoe in "Rural Education and Rural Labor Force in the Seventies," Rural Development Research Report No. 5 (p. 28), Washington, DC: ESCS, U.S. Department of Agriculture.

APPENDIX B

Metro/Nonmetro Mean Annual Earnings of Persons 25 Years Old and Older, by Selected Categories, 1973

Metro/Nonmetro Status and School Years Completed	Mean Annual Earnings ($) White Male	White Female	Black Male	Black Female
Metro:[a]				
Central Cities:				
Elementary:				
Less than 8 years	7,036	3,396	7,042	2,910
8 years	8,906	3,754	7,105	2,880
High school:				
1-3 years	9,949	4,077	7,171	3,385
4 years	11,059	5,167	8,421	4,987
College:				
1-3 years	12,294	5,777	8,656	5,693
4 years	14,888	6,720	11,653	7,597
5 years or more	17,416	8,677	b	b
Suburbs:				
Elementary:				
Less than 8 years	7,898	3,040	5,127	b
8 years	9,008	3,896	b	b
High school:				
1-3 years	10,629	3,857	7,518	3,755
4 years	12,338	4,710	9,183	4,507
College:				
1-3 years	13,724	5,247	b	6,052
4 years	16,613	6,581	b	b
5 years or more	18,869	8,788	b	b
Nonmetro:				
Elementary:				
Less than 8 years	5,791	2,489	3,463	1,256
8 years	7,381	2,724	3,966	1,710
High School:				
1-3 years	8,506	2,990	5,727	2,666
4 years	10,369	3,814	6,789	3,346
College:				
1-3 years	10,743	4,229	b	b
4 years	13,545	5,979	b	b
5 years or more	15,813	7,963	b	b

[a]Counties within Standard Metropolitan Statistical Areas (SMSAs).
[b]Data base of fewer than 75,000 persons.

Source: Data compiled from the U.S. Bureau of the Census, Current Population Reports, by F. Fra[illegible] in "Rural Education and Rural Labor Force in the Seventies," Rural Development Research Report No. 5 (p. 31), Washington, DC: ESCS, U.S. Department of Agriculture.

REFERENCES

Armington, C., Harris, C., & Odle, M. (1983, September). Formation and growth in high technology businesses: A regional assessment. (Mimeo). Washington, DC: The Brookings Institution.

Ayers, R., & Miller, S. (1982, May/June). Industrial robots on the line. Technology Review, 35-46.

Blakely, E., & Bradshaw, T. (1983, October). Rural America: A new public policy frontier. In Agricultural communities: The interrelationship of agriculture, business, industry, and government in the rural economy. (pp. 52-89). Committee print prepared by the Congressional Research Service, Library of Congress, for the Committee on Agriculture, U.S. House of Representatives, 98th Congress, 1st Session. Washington, DC: U.S. Government Printing Office.

Ball, J., & Jamison, D. (1972). Computer assisted instruction for dispersed populations: Systems cost models. Industrial Science, 1, 469-501.

Bonnen, J. (1983, December). Historical sources of U.S. agricultural production. American Journal of Agricultural Economics, 65 (5), 958-66.

Buttell, F. (1984, April). Biotechnology and the struggle over agricultural research policy. Paper presented to workshop on Ethical and value choices in the selection of agriculture research goals held in Washington, DC. Ithaca, NY: Dept. of Rural Sociology, Cornell University.

Campo, F., & Norrlof, C. (1982, July). The estimation of income distribution from household sample surveys. TWG/ACC. E8. New York: Department of International Economic and Social Affairs, United Nations.

Carlson, N., Frey, T., Lannom, L., Mitchum, R., Sonka, S., & Zumbach, M. (1983). The management difference: Future information needs of commercial farmers and ranchers. Chicago: Arthur Andersen and Company.

Chartrand, R., Carr, A. B., & Miller, N. (1982, November). Information services for agriculture: The role of technology. Report No. 82-183 S. Washington, DC: Congressional Research Service, Library of Congress.

Congressional Research Service, Library of Congress. (1982, December). Information technology for agricultural America. Subcommittee on Department Operations, Research, and Foreign Agriculture of the Committee on Agriculture, U.S. House of Representatives, 97th Congress, 2nd Session. Washington, DC: U.S. Government Printing Office.

Council of Economic Advisers. (1984, February). Economic report of the President. Washington, DC: U.S. Government Printing Office.

Cuperus, G., Rommann, L., & Ward, C. (1983). Haymarket. Current report CR-465-0483. Stillwater: Cooperative Extension Service, Oklahoma State University.

Dillman, D. (1983). Rural North America in the information society. The Rural Sociologist, 3(5), 345-57.

Ethridge, D. (1978, December). A computerized remote-access commodity market: TELCOT. Southern Journal of Agricultural Economics, 10, 177-82.

Fratoe, F. (1978, October). Rural education and rural labor force in the seventies. Rural Development Research Report No. 5. Washington, DC: ESCS, U.S. Department of Agriculture.

Galambos, E. C. (1983). Technician manpower in the South: High-tech industries or high-tech occupations? Atlanta: Southern Regional Education Board.

Hogue, P. (1983). Trends affecting the American workplace. Washington, DC: National Commission for Employment Policy.

Joiner, L., Silverstein, B., & Clay, M. (1981, April). Independent study: Route to academic equity for rural high schools. Educational Leadership, 578-80.

Karmin, M., Lanier, L., Scherer, R., Seamonds, J., & Bosc, M. (1984, January 16). High tech: Blessing or curse? U.S. News and World Report, 96(2), 38-44.

Malecki, E. (1983). Technology and regional development: A survey. International Regional Science Review, 8(2), 89-125.

McKenzie, S. (1982, fall). The microcomputer and the politics of rural land. American Land Forum Magazine, 14-18.

National Science Foundation. (1982, October). Changing employment patterns of scientists, engineers, and technicians in manufacturing industries: 1977-80. National Science Foundation final report NSF 1982-331. Washington, DC: U.S. Government Printing Office.

North Central Computer Institute. (1981). NCCI (brochure). Madison, Wisconsin: WARF Building.

Rosenfeld, S. (1983, November). Analysis of emerging issues: Prospects for economic growth in the nonmetropolitan South. Research Triangle Park, NC: Southern Growth Policies Board.

Rural Ventures, Inc. (1983). Revitalizing rural areas and small towns through human and economic development. Bloomington, MN: Rural Ventures, Inc.

Ruttan, V. (1979). Bureaucratic productivity: The case of agricultural research. Ag World, 5(3), 1-7.

Small talk on big issues. (1983, December 1). Capsules, 3(9). Mississippi State, MS: Southern Rural Development Center.

Software: The new driving force. (1984, February 27). BusinessWeek, 74-84.

Strain, R., & Fieser, S. (1982, March). Updated inventory of agricultural computer programs. Circular 531. Gainesville, FL: Food and Resource Economics Department, University of Florida.

Tomashovic-Devey, D., & Miller, S. M. (1983, May/June). Can high-tech provide the jobs? Challenge, 26(2), 57-63.

Tweeten, L. (1983, March 4). The economics of small farms. Science, 219, 1037-41.

Tweeten, L. (1983). Food for people and profit: The ethics of the capitalist food system. In Ray Goldberg (Ed.), Research in Domestic and International Agribusiness Management, Vol. 4. Greenwich, CT: JAI Press.

Tweeten, L. (1983, October). Past and prospective economic development of rural communities. In Agricultural communities: The interrelationship of agriculture, business, industry, and government in the rural economy. (pp. 174-97). Committee print prepared by the Congressional Research Service, Library of Congress, for the Committee on Agriculture, U.S. House of Representatives, 98th Congress, 1st Session. Washington, DC: U.S. Government Printing Office.

Tweeten, L., & Brinkman, G. (1976). Micropolitan development: Theory and practice of greater-rural economic development. Ames, IA: Iowa State University Press.

Twist, B. (1982, December). Machinery technology. Pp. 450-64 in the proceedings of the RCA Symposium: Future agricultural technology and resource conservation held in Washington, DC. Ames, IA: Iowa State University Press.

U.S. Bureau of the Census. (1981). 1977 Census of Manufacturers. Washington, DC: U.S. Government Printing Office.

U.S. Bureau of the Census. (1984, July). Data users news, 19(7). Washington, DC: U.S. Government Printing Office.

U.S. Department of Agriculture. (1982, November). 1982 Handbook of Agricultural Charts (Agricultural handbook No. 609). Washington, DC: U.S. Government Printing Office.

U.S. Department of Agriculture. (1983, October). Economic indicators of the farm sector: Income and balance sheets statistics, 1982. ECIFS 2-2. Washington, DC: U.S. Government Printing Office.

U.S. Department of Labor. (1981, October). Employment trends in computer occupations. Bureau of Labor Statistics Bulletin 2101. Washington, DC: U.S. Government Printing Office.

Ward, C. (1982). Marketing Oklahoma feeder cattle by video-auction. OSU Extension Facts No. 463. Stillwater, OK: Cooperative Extension Service, Oklahoma State University.

Ward, C. (1983). Marketing Oklahoma lambs by tele-auction. OSU Extension Facts No. 456. Stillwater, OK: Cooperative Extension Service, Oklahoma State University.

Woods, M., Doeksen, G., & Lenard, V. (1983, October). Computer programs available to measure growth and decline. (Paper presented at Southern Regional CRD Triannual Training Program, Birmingham, AL.) Stillwater, OK: Cooperative Extension Service and Department of Agricultural Economics, Oklahoma State University.

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