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Food production in the emerging information society: A political-economic analysis

Goe, William Richard, Ph.D.
The Ohio State University, 1988
FOOD PRODUCTION IN THE EMERGING INFORMATION SOCIETY:
A POLITICAL - ECONOMIC ANALYSIS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of the Ohio State University

By

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* * * * *

The Ohio State University
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INTRODUCTION

For the past several decades, social theorists and futurists have predicted that advanced industrial nations are in the nascent stages of a major social transformation. There has been a general consensus among these advocates that advanced industrial nations are undergoing an extended period of change in which the foundation for a new social structure is being prepared. In the 1970s, it was predicted that the changes underway in many advanced industrial societies, especially the United States, could best be described by such labels as post-industrial society, technetronic society, the knowledge society and post-affluent society among others (Bell, 1973; Brzezinski, 1970; Drucker, 1969; Gappert, 1975; Touraine, 1971). More recent forecasts predict that advanced industrial nations are becoming information societies—where the creation, processing, handling, and transfer of information is increasingly the most critical activity underlying socioeconomic activity. Highly interrelated with this process is the growing use of technologies derived from the convergence of computers and telecommunications (Cleveland, 1982; 1985; Dizard, 1985; Masuda, 1981).

There are many indications that broad, sweeping changes are underway in industrial societies. Of critical significance is a restructuring of the global economic order. The hegemonic position of the United States in the international economy is being inexorably challenged due to the growth of other nations' economies, particularly Japan's. A new international division of labor is emerging in relation to the production of goods and services and global wealth is being redistributed (Kenney and Florida, 1988).

1For a good overview of earlier forecasts, see Marien (1973).
Restructuring and increasing competition in the international economy has prompted widespread change within the United States. The industrial and occupational structures of the U.S. economy have undergone significant transition. Many of the traditionally robust manufacturing industries that were the heart of the industrial economy, such as steel, automobiles, farm machinery, and consumer electronics, have experienced severe decline. In response to decline and foreign competition, firms in many U.S. industries have been forced to reorganize and devise new strategies in order to remain competitive.

Advanced technology has become a critical element in this process. New technologies can reinvigorate or increase the competitiveness of industries through application to production processes and provide new opportunities for economic growth through the development of new industries and commercial products. While the United States has clearly held a dominant position in technological development for much of the postwar period, it is widely perceived that other nations, especially Japan, are rapidly closing the gap in their ability to harness technological advances for economic growth and development (Thurow, 1985). Thus, an important facet of restructuring in the international economy is the increasing competition among nations to capture the economic benefits of newly developed commercial technologies and make production processes more efficient through technological application.

Technologies derived from linking computers and information processing equipment with telecommunications have become increasingly important in both of these respects. These technologies have become a central element of strategies aimed at increasing productivity in the production of goods and services, thereby increasing the competitiveness of adopting firms (Cohen and Zysman, 1987; Locksley, 1986). Further, the growing importance of these technologies has created vast market opportunities for commercial products and services.
Collectively, technologies combining computers and information processing equipment with telecommunications have become known as information technology. One example of an application of information technology is the networking of computers at different geographic locations via satellite systems. A second example is the facsimile machine which reduces paper documents to a computerized code, transmits the code over telephone lines, and reproduces the documents at another location equipped with a second facsimile machine.

The convergence of computers and telecommunications largely began in the 1960s. On the one hand, computer technology was incorporated into communications systems. For example, computers and microelectronics were integrated into satellite systems which greatly enhanced their communications capabilities (Ide, 1982). This process eventually extended into telephone networks, radio and television as well (See Figure Introduction.1).

On the other hand, communications technology was incorporated into computer systems. Central to this process were innovations developed by a key military research and development agency -- the Defense Advanced Research Projects Agency (DARPA). First, DARPA scientists developed time sharing systems. Time sharing allows a number of users to interact with a mainframe computer through remote terminals connected to the mainframe through communications links. This was followed by computer networking systems which allow computers at different geographic locations to transfer or

---

3Information is defined as the sum total of all the facts and ideas that are available to be known by a person at any given moment in time. This is in contrast to knowledge which involves refining the mass of facts and selecting and organizing what is useful (see Cleveland, 1982). Technology is defined as an organized body of knowledge which allows practical human purposes to be achieved in a reproducible manner (Mesthene, 1970:25; Brooks, 1982). The distinction has been made between "physical" technology (e.g., a machine), "social" technology (e.g., a form of social organization) and "intellectual" technology which consists of a set of problem-solving rules such as a computer program (see Bell, 1973:29-30).
QUICK!
WHICH IS THE PHONE,
AND WHICH
IS THE COMPUTER?

Once, a phone was
a phone and a com-
puter was a computer.
And nobody could
tell the difference.

Today, however, tele-
phones routinely boast
computer memories, com-
puter intelligence, even
computer screens.

And computers are
discovering the power
of networking, as tele-
phones already have.
The name of the
game is getting the right
information to the right
people at the right time.

Because being able
to do that easily will
make our work more pro-
ductive and our lives
less hurried.

And that’s what
AT&T is all about today.

Our goal is to do
for information what we
have already done for
conversations.

To accomplish that,
the people at AT&T Bell
Laboratories are working
to combine everything
you like about telephones
with everything you
expect from computers.

So computers will
finally deliver what they
have been promising
for decades.

Consider some
e very simple example. Same day soon,
instead of being turned
to the new cars available
in a dealer’s inventory,
you’ll be able to sit down
at a computer terminal
in the dealer’s showroom
and enter the model you
want, the engine, the
options, the color, etc.

A data network
will automatically trans-
late your order into
instructions to dozens
of suppliers and plants
in the production process.
The result is a custom-
made car delivered faster
than you ever thought possible.

In banking, powerful
and versatile data net-
works could mean loan
approval in minutes
instead of weeks. And
account balances that are
always current.

In retailing, a chain
whose stores employ
data networks could
always have hot-tailing
themes in the stores
where they’re selling hot
wax. Please both the
customer and the com-
pany controller.

The idea is networks
which not only move in-
fornation efficiently but
which also enterprises,
manages and applies it
in the most useful way.

All automatically.

Just as the AT&T
long distance network
handles a telephone call.

As an entirely automati-
cal.

Which is to say, we’re
very close to the day
when you won’t be able
to tell a phone from
a computer, and won’t
even care.

But until then, the
phone cord is the one on
the top.

AT&T
The right choice.

FIGURE INTRODUCTION.1.Advertisement for Convergence of Computers and
Telecommunications
exchange data via communications networks. Since these initial breakthroughs, these complementary forces of technological development have continued to produce new forms of information technology which have found application throughout advanced industrial societies.

Broadly conceived, information technology involves: (a) the ability of computer technology to process, organize and store information needed to coordinate or perform specific tasks (e.g., the provision of instructions for automated machinery); combined with (b) the ability to rapidly transmit computerized information to any geographic point equipped with the necessary technology. In effect, information technology allows information to be processed, organized, stored and instantly transferred or exchanged across geographic distances in order to optimally control or coordinate social activity towards desired ends. This is illustrated by the use of computerized information beamed from intelligence satellites to the U.S. government in order to coordinate foreign policy or by the retrieval of computerized medical information from the National Library of Medicine in Bethesda, Maryland by medical centers in Alaska in order to facilitate the diagnoses of patients.

Since communication, i.e., the exchange of information, is a necessary condition of social organization (Olsen, 1968:74), information technology has significant social implications in addition to its economic ones. The more efficient technological systems for the transfer and exchange of information provided by information technology is a critical element in the reorganization of U.S. industry in response to decline and foreign competition. Information technology can allow new, more efficient forms of social organization as well as new patterns of social behavior. The rapid growth in the application of information technology across industries and occupations is the basis of predictions that advanced industrial societies are undergoing transitions to information societies.
The Emerging Role of Information Technology in U.S. Agriculture

Like other industry sectors in the United States, the agricultural system is being affected by the shifts in the global economy. Throughout much of the 1980s, the U.S. agricultural system has been subject to the most severe recession in the agricultural economy since that experienced in the 1920s and 1930s. Factors that have contributed to the recession are a decline in global demand for unprocessed U.S. agricultural products and the strengthening of competition in international agricultural markets (e.g., Argentina and Brazil). The agricultural system also currently faces the problem of reorganization and the creation of new strategies necessary for recapturing shares in international markets and strengthening its competitive position in the global economy.

Information technology is perceived as an important factor influencing the future competitiveness of the U.S. agricultural system. For example, a recent study by the Office of Technology Assessment proclaims that U.S. agriculture is entering the "era of biotechnology and information technology" (Office of Technology Assessment, 1986:4). Information technology is portrayed as an important source of future productivity gains in agricultural production and therefore capable of strengthening the competitiveness of agricultural producers. Additionally, information technology is finding application in off-farm industries and organizations that are interlinked with and dependent upon the process of agricultural production. In effect, the integration of the U.S. agricultural system into the forthcoming information society is likely to be a critical process affecting its ability to remain competitive in the global economy.

The purpose of this dissertation is to examine the social process by which information technology is being incorporated into the U.S. agricultural system. The broader forces of change underlying the transition to an information society have implications for the agricultural system as well as other sectors of the U.S. political
economy. However, these implications have never been addressed in any systematic fashion. The first chapter traces the evolution of the concept of an information society as a theoretical construct and outlines its basic underlying premises.

A major issue of debate is whether the constellation of change processes underlying the transition to an information society represents a marked transition from a society based on an industrial economy. Some observers believe that these changes merely represent an extension of industrialism or industrialism with new rules. This issue is examined in the context of the diversity of ways in which information technology is finding application in the United States.

An underlying feature of the transition to the information society is the development of a telecommunications infrastructure that will allow computerized information to be transferred and/or exchanged between computers and other information processing technologies. A critical factor that will influence the integration of the agricultural system into the information society is the ways in which this infrastructure provides outreach to the spatial locale of agricultural production -- rural America. The second chapter discusses political and economic factors influencing the development of "digital" telecommunications systems needed for applications of information technology and outlines the key technologies involved in these systems. This is followed by a discussion of factors shaping the extension of digital telecommunications into rural America.

Technology is an indispensable element of human labor and work processes are organized around the capabilities and requirements of technology. Sociotechnical innovation consists of the combination of technological change and organizational change that occurs as technological innovations are developed and incorporated into the activity of social organizations. The third chapter outlines the social forces that have propelled and influenced sociotechnical innovation during the historical evolution
U.S. capitalism. The role of sociotechnical innovation in the historical development of the U.S. agricultural system is then examined.

The development of applications of information technology for agriculture provides the possibility of new forms of sociotechnical innovation by allowing the restructuring of organizational linkages between the farm sector and other industry sectors in the agricultural system. This is due to the innovative services being developed from information technology applications. The potential sociotechnical innovation resulting from the development of teleshopping, telebanking and electronic marketing services is also examined in Chapter Three.

The development of technological systems for the dissemination and exchange of agricultural information has been an important factor underlying the historical development of the U.S. agricultural system. Videotex and teletext are applications of information technology that have been developed to provide new systems for the dissemination and exchange of agricultural information. These innovations provide advantages over other technological systems such as the more rapid delivery of timely agricultural information. The fourth chapter traces the historical development of sociotechnical systems for the dissemination of agricultural information in the United States. The development of videotex and teletext systems for agriculture is then discussed.

The growing role of information technology in advanced industrial societies has highlighted the importance of information as an input in the production of goods and services. The advanced capabilities in managing information provided by information technology has allowed for the development of computerized information services which sell information in the marketplace as an economic good. Federal information policy during the Reagan era has facilitated the transformation of computerized information into an economic good through the privatization of government information services.
Chapter Four additionally examines the implications of Federal information policy and the privatization of government agricultural information services involving the use of information technology.

The process of agricultural production is being transformed through application of information technology. Applications that are already established include microcomputers in combination with videotex systems, teletext systems and computer-automated feeding and irrigation systems. Applications that are under development include robotics and a variety of remote sensing applications. Chapter Five examines these applications of information technology and their implications for agricultural production.

Recent estimates suggest that microcomputers in combination with videotex and teletext systems are currently the most widely established applications of information technology in agricultural production. However, in absolute terms, these technologies have been adopted by only a small percentage of all U.S. agricultural producers. An acceleration of the use of information technology in agricultural production is likely to hinge upon the sequential process by which agricultural producers adopt and then socially adapt to agricultural videotex and teletext systems.

Adoption refers to the purchase of a new technology or technology-based service. Social adaptation refers to the continual use of a new technology or technology-based service and its integration into the technical basis of an organization's activities. Social adaptation to a new technology generally hinges upon the ability of an organization to internalize the costs of the technology and realize its benefits. Failure to internalize these costs and realize the benefits can lead to a rejection of the technology. Both the costs and benefits of agricultural videotex and teletext systems are outlined in Chapter Five.
Data were collected from a sample of 250 agricultural producers in a two state area of Ohio and Michigan with experience in using agricultural videotex systems. The farm structural characteristics and information management practices of these early adopters of agricultural videotex technology are examined in Chapter Six. Data concerning the ability of these agricultural producers to internalize the costs and realize the benefits of agricultural videotex systems were also collected. The relationships between social adaptation to agricultural videotex and these cost/benefit factors are also analyzed in Chapter Six through the use of multivariate statistics.

The transition to the information society subsumes a constellation of change processes which are critical to the future of advanced industrial societies. Applications of information technology are increasingly penetrating all aspects of life and playing a greater role in shaping the human existence. This dissertation is the first study that comprehensively examines the role of information technology in an often overlooked, but essential industry -- food production.
CHAPTER I

THE TRANSITION TO THE INFORMATION SOCIETY:
POST-INDUSTRIALISM VERSUS EXTENDED INDUSTRIALISM

The "information society" is a theoretical construct that emphasizes the growing role of computers and telecommunications in shaping the future of advanced industrial societies. This construct highlights and emphasizes several dimensions of social change presently being realized in advanced industrial societies and assumes that an increasing predominance of these tendencies represents a marked departure from a society based upon an industrial economy. With the growing use of information technology, advanced industrial societies are currently undergoing transitions to information societies.

The concept of an information society evolved from theoretical works that were predominantly initiated during the turbulence of the 1960s -- an era when the ideology of progressive industrialism was being challenged in conjunction with extensive social and political disruption (Kumar, 1978:185-192). The dynamics of this period suggested that advanced industrial societies were undergoing a period of extensive transition with an uncertain future in the balance. These conditions prompted a number of social scientists to attempt to forecast the potential outcomes of this transformation and the characteristics of the new social structure that would likely emerge.

This futuristic theoretical movement was not limited to the United States, but was also joined by European social scientists such as Alain Touraine (1971). Furthermore, eastern European and Japanese scholars were also active participants in these debates.
In the United States, this movement was led by such social scientists as Herman Kahn, Peter Drucker, John Kenneth Galbraith and Zbigniew Brzezinski whose works attempted to forecast the future structure of advanced industrial societies. However, the most prominent of these forecasts was that of Harvard sociologist Daniel Bell whose vision of "post-industrial" society became the most widely utilized and accepted. Due to its popular use, the term post-industrial society has become virtually synonymous with the period of transition being experienced within advanced industrial nations.

Bell's (1973:14) theoretical scheme of post-industrial society revolves around five primary dimensions of social change:

1. **Economic Sector** -- the change from a goods producing to a service economy;
2. **Occupational Distribution** -- the pre-eminence of the professional and technical class;
3. **Axial Principle** -- the centrality of theoretical knowledge as the source of innovation and of policy formulation for the society;
4. **Future Orientation** -- the control of technology and technological assessment;
5. **Decision Making** -- the creation of a new "intellectual technology."³

One consequence of Daniel Bell's social forecast entitled *The Coming of Post-Industrial Society* was that it stimulated a heated debate within the social sciences concerning the future direction of advanced industrial societies (for example, see Ferkiss, 1979; Gappert, 1974; 1975; Gershuny, 1978; Janowitz, 1974; Little, 1973; Marien, 1973; Olsen, 1974). Further, Bell's work integrated and highlighted a diversity of

³By intellectual technology, Bell was referring to mathematical algorithms such as linear programming or sets of problem solving rules such as a game theory that could be used to replace intuitive judgements in decision making. Bell (1973:29-31) further notes that the usefulness of intellectual technology in modeling the "organized complexities" of society would be limited without computer technology.
important trends that were occurring in the United States, many of which had been identified previously by other social scientists. There are several of these trends in particular that have provided a theoretical foundation for the information society concept.

One of these trends is the historical shift in the locus of employment. The progression of industrialism in the United States has resulted in an increasing proportion of the labor force becoming employed in the service sector of the economy. This trend has also occurred in most other advanced industrial societies (see Singelmann, 1978; Gershuny, 1978). According to Bell, post-industrial society would be characterized by the increasing concentration of employment in service-producing industries as well as the growing consumption of services (Bell, 1973:127-129).

Changes in the distribution of employment during the twentieth century in the United States reveal several distinct trends. There has been an absolute and relative decline in agricultural employment since 1900 (see Table 1.1). Whereas 38 percent of the U.S. labor force was employed in agriculture in 1900, only 3.6 percent was so employed in 1982. In conjunction with this decline, there was a growth of employment in both goods-producing industries and service industries. The percentage of the U.S. labor force employed within the service sector has steadily increased since 1850. By

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4The service sector is commonly defined as consisting of the following industry sectors utilizing the Standard Industrial Classification (SIC) code: transportation, communication and public utilities, wholesale and retail trade, finance, insurance and real estate, services and government. Thus, service industries are defined as the residual of industries directly engaged in the production of primary or secondary goods (Shelp 1981:10; Daniels, 1985:4). Jonathan Gershuny (1978:56) defines services, in contrast to manufactured goods, as "immaterial, impermanent, made by people for people...and consumable only at the instant of production. At the moment of its acquisition by the consumer, a good is a thing whereas a service is a state or activity or sensation." However, clearly some end-products of service industries could take the form of tangible objects such as insurance policies or bank statements. This illustrates the conceptual difficulties in defining the service economy.

5The goods-producing sector of the economy includes mining, construction and manufacturing industries (Urquhart, 1984:16).
Table 1.1.
Distribution of Employment by Major Industry Sector, 1850-1982
(In percent)

<table>
<thead>
<tr>
<th>Year</th>
<th>Agriculture</th>
<th>Goods-producing Industries</th>
<th>Service-producing Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>64.5</td>
<td>17.7</td>
<td>17.8</td>
</tr>
<tr>
<td>1860</td>
<td>59.9</td>
<td>20.1</td>
<td>20.0</td>
</tr>
<tr>
<td>1870</td>
<td>50.8</td>
<td>25.0</td>
<td>24.2</td>
</tr>
<tr>
<td>1880</td>
<td>50.6</td>
<td>25.1</td>
<td>24.3</td>
</tr>
<tr>
<td>1890</td>
<td>43.1</td>
<td>28.3</td>
<td>28.6</td>
</tr>
<tr>
<td>1900</td>
<td>38.0</td>
<td>30.5</td>
<td>31.4</td>
</tr>
<tr>
<td>1910</td>
<td>32.1</td>
<td>32.1</td>
<td>35.9</td>
</tr>
<tr>
<td>1920</td>
<td>27.6</td>
<td>34.6</td>
<td>37.7</td>
</tr>
<tr>
<td>1930</td>
<td>21.8</td>
<td>31.7</td>
<td>46.6</td>
</tr>
<tr>
<td>1940</td>
<td>18.3</td>
<td>33.1</td>
<td>48.6</td>
</tr>
<tr>
<td>1952</td>
<td>11.3</td>
<td>35.5</td>
<td>53.3</td>
</tr>
<tr>
<td>1957</td>
<td>9.8</td>
<td>34.3</td>
<td>56.0</td>
</tr>
<tr>
<td>1962</td>
<td>7.8</td>
<td>33.1</td>
<td>59.1</td>
</tr>
<tr>
<td>1967</td>
<td>5.3</td>
<td>34.7</td>
<td>60.1</td>
</tr>
<tr>
<td>1972</td>
<td>4.4</td>
<td>31.4</td>
<td>64.2</td>
</tr>
<tr>
<td>1977</td>
<td>3.7</td>
<td>29.7</td>
<td>66.6</td>
</tr>
<tr>
<td>1979</td>
<td>3.6</td>
<td>30.2</td>
<td>66.3</td>
</tr>
<tr>
<td>1982</td>
<td>3.6</td>
<td>27.2</td>
<td>69.2</td>
</tr>
</tbody>
</table>

Source: Urquhart (1984:16)

* Includes employment in forestries, fisheries and agriculture.
@ Includes employment in mining, construction and manufacturing.
# Includes employment in transportation, communication and public utilities, wholesale and retail trade, finance, insurance and real estate, services and government.
1952, over one half of the labor force was employed in the service sector. The service sector has continued to expand, dominating the structure of employment in the U.S. The percentage of the labor force employed in the goods-producing sector expanded at a slower rate, reaching a peak of 35.5 percent in 1952 and then beginning a long term decline. This decline was largely a relative one until 1979 when employment in goods-producing industries began to decline absolutely (U.S. Department of Labor, 1987:43). This has been primarily due to industrial decline, labor displacement through further automation or corporate restructuring and the shifting of production work "offshore" to take advantage of lower labor costs and/or to be closer to markets (Cohen and Zysman, 1987:197). Since 1980, there has been a net growth of 9.6 million jobs with the vast majority being accounted for by service-producing industries (U.S. Department of Labor, 1987:43).

Daniel Bell's inclusion of this trend as a feature of post-industrial society was based upon the model of economic progress proposed by A.G.B. Fisher (1935) and Colin Clark (1940) which helped popularize the three sector industrial classification scheme of market economies. Fisher and Clark proposed that the shift of the locus of employment to the service sector represented an inevitable stage of economic progress. As nations became industrialized and sectoral differences in productivity emerged, a larger proportion of the labor force would shift from the primary sector and become concentrated predominantly in manufacturing and other secondary industries. Concurrently, as national incomes rose, there would be a greater demand for services and a subsequent shift of employment from secondary industries into the service sector (Clark, 1940; Bell, 1973: 14, 75; Browning and Singelmann, 1978: 484-485; Singelmann, 6Fisher (1935) and Clark (1940) divided the economy into primary industries (agriculture, mining, fishing and forestry), secondary industries (manufacturing, construction and utilities) and tertiary industries (commerce, transport, communications and services).
The shift of employment into the service sector represented the third evolutionary stage of market economies.

As indicated by the data in Table 1.1, employment trends in the United States have not historically conformed to this model. The shift of employment out of the agricultural sector resulted in a higher rate of employment growth in service-producing industries than in the goods-producing sector of the economy. Research has shown that only employment trends in the advanced industrial nations of Europe have conformed to the Fisher-Clark model (see Singelmann, 1978:1233). Nevertheless, Bell conceived the rise of post-industrial society as representing a progressive evolutionary stage beyond industrial society based on goods-production.

A second important trend identified as a feature of post-industrial society was a shift in the occupational structure of advanced industrial societies. As the structure of industry was transformed and the locus of employment shifted to the service sector, there was a concomitant growth of jobs in white collar professional, technical, managerial, and clerical occupations. Employment in white collar occupations steadily increased from 17.6 percent of the U.S. labor force in 1900 to 52.2 percent in 1980 (see Table 1.2). The primary source of this growth was in clerical, professional and technical occupations.

Employment within blue collar occupations was characterized by cyclical fluctuations and reached a peak of 41.1 percent of the U.S. labor force in 1950. Over the subsequent three decades, the percentage of the work force employed in blue collar, production-related occupations steadily declined to 31.7 percent. The percentage of workers in service occupations increased moderately from 9 percent in 1900 to 13.3
Table 1.2.
Changes in the Occupational Structure of Employed Persons in the United States, 1900-1980

(percentage distributions)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>White Collar Workers</td>
<td>52.2</td>
<td>47.4</td>
<td>40.1</td>
<td>36.6</td>
<td>31.1</td>
<td>29.4</td>
<td>24.9</td>
<td>21.3</td>
<td>17.6</td>
</tr>
<tr>
<td>Professional,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical &amp; Kindred</td>
<td>16.1</td>
<td>14.5</td>
<td>10.8</td>
<td>8.6</td>
<td>7.5</td>
<td>6.8</td>
<td>5.4</td>
<td>4.7</td>
<td>4.3</td>
</tr>
<tr>
<td>Managers, Officials</td>
<td>11.2</td>
<td>8.1</td>
<td>8.1</td>
<td>8.7</td>
<td>7.3</td>
<td>7.4</td>
<td>6.6</td>
<td>6.6</td>
<td>5.8</td>
</tr>
<tr>
<td>and Proprietors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clerical &amp; Kindred</td>
<td>18.6</td>
<td>17.8</td>
<td>14.1</td>
<td>12.3</td>
<td>9.6</td>
<td>8.9</td>
<td>8.0</td>
<td>5.3</td>
<td>3.0</td>
</tr>
<tr>
<td>Workers</td>
<td>6.3</td>
<td>7.0</td>
<td>7.1</td>
<td>7.0</td>
<td>6.7</td>
<td>6.3</td>
<td>4.9</td>
<td>4.7</td>
<td>4.5</td>
</tr>
<tr>
<td>Blue Collar Workers</td>
<td>31.7</td>
<td>36.6</td>
<td>37.7</td>
<td>41.1</td>
<td>39.8</td>
<td>39.6</td>
<td>40.2</td>
<td>38.2</td>
<td>35.8</td>
</tr>
<tr>
<td>Craftsmen, Foremen &amp; Kindred Workers</td>
<td>12.9</td>
<td>13.9</td>
<td>13.6</td>
<td>14.1</td>
<td>12.0</td>
<td>12.8</td>
<td>13.0</td>
<td>11.6</td>
<td>10.5</td>
</tr>
<tr>
<td>Operative &amp; Kindred</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workers</td>
<td>10.6</td>
<td>18.0</td>
<td>18.9</td>
<td>20.4</td>
<td>18.4</td>
<td>15.8</td>
<td>15.6</td>
<td>14.6</td>
<td>12.8</td>
</tr>
<tr>
<td>Laborers, Except</td>
<td>3.6</td>
<td>4.7</td>
<td>5.2</td>
<td>6.6</td>
<td>9.4</td>
<td>11.0</td>
<td>11.6</td>
<td>12.0</td>
<td>12.5</td>
</tr>
<tr>
<td>Farm and Mine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Workers</td>
<td>13.3</td>
<td>12.8</td>
<td>11.2</td>
<td>10.5</td>
<td>11.7</td>
<td>9.8</td>
<td>7.8</td>
<td>9.6</td>
<td>9.0</td>
</tr>
<tr>
<td>Farm Workers</td>
<td>2.8</td>
<td>3.1</td>
<td>6.0</td>
<td>11.8</td>
<td>17.4</td>
<td>21.2</td>
<td>27.0</td>
<td>30.9</td>
<td>37.5</td>
</tr>
</tbody>
</table>

percent in 1980 while employment in agricultural occupations declined drastically from 37.5 percent in 1900 to 2.8 percent in 1980. Bell believed that the decline in manual blue collar occupations and the growth of white collar workers, especially in professional and technical occupations, signaled the rise of a new professional and technical elite class. The occupational structure of post-industrial society would be dominated by knowledge workers and technical skill and knowledge would become the basis of power and status for the professional and technical elite (Bell, 1973:343, 374-376, 426).

Knowledge was defined as the strategic resource of post-industrial society because of its underlying role in the economy.

The post-industrial society, it is clear, is a knowledge society in a double sense: first, the sources of innovation are increasingly derivative from research and development (and more directly, there is a new relation between science and technology because of the centrality of theoretical knowledge); second, the weight of society—measured by a larger proportion of Gross National Product and a larger share of employment—is increasingly in the knowledge field (Bell, 1973:212).

As theoretical knowledge emerges as the strategic resource of post-industrial society, Bell predicted that problems will surface relative to managing the underlying basis of knowledge—information. These problems will be: (1) managing the sheer amount of information one has to absorb; and (2) information will become more technical requiring greater knowledge to understand. Therefore, information will increasingly require interpretation by specialists (Bell, 1973: 467-468). Although not heavily emphasized until his later works, Bell (1973:30,347) recognized the importance of computer technology in information processing and knowledge creation for use in guiding decision making processes.

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7This indicates that the historical expansion of employment in service producing industries did not primarily involve the growth of jobs in service occupations, but rather in white collar clerical, professional, technical and managerial occupations within service firms.
In a broader and general sense, Daniel Bell's vision of post-industrial society consisted of a constellation of social change processes that had begun to manifest themselves during the advance of industrialism. Bell predicted that these processes would continue to extend themselves, gradually dominating and transforming the social order of advanced industrial nations, resulting in post-industrial social structures.

Post-Industrial Society to Information Society

In addition to being an era of extensive social change, the period in which The Coming of Post-Industrial Society and other social forecasts were conceived was also a period of rapid technological development in microelectronics. The drive to miniaturize transistors led to the development of integrated circuits in the early 1960s. International Business Machines (IBM) introduced the first computer with integrated circuits in 1964 (National Institute for Research Advancement, 1985:38). Miniaturized integrated circuits greatly reduced the size and cost of computers and led to the development of the suitcase size minicomputer (Bylinsky, 1981:5). While still confined to institutional use, smaller and cheaper computers facilitated the more widespread use of computer technology in the United States.

Research and development generated continual improvements of integrated circuits through placing a greater number of micro-miniaturized transistors on a silicon chip. As it progressed, this process became known as large scale integration (LSI). In 1971, Ted Hoff, an engineer at Intel, generated a major breakthrough in LSI through developing the microprocessor -- a whole computer on a single silicon chip (Rogers and Larsen, 1984).

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8Integrated circuits consist of thousands of micro-miniaturized transistors placed on a sliver of silicon only a fraction of an inch thick (Bylinsky, 1981:5).
In essence, the microprocessor is a miniature computer that is less than 1/6 x 1/8 inches in diameter and capable of performing tasks such as running a complex calculator, controlling an elevator, and many other tasks depending on its program (Bylinsky, 1981:6). Through its capacity to provide programmed information to control machines, the microprocessor has had and will continue to have a significant impact on advanced industrial societies.

Starting with electronic calculators and digital watches in the mid 1970s, spin-off applications have continued to be developed from the microprocessor. Consumer goods such as microwave ovens, automobiles and washing machines have all been improved as a result of microprocessor applications. Manufacturing and other industrial processes have become further automated through robotics and other applications such as numerically controlled machine tools and computer-aided design and computer-aided manufacturing (CAD/CAM) systems. Finally, the movement toward "office automation" has been undergirded by what is perhaps the most widely recognized progeny of the microprocessor -- the microcomputer.

Since the microprocessor allowed unparalleled reductions in the size and cost of computer circuitry, it has allowed the production of extremely small computers that can be produced and sold to consumers for under one thousand dollars. The first commercially successful microcomputer in the United States, the Altair 8800, was produced by Micro Instrumentation Telemetry Systems and sold in 1975 in the form of a kit for the hobbyist (Osborne, 1979:28-29; Ide, 1982; Rogers and Larsen, 1984).

The lack of developed software limited the utility of the Altair 8800. However, by 1977, Apple Computer, Tandy Corporation's Radio Shack, and Commodore Ltd. had developed more sophisticated microcomputers that were sold completely assembled. Further, software for these machines was rapidly being developed by software programmers across the United States (Rogers and Larsen, 1984). With these developments, the
market for the microcomputer (or personal computer) exploded and it rapidly became an established product. This was followed by the growth of the software and peripherals industries.

Perhaps the most important consequence of the microcomputer is that its lower cost and small size has made access to computing possible for smaller institutions and homes. The computer is no longer the exclusive preserve of large educational, industrial, financial and government institutions as during the earlier period when mainframes were the predominant machines. Further, the recent introduction of a battery-powered, lap-top microcomputer by major computer firms has decoupled computer use from physical locations equipped with electricity. The former physical and economic barriers to computer use are being eliminated as microelectronics technology advances. Computers are becoming an ever more pervasive influence in the office, factory and, increasingly, the home. Across a wide spectrum of industry and occupational sectors, work processes have been transformed through the continuing evolution of computer technology.

Spin off applications from the synthesis of computers and communications also became manifest in the 1970s. The full development of computer networking by DARPA allowed 50 computers at 38 research laboratories across the United States to exchange information. This innovation eventually led to the establishment of commercial computer networking services available to businesses and the public. Applications of DARPA's concept of computer timesharing were also brought into use as remote computer terminals were used to access data banks and interact with larger central computers (Denicoff, 1979:373-374; Marbach, 1985:64).

The rapid evolution of microelectronics and information technology in the 1970s along with the highly touted potential of these technologies began to generate a growing awareness among social scientists of the emerging importance of these
technologies in shaping the future of advanced industrial societies. Computers, information technology and the novel capabilities they provide in using information to guide societal activity gradually moved from a peripheral to a focal point in the debate concerning the future of advanced industrial societies. In the late 1970s, the information society concept began to gain popularity. However, the term "information society" had been created prior to this point and the centrality of computers and telecommunications technology in the transformation of advanced industrial societies had also been recognized by earlier theorists.

The term "information society" is usually credited to the writings of Hayashi Yujiro, a former professor of Engineering at Tokyo University. It was used in a 1969 report by the Japanese Economic Advisory Council entitled Japan's Information Society: Visions and Tasks (Morris-Suzuki, 1986:77). Thus, the term was created before technological progeny from the synthesis of computers and communications began to have a major impact on advanced industrial societies.9

The pervasive societal impact of information technology was also presciently recognized by others. In Between Two Ages: America's Role in the Technetronic Era, which was published three years before The Coming of Post-Industrial Society, Zbigniew Brzezinski (1970:9) states:

The post-industrial society is becoming a "technetronic" society: a society that is shaped culturally, psychologically, socially, and economically by the impact of technology and electronics particularly in the area of computers and communications.

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9It is interesting to note that the term "post-industrial" was first used in a book written by Arthur J. Penty entitled Old Worlds for New: A Study of the Post-Industrial State which was published in 1917 (Bell, 1973:37).
Despite this prescient insight, Brzezinski's vision of technetronic society did not gain the level of popularity and appeal of Bell's post-industrial society. It was not until the potential societal capabilities of emerging computer/communications technologies became more readily apparent that social scientists began to closely examine their social, economic and political ramifications and emphasize their centrality in shaping the future of advanced industrial societies.

A study which lent considerable support to the information society concept was that conducted by Marc Porat entitled The Information Economy which was published by the United States Department of Commerce in 1977.¹⁰

Porat divided the U.S. economy into three sectors:

1. **Primary information sector**—this includes all industries that produce, process or sell information goods or services. Included here are such diverse industries as computer manufacturing, telecommunications, printing, mass media, advertising, accounting and education;

2. **Secondary information sector**—this includes the informational activities of the public bureaucracy and private bureaucracies which is the portion of every noninformation firm that engages in purely informational activities such as research and development, planning, control, marketing and record-keeping; and

3. **Non information sector**—is the remaining portion of the economy net of information activities (Porat, 1978:8).

Porat found that in 1967, 25.1 percent of the U.S. Gross National Product (GNP) originated within the primary information sector and 21.1 percent of GNP was generated by the secondary information sector. These information activities engaged

¹⁰Porat's work was based upon Fritz Machlup's (1962) study entitled The Production and Distribution of Knowledge in the United States. In this pathbreaking study, Machlup estimated that 29 percent of the U.S. Gross National Product in 1958 was accounted for by "knowledge industries"—education, research and development, communications media, information machinery and information services. Further, 31 percent of the labor force was engaged in this sector. Daniel Bell (1973:175-176, 212-213) cited Machlup's study in specifying knowledge as the key resource of post-industrial society.
FIGURE 1.1. Shifts in the U.S. Labor Force and the Growth of Information-Based Employment

Source: Porat (1978:7)
approximately 46 percent of the labor force (see Figure 1.1) which earned over 53 percent of all labor income (Porat, 1978:4).

These findings suggested that the historical growth of the service sector and white collar professional, technical, managerial and clerical workers in the United States was undergirded by the growth of industries directly or indirectly involved in the production of information-based goods and services and work involving the handling and processing of information. Porat (1978:11) posited that information was the key resource underlying the economic transformation of the United States and information technologies were the key components of our technological infrastructure.

Another important study which helped focus attention on the important role of computers and telecommunications was *L'Informatisation de la societe* (The Computerization of Society) which was published in France in 1978 by Simon Nora and Alain Minc. Written as a report to French President Valery Giscard d'Estaing, this study sought to show how information technology (called "telematique" by the French) would transform French society. Nora and Minc stressed that France's political and economic infrastructures must be positioned to facilitate this change in order for the country to regain its economic competitiveness and maintain its sovereignty.

The increasing interconnection between computers and telecommunications -- which we will term "telematics" -- opens radically new horizons. Means of communication have certainly not been structuring communities only in our own day. Roads, railways, and electricity are so many stages along the way from the family to local, national and multinational organization. Unlike electricity, "telematics" will not transmit an inert current, but will convey information, i.e., power. The telephone line or the television channel are the building blocks for this change. Today, they are combined into polyvalent transmitters and are starting to link computers and data banks. Satellites will soon provide them with a potent tool... In varying degrees, telematics will affect all of the long- and short-term aspects of the French crisis (social and economic). It will affect the economic balance, modify power relationships, and increase the states sovereignty (Nora and Minc, 1980:4).
Both Porat's and Nora and Minc's studies drew increased attention to the social, economic and political ramifications of information technology. Since the publication of these works, there has been a burgeoning growth of studies which have outlined the multifaceted role of computers and telecommunications in transforming advanced industrial societies.\(^\text{11}\)

In his later works, Daniel Bell (1977; 1979\(^a\); 1979\(^b\); 1981) also began to place greater emphasis on the centrality of information technology in this transformation. Bell (1979\(^b\); 1981) created an outline of "The Social Framework of the Information Society" which was based upon several dimensions of post-industrial society, but gave greater emphasis to the role of computers and telecommunications in transforming advanced industrial societies.

In the coming century, the emergence of a new social framework based on telecommunications may be decisive for the way in which economic and social exchanges are conducted, the way knowledge is created and retrieved, and the character of the occupations and work in which men engage. This revolution in the organization and processing of information and knowledge, in which the computer plays a central role, has as its context the development of what I have called the post-industrial society (Bell, 1979\(^b\):163).

Like the various social forecasts of the late 1960s and 1970s, interpretations of the emerging information society have been highly divergent. On one hand, there have been a group of forecasts constructed from a functionalist perspective that are largely built upon Bell's vision of post-industrial society. On the other hand, there have been a number of critical works that question the validity of a social transformation to an

\(^{11}\)Like the period in which The Coming of Post-Industrial Society was conceived, there have been a number of new labels created to describe the impact of information technology on advanced industrial societies. Alternative labels to "the information society" include "the microelectronic revolution," "the information age," "the computer age" and the "computerized society" (Forester, 1981; Dizard, 1985; Dertouzos and Moses, 1979; Nora and Minc, 1980). It appears that "the information society" has emerged as a more popular label during the course of the 1980s and the term "information technology" has become the most popular replacement for computer/communications technology. Thus, these two terms are used interchangeably in this text.
information society. These criticisms are largely based upon the context in which
information technology is being applied within advanced industrial societies.

Theoretical Premises of the Information Society

A primary underlying premise of the information society is that the production
and use of information will become the driving force behind the formation and
development of advanced industrial nations as they emerge from the post-industrial
transition. Information technology will provide the technological infrastructure for this
transition process by allowing new capabilities in the organization, processing, storage
and exchange of information for use in societal activity (Bell, 1981:504-505; Cleveland,
1982:36; Masuda, 1981:29; 1985:620-621). Examined in more tangible terms, these
premises have several important implications.

First, they signify that information products and services (as defined by Porat)
are becoming the focal point of economic growth in global market economies. Some
observers contend that information technology will be the central driving force in
stimulating the next long term expansion in the global economy (for example, see
Perez, 1985; Freeman, 1985).

There is already clear evidence that information products and services have
become a major international economic battleground. Not only are producers of infor-
mation products and services attempting to capture domestic markets in their own
countries, but are merging and consolidating their capital in order to compete more
effectively in international markets. Examples of this process include American
Telephone and Telegraph's (AT&T) accord with the Netherlands's N.V. Philips, Honey-
well Incorporated's pact with Japan's NEC Corporation, and France's Groupe Bull S.A.,
and ITT Corporation's venture with France's Cie. Generale d' Electricite (B. Davis,
1986a; Gibson and Browning, 1986; Kamm, 1986). The adoption of information
technology across industry sectors within all advanced industrial nations has created vast market opportunities which are providing an important source of global wealth.

Additionally, the adoption and utilization of information technology is providing a crucial competitive edge in the production of goods and services. It provides firms competitive advantages by allowing: (a) further automation of the production of goods and services; (b) more efficient organization of labor processes; (c) greater control over branches of multilocalational organizations; and (d) the more effective use of information to facilitate better decision making. On a broader scale, it enhances the productivity of an entire national economy through allowing the more efficient organization of linkages between industry sectors (Borrus et al., 1984:15; Perez, 1985; Blackburn et al., 1985; Marchand and Horton, 1986; Harris, 1985a; Locksley, 1986:84-85).

A second important implication of the emergence of information as the driving force of advanced industrial societies is that information technology is transforming the ways in which information is used in the labor process, thereby changing the nature of work itself. Given the historical shift of the labor force to service sector jobs and white collar occupations involving the handling and processing of information, information technology has already had a transformative effect on a large proportion of these occupations. Through its incorporation into manufacturing processes, information technology is changing the nature of work in blue collar occupations as well. The incorporation of information technology into labor processes is changing the societal requirements necessary for a productive labor force.

Computer literacy is increasingly becoming an important labor qualification. Therefore, a crucial element of the shift to an information society will be educational and technical training programs necessary to create a computer literate society. The synthesis of computer and telecommunications has created a much wider range of information conduits and has expanded the flow and accessibility to information for
users of information technology (Compaine, 1981:135). Another critical element of the shift to an information society will be developing a labor force with the conceptual skills and ability to manage and interpret this expanded flow of information in order to effectively coordinate social action toward desired ends -- a process that has been entitled the creation of "knowledge workers" (Marchand and Horton, 1986:256-268).

While knowledge workers will likely be an important dimension of the labor force in the emerging information society, the total range of consequences of information technology for labor processes are currently undetermined. Functional theorists have emphasized that information technology has the potential of completely automating menial and subsistence labor tasks, thereby liberating workers to pursue new possibilities and fulfill their aspirations (Masuda, 1985:628).

On the other hand, critical theorists contend that information technology is simply another means of controlling workers and its application is leading to the "deskilling" of work in knowledge-oriented occupations much like industrial machinery deskilled labor process in occupations related to goods production (Cooley, 1980; 1981; Rojas, 1986; Kumar, 1978:293).12

There can be little doubt that information technology can be used as a substitute for human labor in particular labor processes (e.g. robots replacing assembly line workers in manufacturing). Where this strategy is cost-effective and there is an absence of social and political resistance, i.e., resistance by organized labor or regulation, it is likely to be implemented. Whether this will free workers to pursue their aspirations and fulfill their potentials will depend, in the short term, upon societal mechanisms which will allow them to receive the wages necessary to reproduce themselves and their families.

---

12Cooley (1980) provides an excellent treatise on the effect of information technology on labor processes in architecture.
Whether information technology will lead to the deskilling or "Taylorization" of knowledge work will likely be dependent on the way in which it is applied and its subsequent consequence for affected labor processes. In cases where it is used as a replacement for human mental labor, it is more likely to have a deskilling effect upon the particular occupation. In cases where it is used to augment human mental labor, it is more likely to enhance a labor process, possibly "upgrading" the skills necessary for an occupation.

This underscores the fact that information technology provides a complex range of societal potentials that may be completely, partially, or not at all realized. The choices that are made regarding the application of information technology will determine its future consequences. These choices will be shaped by the particular social, economic and political infrastructures of each advanced industrial nation and in turn, information technology is likely to shape the future of these infrastructures. The key lies in the technological infrastructure of computer and communications systems that is currently being constructed and expanded. This will allow electronic information to be instantly exchanged at any point around the globe by those possessing the necessary technology. The emergence of an information society depends upon the development of this infrastructure.

Masuda (1981:36–39) outlines four overlapping developmental stages of computerization necessary for the realization of an information society. The first stage is the computerization of science which involves the incorporation of computer technology into scientific research involving national defense and space exploration. This was accomplished from approximately 1945 to 1970 (see Table 1.3).

The second stage involves the computerization of management and administration in both private enterprise and government for the purpose of increasing business efficiency. This was largely accomplished from 1955 to 1980. The third and fourth
Table 1.3.
The Developmental Stages of Computerization in the Transition to an Information Society

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bases of Computer Usage</td>
<td>Big Science</td>
<td>Management</td>
<td>Society</td>
<td>Individual</td>
</tr>
<tr>
<td>Goal</td>
<td>National defense space exploration</td>
<td>Gross national product (GNP)</td>
<td>Gross national welfare (GWN)</td>
<td>Gross national satisfaction</td>
</tr>
<tr>
<td>Values</td>
<td>National prestige</td>
<td>Economic growth</td>
<td>Social Welfare</td>
<td>Self-actualization</td>
</tr>
<tr>
<td>Subject</td>
<td>Nation</td>
<td>Organization</td>
<td>General public</td>
<td>Individual</td>
</tr>
<tr>
<td>Object of computer use</td>
<td>Nature</td>
<td>Organization</td>
<td>Society</td>
<td>Human beings</td>
</tr>
<tr>
<td>Scientific base</td>
<td>Natural sciences</td>
<td>Management sciences</td>
<td>Social sciences</td>
<td>Behavioral sciences</td>
</tr>
<tr>
<td>Information object</td>
<td>Attaining scientific goals</td>
<td>Pursuing business efficiency</td>
<td>Solving social problems</td>
<td>Intellectual creation</td>
</tr>
</tbody>
</table>

Source: Masuda (1980:37)
stages of the computerization process are currently ongoing. The third stage involves society-based computerization in which computer technology is applied to meet social needs such as medical care and education. Masuda (1981:38) states that this stage began in 1970 and is likely to continue through 1990. The final stage involves individual-based computerization in which all persons will be able to use computer information to resolve problems and pursue new future possibilities. This stage began in 1975 due to the invention of the microcomputer and will be realized by the year 2000.

Masuda (1981:40-41) also examines how the exchange of computerized information has expanded geographically due to the integration of computers and telecommunications. Initially, the use of computerized information was restricted to institutions possessing a mainframe computer. As time sharing and computer networking developed, the exchange of computerized information became possible on a regional and national level. Finally, the development of electronic information networks using communications satellites has made global exchange possible.

Masuda (1981:77) posits that as the global infrastructure develops, the "information utility" \(^\text{13}\) will become indispensable to the support, development and maintenance of socioeconomic activity. The information utility will become the symbol of the information society much like the factory was the symbol of industrial society.

Dizard (1985:5-6) presents a less detailed, but more realistic three stage model of the transition to the information society. The first stage of the transition is well underway and involves the construction of a complex information and telecommunications infrastructure to be used for the electronic exchange of information. The second stage of the transition is currently emerging and involves the increasing

\(^{13}\)An information utility is a computerized data base that can be accessed from geographically dispersed locations via information technology.
dependence of both private and public industries and organizations on the services provided by new information technologies. Considerable dependence already exists and is increasing rapidly as new applications are developed.

The third and most far reaching stage of the transition will accelerate over the next decade and will involve the mass consumption of high technology information services. The use of information technology will increasingly extend outside of "big business" and "big government" to homes and small organizations (Dizard, 1985:6).

In assessing the status of U.S. society, we have clearly advanced at least incrementally along all the stages of both Masuda's and Dizard's models of development. Information technology has enjoyed the most widespread penetration in large educational, business and government institutions. With the decreasing costs of information technology due to miniaturization, it is enjoying increasing penetration in small businesses and other organizations. The stage that has progressed the least is likely the penetration and use of information technology within the home.

Given that the predominant means of diffusing the technology in advanced industrial societies is the market mechanism, it is not likely that all groups and individuals will be able to participate in the information society, because they will lack the financial wherewithal or educational skills to do so. The transition to the information society is concentrated within the advanced industrial nations and the economic advantages provided by information technology may further the gap between developed and underdeveloped nations (Arriaga, 1984: 23-25; Valaskakis, 1984).

Some observers contend that the increasing penetration of information technology into all aspects of our lives simply represents a process of reindustrialization, an extension of industrialism, or industrialization with new rules, rather than the onset of a novel social system (Cohen and Zysman, 1987:26-27; Valaskakis, 1982; 1984). The emergent changes due to information technology only contribute to an appearance of a
post-industrial society due to their role in contributing to the creation of new services and knowledge-based occupations and in facilitating the further dispersion of the international division of labor in the manufacture of goods.

Information technology is promoting a broad set of change processes. As previously mentioned, these include: (a) the transformation of labor processes; (b) new possibilities in the structure of organizations; (c) the potential to coordinate social action more effectively due to having greater access to information necessary to make decisions and (d) new interaction patterns through substituting human/machine interactions for human interaction. However, it is questionable whether this set of changes is as radical as that involved in the transformation from a feudal agrarian society to one based upon industrial capitalism (Rosenbrock, 1985).

There is considerable evidence that information is becoming a driving force in the economy as information technology is providing: (a) an important source of global wealth; (b) a competitive edge for adopting businesses and institutions; and (c) is increasingly being used by the majority of the labor force that is engaged in information handling and processing. However, the evolution of these change processes is not being driven by the logic of a new social system. Rather, it is being driven by the same logic of industrial capitalism, i.e., the need to maximize economic efficiency and profitability. This logic often "spills over" into the operating principles of non-profit organizations in capitalist societies, promoting the adoption of information technology in these organizations as well. The ways in which information technology is being applied in U.S. society tend to support the thesis that the change resulting from its application reflects a further extension of industrialism.

14This transformation involved radical and highly visible change processes. Workers moved off the farm and became wage laborers in factories, large urban centers evolved and social relationships were transformed from the gemeinschaft to gesellschaft (Toennies, 1957).
Uses of Information Technology in the United States

The ways in which information technology is being applied in U.S. society provides insight into the essential characteristics of the transition to an information society. Currently, the locus of application is concentrated in the workplace. In the manufacturing sector, automated manufacturing machinery such as robots, numerically-controlled machine tools and computer-aided design and computer-aided manufacturing systems (CAD/CAM) are being linked into a unified network with central computers via communications systems. This strategy has been entitled "computer integrated manufacturing" (CIM) (Sillitoe, 1985:82; Zygmont, 1987:28).

CIM is not only allowing the reorganization of production on the factory floor, but also is allowing the reorganization of social linkages within and between industries. There are three basic CIM strategies that are emerging. One strategy is "beginning to end" integration. Through utilizing information technology, this strategy creates an information flow that links all stages of a product's development cycle from design and planning through engineering and production to support departments such as marketing and technical publications. An alternative strategy is "top to bottom" integration which consists of a network of computers that links all levels of a manufacturing firm's organizational hierarchy. This type of integration strategy facilitates the flow of information from management to the production floor for better control of manufacturing operations and from the shop floor to management to enhance decision making and planning.

A final strategy is "inside to outside" integration which consists of a computer network for data exchange between a manufacturer and its suppliers, distributors and customers (Zygmont, 1987:28). These strategies indicate that CIM is transforming the social linkages in the sequential system of production to distribution and support of manufactured goods. CIM allows greater economic efficiency, i.e., productivity, beyond
automated production alone by providing a smoother flow of information for the more effective coordination of social action between organizational hierarchies of industries and between firms involved in the goods production, distribution and support system.

Through inside to outside integration, information technology is also having a profound impact on the wholesale and retail trade sectors as well. Retail trade firms are being electronically linked with wholesale distributors in a number of industries including pharmaceuticals, apparel and food distribution (Harris et al., 1987). For wholesale firms, computer networks allow the automation of such tasks as receiving retail product orders, dispatching orders to warehouses and printing retail price stickers. This not only solidifies sales contracts by creating conveniences for retail firms, but also reduces labor costs by eliminating the necessity of sales persons. Further, by being networked to manufacturers, wholesale distributors can provide data on product demand so production runs can be scheduled more efficiently (Hamilton and Welch, 1987). This particular form of inside to outside integration has also become known as "electronic data interchange" (Harris et al., 1987).

Within retail trade firms, point-of-sale terminals at check out counters linked to central computers allow sales data to be instantly processed and assembled. With updated patterns of consumer demand readily available, retail sales firms can minimize costly inventories of low demand products and allocate shelf space accordingly on the basis of sales volumes (National Institute for Research Advancement, 1985:51). Many large multilocational retail trade firms in the U.S. such as J.C. Penney, Wal-Mart and K-Mart are having their establishments linked nationwide through computer networks (see Brody, 1987:43; Harris et al., 1987:80).

In finance, applications of information technology such as electronic funds transfer (EFT) and automated teller machines (ATM) are transforming the banking industry. EFT allows the instantaneous transfer of funds between banking institutions
thereby reducing the time necessary for debit settlements and the exchange of money between and within banking firms (Ide, 1982:71). ATMs allow bank accounts to be accessed at anytime from geographically dispersed locations (Lamborghini, 1982:147-148; National Institute for Research Advancement, 1985:51-52). ATMs not only provide customer convenience, but also provides the possibility of reducing labor costs through replacing bank tellers (Friedrichs, 1982:198).

It has been stated that the organizational structure of banking is likely to undergo radical changes due to the application of information technology (Lamborghini, 1982:147). There are signs that this may already be occurring in the United States. The banking industry in the deregulated environment of the 1980s has been characterized by waves of mergers and consolidations leading to the emergence of "super-regional" banks with operations in multiple states (Guenther, 1987). The growth of interstate banking has been facilitated by information technology since it allows greater control of geographically dispersed banking establishments.

Information technology has also had profound consequences for financial trading in stocks, securities and other instruments. Through computerized program trading, information technology allows stocks and futures options to be traded much more rapidly in response to changing market conditions (Russell, 1986). This technology has been partially blamed for the record stock market collapse in October, 1987 (Ricks and Langley, 1987). Electronic information delivery services using videotex or teletext technology allow current commodities and securities quotes to be instantly obtained allowing more effective trading (Field and Harris, 1986:84).\footnote{Videotex and teletext technologies are described in greater detail in Chapter 4.}

\footnote{For example, E. F. Hutton utilizes a telecommunications and satellite network to deliver financial information to its 400 retail offices (Field and Harris, 1986:84).}
Computer networking and electronic information services are also having significant impacts in a wide range of other industries in the service sector. In transportation, information technology allows electronic surveillance of shipping and trucking movements\textsuperscript{17} and electronic booking of airline reservations\textsuperscript{18}. In medical services, electronic information systems allow instant access to such information as medical records, patient histories, and diagnoses (National Institute for Research Advancement, 1985:54). Additionally, these systems are becoming increasingly important in legal services through providing instant access to large data banks of legal information for use in writing briefs or other legal procedures\textsuperscript{19}.

In administrative and management functions across all industry sectors including government, applications of information technology are driving the office automation movement. Computers of all sizes and office work stations are being linked together in networks to allow information to be more easily exchanged and shared among office workers (Wilson and Schiller, 1987:112). Other technologies being utilized in this process are electronic mail, voice mail, facsimile machines and videoconferencing. These applications are facilitating the more efficient exchange of information within firms, between branch offices of multilocational organizations, and between separate

\textsuperscript{17}Mardata, owned by Lloyd's Maritime Data Network, Inc., and Geostar, owned by Geostar, Inc. are examples of shipping and trucking services (see Field and Harris, 1986:84; Wessel, 1986a). Through using satellite networks, these services allow the global location of individual ships and trucks to be instantly pinpointed. Other applications of information technology allow the location and status of goods being transported to be continuously tracked and monitored.

\textsuperscript{18}These systems have become a source of controversy in the airline industry. The five systems that are operative are owned by the large carriers (United Airlines, American Airlines, Eastern Airlines, Transworld Airlines, and Delta Airlines). Other airlines have charged that these systems have given the large carriers an unfair competitive advantage since they must pay fees to have their flights listed and close to 70 percent of all airline tickets are sold by travel agents who utilize these systems (McGinley, 1987).

\textsuperscript{19}An example is Mead Corporation's LEXIS electronic information service which is currently used by most major law firms (Z. Schiller, 1986:90).
firms. The growing use of these technologies may lead to the "paperless" office where all data, documents and diagrams are written, processed, stored and exchanged electronically (National Institute of Research Advancement, 1985:51).

In all of these cases, information technology is electronically providing instant access to and/or exchange of information so that social action can be coordinated more effectively towards desired ends. This capability has made some individuals and organizations willing to pay for access to electronic information and an industry is gradually taking shape in the United States. Information is being transformed into a commodity that is being electronically packaged and sold in the international marketplace (Compaine, 1981:133; Helm and Harris, 1986:126; H. Schiller, 1981:48; Marchand and Horton, 1986:180-185). Consumers have been most willing to pay for financial and business information as the market for electronic information is dominated by firms selling information of this type (see Table 1.4).

The development of the electronic information industry has faced many obstacles to its development -- primarily a lack of ability to develop an extensive market due to the reluctance of consumers to pay for the high cost of electronic information (Helm and Harris, 1986). Utilizing the market mechanism as the primary means of distribution restricts the use of electronic information to those with the ability to pay. Therefore, it is not clear whether the information utility will become the symbol of the information society (Masuda, 1981:77). This is further obscured by the fact that many large businesses and organizations have developed their own in-house electronic information systems rather than outsourcing this service from specialized independent firms.
Table 1.4.

Types of Information Sold and Revenues of Top Firms in the Electronic Information Industry

<table>
<thead>
<tr>
<th>Company</th>
<th>1985 Revenues (millions of dollars)</th>
<th>Type of Information Sold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reuters</td>
<td>$505</td>
<td>Commodities and securities quotes, news</td>
</tr>
<tr>
<td>Dun &amp; Bradstreet</td>
<td>325</td>
<td>Credit and miscellaneous business information</td>
</tr>
<tr>
<td>Quotron</td>
<td>187</td>
<td>Securities quotes</td>
</tr>
<tr>
<td>TRW</td>
<td>160</td>
<td>Credit checks</td>
</tr>
<tr>
<td>Mead</td>
<td>154</td>
<td>Local and general business information</td>
</tr>
<tr>
<td>Telerate</td>
<td>149</td>
<td>Commodities and securities quotes</td>
</tr>
<tr>
<td>McGraw Hill</td>
<td>120</td>
<td>Financial information</td>
</tr>
<tr>
<td>Dow Jones</td>
<td>100</td>
<td>Securities and general business information</td>
</tr>
</tbody>
</table>

Source: Field and Harris (1986:84)
The social uses of information technology that have been outlined are only possible because of sets of programmed instructions which tell the machines what to do, i.e., software. The current and future societal consequences of information technology will be dependent upon the software that has been and will be developed.

In many cases, the development of software has lagged behind, limiting the capabilities provided by technical improvements and breakthroughs in computer hardware. This is primarily because software writing is still a labor intensive production process that often involves countless hours of "debugging" in order for programs to operate correctly (Ide, 1982:53). The time necessary for writing software may be reduced in the future through advances in computer-aided software engineering which will automate this process (Wessel, 1986b.). As the development of software with greater capabilities continues, the societal impact of information technology will become even more pronounced.

The major software developments of the future are expected to lie in expert systems and artificial intelligence (AI). Generally regarded as a less sophisticated application of AI, expert systems are software programs which consist of a series of if-then problem solving rules. Given data that specifies a set of particular conditions, expert systems can make judgments and recommend a particular course of action based upon the underlying logic of these rules (Lemmon, 1986:29; White, 1985:10-11).

Expert systems have already been developed for a wide range of applications such as evaluating job applicants and bank loan applications, managerial decision making and medical diagnoses (Athanasiou, 1985:15; Boden, 1985:99; Bulkeley, 1986; Galante, 1986; White, 1985:11). They are gradually entering the mainstream of

A current example is the lack of software to take advantage of the power of the new 80386 microchip that has been incorporated into several new microcomputer models (Duke, 1987). This microchip has the potential of providing microcomputers computing power equivalent to a small mainframe computer.
computing and are expected to multiply in use over the next decade (Bulkeley, 1986; Boden, 1985:96).

It is hoped that AI will provide much more complex software applications, that when combined with advanced hardware developments such as parallel processing, will allow machines to mimic human intelligence and learning capabilities (Denicoff, 1979:375-380; Minsky, 1979). However, advances in AI have been very slow in coming even though several billion dollars has been poured into AI research. This has brought the feasibility of AI into question with some scientists dismissing it as a myth (see Athanasiou, 1985; Weizenbaum, 1985). While the full development of AI may not be attainable, the advancement of expert systems will extend the process by which information technology is amplifying and replacing mental labor, much like mechanization amplified and replaced physical labor during the Industrial Revolution.

The ways in which information technology is being applied in the United States supports the interpretation that the emerging information society represents an extension of industrialism. The dominant motivating logic guiding the application of information technology is that of industrial capitalism, i.e., maximizing economic efficiency and profitability. This logic can be seen in that the primary locus of application of information technology is in the workplace, the cornerstone of social organization in industrial societies. As succinctly stated by Harlan Cleveland (1985:18-5):

The information society does not replace, it overlaps, the growing and extracting and processing and manufacturing and recycling and distribution and consumption of tangible things. Agriculture and industry continue to progress by doing more with less through better knowledge.

It must be emphasized, however, that information technology does provide novel possibilities in extending the logic of industrial capitalism. This can be seen in the way it has allowed for more efficient organizational linkages between manufacturers,
wholesale distributors and retail trade firms, thereby creating a more efficient system for producing and distributing goods. Such new organizational possibilities represent an essential feature of social change that is occurring through the transition to the information society (Cleveland, 1985:187).

The Neglected Role of Agriculture in the Information Society

Whether the transition to the information society represents a post-industrial transition or an extension of industrialism, post-industrial and information society theories leave many conceptual gaps to be filled. Even if the majority of the labor force is shifting into the service sector and occupations involving information handling and processing, and even if information is becoming the driving force of development, what will be the role of the agricultural sector in the emerging information society? This role is never clearly delimited by post-industrial and information society theorists.

Agriculture has merited attention only in so far as it has declined as an important source of employment in advanced industrial societies. As pointed out by Cohen and Zysman (1987:13), the shift of employment out of agriculture in the United States did not mean a shift out of agricultural production.

While shifting the source of societal wealth to the goods-producing sector, the rise of industrialism did not diminish the importance of food production and consumption as a necessary societal requisite. However, industrialism has obscured the importance of agriculture as the growing majority of the populace shifted to large urban centers and became increasingly removed, both culturally and spatially, from the agricultural system.

The agricultural system has been characterized as the "island empire" (Mayer and Mayer, 1974) signifying its isolation from mainstream industrial society. However, there is every indication that agriculture is highly interlinked with industrial society and has mirrored changes in the industrial system. Spin off applications of
technologies developed within the industrial sector contributed to agriculture enjoying
the highest rate of productivity growth of all industry sectors during the height of the
U.S. industrial expansion in the post World War II period (Kenney et al., 1987; Fuchs,
1968:52).

This rate of productivity has allowed the percentage of the labor force engaged in
agricultural production to continue to decline without threatening the security of the
food supply in the United States. However, it obscures the fact that the rise of
industrialism transformed and shaped the agricultural system, increasing its organiza-
tional complexity.

In general, productivity increases usually imply an ever greater indirectness in the production process and an ever greater specialization of imports (including labor). The more advanced or modern the production process, the longer and more complicated the chains of linkages. . . a modern American farmer is really the point man in a long, elaborate chain of specialists--most of whom don't often set foot on the farm--all of whom are vital to its successful operation and directly depend on it (Cohen and Zysman, 1987:14).

The advance of industrial society transformed the agricultural system by establish-
ing a set of complex linkages with manufacturing and service industries outside the
farm sector which allowed agriculture to become the most highly productive sector of
the economy. In, effect the agricultural system was extended beyond the farm sector
to encompass segments of the manufacturing and service sectors. Through industri-
alism, the social structure of agriculture became increasingly specialized and differenti-
tiated. The major proportion of the labor force connected with food production and
distribution became employed in occupations outside of agricultural production.

If this historical process provides any indications, the constellation of social change processes that has been entitled the transition into an information society also portends significant changes in the agricultural system. Applications of information technology have been developed for all industries comprising the U.S. agricultural
system. This will present new organizational possibilities for the agricultural system as well as changing the nature and form of agricultural work. A key to the integration of the agricultural system into the information society hinges upon the extent and means in which the electronic computer/telecommunication infrastructure currently being prepared will be extended into the spatial local of agricultural production--rural America.
CHAPTER II

THE DEVELOPMENT OF DIGITAL TELECOMMUNICATIONS IN THE UNITED STATES: HOW WILL RURAL AMERICA HAVE ACCESS?

A vital stage in the transition to the information society is the development of a telecommunications infrastructure that will allow information to be electronically exchanged between computers or other information processing technologies across geographic distances. Much like the development of computers, this infrastructure is evolving rapidly, making possible many of the applications of information technology that were discussed in the first chapter. Given that telecommunications networks will provide the electronic highways for the exchange of computerized information, access to these networks will determine who can and cannot participate in the emerging information society. As succinctly stated by Nora and Minc (1980:84):

*Telecommunications are the obligatory point of passage for computers whenever they communicate with one another. Implantation and management of systems will determine most of the economic, industrial, and social effects of the new data processing. Their capillarity may facilitate territorial reorganization. Their tariffs will arbitrate the respective interests of the large and small firms; they will facilitate or control the access of households to new services and thus the benefits they receive. The politics of network systems will decide whether telematics remains the activity of some few powerful fiefs or is distributed democratically.*

46
From a technological standpoint, the emerging telecommunications infrastructure has developed along two primary dimensions. One focal point of development has been the modification of the previously existing telecommunications infrastructure (telephone lines, microwave relay stations, communications satellites, television, radio and coaxial cable networks) to accommodate the exchange of "digital" information between computers and microelectronics technologies.\(^{31}\)

Different forms of information such as data, text,\(^{33}\) voice and video have traditionally been disseminated through different media such as printed publications, telephone, radio and television networks. With information technology, all forms of information can be computerized and reduced to a common digital base. This capacity is eliminating the need for separate media and making it possible to electronically transmit all forms of information through a single medium (National Institute of Research Advancement, 1985:42). This is blurring the distinctions between media and leading to the convergence of historically separate modes of communication (Pool, 1983:23,27). A second focal point in preparing the telecommunication infrastructure for the emerging information society has been the development of new telecommunications technologies such as fiber optic cable, which permit these more advanced capabilities in

\(^{31}\)"Digital" refers to information expressed in the binary code utilized within the internal electronic circuits of a computer. The basic unit of digital information is the "bit" or binary digit which is expressed as one of two digits—a 0 or 1—and is associated with a logic gate within the electronic circuitry of the computer in an on or off position. With digital information, letters, characters, words, sounds and images are represented by sets of bits known as "bytes". Thus, the exchange of digital information involves the transmission of a sequence of electronic pulses which are symbolic sets of 1s and 0s and could represent text, data, voice, or images. The speed of a telecommunications channel is measured in a scale of bits per second known as a "baud" (Ide, 1982:46).

\(^{33}\)Data refers to purely numeric information while text refers to alphanumerical information.
the transmission of digital information.\textsuperscript{22}

The development and modification of the telecommunications infrastructure underscores the fact that the ability to exchange information in digital form is one of the fundamental processes underlying the transition to the information society. Therefore, the timing of this transition will be both limited and influenced by the speed in which the telecommunications infrastructure is transformed to allow the more widespread exchange of digital information between computers and other information processing technologies.

\textbf{Forces Influencing the Development of the Infrastructure for Digital Telecommunications in the United States}

The development of the infrastructure for digital telecommunications in the United States transcends the telecommunications and computer industries. Computer companies are developing ways of networking computer technologies with communications. Simultaneously, telecommunications firms are developing ways of adapting and utilizing their networks for the provision of services involving the exchange of digital information between computers and information processing technologies. The products and services evolving from these complementary developmental forces represent new sources of economic growth in an already important sector of the U.S. economy. In 1983, the U.S. market for telecommunications equipment and services was approximately $116 billion, or about 3 to 4 percent of the United States Gross National Product (Borrus et

\textsuperscript{22}Fiber optic cable permits the transmission of digital information over light waves rather than electromagnetic waves used in all previously developed electrical communications media. Fiber optics provides significant advantages by allowing greater transmission capacity, faster transmission speeds, higher fidelity and greater flexibility in use compared to electromagnetic transmission media (Dizard, 1985:46; Ide, 1982:62-65; Sigurdson, 1984:11). For example, it is possible to transmit the entire Encyclopedia Britannica over a pair of fiber optic cables in less than one minute. Further, while a twisted pair of copper cables is needed to transmit one telephone call, a pair of hair-thin fiber optic cables can transmit more than 8,000 calls simultaneously (Sigurdson, 1984:11; Wynter, 1986).
With revenues of this magnitude at stake, the development of the digital telecommunications infrastructure in the United States has become a major economic battleground with a large number of domestic and foreign corporations vying to capture the profit potential provided by the expanding demand for telecommunications products and services. The crucial stake in this corporate battle is determining who will control the largest market shares for the products and services contributing to and evolving from the transformation of the telecommunications infrastructure (see Table 2.1).

The politics of telecommunications has played a major role in shaping the development of the telecommunications infrastructure. The emphasis of the Reagan administration on deregulation has resulted in several important shifts in U.S. telecommunications policy. Of fundamental significance has been the Federal Communications Commission's (FCC) "Computer II" decision in 1982 which subsequently led to the divestiture of the heavily regulated monopoly on the telephone industry controlled by AT&T (Borrus et al., 1984:7; Dizard, 1985:10; Gladwell, 1986:8; Locksley, 1986:92).

---

24One aspect of this process has been a growing convergence between the telecommunications and computer industries. This is best exemplified by the much publicized diversifications of AT&T into computers and computer networking and IBM into producing telecommunications products and services. For example, AT&T has purchased a stake in Ing. C. Olivetti & Company of Italy and is marketing Olivetti computers while IBM has acquired stakes in MCI Communications, Incorporated and Rolm Corporation to become involved in the provision of telecommunications services and the manufacture of telephone equipment (Carroll and Swartz, 1987; Dizard, 1985:104-111; Locksley, 1986:91-94; Marcom, 1986; Marcom and Barnes, 1985). However, neither firm's cross-industry foray has been highly successful (Guyon, 1986a; 1986b; Marcom, 1986; Marcom and Barnes, 1985; Carroll and Swartz, 1987) and the new interlinkages between the two industries are still coalescing.
Table 2.1.
Selected Services and Products of the
Telecommunications Sector

<table>
<thead>
<tr>
<th>Network Services</th>
<th>Network Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common Carriers</strong></td>
<td>Central Office Switching</td>
</tr>
<tr>
<td>e.g. &quot;AT&amp;T&quot;</td>
<td>e.g. *digital telephone switches</td>
</tr>
<tr>
<td>*Bell regional holding and</td>
<td></td>
</tr>
<tr>
<td>*Telephone operating companies</td>
<td></td>
</tr>
<tr>
<td>*Independent telephone companies</td>
<td></td>
</tr>
<tr>
<td><strong>Specialized Common Carriers</strong></td>
<td>Customer Premises Terminal</td>
</tr>
<tr>
<td>e.g. &quot;MCI&quot;</td>
<td></td>
</tr>
<tr>
<td><strong>Valued-Added Carriers</strong></td>
<td>Network Transmission</td>
</tr>
<tr>
<td>e.g. *Combined networks</td>
<td>e.g. *cable transmission</td>
</tr>
<tr>
<td></td>
<td>*microwave</td>
</tr>
<tr>
<td></td>
<td>*Satellite microwave</td>
</tr>
<tr>
<td></td>
<td>*fiber optic cables</td>
</tr>
<tr>
<td><strong>International Record Carriers</strong></td>
<td></td>
</tr>
<tr>
<td>e.g. &quot;ITT&quot;</td>
<td></td>
</tr>
<tr>
<td><strong>Domestic Satellite Carriers</strong></td>
<td></td>
</tr>
<tr>
<td>e.g. *Satellite Business Systems</td>
<td></td>
</tr>
<tr>
<td><strong>Data Communications Equipment</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Modems</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Multiplexers</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Communications Processors</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Test Monitoring and Control Equipment</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Network Software</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Local Area Networks (LAN)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Office Work Stations</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Business Communications</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Facsimile</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Electronic Mail</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Voice Recognition, Response Mail</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Video Conferencing</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Teletext</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Videotex</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Borrus et al. (1984:13)
In 1984, AT&T was split into seven independent regional telephone companies that would provide local telephone service while AT&T retained its research (formerly Bell Laboratories), manufacturing (formerly Western Electric) and long distance telephone (formerly Long Lines) service divisions (see Table 2.2). In return, the FCC allowed AT&T to enter markets from which it was previously banned. Domestically, these markets include equipment sales, data communications, electronic information processing and office automation. Internationally, affected market include equipment sales and service provision (Gladwell, 1986:10; Locksley, 1986:92).

The stated purpose of "Computer II" was to reduce government involvement in regulating sectors of the telephone industry (primarily telephone equipment and long distance service), allow competition to lower the cost of long distance telephone service for consumers and stimulate innovation in telecommunications equipment and services (Dizard, 1985:103; Gladwell, 1986:9; Pasztor and B. Davis, 1987; Saddler, 1986).

The "Computer II" decision not only opened up the long distance telephone and telephone equipment industries to other corporate competitors, but also allowed AT&T to become a competitor in markets for the provision of products and services based on information technology. While it is questionable whether the divestiture of AT&T has resulted in true competition in the provision of long distance telephone service, there can be little doubt that the infrastructure for digital telecommunications has been expanded to allow a wider array of services based on information technology.

---

25AT&T's long reign as the monopolistic provider of telephone service in the United States provided it a comparative advantage from the onset of deregulation. AT&T had the much easier marketing task of retaining customers rather than pirating them away from a firm with a historical reputation of providing reliable service. Further, AT&T had a vast telecommunications infrastructure already in place and despite the divestiture, AT&T remained one of the world's largest corporations.
Table 2.2.
Structure of AT&T Before and After the 1984 Divestiture

<table>
<thead>
<tr>
<th>Pre-Divestiture</th>
<th>Post Divestiture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AT&amp;T Long Lines Division</strong></td>
<td><strong>AT&amp;T</strong></td>
</tr>
<tr>
<td>Western Electric</td>
<td>AT&amp;T Technologies</td>
</tr>
<tr>
<td>Bell Laboratories</td>
<td>*AT&amp;T Information Systems</td>
</tr>
<tr>
<td>AT&amp;T Information Systems</td>
<td>*AT&amp;T Technologies</td>
</tr>
<tr>
<td>22 Local Telephone Operating Companies</td>
<td>*AT&amp;T International</td>
</tr>
<tr>
<td>AT&amp;T International</td>
<td>*Bell Labs</td>
</tr>
<tr>
<td>Advanced Mobile Phone Service</td>
<td>AT&amp;T Communications</td>
</tr>
</tbody>
</table>

**The Regional Bell Companies**

- USWEST
  - *Mountain Bell
  - *Northwestern Bell
  - *Pacific Northwest Bell
  - *Southwestern Bell
  - *Southwestern Bell
  - Pacific Telesis
  - *Nevada Bell
  - *Group Pacific Bell

- Ameritech
  - *Ohio Bell
  - *Michigan Bell
  - *Illinois Bell
  - *Wisconsin Bell
  - *Indiana Bell

- Bell Atlantic
  - *New Jersey Bell
  - *Bell of Pennsylvania
  - *Diamond State Telephone
  - *The Chesapeake & Potomac Cos.(4)

- NYNEX
  - *New York Telephone
  - *New England Telephone

- BellSouth
  - *South Central Bell
  - *Southern Bell

Source: Gladwell (1986:10-11)
This is not only because AT&T has been allowed to focus its vast resources on developing new information technology-based products and services in addition to "digitalizing" its telecommunication network through the installation of technologies such as fiber optics and digital telephone switching. In attempting to compete with AT&T, other telecommunications firms are constructing their own networks and are also producing new products and services based on information technology. These new networks are being constructed using the most modern digital technology and have greatly enlarged the national capacity for digital telecommunications. It has also become necessary for competing firms to develop innovative services in order to create new sources of revenue since AT&T has largely maintained its lock on the market for long distance telephone (voice) service (Wilke and Maremont, 1986).

Two additional telecommunications firms that have played a major role in expanding the digital telecommunications infrastructure are MCI Communications, Incorporated and US Sprint Communications Company which control the second and third largest number of telecommunications network circuit miles behind AT&T. By 1985, 1.5 billion miles of telecommunications network circuit miles had been constructed by these three firms alone (see Table 2.3).

**TABLE 2.3.**

| Firms Controlling the Largest Number of Telecommunications Network Circuit Miles (1985)* |
|---------------------------------|---------------------------------|
| **Company**                  | **Number of Miles**           |
| AT&T                          | 932 million@                  |
| MCI                           | 320 million                   |
| GTE Sprint#                   | 170 million                   |
| US Telecom#                   | 48.6 million                  |

*Source: Guyon (1986c)*
@*Figure is estimated.*
#*These companies were merged in 1986 to form US Sprint.*
*Network circuit miles indicate network capacity. One circuit mile equals one standard voice conversation sent one mile.*
The capacity of AT&T's telecommunications network is much larger than that of MCI or the combined GTE Sprint and US Telecom (US Sprint) because the company was allowed to retain the nationwide system it constructed before the divestiture. AT&T's network consists of a complex combination of coaxial cable, microwave, satellite and fiber optic routes connected to a large number of regional switches that route telephone calls (Guyon, 1986d).

In general, other long distance telephone companies also use a combination of transmission media, which are either owned or leased from other telecommunications firms. For example, the initial network utilized by MCI (formerly called Microwave Communications, Incorporated) consisted entirely of a point-to-point microwave service between St. Louis and Chicago (Seipp, 1978:4). In the course of expanding its service, MCI acquired a substantial stake in IBM's Satellite Business Systems and also leased network access from other telecommunications firms to cities not covered by its own network (Guyon, 1986c; Wilke and Maremont, 1986). One reason behind the construction of telecommunications networks by AT&T's competitors is the drive to reduce the cost of leasing network circuits from other firms (Wilke and Maremont, 1986).

Opening up the long distance telephone industry has clearly had an effect in expanding the digital telecommunications infrastructure and the provision of information technology-based services. A factor that could provide an additional stimulus in the future is the potential for further deregulation of the regional Bell companies. The 1984 federal decree that led to AT&T's divestiture also mandated that the regional Bell companies be prohibited from: (a) providing interstate long distance telephone service; (b) providing electronic information services; (c) manufacturing telephone equipment; and (d) engaging in enterprises other than local telephone service, marketing customer premises equipment and publishing directories (Whalen, 1986). Proposals to engage in
any businesses outside these areas must be granted waivers by the presiding Federal judge, United States District Judge Harold H. Greene (Deigh, 1986).

The regional Bell companies have been permitted to enter many businesses that are not regulated under the divestiture agreement. This has led to a spate of mergers, acquisitions and start-ups as the regional Bell companies have invested in a variety of nonregulated businesses including computer software, retail marketing of computers and communications system design and consulting (Gladwell, 1986:11; Roberts, 1986a).

The post-divestiture period has been marked by a continuous lobbying battle as the regional Bell companies have assiduously pushed to expand into the businesses from which they were prohibited. On one side has been the regional Bell companies, the Department of Justice, the Commerce Department's National Telecommunications and Information Administration and the FCC, which have argued that the restrictions must be removed. These groups have claimed that such restrictions are thwarting technological development, denying consumers and small businesses access to innovative, information technology-based services, and preventing true competition in the long distance telephone industry (Coccia, 1987; B. Davis, 1987a; 1987b; Pasztor and Davis, 1987).

On the opposing side has been a broad-based coalition of long distance telephone companies, newspaper publishers, telephone equipment manufacturers and consumer interest groups. Consumer interest groups fear that the removal of these barriers will lead to increases in residential telephone rates while the other groups are attempting to protect their market shares in long distance telephone service, telephone equipment and electronic publishing and information services (B. Davis, 1987a; 1987b; Roberts, 1987a; Roberts and Davis, 1987).
A variety of unsuccessful attempts have been made to strip Judge Green of his authority over the case including the ill-fated Federal Telecommunications Policy Act of 1986 which was proposed by Senate Majority Leader Robert Dole, but failed to gain support in Congress (B. Davis, 1987a; 1987b; Whalen, 1986:16). Thus far, Judge Green has upheld all of the restrictions with one exception. In September 1987, he ruled that regional Bell companies could use their telephone networks to provide information services. However, these services must be produced by other companies, and can only be distributed by the regional Bell firms (B. Davis, 1987b; High Technology Business, 1987).

Since this ruling, the regional Bell companies have been forming alliances with firms producing electronic information services. For example, BellSouth has formed an agreement with US Sprint's Telenet which allows customers access to information services provided over this commercial computer networking service (Roberts, 1987b). A potentially significant innovation that has emerged is "gateway" services. Gateways allow customers to access a number of electronic information services over a single local telephone number via microcomputers. With previous arrangements, it was necessary for customers to subscribe to each information service separately. In turn, all of these services had to be accessed through different telephone numbers and "log-on" procedures (High Technology Business, 1987; Roberts, 1987c). It is believed that the convenience of gateways could greatly expand the use of electronic information services (Roberts, 1987c).

Allowing the regional Bell companies to compete in prohibited markets could facilitate the transition to the information society in several ways. First, it could further expand the national capacity of the infrastructure for digital telecommunications if the regional Bell firms were allowed to compete in the market for interstate long distance telephone service. Regional Bell companies desiring to
compete in this market would likely construct their own nationwide telecommunications networks using modern digital technology following the lead of MCI or US Sprint.26

Easing the restrictions on the regional Bell firms could also stimulate further innovation in telecommunications services and equipment by allowing a greater number of large, well-established firms to compete in these markets. The development of gateways services exemplifies this possibility. In turn, this could contribute to expanding the use of information technology-based services in the United States. One potential cost of removing these barriers is that residential telephone rates could rise if the regional Bell companies are allowed to subsidize nonproﬁtable services by raising rates for proﬁtable services such as local telephone service.

Technological Systems for Digital Telecommunications

Telecommunications firms that are central to the telephone industry are clearly positioning themselves to be major forces in inﬂuencing the transition to the information society in the United States.27 They own and control extensive infrastructures of telecommunications networks. Their networks subsume a diversity of technological conduits for the exchange of digital information such as telephone, microwave, and satellite systems. Finally, they are in the process of transforming their networks to provide new sophisticated services based upon information technology as well as being involved in manufacturing the technology necessary for this transformation.

26The regional Bell companies have already invested in incorporating ﬁber-optic cable into their local networks. For example, Southwestern Bell Corporation, Ameritech and BellSouth reported 160,000, 115,000 and 170,000 miles of ﬁber-optic cable installed in their networks by the end of 1986 (Southwestern Bell Corporation, 1986; Ameritech, 1986; BellSouth Corporation, 1986).

27This includes the computer ﬁrms that have invested in the telephone industry such as IBM.
The traditionally distinct service provided by the telephone system is being obscured as voice traffic is becoming one of many services being provided through these networks. Telephone systems have historically played a major role in the development of information technology as they have been and will continue to be central conduits for the exchange of digital information between computer technologies. There are several alternative systems that have been developed to serve this purpose.

One system utilizes nondigital, common carrier telephone networks to exchange digital information between computer technologies. This is accomplished through the use of a modulator/demodulator (commonly known as a modem). Through a modem, digital signals from a computer or computer-based machine are transformed into telephone audio (analog) signals and transmitted over the commercial telephone network to a second computer or machine which is also linked by a modem. The signals are transformed back into digital form and processed by the second machine. With this form of computer networking, users must pay commercial local and long distance telephone costs depending upon the distances involved in transmission and reception. A second variable affecting cost, especially with long distance calls, is the speed in which information is transmitted by the modem. The bits-per-second transmission rates of modems are increasing as the technology advances. However, this system only allows asynchronous transmission. Thus, only one machine can be transmitting with the other receiving at any given time. This is not as efficient as networking systems allowing synchronous transmission.

In 1986, it was estimated that only 13 to 16 percent of all personal computers were equipped to communicate with modems (Shulman, 1987). Thus, the use of this system for networking computers is not extensive despite being one of the earliest
developed systems for digital telecommunications via telephone networks. Another use of common carrier telephone networks for the exchange of digital information that perhaps is currently more popular is the utilization of facsimile machines to transmit and reproduce paper documents (Kneale, 1987).

A second system utilizing telephone networks involves the use of dedicated user lines which are telephone lines that are leased or owned for private use. Dedicated user lines allow synchronous transmission and are much faster and more efficient than commercial telephone networks in exchanging digital information. However, their cost is comparatively much higher. It has been estimated that 50 percent of all telephone lines are dedicated user lines that are leased or owned by corporations to communicate with branch offices. During a business day, voice traffic dominates the use of these lines. At night they are used primarily to exchange sales, marketing and inventory data between computers (Shulman, 1987).

A third system for exchanging digital information involves the use of commercial packet switching networks. These networks were spun off from the original computer networking technology developed by DARPA. These networks are generally international in scope and can be accessed by dialing a local telephone number. Once hooked in, computerized data can be exchanged anywhere that is linked within the network’s grid. The major costs of these networks are generally subscription fees and on-line access charges. A number of these commercial networks have been developed since the mid 1970s when DARPA began operating its packet switching network entitled ARPANET (see Table 2.4).

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This low rate of utilization has likely contributed to the slow growth of electronic information services whose computerized data banks are generally accessed by personal computers over commercial telephone networks.
Table 2.4.

Packet Switching Networks in the United States

<table>
<thead>
<tr>
<th>Network Name</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telenet</td>
<td>US Sprint Communications Company</td>
</tr>
<tr>
<td>Tymnet</td>
<td>McDonnell Douglas Corporation</td>
</tr>
<tr>
<td>Accunet</td>
<td>AT&amp;T</td>
</tr>
</tbody>
</table>

Source: Compiled by the author.

The telephone industry benefits from commercial packet switching networks in several ways. First, they are accessed through local commercial telephone networks which benefits independent and regional Bell companies. Second, they provide additional sources of revenue to telephone companies owning and providing this service. However, telephone companies are not the only industries providing this service. Other industries (e.g., aerospace -- McDonnell Douglas) with interests in computers and information technology have also developed these services.

The Integration of Fiber Optic Cable into the Digital Telecommunications Infrastructure

Because of its greater communications capabilities, fiber optic cable is rapidly becoming a significant transmission medium in the digital telecommunications infrastructure. Since the primary initial use of fiber optic cable is for voice traffic, telephone companies are playing a major role in constructing fiber optic networks. The first fiber optic network circuit was completed by AT&T in 1983 and linked Boston and Washington, D.C. (Dizard, 1985:46).
Since the divestiture of AT&T, the amount of fiber optic cable available for utilization has expanded rapidly. This expansion is being driven by both long distance and local telephone companies seeking to gain a competitive edge by incorporating fiber optic capabilities into their services. While the rush to deploy fiber optic networks is primarily to capture market shares in telephone service, it is anticipated that large fiber optic markets in computer networking and video transmissions will develop in the future (Wynter, 1986).

By 1986, over 20,000 miles of fiber optic cable was in service in the United States (see Table 2.5). At that time, US Sprint was the industry leader in the number of miles in service with AT&T ranking second.

**Table 2.4.**

<table>
<thead>
<tr>
<th>Network Owner</th>
<th>Planned Miles</th>
<th>Miles in Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Sprint</td>
<td>23,000</td>
<td>6,200</td>
</tr>
<tr>
<td>AT&amp;T</td>
<td>10,200</td>
<td>5,200</td>
</tr>
<tr>
<td>MCI</td>
<td>7,000</td>
<td>2,500</td>
</tr>
<tr>
<td>National Telecommunications Network</td>
<td>11,160</td>
<td>4,123</td>
</tr>
<tr>
<td>Regional Networks</td>
<td>9,126</td>
<td>2,480</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>60,466</strong></td>
<td><strong>20,503</strong></td>
</tr>
</tbody>
</table>

Source: (Wynter, 1986)

While MCI ranked behind the other major long distance companies in number of miles of fiber optic cable in service in 1986, it became the first firm to complete the first coast-to-coast fiber-optic network in 1987 (see Figure 2.1).

The Role of Satellites in the Digital Telecommunications Infrastructure

Another important technological link in the digital telecommunications infrastructure is satellites. Satellites not only serve as telecommunications links in the telephone and television industries, but also are extremely crucial for collecting information. The latter function involves the use of probes and remote sensing for
Starting this month, The Information Age comes of age.

MCI announces coast-to-coast fiber optic network.

MCI's coast-to-coast digital fiber optic network provides businesses with the cleanest, clearest voice and high-speed data communications available anywhere coast-to-coast, border-to-border.

While other communications companies make promises, MCI makes history. Because MCI has invested billions of dollars in technologies like fiber optics, we are uniquely qualified to respond to your needs. MCI was the first company to offer a competitive long distance service. The first to introduce single-mode fiber optics. The first to provide worldwide delivery of electronic mail. Now, MCI is setting the standards in the telecommunications industry once again.

Our fiber optic link is just the latest example of MCI innovation hard at work for your business. And just one of the reasons almost all of the FORTUNE 500 turn to MCI. Let us show you how our innovative products and services can make your 1987 even more productive.

FIGURE 2.1. Completion of First Coast-to-Coast Fiber Optic Network
collecting meteorological data, monitoring natural resources and for military surveillance (Ide, 1982:61). Being the space equivalent of a microwave switching tower, satellites give the microwave path a line-of-sight capacity that extends across one third of the earth’s surface. In their telecommunications capacity, satellites have made the cost of communication increasingly less sensitive to distance (Pool, 1981:162).

Because of the advancements in microelectronics over the past several decades, satellites have undergone considerable development in the sophistication of their communications capabilities while declining in cost. These developments included the incorporation of digital circuitry, which has allowed satellites to handle digital communications (Dizard, 1985:53; Ide, 1982:60). Satellites are gradually becoming vital in the transmission of digital data between computer technologies and are being used for "stand alone" private data network services in addition to serving as links in commercial telephone and television networks. For example, the service provided by Satellite Business Systems uses an all-digital format and is capable of providing transmissions of voice, high speed data, facsimile and video on an integrated basis while bypassing the long distance and local telephone networks (Dizard, 1985:105).

Many of the information technology-based services that involve linking branch establishments of multilocalational organizations use satellite networks as the medium for transmitting and exchanging digital information. Large retail trade firms such as K-Mart and J.C. Penney, financial service firms such as Merrill Lynch and manufacturers such as Digital Equipment use this type of system to link computers in their branch establishments to transmit and exchange information (Brody, 1987:43; Marcom, 1985).

In conjunction with the deregulated environment that has emerged in the telephone industry, satellite telecommunications has also involved an easing of FCC regulations. The Communications Act of 1962 required FCC licensing not only for
satellites and satellite radio frequencies in the electromagnetic spectrum, but also for earth stations. Under the original act, both transmission and receive-only earth stations required licenses. However, in 1979, the FCC repealed the license requirement for receive-only earth stations (Pool, 1983:222-223). This has facilitated an increasing proliferation of receive-only earth stations (more popularly known as satellite dishes) among the U.S. populace which are being used primarily to receive television programming. Furthermore, the FCC has adopted an "open skies" policy which allows all licensed companies to compete for the provision of domestic service (Pool, 1983:44).

The strategic significance of satellites in the global telecommunications infrastructure has drawn many large U.S. corporations into the satellite industry who are attempting to capture the profit potential provided by the manufacture of satellite technology and the provision of satellite services (see Table 2.6).

The importance of satellites as links in the global and domestic telecommunications infrastructure has undoubtedly increased over the past several decades. However, there are several obstacles that are likely to inhibit a future expansion in demand for satellite services. One obstacle is the growing proliferation of fiber optic cable within land line networks. Fiber optics allow much faster and efficient telecommunications at a cost that may fall below that of satellites. This has led to predictions that future demand for satellite services could decline as a greater proportion of voice, data and video traffic is shifted to fiber optic networks (Brody, 1987:43; Large, 1985; Schwadel, 1987; Sigurdson, 1984:11-12). Another problem facing satellite services is the escalating insurance costs and high risk involved in launching satellites as witnessed by the recent launch failures of the space shuttle Challenger and several European Ariane rockets while attempting launches (Brody, 1987:43; White, et al., 1986).
Table 2.6.
Selected Firms in the Satellite Industry (1987)

<table>
<thead>
<tr>
<th>Satellite Manufacturers</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Astro-Space Division</td>
<td>General Electric</td>
</tr>
<tr>
<td>Hughes Aircraft Company</td>
<td>General Motors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Satellite Owners/Service Providers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AT&amp;T</td>
<td></td>
</tr>
<tr>
<td>Communications Satellite Company (COMSAT)</td>
<td></td>
</tr>
<tr>
<td>Contel/American Satellite Corporation*</td>
<td></td>
</tr>
<tr>
<td>GE American Communications</td>
<td>General Electric</td>
</tr>
<tr>
<td>GTE Spacenet</td>
<td>GTE</td>
</tr>
<tr>
<td>Hughes Communications</td>
<td>General Motors</td>
</tr>
<tr>
<td>Satellite Business Systems®</td>
<td>MCI</td>
</tr>
<tr>
<td>Western Union Company</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-Ownership Service Providers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonneville</td>
<td></td>
</tr>
<tr>
<td>Cylex Communications</td>
<td></td>
</tr>
<tr>
<td>EDS Communications*</td>
<td>Martin Marietta</td>
</tr>
<tr>
<td>Private Satellite Network</td>
<td></td>
</tr>
<tr>
<td>Tridom</td>
<td></td>
</tr>
<tr>
<td>VideoStar Connections</td>
<td></td>
</tr>
<tr>
<td>Xerox Computer Services</td>
<td>Xerox</td>
</tr>
</tbody>
</table>

Source: Brody (1987:42)

*Contel Corporation purchased a 50% stake in American Satellite Corporation in 1979.

*GMC purchased Satellite Business Systems from IBM in 1985 by trading a 16.6% stake in its ownership.
One way the satellite industry has responded to the cost problem is the development of innovative earth stations entitled "very-small-aperture terminals" or VSATs. VSATs are compact earth stations that are smaller, less costly, easier to install and less likely to be prohibited by urban zoning regulations than conventional earth stations. VSATs have lowered the cost of satellite services for consumers, which will likely make them more price competitive with fiber optic networks. The lower cost of VSATs has helped stimulate the further proliferation of private satellite networks for linking branch establishment of multilocational organizations. VSATs have also contributed to the growth of business television which uses "narrowcast" programming to transmit industry or firm specific information to a select audience at a low cost (Brody, 1987:43; Bulkeley, 1985).

Whether or not the use of commercial satellite services declines, satellites will continue to be extremely important for their information acquisition capabilities. This function isn't only vital to national security, but also has the potential of spinning off commercial services. For example, the privatization of the Federally-owned Landsat satellite system by the Reagan Administration in 1985 led to the formation of Earth Observation Satellite Company (EOSAT), a joint venture of General Motors' Hughes Aircraft Company subsidiary and General Electric Corporations' RCA subsidiary. EOSAT is attempting to develop a commercial service from selling photographs taken by the Landsat satellites. The information from these photographs is being used by such groups as oil prospectors, the news media, and crop forecasters attempting to speculate more effectively in the futures market (Large, 1986; McGinley, 1986; Wall Street Journal, 1985).

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20 VSATs are anywhere from two to six feet in diameter compared to conventional earth stations which are ten feet.
Technologies for Digital Communications Within Organizations

In addition to linking into the digital telecommunications infrastructure to exchange digital information across geographic distances with other organizations or branch establishments, many organizations such as businesses and government agencies are constructing digital networks within their physical facilities. This allows digital information to be instantly exchanged between organizational divisions and departments, thereby promoting the more effective coordination and control of activity. An illustrative example is computer networking within an administrative office.

The predominant technology for networking computers in a local setting is "local area networks" or LANS. Simply put, LANS consist of a bundle of cables that let computers, terminals, and printers communicate with each other at high speeds. LANS permit information to be shared and exchanged by separate computers, computing power to be shared among users and output to be routed to different printers throughout a facility (Zieman, 1986).

An increasingly popular technology for linking into the emerging digital telephone network is the "private branch exchange" or PBX. PBXs are analagous to on-site digital telephone switchboards and are generally utilized by organizations with a large number of telephones. In addition to being used for voice traffic, PBXs can also be used for voice mail and transmitting and routing digital data between computers (Zieman, 1986).

With the expanded capabilities in intraorganizational communications provided by information technology, a growing number of organizations (primarily large businesses) are constructing increasingly sophisticated networks for digital telecommunications between organizational divisions and branches (D.Davis, 1987a:24). Some of these "private" networks are large enough where owning companies have the capability of entirely bypassing commercial telephone, satellite and microwave networks. For
example, Boeing Company has constructed its own corporate telephone network to link branch offices and plants (Simison, 1986). Other forms of private networks rely on previously mentioned commercial network services such as dedicated user lines or satellite networks using VSATs.

The use of private networks for intraorganizational communications has predominantly been the preserve of large corporations with the capacity to absorb the necessary large capital investment. These cost restrictions have stimulated an organizational innovation entitled "shared tenant services" which involves a number of small organizations sharing the investment necessary for more sophisticated networks. Also known as "smart office buildings," shared tenant services involve sophisticated digital networks such as LANS being constructed in a single physical facility with services being shared among organizations either leasing space or investing in the facility (Zieman, 1986).

It is currently not uncommon for organizations to utilize different technological networks, whether digital or nondigital, for different types of communication and information exchange. For example, an organization could utilize the public telephone network for external voice communication, a PBX to handle internal voice traffic and a LAN for the exchange of information between office computers. An important technological breakthrough that will eliminate the need for utilizing different technological networks for different modes of communication is Integrated Services Digital Network (ISDN).

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30 The ability of large companies with high volumes of telecommunications traffic to bypass commercial telephone companies is one factor being cited in support of deregulation of the telephone industry. It has been estimated that 60 percent of telephone company revenues come from 4 percent of business users. With business telephone rates being used to subsidize residential rates, many high volume business users are bypassing the commercial telephone networks and opting to construct their own networks or utilize nonregulated independent services in order to reduce their communications costs (Gladwell, 1986:12).
ISDN is a new telecommunications system design that allows voice, data, text and video in digital form to be transmitted through a single, unified network. ISDN makes possible a number of new innovative telecommunications services. For example, while engaging in a telephone conversation, users could simultaneously be transmitting data between computers (D. Davis, 1987b:28). ISDN will reduce telecommunications costs for large businesses by eliminating the need for maintaining separate networks for such functions as telephone conversations, the exchange of computerized data and videoconferencing (Keller et al., 1986). Further, it will allow new computer-based services such as home banking and electronic mail to be used more easily (Hafner, 1986).

The telephone companies are also the driving force in integrating ISDN into the telecommunications infrastructure. ISDN is still largely in the research and development stage and is predicted to be commercially available in 1988 (Keller et al., 1986:190). Both the long distance and regional Bell companies are conducting trials of ISDN and the first available services are being targeted toward large businesses (D. Davis, 1987b:27).

One of the most publicized trials is being conducted by Ameritech's Illinois Bell unit at McDonald's Corporation's headquarters in Oakbrook, Illinois. This experiment involves the use of ISDN to provide voice, data, video and electronic messaging over a single unified network (Ameritech, 1986:19; D.Davis, 1987b:28). Other large corporations that are planning to install ISDN include AT&T, Shell Oil Company and Tenneco (Southwestern Bell Corporation, 1986:11).

The greatest potential benefit of ISDN is that it will permit both high speed data transmissions and voice over public telephone networks. Without ISDN, both of these services can be obtained only through leasing dedicated user lines, using other commercial private data networks such as satellite services, or by an organization
constructing its own private communications network. All of these options are much higher in cost than that projected for ISDN (D. Davis, 1987b:28-29).

**Important Issues Surrounding the Extension of the Digital Telecommunications Infrastructure into Rural America**

As a total process, the development of a digital telecommunications infrastructure in the United States has been an ongoing, evolutionary process involving a complex set of technologies. Outmoded technologies in the infrastructure are being replaced by improved digital technologies. This process of technological advancement coupled with those in computers and microelectronics have provided opportunities for the development of new information services which can allow individuals and organizations greater access to information in new ways. This provides the potential of more effectively coordinating social action toward desired ends.

At some future point, the exchange of information in digital form will likely become the telecommunications standard in the United States. As previously contended, the ability to access digital telecommunications will be a necessary condition for realizing the full benefits of information technology and integrating into the emerging information society. This chapter has outlined the wide array of technologies through which access may occur. However, as has been pointed out, access can be gained only through purchasing the necessary equipment and services.

Only large corporations have been able to afford the massive capital investment necessary to construct their own private digital telecommunications networks. Other individuals or organizations desiring access to digital telecommunications must purchase it in the form of a commercial service. In one sense, this implies that democratic participation in the emerging information society in the United States will be highly dependent upon the geographic distribution of the markets for telecommunications services as well as their cost.
This raises the critical issue of whether markets for all services will encompass all spatial locales in the United States. Will rural America have access to the same array of digital telecommunications services as urban America? The ways in which the U.S. agricultural system is integrated into the emerging information society will be heavily influenced by the outcome of this issue.

Information technology has significant implications for rural America. Through allowing greater coordination and control of organizational activity across geographic distances, information technology could promote a further dispersion of businesses from centralized urban locations to less populated areas. By allowing workers to "telecommute" and work within their homes, information technology could facilitate a population shift to rural areas. Through incorporating the use of specialized electronic information services and videoconferencing, rural services such as education and health care could be augmented. Rural firms in industries that are being transformed by information technology will be equally affected as their urban counterparts. However, the extent in which these beneficial changes can be realized is dependent upon the ways in which access to digital telecommunications is extended into rural areas.

Federal and state telecommunications policy or a lack of policy will clearly be a major factor shaping this process. While Federal and state policy has affected what firms can manufacture telecommunications equipment and how and what types of services can be provided at what cost, it has done little to shape the construction of the digital technological infrastructure itself. This has been left to market competition (Cohen and Zysman, 1987:190). Therefore, the geographic areas that are encompassed by the emerging digital telecommunications infrastructure will, to a large degree, be determined by their potential rate of return on investment. As appropriately stated by Robert Lekachman (1977:175-176):
When marketplace forces are relied upon to allocate resources among producers and consumers, markets are defined by the presence of available capital and the most desireable markets are identified by the ease with which capital can be acquired and turned into providers' profits. Capital which is concentrated, accessible, and disposable is more attractive than capital which is dispersed, difficult to access, and hard to pry away from the consumer. Desireable markets are those floating in abundant capital. These are the markets that will be served under conditions of laissez-faire.

The economics of constructing a digital network based on land lines (e.g., fiber optic cable) simply do not warrant a substantial rate of return on investment in sparsely populated areas with low volumes of telecommunications traffic (Young and Bransford, 1983:108, 110-111). This is not only true for the present situation, but was also the case with the provision of rural telephone service long before the advent of digital technology and the AT&T divestiture.

In the pre-divestiture era, it was estimated that the 22 operating Bell companies provided residential telephone service to 80 percent of the U.S. population that was spread over less than half of the U.S. geography. In comparison, approximately 1,300 independent telephone companies served 20 percent of the population and about two-thirds of the U.S. geography (U.S. Congress, 1983:220; Young and Bransford, 1983:110). This indicates that a major proportion of rural telephone service was provided by independent telephone companies. During much of the twentieth century the Bell companies viewed rural markets as a marginal economic investment and have largely eschewed extending their networks in rural areas except under conditions of competitive or regulatory pressure. Small-town and rural America became a natural market for independent telephone companies seeking to establish themselves in the telephone business (Fisher, 1987:9-10).
These arrangements for rural telephone service have continued in the post-divestiture era. Therefore, the construction and operation of digital land line networks for rural America will largely be dependent on smaller independent telephone companies that may lack the capital necessary to incorporate advanced digital technology into their networks. One response of the independent telephone companies related to this problem has been the formation of joint ventures by a number of independent firms at the state level.

In Indiana, 27 independent telephone companies have formed a joint venture with U.S. Switch, Incorporated creating Indiana Switch. In Wisconsin, a number of independent companies have joined to form Wisconsin Independent Telecommunications System, Incorporated. In both of these joint ventures, independent telephone companies are integrating their separate networks through central telephone switches and incorporating fiber optic cable into their systems. These networks will allow many rural residents for the first time, access to long distance telephone services provided by firms other than AT&T (Kotlowitz, 1986; Roberts, 1986b). These joint ventures provide one way in which rural telephone systems may become fully digitalized.

Several other independent telecommunications firms have also initiated construction of fiber optic networks in limited sectors of rural America. National Telecommunications Network has constructed a fiber optic network throughout Iowa with connections to most major midwest cities. Another independent firm, Walker Telecommunications Corporation, is constructing a similar network in parts of rural Michigan (Wynter, 1986).

While these examples indicate that land line networks for digital telecommunications are taking shape in parts of rural America, a major issue for the future is, "To what extent will this continue?" Will all rural businesses and residents have modern, fully digitalized telecommunications channels to access information technology-based
services through interstate and intrastate land line connections?\textsuperscript{31} Or, will they continue to rely on soon to be out-dated copper cable lines and telephone modems as is currently the case?

A major factor shaping the future outcome of these issues is deregulation. The FCC has actively promoted telephone deregulation during the Reagan era and many states have implemented deregulation policies which have allowed rates for residential telephone service to be raised (B. Davis, 1986b; 1986c; Gladwell, 1986:10). Before the AT&T divestiture, rates for residential telephone service and rural phone systems were held down through subsidies provided by long distance service and large volume users such as large businesses. With deregulation, these subsidies are no longer required. The cost of telephone service is being shifted more to residential customers and low volume traffic areas while rates for long distance service and high volume business users are declining.

A 1986 study by the Consumer Federation estimates that residential rates have risen 40 percent while rates for interstate long distance service has declined by 17 percent since the AT&T divestiture. In total, the average residential customer is paying an estimated 20 percent more for overall telephone services (B. Davis, 1986b; 1986c).

A significant future issue is whether the shift in rates will proceed to the extent that it will prohibit access to telephone and new information technology-based services for lower socioeconomic groups and small businesses. A second equally important issue

\textsuperscript{31}This will likely depend on the technologies utilized in connecting rural businesses and residents. Long distance telephone networks are rapidly becoming digitalized through fiber optic cable and digital telephone switches which will allow computer technologies to exchange information without modems. Digitalization will need to be extended to the networks operated by the independent telephone companies and the regional Bell companies which link rural businesses and residents.
is whether these services will be available in low volume traffic areas such as rural America. Deregulation creates the possibility of a massive rise in rural telephone rates, neglect in maintaining and/or updating the technology in rural networks and the reduction or elimination of rural services altogether, if they are found to be non-profitable or provide a low rate of return on investment. There is already evidence that rural telephone rates are soaring in some deregulated states. For example, in the rural town of Crawford, Nebraska (which has implemented deregulation), it has been estimated that rates for telephone service provided by Northwestern Bell Telephone Company have risen 300 percent since the 1984 divestiture of the Bell system (Richards, 1987).

At the present, it appears that access to fully digitalized telecommunications channels based on land lines will not be uniform for all parts of rural America. Whether a rural area will have such access in the future will predominantly depend upon Federal and state policy, the strategies used by the independent and regional Bell firms in servicing rural businesses and residents and the demand by the rural populace for digital technology and information technology-based services accessed through land lines.

Satellites may be a more appropriate technology for providing rural America access to digital telecommunications. Satellite networks are insensitive to distances and access can be gained by simply installing an earth station at the site of reception. In a number of experimental projects, information services provided by satellite networks have been found to be highly beneficial in enhancing educational and medical services in rural areas (Young and Bransford, 1983:111, 115). However, as with land lines, the development of satellite networks in the United States is dependent upon marketplace forces. Due to a small market size, there is not any major economic
incentive to construct satellite networks specifically for rural populations. The development of such a network is likely to represent a secondary focus for a private sector firm providing such a service and possibly would pose an economic risk.

At the present time, the major stimulus for developing satellite networks for rural areas has come from policy makers at the state level. Approximately 26 states have developed satellite networks to enhance rural education programs (Bransford, 1988). However, these networks are not yet being utilized to provide other types of information services. A more encompassing satellite communications system for rural areas has been proposed by a subsidiary of McCaw Communications Company entitled Mobilesat. However, in a 1986 hearing, the FCC denied the company access to the frequency in the electromagnetic spectrum necessary to fully develop the system (B. Davis, 1986d). The outcome of this case is still pending due to appeal.

In conclusion, access to digital telecommunications in rural America is uneven and location specific. Despite the growing proliferation of receive-only earth stations in rural areas to obtain satellite television broadcasts, it is likely that more ubiquitous telephone networks will serve as the main conduit in the near future for the use of applications of information technology by rural businesses and residents.

Given the reliance on market competition to develop the digital telecommunications infrastructure in the United States, it is not likely in the short term that many rural telephone networks will contain the most modern digital technology such as ISDN and fiber optic cable. Rather, most rural businesses and residents will be forced to rely on less sophisticated nondigital technical systems such as copper cable lines and modems to exchange digital information. The most modern digital technologies will become initially available in urban areas with high volumes of telecommunications traffic. Until sufficient rural demand exists or further policy shifts occur, only those
rural organizations with the ability to pay will have access to the most modern digital telecommunications equipment and services.
Over the past two decades, applications of information technology have been developed for the industries that comprise the U.S. agricultural system. This encompasses not only agricultural production, but also the diverse manufacturing and service sector industries and organizations that are interlinked with and dependent upon agricultural production. This technological transition has initiated a broad set of changes that have significant implications for all sectors of the agricultural system. These changes provide an indication of how food production may be reorganized in the emerging information society.

Information technology is allowing a transformation of the means by which information is acquired, exchanged and distributed within the agricultural system. Furthermore, information technology is transforming labor processes in the production and distribution of food products and is allowing a restructuring of the social linkages between the industry sectors comprising the U.S. agricultural system. One means of understanding the ramifications of this change is the use of organizational analysis. This provides a systematic framework for examining the consequences and future implications of the application of information technology within the agricultural system.
Technology and Social Organization--The Analysis of Sociotechnical Systems

Organizations are social units or human groupings that are deliberately constructed and reconstructed by social actors attempting to reach specific goals. A critical aspect of organizations is an ordering of social relationships (e.g., a division of labor) which exists for the purpose of carrying out specific activities related to the realization of organizational goals (Gross and Etzioni, 1985:5). By allowing organizational tasks to be carried out more reliably and efficiently through its application, technology has historically become a crucial element within social organization. The interface between technology and social organization forms a sociotechnical system (Brooks, 1982; Trist, 1981).

Brooks (1982:9-10) distinguishes between social innovation and sociotechnical innovation. Social innovation consists of a novel form of social organization (social technology) whose purpose of formation is unrelated to physical technologies such as machines. The Cooperative Extension Service or the United Parcel Service are examples. Physical technologies may then be integrated within the organization in order to improve the process of carrying out organizational tasks.

In comparison, sociotechnical innovation consists of the complex of organizational changes resulting from the development of new physical technology such as computers or the tractor. This change consists of a restructuring of social relationships within organizations resulting from adapting and integrating the technology into organizational activity. This can also lead to the formation of new organizations and the restructuring of extant organizations necessary for the development, diffusion and social support of the technology.
As a unit of analysis, sociotechnical systems can be examined at three broad levels -- each of which is interrelated:

1. **Primary systems** -- sociotechnical systems which carry out the set of activities involved in an identifiable and bounded subsystem of a whole organization;

2. **Whole Organizational systems** -- the configuration of sociotechnical systems which carry out the entire range of activities involved in a single whole organization; and

3. **Macrosocial systems** -- sociotechnical systems in communities, industrial sectors and institutions operating at the overall level of a society (Trist, 1981:11).

New physical technologies have the potential of initiating sociotechnical innovation at all three levels as exemplified by information technology.

Information technology is permitting sociotechnical innovation at the primary, organizational and macrosocial levels within U.S. agriculture. This has occurred through its integration into the activity of agricultural organizations and the formation of new organizations and organizational linkages for the development, diffusion and support of the various applications of information technology. This sociotechnical innovation is being driven by the broader forces of the transition to an information society as applications of information technology are being developed and diffused throughout all sectors of advanced industrial societies.

Viewed in a historical sense, however, these changes represent only one shift along a historical path of sociotechnical innovation in U.S. agriculture. The social history of U.S. agriculture can be viewed as an evolutionary unfolding of sociotechnical innovation as the development and application of technology to agricultural production reduced the amount of labor necessary to produce a sufficient food supply. This, in turn, influenced and became influenced by the evolution of the organizational structure of U.S. agriculture. Sociotechnical innovation in U.S. agriculture has been shaped and propelled forward by a constellation of social forces that are inherent to capitalism as
a social system. These social forces are currently providing stimuli for sociotechnical innovation resulting from information technology.

Social Forces Affecting Sociotechnical Innovation

By providing the ability to achieve practical human purposes in a reproducible manner, technology has been a central element in the social development of human civilization. Technology facilitated social reproduction by allowing human groups to more easily shape a continued existence from the natural environment. Technology allowed the production of a surplus of goods beyond levels necessary for subsistence and allowed labor power to be shifted and focused on other aspects of human life. In this process, technology became an indispensable element of human labor and work processes became organized around the capabilities and requirements of technology.

In the late twentieth century, it has been observed that technological development and advancement appears to be accelerating (Bell, 1973:191). This advancement is primarily attributable to the increased organization of social forces focused on the development and advancement of new technology coupled with the accumulation of knowledge. Purposive advancement of technology through organized research and development has become an essential process within capitalist societies and sociotechnical innovation a necessity (for a discussion, see Noble, 1977). This process is being driven by the logic and dynamics inherent to advanced capitalism as a social system.

There can be little doubt that the historical emergence and advance of capitalism as a dominant global social system has provided a tremendous stimulus to the advancement of technology. This phenomenon was observed by the classical social theorists such as Marx (1977:579) in describing the transition from the period of simple

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This process was noted by the classical theorists. For example, Marx (1977:285) notes that, "as soon as the labor process has undergoes the slightest development, it requires specially prepared instruments."
manufacture to large-scale industry when machine techniques were developed to produce machines themselves:

As soon as the factory system has attained a reasonable space to exist in, and reached a definite degree of maturity, and in particular as soon as the technical basis peculiar to it, machinery, is itself produced by machinery, as soon as the general conditions of production appropriate to large scale industry have been established, this mode of production acquires an elasticity, a capacity for sudden extension by leaps and bounds, which comes up against no barriers except those presented by the availability of raw material and the extent of sales outlets (emphasis mine).

The advance of capitalism transformed the organizational infrastructures of capitalist societies. Societal production became relegated to organizations motivated by the logic of production for profit which flourished and became dominant fixtures within the organizational infrastructures of capitalist societies. Max Weber (1978:85-109) termed this motivating logic the "formal rationality of economic action." Following this logic, economic organizations engaged in profit making begin to orient their activities on the basis of rational calculations of estimated profitability expressed in monetary terms. Weber (1978:102) alluded to the fact that technology became a critical variable in this rational calculus:

The comparison of different kinds of processes of production, with the use of different kinds of raw material and different ways of treating them, is carried out today by making a calculation of comparative profitability in terms of money costs.

The growing predominance of organizations with activities guided by the calculus of economic rationality had a major effect in stimulating technological advance. This was due to the fact that technology could be harnessed to increase productivity and therefore, maximize profitability. Competition among for-profit organizations provided
an important motivating force for developing new techniques to increase the productivity of labor power.\textsuperscript{55}

Technology has been characterized as having two primary roles within capitalist market economies. On one hand, it enlarges the scope of economic activity by yielding new processes and products which generally: (a) become consumer goods; or (b) are employed in production processes. This has been labelled the \textit{extensive} role of technology which: (1) provides new sources of profits; (2) stimulates the formation of new organizations to develop, produce and support technology; and (3) creates new sources of employment (Narashimhan, 1983:68). Friedland (1980:201) points out that technological development also occurs due to social conditions such as the necessity of finding a substitute for a labor supply when faced with a scarcity of labor or as a control factor when labor becomes recalcitrant to fulfill the expectations of the upper levels of the hierarchy in a production system.

On the other hand, when technology is employed in production, it has the general tendency of increasing efficiency and productivity, i.e., rationality. This has been termed the \textit{intensive} role of technology which generally acts to reduce employment through the substitution of technology for human labor (Narasimhan, 1983:68). In social organizations motivated by the calculus of production for profit, the intensive use of technology has the potential of increasing profitability by lowering the cost of a unit of output, i.e., increasing productivity.

\textsuperscript{55} This was observed by Marx in his discussion of the concept of relative surplus value. Under the Marxian schematic, this motivating force became even more pronounced when restrictions on the number of hours allowed in a working day were enforced by law in capitalist societies. Marx (1977:432) states, "The technical and social conditions of the process and consequently the mode of production itself must be revolutionized before the productivity of labor can be increased. Then with the increase in the productivity of labor, the value of labor-power will fall, and the portion of the working day necessary for the reproduction of that value will be shortened."
Through stimulating the formation of new organizations and the restructuring of extant organizations for the development, production, diffusion and social support of technology, the extensive role of technology changes the organizational infrastructure of capitalist societies. Simultaneously, the intensive role of technology provides a motivating force for incorporating technology within the context of social organization and applying it to organizational activities. This transforms the social arrangements within organizations for carrying out activities. By motivating technological change, the extensive and intensive roles of technology simultaneously promote sociotechnical innovation.

This is not to imply that there is a one way causal relationship between technological change and organizational change. Organizational development and change has also been critical in the development of new technology as advanced industrial societies have organized for the purposive development of new technology. Technological and social development are therefore, interactively shaped by each other and sociotechnical innovation results from this interactive process (Cohen and Zysman, 1987:95; Galbraith, 1967:32).

The logic of the extensive and intensive roles of technology in market economies suggests that sociotechnical innovation occurs in a steady, linear process of development. However, the historical record indicates that sociotechnical development has been an evolutionary, unfolding process that has occurred within the ebb and flow of periods of technological stagnation and rapid development (Mensch, 1979:119-136; Schumpeter, 1950:83-84). This is especially the case when contrasting what Mensch
Basic innovations have historically tended to be developed in cyclical surges of rapid development followed by periods of relative stagnation where few basic innovations emerge (Mensch, 1979:119-136). Schumpeter (1950:83-84) termed these periodic surges of development "gales of creative destruction." In contrast, improvement innovations have historically tended to be developed in a more linear, continuous fashion as existing technologies are refined and improved (Mensch, 1979:47).

This historical pattern of technological innovation has been accompanied by an evolutionary process of organizational development for the purposive advancement of technology through research and development. During the nineteenth century in the United States, organized research and development was not extensively formalized as an activity within economic organizations. Many important innovations were the result of the efforts of independent inventor/entrepreneurs.

Agriculture became one of the first industries to be formally organized for purposive research and development. However, this occurred primarily within the not-for-profit sector of the economy. Agricultural chemistry programs were established in American universities in the late 1840's. The United States Department of Agriculture and the land grant university system were established in 1862 and the State Agricultural Experiment Stations in 1887 (Rasmussen, and Baker, 1972; Rossiter, 1975:167). Advancing technology for improving agricultural productivity was a central focus of all these organizational entities.

Basic innovations are new technologies that produce new markets and industrial branches while improvement innovations refer to the further development and refinement of an existing technology (Mensch, 1979:47). Basic innovations result from the process of invention. Invention is the process where the principles underlying a technology are first discovered while innovation occurs when a newly developed technique is put into regular production for the first time, or when an organized market for a new product is first created. The period between invention and innovation varies chronologically for different technologies.
Before 1900, there was little formal research and development in the industrial sector. Industrial engineers tended to focus their attention on translating the sporadic discoveries of university-based scientists and freelance inventors into patentable processes rather than be concerned with the actual production of scientific discovery. The electrical and chemical industries were the first to establish systematic research as part of their business. By 1930, industrial research has become well established across most major industries including rubber, petroleum, automobiles and pharmaceuticals (Noble, 1977:110-111).

The critical importance of military research during World War II contributed to the development of the modern day military-industrial complex. The U.S. Government allocated funding for the establishment of Federal research laboratories and a complex organizational network of government organizations, universities and industries was formed to develop and produce technology for military purposes (Bell, 1973:402). This organizational network has flourished in the 1980s with the Reagan Administration's military keynesian strategy involving radically increased defense (and deficit) spending.

This brief historical sketch illustrates how the development of technology in the United States contributed to and was influenced by the evolutionary development of a complex organizational infrastructure focused on developing and advancing technology. This was further augmented by the historical development of organized distribution (wholesale and retail trade) and support infrastructures (e.g., repair services and consulting) for specific technologies.

The extensive consequences of sociotechnical innovation (growth in organizational complexity) have not always progressed in a smooth, unrestricted manner. This process has often been affected and channeled by such factors as policy constraints or technological limitations such as the lag between invention and innovation. For example, the complexity of the organizational infrastructure in the U.S. telephone
industry was heavily shaped and restricted by Federal regulation until the AT&T divestiture. In the post-divestiture era, the complexity of the telephone industry has increased as witnessed by the merging of the telecommunications and computer industries and the formation of competing long distance companies. However, its growth continues to be restricted by policy as exemplified by the regulations placed on the regional Bell companies.

Sociotechnical innovation resulting from the intensive use of technology in production has also not always occurred in an inevitable unfolding of modernization as new innovations have been developed. Given that technology and social organization reciprocally influence each other, technology has often been rejected and abandoned as well as adopted and integrated into organizational activity. The replacement of human labor through technological substitution has not always occurred without resistance as illustrated by the Luddites of nineteenth century England. The incorporation of technology into organizational activity is often impeded by obstacles that must be overcome or circumvented in order for sociotechnical innovation to result from the intensive use of technology.

Within market economies, the intensive use of technology generally becomes possible only after the organizational infrastructure is in place to develop, diffuse and support the technology involved. Even then, its adoption and incorporation into organizational activity involves direct, indirect and hidden costs. The direct costs are the price of the technology and its supporting equipment and services. The indirect costs include the retraining of labor and the reorganization of jobs and responsibilities necessary to incorporate the technology into organizational activity. The hidden costs include the conflicts that can arise over application and responsibility and the disruptions in work processes that come with technological malfunction (Cohen and Zysman, 1987:165).
The nature of these costs underscore the importance of social adaptation to technology as a dimension of sociotechnical innovation. While the extensive and intensive roles of technology in the market economy provide motivating forces for sociotechnical innovation, such innovation is not likely to be enduring or permanent unless social adaptation to technology occurs. That is, the infrastructure of organizations for the development, distribution and support of technology is maintained and the socioeconomic costs of technology are internalized by adopting organizations. An additional factor is that the benefits of a newly adopted technology in improving labor productivity or the quality of output must be assessed by organizational members as sufficient compared to the costs of utilizing the new technology. This assessment includes a comparison of the new technique with previously utilized techniques.\textsuperscript{35} Utilizing the market mechanism as the means to diffuse new technology has an important influence on whether sociotechnical innovation becomes enduring or temporary. If sociotechnical innovation involving a particular technology is to be enduring, adequate markets for the technology must be developed in order for the development, distribution and support infrastructures to be maintained.\textsuperscript{36} Further, adopting organizations must be able to absorb the costs and reorganization of activities necessary to accommodate the new technology. Organizational members must develop the skills necessary to use the technology and the benefits of the technology must be

\textsuperscript{35}There is generally a learning curve involved in developing the skills necessary to use a technology which affects the ability to assess the superiority of a new technique versus an old technique. In turn, these two processes may rely on improvement innovations as new technology is refined and improved (N. Rosenberg, 1972: 17).

\textsuperscript{36}This means only that if markets cannot be developed, wholesale and retail distribution outlets may stop selling the technology, thereby cutting off consumption and adoption of the technology. The relationship with development activities is less clear cut. Technology may need considerable improvement and refinement before adequate markets can be developed.
realized and/or deemed sufficient by adopting organizations. If one or more of these conditions are not met, sociotechnical innovation may be only temporary.

As this discussion indicates, the process of sociotechnical innovation in capitalist societies clearly subsumes a complex set of internal dynamics. It is a process that is propelled forward and shaped by a wide range of economic, social and political forces. However, sociotechnical innovation is not necessarily inevitable. It is a process that may face many obstacles that limit its effects, make its effects temporary or prevent it from occurring altogether. It is a process that may revolutionize previously stable sociotechnical systems as well as make others obsolete. These dynamics of sociotechnical innovation have been instrumental in shaping sociotechnical development in U.S. agriculture including the current period of technological transition involving information technology.

Sociotechnical Systems in U.S. Agriculture

The macro organizational structure of the agricultural system in the United States has been conceptualized as consisting of three sectors: (1) the input sector, which produces and distributes farm inputs; (2) the farm sector, which produces agricultural commodities; and (3) the processing and marketing sector, which processes and distributes food products to the U.S. public (Goss et al., 1980:97). A fourth division that could be added to this schematic would be the governance and education sector (see figure 3.1) which includes agricultural agencies in Federal and state governments and educational institutions which provide training for labor in all organizational sectors of the agricultural system as well as develop technology for use in agricultural

\[\text{For example, the sociotechnical system for communication utilizing the telegraph has been made increasingly obsolete as new communication technologies have been developed. In order to insure their survival, the response of firms belonging the telegraph industry was to develop and upgrade the technology in their systems (e.g. telex) as well as diversify into systems using other technologies such as satellite services.}\]
FIGURE 3.1. Schematic of the Macro Organizational Structure of the U.S. Agricultural System

Note: All S.I.C. Categories specified as agricultural or related to food production are included. However, not all industries that could potentially serve agricultural markets are listed (e.g., gasoline stations, S.I.C. 5541).
production (Goe and Kenney, 1987a:14).

The Input Sector

The input sector is responsible for the production, distribution and support of technology for intensive use in agricultural production such as seeds, fertilizer, agrochemicals, machinery, petroleum and finance (Goss et al., 1980:97). In present day agriculture, this sector of the macro organizational structure consists of a complex of manufacturing and service sector industries including wholesale trade, retail trade, finance, insurance, real estate and services such as machinery and equipment repair and accounting. This complex infrastructure evolved historically as the technical complexity of agricultural production progressed and American capitalism developed as a social system.

The development of technology for agricultural production gained momentum in the early nineteenth century in the United States. Prior to this, agricultural productivity was largely dependent upon the intensity of human labor. A greater expenditure of human labor was necessary in order to increase agricultural output due to the nature of existing production technologies. While tools such as the ax, hoe, sickle and scythe were generally utilized which reduced the amount of labor necessary for certain phases of agricultural production, their operation was dependant upon human muscle for motive power. Animal motive power was used for a number of tasks including transportation and turning the soil in preparation for planting through the use of a wooden plow with an iron cutting edge.

The relative scarcity of farm labor in the sparsely populated areas of the rural United States at this time, motivated the need for discovering ways of extending the capacity of family farm labor and increasing agricultural output. This was desirable not only because it allowed farmers to more easily produce the food necessary to provide for their families, but also because it allowed greater participation in the
scent agricultural marketing system and thus, greater economic returns from farming (Cochrane, 1979).

Nathan Rosenberg (1974) notes that it was mechanics, rather than science, that undergirded the Industrial Revolution of the eighteenth and nineteenth centuries. Given the comparative lack of organized research and development and accumulation of knowledge, science played a minor role in developing the technology necessary for early industrialization. Technical advances in industry through mechanization played an important role in the transformation of the mode of production in United States agriculture. Mechanization provided the solution to extending the capacity of family farm labor in the first half of the nineteenth century.

Advances in machine tools and the invention of the slide rest by Henry Maudslay in the first decade of the nineteenth century allowed the standardization of iron parts for machinery and permitted them to be produced with more accuracy and greater speed. In turn, the production of "machines by machines" was significant for agriculture by allowing farm tools made of iron to be manufactured more efficiently (Schlebecker, 1975:76-77).

In 1813, R. B. Chenoworth of Baltimore patented a cast iron plow with standardized, replaceable parts. His design was subsequently improved upon by Jethro Wood, who was issued patents in 1814 and 1819 and is generally credited for this invention (Schlebecker, 1975:99). The development of an iron plow with standardized, replaceable parts appears to have provided the impetus for the further mechanization of United States agriculture, especially grain production, due to its impact on the production process.

After its inception, the cast iron plow was continually modified and made more efficient in turning the soil which greatly increased the area of land that could be plowed with the same exertion of labor. It ostensibly appears that this capacity
provided the conditions for a series of interrelated mechanical innovations as the area
of land under production could not be increased without improvements in the efficiency
of other stages of agricultural production, i.e., planting, cultivating, and harvesting.

U. S. agriculture underwent a "mechanical revolution" during the period of 1810 to 1860
as a cluster of new technologies including the thresher, reaper, combine, harrow, seed
drill and cultivator were developed. These technologies mechanized all phases of grain
production including soil preparation, planting, cultivation and harvesting (see table
3.1). Commercial adoption of these technologies largely began in the 1840s and their
use became common in the 1850s (Cochrane, 1979:196; Ehrensaft, 1980:74; Schlebecker,
1975: 120).

These innovations were largely developed by individual inventor/entrepreneurs who
would secure a patent for their invention and work in conjunction with a local
blacksmith in producing it (Cochrane, 1979:190). As demand for mechanical
technology increased, the farm machinery industry expanded rapidly, being led by such
firms as the McCormick Company, John Deere, the Pitt Company, and the J. I. Case
Company. Factories were constructed and mass production of farm machinery and tools
was undertaken.

The development of chemical technology for agricultural use also began during the
mechanical revolution in U. S. agriculture. There was a growing interest in soil
chemistry among the farm populace. American farmers began experimenting with
alternative mineral and organic fertilizer compounds in addition to the traditional use
of manure and humus. Due to the increasing demand for fertilizer, a commercial
fertilizer industry emerged in the mid 1840s which marketed organic compounds such as

---

Entrepreneur/inventors included R.B Chenoworth and Jethro Wood (cast iron
plow with replaceable parts), John Deere (plow with steel edged share), George W.
Brown (corn planter), George Easterly (riding straddle row cultivator), Obed Hussey and
Cyrus McCormick (reaper), Hiram Moore and J. Hascall (combine), and J. I. Case
(thresher).
Table 3.1

Mechanical Innovations in U. S. Agriculture, 1810-1860

<table>
<thead>
<tr>
<th>Mechanical Innovation</th>
<th>First Known Date of Production</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plow with standardized, replaceable iron parts</td>
<td>1813</td>
<td>Turning the soil</td>
</tr>
<tr>
<td>Cylindrical thresher</td>
<td>1820</td>
<td>Reduction of grain stalk to straw, chaff, and grain</td>
</tr>
<tr>
<td>Expanding cultivator</td>
<td>1830</td>
<td>Weeding</td>
</tr>
<tr>
<td>Reaper</td>
<td>1831</td>
<td>Cutting grain</td>
</tr>
<tr>
<td>Combine (Reaper-Thresher)</td>
<td>1836</td>
<td>Cutting, threshing and winnowing grain</td>
</tr>
<tr>
<td>Sweep Thresher</td>
<td>1837</td>
<td>Reduction of grain stalk to straw, chaff, and grain</td>
</tr>
<tr>
<td>Hinged harrow</td>
<td>1840</td>
<td>Breaking up the soil</td>
</tr>
<tr>
<td>Seed drill</td>
<td>1841</td>
<td>Planting</td>
</tr>
<tr>
<td>Sulky (riding) straddle-row cultivator</td>
<td>1856</td>
<td>Weeding</td>
</tr>
</tbody>
</table>

Source: Schelbecker (1975); Cochrane (1979); Partridge (1973)
guano and minerals such as lime, gypsum and phosphate made of crushed bones. The first commercially manufactured fertilizer was "superphosphates" which was initially produced in 1852 and consisted of crushed bones soaked in sulfuric acid (Rossiter, 1975:149-150).

The development and incorporation of commercial mechanical and chemical inputs into the technical basis of agricultural production began to transform the organizational structure of U.S. agriculture. An infrastructure of factories was constructed to manufacture these technologies. Accompanying the development of the farm machinery and fertilizer industries was a network of wholesale and retail merchants which distributed the technology to the farm sector (see figure 3.2). Support services such as soil analysis and machinery repair emerged (Rossiter, 1975:46). These sociotechnical innovations increased the organizational complexity of the agricultural system as the farm sector became linked with this expanding set of off-farm manufacturing and service industries. The complexity of the input sector continued to expand as new innovations were developed. Newly-formed industries and existing industries became part of the input sector as the new products they produced, distributed or supported became integrated into the technical basis of agricultural production.

Following the logic of Schumpeter, Ehrensaft (1980) found that basic innovations historically became established in U.S. Agriculture in clusters. These periods of rapid technological development roughly coincided with long term phases of expansion in the agricultural economy. The first expansionary period identified by Ehrensaft involved

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89 Following the concept of long term cycles of expansion and contraction in the global economy developed by Russian economist N. D. Konradieff, Schumpeter posited that "epoch making innovations" were the motor underlying expansionary phases. Schumperter (1940:83) states: "The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organizations that capitalist enterprise creates."
FIGURE 3.2. Early Advertisement for Farm Machinery Merchant

Source: Schlebecker (1975:179)
the aforementioned mechanization based on animal motive power which lasted from approximately 1848-1866. The second expansionary phase involved the establishment of the tractor based on the internal combustion engine which occurred from 1897 to 1919. The third expansionary period began in 1940 and involved the establishment of petrochemical inputs (synthetic fertilizers, herbicides and pesticides), further improvements in mechanization based on the internal combustion engine and hybrid seeds.

Each wave of basic innovations spurred sociotechnical innovation as the organizational complexity of the input sector increased and a longer and more complicated chain of linkages was formed and modified to supply technological inputs to the farm sector. The establishment of the tractor led to linkages between the farm sector and the automotive and rubber industries as Ford began producing tractors and Goodyear developed rubber tractor tires (Kenney et al., 1987:9; Williams, 1987:91). The emergence of petrochemical inputs established linkages between the farm sector and the chemical industry. The establishment of linkages between the farm sector and this growing array of off-farm manufacturing and service sector industries provided one means by which agriculture became integrated into the larger industrial economy. (Kenney et al., 1987:3; Goe and Kenney, 1988:3-5; Burbach and Flynn, 1980:27-30).

The Farm Sector

The historical progression of technological development in agricultural production stimulated sociotechnical innovation within the farm sector which contributed to dramatic historical changes in its structure. Each cluster of basic innovations allowed progressively larger gains in productivity which provided an important condition for the movement of the American labor force off the farm and into the factory, thereby promoting the growth of large urban centers.
In plant agriculture, mechanical technology increased productivity primarily through increasing the amount of land that could be cultivated by an individual farm operator. The tractor further extended this capacity. Petrochemical and biological (hybrid seeds) technologies increased plant yields per acre. Mechanical, biological and petrochemical technologies interacted synergistically to dramatically escalate agricultural productivity following World War II (See table 3.2).

Table 3.2

Gains in Agricultural Productivity,
Selected Years, 1870-1970

<table>
<thead>
<tr>
<th>Year</th>
<th>Productivity Index (1967 = 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1870</td>
<td>40</td>
</tr>
<tr>
<td>1890</td>
<td>43</td>
</tr>
<tr>
<td>1910</td>
<td>50</td>
</tr>
<tr>
<td>1930</td>
<td>51</td>
</tr>
<tr>
<td>1950</td>
<td>71</td>
</tr>
<tr>
<td>1970</td>
<td>102</td>
</tr>
</tbody>
</table>

Source: Cochrane (1979:327)

A major factor underlying these productivity gains was that mechanical technology was incrementally substituted for human labor power in agricultural production. Unlike modern farm machinery which generally requires a single operator, early mechanical technologies necessitated additional laborers. Improvements in mechanical technology have historically focused on further automating production tasks, thereby reducing
labor costs for the farm operator. The reaper provides an illustrative example. In addition to the operator, the first models of the reaper required a laborer to ride on the back of the machine and rake the cut grain off a platform and several other laborers walking behind the machine to hand rake and bind the cut grain. Subsequent improvements included a self-raking mechanism and a self-binding mechanism which eliminated the need for additional laborers (Schlebecker, 1975:116-118, 190; Ruttan, 1982:30).
increasing the volume of output (e.g. expanding the amount of land cultivated or increasing yields) and achieving economies of scale. These dynamics coupled with the historical evolution of technological development in agricultural production have had significant consequences for the structure of the farm sector.

The adoption and utilization of the advancing array of agricultural technologies required that farmers have a greater amount of monetary capital in order to purchase these inputs. The growing need of monetary capital facilitated the further penetration of banking and finance into agriculture and the importance of the farm loan escalated. The need to amortize debt became an additional factor underlying the drive to increase productivity through technological application as financial credit became a necessity to participate in industrialized agriculture. As appropriately stated by Burbach and Flynn (1980:26):

### Table 3.3

Changes in Total Farms, Total Farm Acreage, Average Farm Size, Hired Farm Employment and Farm Population, Selected Years,

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Farms (Millions)</th>
<th>Total Farm Acreage (Millions)</th>
<th>Average Size of Farm (Millions)</th>
<th>Total Farm Employment Family-hired (Millions)</th>
<th>Farm Population (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850</td>
<td>1.4</td>
<td>293</td>
<td>203</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>1870</td>
<td>2.7</td>
<td>407</td>
<td>153</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>1890</td>
<td>4.6</td>
<td>623</td>
<td>137</td>
<td>-----</td>
<td>42</td>
</tr>
<tr>
<td>1910</td>
<td>6.4</td>
<td>881</td>
<td>139</td>
<td>13.5</td>
<td>35</td>
</tr>
<tr>
<td>1930</td>
<td>6.3</td>
<td>990</td>
<td>157</td>
<td>12.5</td>
<td>25</td>
</tr>
<tr>
<td>1950</td>
<td>5.4</td>
<td>1161</td>
<td>216</td>
<td>9.9</td>
<td>15</td>
</tr>
<tr>
<td>1970</td>
<td>2.9</td>
<td>1102</td>
<td>373</td>
<td>4.5</td>
<td>5</td>
</tr>
</tbody>
</table>

Source: Burbach and Flynn (1980:25)
Commercial agriculture means that they (farmers) must buy certain necessary inputs such as seed, equipment, fuel, or land. It is the exceptional family farmer that is not burdened with debt. Farmers go into debt to buy their farms, to buy the current season's seeds and fertilizer, to buy equipment to last for years. Credit is as basic to farming as are seeds to sunshine. Moreover, credit is the lever which allows farmers to purchase the land and capital equipment to improve their productivity. But debts bring payments that must be met, regardless of the fortunes of the harvest and the market. As a result, they also become the principal cause of financial insolvency when crops fail or prices fall.

During periods in which prices for agricultural commodities are rising, there has been a historical tendency for farmers to expand their operations through investing in more land and capital equipment in order to exploit the favorable economic conditions and accumulate greater wealth. However, when the inevitable state of overproduction occurs and prices begin to fall (which may be influenced by the economies of scale in production allowed by technology), a proportion of farmers have generally been financially overextended, unable to meet their debt and are forced into bankruptcy.41 Their land and capital equipment have tended to be consolidated by surviving competitors which has contributed to the trend of fewer, but larger farm operation with higher levels of productivity (Burbach and Flynn, 1980:76; Schertz, 1979:14).

This cycle of consolidation is dependent upon the cyclical rise and fall of prices in agricultural markets. It is also largely a characteristic of the industrialized form of agriculture that reached its full development in the U.S. in the post World War II era. The surge of technological development during this period allowed rapid growth in economies of scale in production while simultaneously escalating the necessity of financial capital and incurring debt.

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41 The farmers state of indebtedness is economically beneficial to the input sector. As long as these loans can be fully amortized, the complex of manufacturing and service industries linked to the farm sector stands to benefit.
The data in tables 3.2 and 3.3 support this interpretation. The trend toward fewer but large farms has been underway since 1910 while agricultural productivity doubled between 1930 and 1970. Further, the percentage of the composition of farm inputs represented by capital compared to labor has approximately reversed from 1870 to 1976 as technologies produced and distributed outside the farm sector have grown in importance as inputs in agricultural production (See table 3.4).

Table 3.4

<table>
<thead>
<tr>
<th>Year</th>
<th>Labor</th>
<th>Real Estate</th>
<th>Capital*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1870</td>
<td>65%</td>
<td>18%</td>
<td>17%</td>
<td>100%</td>
</tr>
<tr>
<td>1900</td>
<td>57%</td>
<td>19%</td>
<td>24%</td>
<td>100%</td>
</tr>
<tr>
<td>1920</td>
<td>50%</td>
<td>18%</td>
<td>32%</td>
<td>100%</td>
</tr>
<tr>
<td>1940</td>
<td>41%</td>
<td>18%</td>
<td>41%</td>
<td>100%</td>
</tr>
<tr>
<td>1960</td>
<td>27%</td>
<td>19%</td>
<td>54%</td>
<td>100%</td>
</tr>
<tr>
<td>1970</td>
<td>19%</td>
<td>23%</td>
<td>58%</td>
<td>100%</td>
</tr>
<tr>
<td>1976</td>
<td>16%</td>
<td>22%</td>
<td>62%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Sources: Cochrane (1979:205)
*Includes all kinds of capital items: Operating capital and physical capital other than land and buildings.

For those farm operators who have elected to expand their operations, incur debt and fully participate in industrialized agriculture, there has been a tendency for only the largest, most efficient producers to survive. This is reflected in the historical trend of income concentration in U.S. agriculture (Schertz, 1979:15–20). For example, in 1982, 83.9% of total net farm income was controlled by the 5.4% of all farms that had over $200,000 in sales (see table 3.5).
Table 3.5
Distribution of Farm Sizes and Percent of Net Farm Income by Sales Class, 1982

<table>
<thead>
<tr>
<th>Sales Class</th>
<th>Value of Farm Products Sold</th>
<th>Percent of All Farms</th>
<th>Percent of Net Farm Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>&lt; $20,000</td>
<td>60.6</td>
<td>-3.8</td>
</tr>
<tr>
<td>Part-Time*</td>
<td>$20,000 - $99,000</td>
<td>25.9</td>
<td>5.4</td>
</tr>
<tr>
<td>Moderate</td>
<td>$100,000 - $199,000</td>
<td>8.1</td>
<td>14.6</td>
</tr>
<tr>
<td>Large</td>
<td>$200,000 - $499,000</td>
<td>4.2</td>
<td>20.4</td>
</tr>
<tr>
<td>Very large</td>
<td>≥$500,000</td>
<td>1.2</td>
<td>63.5</td>
</tr>
</tbody>
</table>

Source: Office of Technology Assessment (1986:8)
*A part-time farm operator spends more than 50% of total work time in a non-farm occupation.

The structure of the farm sector has been evolving toward a bipolar structure due to the growth of farms in the large and very large categories and a decline in moderate-size farms. The large base of small and part time farms makes up one end of the spectrum and the growing number of large farms makes up the other in terms of their importance to U. S. agriculture (Office of Technology Assessment, 1986:9). The number of small and part time farms has declined, but has been somewhat stabilized by the growth and dependency of this class of farms on off-farm income for economic survival (Schertz, 1979:19).

It ostensibly appears that it is the small and medium size farms that depend on farming as a primary source of income that have lacked the wherewithal to endure the periods of overproduction and economic contraction due to the conditions imposed by the "productivity treadmill" in industrialized agriculture. The importance of technological innovation as a means of gaining a competitive edge in industrialized agriculture has thus, contributed to income concentration and the emergence of a bipolar structure of farms in U. S. agriculture.
The Processing and Marketing Sector

An early factor that inhibited the development of commercial food processing was the lack of adequate technology that would permit food preservation. In the early 19th century, Nicolas Appert invented canning in response to a prize offered by Napoleon for developing a method of preserving foods for the French Army. Appert's initial process involved the hermetical sealing of foods in glass containers under pressure and high heat. Once canning was diffused to the United States, it was further developed through improvements in can design. Tin was substituted for glass and the machinery for efficiently manufacturing tin cans was developed. By 1860, a commercial canned food industry had established a foothold in the United States through such products as canned vegetables and condensed milk which had been invented by Gail Borden in 1856 (Schlebecker, 1975:127-128).

Also among the first established processed food industries was cheese production. During the latter half of the nineteenth century, cheese production was gradually shifted off the farm and into the factory where a uniform product in greater quantity could be more easily produced (Schlebecker, 1975:126). These developments marked the beginning of the food processing industry in the United States.

Food processing became industrialized in the latter part of the nineteenth century as mass production machinery and techniques were utilized to produce commercial food products. Brand names and distinct packaging for processed food were developed. Improvements in transportation such as the refrigerated railroad car along with advertising made national marketing of processed food products possible.

The growth of markets was facilitated by the development of grocery store chains such as the Atlantic and Pacific (A&P) Company, the Kroger Company and the National Tea Company. A&P opened the first self-service supermarket in 1913 which lowered food prices and stimulated greater demand for processed food products. All of these
factors, combined with the expanding urban population and industrial labor force, influenced the growth of the food processing industry.

The U.S. food processing industry gradually evolved into a multinational enterprise as U.S. firms established integrated processing and production operations for particular agricultural commodities throughout the world (see Burbach and Flynn, 1980:108-126). The growth of integrated operations also occurred within the U.S. as many food processing companies such as Del Monte Corporation and Minute Maid began producing a large proportion of the agricultural commodities they utilize in their processed food products.

Integration additionally extended into the farm sector as an increasing number of independent farm operations began producing commodities under contract for food processing corporations. In 1970, it was estimated that over 17% of total U.S. farm output was produced under contract. However, subsumed under this total was 85% or more of all broilers, processing vegetables, fluid-grade milk and sugar beets and nearly 50% of all sugarcane, turkeys, citrus and potatoes produced in 1970 (J. Davis, 1980:144; Hightower, 1978:157).

Corporations within the food processing industry historically evolved into a powerful force within the agricultural system. Through marketing and developing food product innovations (e.g. TV dinners), they actively shaped the development of the U.S. diet and exerted control over final (consumer) markets for agricultural products (Kenney et al., 1987). They have also increasingly gained control over agricultural production through establishing corporate farms and through the use of forward contracts with independent agricultural producers (Sporleder, 1983:389).

A major factor influencing the development and growth of the food processing industry was the evolution of the organizational structure for marketing agricultural commodities. Central assembly farmers' markets were the primary links in the early
marketing system. As the volume of agricultural production increased and markets expanded due the growth of the U.S. population, the marketing system became more specialized and differentiated. Bulk storage and shipping became the dominant mode of marketing agricultural commodities and middlemen such as commodity brokers became the central links between the movement of commodities from producers to processors. This was facilitated by the development of more efficient transportation systems and technology for handling and storing large volumes of agricultural commodities such as grain elevators which became common in the mid 1800s (Schlebecker, 1975:130-135).

Another important step in the evolution of the U.S. agricultural marketing system was the development of commodity exchanges which allowed large volumes of commodities to be bought and sold for both present and future delivery. Among the first commodity exchanges was the New Orleans Exchange for cotton which was established in the 1830s and the Chicago Board of Trade which was established in 1848 for the trading of grains. Commodity exchanges for other commodities such as eggs, dairy products, produce, and vegetables were gradually developed (Schlebecker, 1975:136-137:169).

The U.S. Government became involved in the purchase and storage of agricultural commodities with the formation of the Commodity Credit Corporation (CCC) in 1933 as part of the New Deal programs for agriculture. With the severe economic conditions of the depression, the CCC financially subsidized the farm sector through nonrecourse loans and absorbed surplus commodities in hopes of stabilizing and preventing further decline in market prices.\(^{42}\) The CCC quickly accumulated massive stocks of surplus agricultural commodities through default of nonrecourse loans. In the post World War

\(^{42}\)With the nonrecourse loan program, farmers were provided loans using their commodity output as collateral. At the end of the production year, a farmer could sell his product and repay the loan with interest if market prices allowed a return that was above the level of the loan. If not, the farmer had the option of refusing to pay the loan and the government would take possession of the crop.
II period, the U.S. government became actively involved in trading these stocks of commodities, not only with domestic processing and trading companies, but also in international markets (Burbach and Flynn, 1980:63-68, 235-238).

The evolving specialization and differentiation in the U.S. agricultural marketing system extended to international markets as well as domestic markets. This process ultimately manifested itself in the formation of large multinational trading companies (e.g. Cargill, Incorporated and Continental Grain). The activities of many of these firms extend beyond international marketing to encompasses production and processing operations as well.

The entry of the U.S. government in agricultural trade facilitated the growth of these multinational processing and marketing firms through the passage of public law 480 (PL480) in 1954 which was entitled the Agricultural Trade and Development Act. PL480 had two primary purposes:

1. To reduce U.S. surplus commodity stockpiles by allowing foreign governments to import U.S. agricultural products for resale in their countries via long term, low interest loans; and

2. To finance U.S. government food donations to "friendly" countries through private international relief agencies.

Revenues from PL480 loans were reloaned to U.S. multinational companies for the purpose of establishing new subsidiaries in PL480 countries. While the importance of PL480 in stimulating U.S. agricultural exports has declined, it was instrumental in allowing U.S. multinationals to establish foreign markets to support their international production, marketing and processing operations (Burbach and Flynn, 1980:64-67).43

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43PL480 accounted for the financing of approximately 25% of all U.S. agricultural exports during the first twelve years of its existence. By 1977, this figure had dropped to 4%.
In present day agriculture, the processing and marketing sector consists of a complex organizational network that extends across international boundaries and transcends production, marketing and processing functions. The development of food processing parallels industrial development in the United States as technology involved in producing processed food evolved in a similar mode to other industry sectors. Processed food products became mass produced on highly automated assembly lines. Eventually these products incorporated chemical additives for longer shelf life and coloring for better product appearance. Further, attractive packaging and advertising helped create and maintain mass markets for these products. In sum, the production and distribution techniques of modern food processing mirror those in other industrial sectors in advanced capitalist societies (Kenney et al., 1987:12-13; Goe and Kenney, 1988).

From its inception, however, the food processing industry was highly dependent upon its suppliers for the raw materials necessary to manufacture commercial food products, i.e., the farm sector. The evolution of the food processing industry has consisted of various strategies aimed at the wholly or partially circumventing this dependence and gaining greater control over the supply of unprocessed foods. This is illustrated by the growth of integrated corporate production, processing and marketing operations on both the domestic and international level and the use of forward contracting (also known as vertical integration) with independent agricultural producers. In cases where these strategies are not used, food processing firms must largely obtain their supply of unprocessed foods through other organizational channels within the marketing system.
The Governance and Education Sector

The primary functions of the governance and education sector in present day agriculture include:

(a) the provision of a policy framework for coordinating activity within all sectors of the agricultural system;

(b) research and development of new technologies44;

(c) the dissemination of agricultural information; and

(d) the education and training of workers for the reproduction of the U.S. labor force.

The formation of the organizational infrastructure necessary for carrying out these functions occurred over the course of the nineteenth and twentieth centuries and both contributed to and was influenced by sociotechnical development in the input sector, farm sector and processing and marketing sector.

The technological transformation of U.S. agriculture in the first half of the nineteenth century through mechanization occurred with a complete lack of involvement by the government. At this time, there was an absence of a formal organization within the U.S. Government devoted solely to agricultural needs. The most influential social organizations in agriculture at this time were voluntary organizations entitled "agricultural societies." Shortly after the American Revolution, agriculturalists began to organize themselves into state and county level agricultural societies. Several of the earliest agricultural societies included the Philadelphia Society for the Promotion of Agriculture (founded in 1785), the Society for the Promotion of Agriculture, Arts, and Manufactures (founded in New York in 1791) and the Massachusetts Society for

44 As industry became organized for research and development, this activity also became an essential function of firms within the input and processing and marketing sectors. Research has shown that strong cooperative linkages gradually evolved between the governance and education sector and these two sectors for the purpose of developing new technology (see Hightower, 1973).
Promoting Agriculture (founded in 1792). The number of these societies expanded slowly and then rapidly burgeoned between 1827 and 1851 (Rasmussen, 1975:390-403, 447-457).

The general purpose of an agricultural society was to promote agricultural progress by educating farmers on new agricultural methods through "papers, discussions, exhibitions and fairs" among other activities (Rasmussen, 1975). These societies were generally led by wealthy, gentlemen farmers. During the period from 1840 to 1860, the agricultural societies initiated a lobbying effort for the creation of scientific, industrial and technical agricultural schools. They enjoyed some success at the state level and by the mid 1850s, had prompted the establishment of agricultural schools in several states including Michigan and Pennsylvania (Cochrane, 1979:201-202).

In 1852, the state agricultural societies united to form the United States Agricultural Society. This national association led a heightened effort to establish a national system of Federally supported state agricultural colleges. Their cause found a champion in Congressman Justin Morrill of Vermont. Morrill unsuccessfully proposed bills to create a national system of agricultural colleges in 1857 and 1859. However, with the political composition of Congress altered due to the secession of the southern states during the Civil War and President Lincoln needing support in his re-election bid, Morrill’s bill was passed 1862 (Hightower, 1973:9-10; Terrell, 1966:16-17).

Entitled the "Morrill Act," the bill provided an endowment of public land or its monetary equivalent to provide funds for the establishment and support of a system of state agricultural and mechanical colleges. The stated purpose of these colleges was "without excluding other scientific and classical studies, including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts"

Both George Washington and John Adams served as officers in agricultural societies (Rasmussen, 1975).
The system of agricultural and mechanical colleges became known as the land grand university (LGU) system. The LGU system was augmented with the passage of the Second Morril Act in 1890 which provided additional funding for established LGU institutions and funding for the creation of LGU colleges for blacks. These institutions largely completed the infrastructure for formal advanced agricultural education.

The adroitness of the agricultural societies in political lobbying was also influential in the creation of a national agricultural department within the U.S. Government. The initial involvement of the government in agriculture occurred in 1839 when a division was created within the Patent Office with an annual budget of $1,000 for the collection and distribution of agricultural statistics, seeds and plants (Rasmussen and Baker, 1972:5). An assiduous lobbying effort was subsequently undertaken by the agricultural societies for the establishment of a separate agricultural department.

Initially led by the Maryland Agricultural Society, the Massachusetts Board of Agriculture and then the United States Agricultural Society, this lengthy effort culminated in the signing of the 1862 Act of Establishment by President Lincoln which created the United States Department of Agriculture (USDA) (Rasmussen and Baker, 1972:6; Terrell, 1966:17).

Isaac Newton, the first Commissioner of Agriculture, outlined the following objectives for the new department in his first report:

(a) to collect and publish statistical and other useful agricultural information;

(b) to introduce valuable plants and animals to American farming;

(c) to test agricultural implements;

(d) to make chemical analyses of soils, grains, fruits, vegetables and manures;
(e) to establish a professorship of botany and entomology, a library and a museum; and

(f) to serve as the farmers' friend and adviser in Washington (Rasmussen and Baker, 1972:6).

The USDA was officially elevated to cabinet status in 1887.

The formation of the LGU system and USDA represented important "social" innovations (Brooks, 1982:9-10) as they were novel social institutions that escalated and formalized the role of the state in the advancement of United States agriculture. Being funded by public revenues, these institutions symbolized a social investment in agricultural progress through education, the dissemination of agricultural information, the introduction of new plant and animal varieties and scientific research regarding mechanical, chemical and biological technologies for agricultural production. The research and development system within the governance and education sector was further augmented by the formation of state agricultural experiment stations. Early research in agricultural chemistry had found most commercial fertilizers to be fraudulent in content and of little value to the farmer (Rossiter, 1975:150). The marketing of fraudulent fertilizer reached the extent that industry regulation was sought by agricultural scientists and farmers. The regulation of the fertilizer industry provided one underlying reason for the establishment of the first state agricultural experiment station in Connecticut in 1875 (C. Rosenberg, 1976:148; Rossiter, 1975:167). By 1886, twelve states had established agricultural experiment stations (SAES) with the majority being attached to the agricultural colleges of the LGUs (Cochrane, 1979).

The growing number of agricultural experiment stations stimulated agitation for the provision of federal funds for experiment station work. As a result of this lobbying effort, the Hatch bill was introduced into the Senate in July, 1886 by Senator James George of Mississippi. Section 2 of the Hatch Act outlined the purpose of the federal program:
It shall be the object and duty of the State agricultural experiment stations through the expenditure of the appropriations hereinafter authorized to conduct original and other researches, investigations and experiments bearing directly on and contribution to the establishment and maintenance of a permanent and effective agriculture industry of the United States, including researches basic to the problems of agriculture in its broadest aspects, and such investigations as have for their purpose the development and improvement of the rural home and rural life and the maximum contribution by agriculture to the welfare of the consumer (quoted in Hightower, 1973:148-149).

A second important focus of the SAES was to acquire and diffuse practical information on subjects connected with agriculture (Schweikhardt and Bonnen, 1985:6).

The infrastructure for the dissemination of agricultural information within the governance and education sector was further augmented with passage of the Smith-Lever Act in 1914. The Smith-Lever Act authorized Federal appropriations to establish the Cooperative Extension Service whose purpose was to diffuse useful and practical information related to agriculture and home economics. The Cooperative Extension Service was organized as a Federal-state-local partnership with local offices located within each county of a state, state offices located within the LGUs and Federal offices located within the USDA. The creation of the Cooperative Extension Service formalized and brought national coordination to the dissemination of agricultural information generated by the LGUs and SAES by providing a direct link to the farm populace (Cochrane, 1979; United States Congress, 1983). Further, it completed the tripartite mission of the agricultural colleges within the LGU system of teaching, research and extension work.

Information Technology and Macrosocial Sociotechnical Innovation Within the U.S. Agricultural System

Together, the sectors of the macro organizational structure of U.S. agriculture form an interdependent system with all components being linked with one another. However, the historical formation and maintenance of the input sector, the marketing
and processing sector and the governance and education sector was premised upon the existence of the farm sector. This continues to be the case in present day agriculture, despite the historical decline in the number of farms. Therefore, the macrosocial sociotechnical linkages between the farm sector and the other divisions of the agricultural system are of primary significance to the overall functioning of the system. Both physical and social technologies have historically played a role in the formation and maintenance of these linkages.

For example, wholesale and retail trade businesses provide the primary organizational links in the provision of technological inputs to the farm sector for use in agricultural production. Marketing organizations and food processing businesses are the primary organizational links in the physical transfer of unprocessed agricultural commodities out of the farm sector. Obviously, interconnected with the process of physical transfer are transportation technologies supported by the railroad, trucking, shipping and airline industries.

The new products and services based on information technology are stimulating macrosocial sociotechnical innovation within the agricultural system. This is occurring through: (a) the formation or entrance of organizations into the agricultural system for the production, distribution and support of information technology-based products and services for agriculture; and (b) the restructuring of the organizational linkages between the farm sector and the other divisions of the agricultural system. New information technology-based services for agriculture are transforming the means by which the activities underlying these linkages are carried out.
The Formation of the Infrastructure for the Provision of Information Technology-Based Products and Services

Like previous innovations in agriculture, information technology has allowed sociotechnical innovation through the formation of linkages between the farm sector and the wide array of industries involved in the production, distribution and support of information technology-based products and services. Through this process, the range of industries comprising the input sector has been further expanded. The development of the microcomputer industry provided an important precondition for this process.

Microcomputers could be as easily installed within a farm office as within the administrative offices of a large corporation. A primary requirement was that the manufacturing and distribution system begin to focus on developing agricultural markets in addition to those in other industry sectors. This largely occurred in the early 1980s. Apple, Tandy Corporation's Radio Shack unit, IBM, Digital Equipment, and Sperry began to develop a market within the farm sector for microcomputers. The two primary strategies used in developing this market was either direct sales to farm operators by the manufacturing companies or through the formation of joint sales ventures with established farm equipment dealers (Cox, 1983). A retail distribution system was gradually put in place in small towns and rural areas to market microcomputers, peripherals and software to the farm sector (see figure 3.3). Sales by catalogue also became an important means of distributing this technology.

One early obstacle that inhibited the diffusion of microcomputers into the farm sector was a lack of software designed for use in farm management and agricultural production (Extension Committee on Organization and Policy, 1982:4). While spreadsheet analysis and word processing programs are applicable across all industries for administrative purposes, agriculture required software designed for specific agricultural application such as monitoring machinery performance, tracking livestock feeding rations, or forecasting profits from projected crop yields. This problem was somewhat
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No national computer store chain has more experience working with the farm than ValCom. Software from such names as Red Wing and FBS. Computer hardware from IBM, Compaq and AT&T.

And now, more than two years and 140 stores later, ValCom continues to lead the way in farm computerization.

Whether you are just investigating the benefits of adding a computer to your farm operations, or you are seeking to improve the way you use your current computer, your ValCom Computer Center is the place to start.

For your nearest location, write or call ValCom, Valley, NE 68064, 1-402-359-2201, ext. 3431.

You'll find out how ValCom is helping farmers all across the country boost their productivity with computers -- while keeping their hands clean.

FIGURE 3.3. Advertisement for Agricultural Computer Dealer
overcome in the early 1980s as some of the major software developers (e.g. Control Data Corporation), a large number of start-up firms and state branches of the Cooperative Extension Service began to write microcomputer software programs designed specifically for agricultural use.

A support infrastructure for microcomputer use in the farm sector also began to develop. Services such as computer repair and farm computer consulting were provided by microcomputer dealers, entrepreneurs and the Cooperative Extension Service (Ohrtman, 1986). In some areas, computer user groups were formed by adopting farm operators to provide training and develop greater knowledge concerning microcomputer applications (Audirac and Beauleiu, 1986:66, 70). A number of regional computer institutes were formed by the Cooperative Extension Service in the early 1980s through funding provided by the Kellogg Foundation. The purpose of these centers was to develop software and applications of computers and information technology for agriculture (Extension Committee on Organization and Policy, 1982:17-18).

The proliferation of computer technology within the farm sector also stimulated the start-up of entrepreneurial companies that have created a variety of innovative information services to be used as inputs in agricultural production. An illustrative example is the service produced by Earth Data Resources Corporation entitled Soil Hawk. Soil Hawk uses airplanes fitted with special remote sensors to fly over cropping areas to collect data on crop and soil conditions such as water content and degree of insect infestation. This data is then transformed by computer into color coded maps which identify problematic areas and pinpoint exactly where field adjustments of inputs are needed such as increasing irrigation or applying pesticides (Kirpatrick, 1986:7). This computer-based information service can increase productivity by allowing the more efficient application of inputs while simultaneously preventing decreases in yields.
The Restructuring of Macrosocial Organizational Linkages Between The Farm Sector and Other Organizational Divisions of the Agricultural System

Contributing to and resulting from the diffusion of the microcomputer within the farm sector was the emergence of agricultural applications of information technology. On-farm use of microcomputers provided one condition for combining computers with telecommunications in order to utilize information technology-based services. The services being developed from applications of information technology can allow the restructuring of organizational linkages between the farm sector and the other organizational sectors of the agricultural system. Some of these services are much further developed and established compared to others. Therefore, the sociotechnical innovation resulting from some applications is largely a possibility rather than actuality.

The linkages between the farm sector and the input sector have the potential of being transformed through the development of teleshopping and telebanking services. Teleshopping allows commercial products to be purchased electronically through the use of interactive computer systems.46 Home shopping has gained some popularity in urban areas through the use of cable television networks and videotex services. One service being contemplated for agriculture would allow technological inputs to be ordered and purchased directly from the farm through computer systems. Once ordered, the products would be shipped directly to the farm.

46Interactive systems allow two-way communication between computers and computer-based technologies.
The full development of this sociotechnical system for distributing technological inputs to the farm sector could likely have a negative impact on retail input dealers because they would allow the farmer to bypass these sales outlets and buy directly from wholesale firms and manufacturers (Goe and Kenney, 1986:267; Nowels, 1985:45K). Alternatively, the integration of retail input dealers within such a system could also allow them to maintain their importance as links within the distribution system through creating an electronic data interchange system with manufacturers and wholesale suppliers (Nowels, 1985:45K).

While this innovative sociotechnical system for product distribution is increasing efficiency in other industry sectors, it has yet to be developed and implemented for use within the farm sector. The development of this service has been contemplated for several years by Agridata Resources, Incorporated as part of their AGRIDATA information service, but has yet to be implemented (Morse, 1984:33). AGRIDATA does contain a computerized catalogue in its data base that provides advertising and information on commercial agricultural inputs. However, inputs cannot be purchased through the service.

Telebanking services portend to transform the linkages between the farm sector and the banking industry. These services allow certain transactions such as bill payments and loan applications to be performed by the customer from the home, office or other remote locations through interactive computer systems. The development of this new sociotechnical system for commercial banking and finance could have important ramifications for the future agricultural credit system. Farmers could more easily bypass local community banks and borrow directly from the large money center banks that can provide credit at a lower cost (Goe and Kenney, 1986:266). Although these systems have been tested by several large urban banking firms, the extent of their use in rural America currently is minimal.
The linkages between the farm sector and the processing and marketing sector are being transformed through the development of electronic marketing services. These services allow agricultural commodities to be traded through interactive computer networks from geographically dispersed locations. The establishment of this new sociotechnical system for marketing agricultural commodities has progressed much further compared to teleshopping and telebanking services.

Electronic marketing services existed in some form before the advent of computer networking. For example, the first electronic service utilized telephone conferencing to conduct teleauctions. The first electronic marketing service utilizing computer networking (entitled TELCOT) was created in 1975 when the Plains Cotton Cooperative Association of Lubbock, Texas began trading cotton through computer networks that linked sellers and buyers (Bell et al., 1983:2). A second system utilizing computer networking, entitled ECI, was established in 1978 by Egg Clearinghouse, Incorporated of Durham, New Hampshire for the trading of eggs (Henderson, 1984:851).47 Interest in computerized electronic marketing escalated when the USDA announced an initiative to partially subsidized experimental electronic marketing projects. A number of additional services were then established for marketing lambs, feeder cattle, hogs and wholesale meats (see table 3.6).

Evaluations of electronic marketing services identified six general economic benefits for buyers and sellers of agricultural commodities:

1. **Improved marketing information** -- the more rapid exchange of marketing information allowed buyers and sellers to be matched efficiently;

2. **Increased marketing efficiency** -- transportation and handling costs during marketing were reduced;

---

47 FCI originally operated from 1972 to 1978 as a manual telephone clearinghouse.
(3) **Greater pricing accuracy** -- market prices more quickly reflected true market values for specific products at defined locations at given times;

(4) **Increased competition among buyers and sellers** -- was increased by exposing the offers of sellers to a larger number of buyers;

(5) **Higher prices** -- increased competitive interaction among buyers and increased marketing efficiency resulted in higher prices for sellers; and

(6) **Improved market access** -- decentralized access allowed buying and selling opportunities to be more easily located (Bell et al., 1983:8-11; National Symposium of Electronic Marketing of Agricultural Commodities, 1980:31-41).

Despite the economic benefits of electronic marketing services, several of the services that were developed failed to gain widespread acceptance and were discontinued. This suggests that for particular agricultural commodities, this sociotechnical innovation was rejected due to a lack of social adaptation to the technology and an unwillingness to internalize the costs among potential and/or actual users. These likely represent important obstacles that must be overcome or circumvented in order for the sociotechnical innovation resulting from computerized agricultural marketing services to be enduring and significant. The full development of computerized marketing services for agriculture promises to hasten the further decline of central assembly agricultural markets and displace commodity brokers (Goe and Kenney, 1986:267; Henderson, 1984:850; Sporleder, 1983:393). Producers can bypass these organizational links in the marketing system and sell directly to buyers. In the short term, however, these effects are likely to continue to be commodity specific.

The restructuring of organizational linkages between the farm sector and the input and processing and marketing sectors due to the development of teleshopping, telebanking and computerized electronic marketing services largely represent possibilities that may or may not occur to any significant extent. Out of these sociotechnical innovations, only electronic marketing has become incrementally established. It is yet unclear whether these sociotechnical innovations will have
<table>
<thead>
<tr>
<th>Name</th>
<th>Commodities Traded</th>
<th>Operating Organization</th>
<th>Financial Support</th>
<th>Operational period</th>
</tr>
</thead>
<tbody>
<tr>
<td>TELCOT</td>
<td>Cotton</td>
<td>Plains Cotton Cooperative Assoc., Lubbock, TX</td>
<td>Private</td>
<td>Since 1975</td>
</tr>
<tr>
<td>ECI</td>
<td>Eggs</td>
<td>Egg Clearinghouse Inc., Durham, NH</td>
<td>Private, AMS/USDA</td>
<td>Since 1978</td>
</tr>
<tr>
<td>HAMS</td>
<td>Hogs</td>
<td>Ohio State University, Columbus, OH, Producers Livestock Assoc., Columbus OH. Agriculture</td>
<td>AMS/USA, OH State University, OH. Dept. of Agriculture</td>
<td>Nov., 1980-June, 1981</td>
</tr>
<tr>
<td>CATTLEX</td>
<td>Feeder cattle</td>
<td>Texas A&amp;M University, College Station, TX</td>
<td>AMS/USDA, Texas A&amp;M</td>
<td>Sept. 1980-Nov., 1987</td>
</tr>
</tbody>
</table>

any type of significant impact on the structure of the U. S. agricultural system in the near future. It is more likely that the establishment of these macrosocial sociotechnical innovations will be very gradual.

The macrosocial linkages that have been the most affected through the application of information technology are those between the governance and education sector and other sectors of the agricultural system. This has primarily involved systems for disseminating and exchanging agricultural information. Computer-based information services are transforming the sociotechnical infrastructure by which information is disseminated and exchanged within the U.S. agricultural system.
CHAPTER IV

INFORMATION TECHNOLOGY AND MACROSOCIAL SOCIOTECHNICAL INNOVATION IN AGRICULTURAL INFORMATION SYSTEMS

The exchange of information between the industries and organizations comprising the macro organizational sectors of the U.S. agricultural system is a critical element to the functions of the system as a whole. For example, agricultural producers must be aware of events and conditions in other sectors of the agricultural system such as the capability, availability and cost of technological inputs for production, shifts in agricultural policy and conditions in financial and agricultural markets. Access to information concerning conditions within the broader agricultural system is a vital element for effectively coordinating agricultural production towards desired ends. In essence, the transfer and exchange of information is a necessary condition for the effective coordination of social activity, no matter what organizational context is considered (Olsen, 1968:74).

An important facet of sociotechnical development in U.S. agriculture has been the historical development of an infrastructure of sociotechnical systems for the dissemination and exchange of agricultural information. As new communications technologies were developed, they were incorporated into this infrastructure and utilized for the dissemination and exchange of agricultural information. Applications of information technology are providing new sociotechnical components to this infrastructure.
The advanced capabilities of information technology in the dissemination and exchange of information have contributed toward an increasing awareness of the importance of information in the coordination of socioeconomic activity. In contrast to other industries, the U.S. Government has historically been a major generator and distributor of agricultural information as a public service. However, this role has been brought into question as the potential of information technology to provide commercial information services is being realized.

Information technology is a central element in a movement to reorganize the government infrastructure for the dissemination of agriculture information to accommodate the interests of the private sector. The movement towards the privatization of agricultural information suggests that the infrastructure for the dissemination and exchange of agricultural information may be markedly different in the emerging information society compared to that which has characterized industrialized agriculture.

The Development of Sociotechnical Systems for Information Dissemination and Exchange in U.S. Agriculture

The dissemination of agricultural information to the farm sector has been an important element in the development of United States agriculture. The infrastructure of organizations providing information to the farmer has changed over time as new agricultural information needs emerged and advances in communications technology allowed new methods of information dissemination and exchange.

Immediately following the American Revolution, information dissemination to the farm sector relied upon social interactions among farmers, hand-carried letters and newspapers. Specialized agricultural journals emerged with the publication of the Old Farmers Almanac in 1792 and American Farmer magazine in 1819 (Rasmussen, 1975:446; U.S. Congress, 1983:44). In the introductory issue, the purposes of American Farmer were outlined:
The great aim and the chief pride, of the "American Farmer" will be, to collect information from every source, on every branch of Husbandry, thus to enable the reader to study the various systems which experience has proved to be the best, under given circumstances; and in short, to put him in possession of that knowledge and skill in the exercise of his means, without which the best farm and the most ample materials, will remain but as so much dead capital in the hands of their proprietor. Besides articles on the main subject of the paper, it will present original and selected essays and extracts calculated for amusement or instruction, and a substantial detail of passing occurrences and finally, it will contain a forthful account of the actual prices of all those principal articles, which the people of the country have to buy, or to sell, in the Baltimore market (quoted in Rasmussen, 1975:446).

Agricultural journals quickly grew in number and became important sources of information on new discoveries and techniques in agricultural production as well as marketing information.48

The formation of the USDA in 1862 marked the formal entrance of the Federal Government into the generation and distribution of agricultural information. This was further augmented by the formation of the land grant university (LGU) system via the Morrill Act in 1862 and the State Agricultural Experiment Stations via the Hatch Act in 1887. These organizational systems greatly increased the quantity and quality of agricultural information generated for distribution to the farm sector. However, the predominant technical means of disseminating the information were printed publications and social interaction.

The development of the telegraph in 1844 marked the birth of electrical communications. One use of this technology was for the dissemination of agricultural information. Telegraph services were used to transmit market prices to farmers for use in marketing decisions (Thompson, 1947:444). While the telegraph greatly boosted the speed of information transfer, it was not a service that could be connected to the rural home or farm. In effect, the organizational arrangements underlying the postal

service and telegraph systems were not the most efficient for rapidly disseminating agricultural information to the farm sector. Agricultural journals, newspapers and books were not delivered directly to the farm by the postal service and had to be picked up in the nearest town or city. Further, access to telegraph services by rural residents required a visit to the local telegraph office. With these arrangements, cities and rural towns and communities were the important spatial locales for the acquisition of agricultural information by the farm sector. Sociotechnical systems had yet to be developed that would disseminate agricultural information directly to homes in outlying rural areas.

The reduction in "information float" or the time between the generation of agricultural information and its dissemination to the farm sector was gradually reduced as new social arrangements were created and new communication technologies were developed. The creation of the rural free delivery (RFD) program in 1896 led to a restructuring of the system for rural postal service. Under RFD, mail was delivered directly to rural homes. The creation of RFD was largely the result of agitation by the Grange and farmers from outlying rural areas as was described in the U.S. Department of Agriculture, Yearbook, 1900:

> The new agitation took the form, not of a request for free delivery in villages where none of the patrons lived more than a mile or so from their village post office, but of a movement to give country delivery to farmers who lived from 2 to 12 miles from any post office, and who in consequence had to waste the best part of a day whenever they wished to mail a letter or expected to receive one, or desired to obtain a newspaper or magazine for which they had subscribed (quoted in Rasmussen, 1975:1713).

In the same publication, the benefits of having newspapers and publications delivered directly to the farm on a daily basis were outlined in letters to the USDA from farmers.
E.D. Norman, Thornbury, Iowa... It (RFD) will greatly assist the farmer in a material or practical way by giving him the markets and United States weather forecasts daily. Of the two, I regard the weather forecasts fully as important as the markets. Under the old system the farmers, for whom to a large extent the weather bulletins are intended, do not see them with sufficient regularity to be of much value to them. And at that season of the year when the weather forecasts are of most value to the farmer (harvest time) he is too busy to visit the post office to either see the bulletin there displayed or to get his daily paper (quoted in Rasmussen, 1975:1719).

Innovations in electrical communication following the telegraph created more rapid and efficient sociotechnical systems for disseminating agricultural information directly to the farm sector. As part of developing telegraphy, it was recognized that its cost could be lowered if several messages could be sent simultaneously over the same wire using electrical impulses with different tones. This concept was called the multiple telegraph. Alexander Graham Bell was subsidized by venture capitalists to invent such a device and in the process, accidentally invented the telephone in 1876 (Pool, 1983:26; U.S. Congress, 1983:45).

The social utility of the telephone was not readily apparent at its inception as it was originally conceived as a one-way communications device that could be used to broadcast music and other entertainment (Aronson, 1977:20). Its capabilities became apparent only after technical improvements made two-way conversation (interactive communication) feasible. Cherry (1977:114-115) points out that it was the development of the telephone exchange in 1878 that gave the telephone its social significance. The telephone exchange interconnected a number of telephones into a network which stimulated the growth of new forms of social organization and interaction. This occurred because the telephone exchange permitted choice of social contacts on request, without introduction or familiarity and in novel ways without historical precedent.
Telephone networks were not initially extended into rural areas as the fledgling Bell companies focused their marketing efforts on urban areas. The original telephone patents expired in 1893-1894 which opened up the telephone industry to competition. It was then that rural telephone networks began to develop, although the Bell companies still largely ignored rural markets. Early rural telephone networks were primarily constructed and operated by local telephone entrepreneurs and private cooperatives (the initial independent telephone companies). Many were poorly constructed and undercapitalized (Fisher, 1987:6-9).

Rural telephone networks grew rapidly during the first several decades of the twentieth century. The first full telephone census in 1902 reported that 3% of all U.S. farms had telephones. These figure expanded to 30% in 1912 and 39% in 1920 (see table 4.1).

### Table 4.1.

<table>
<thead>
<tr>
<th>Year</th>
<th>% of Farms with Telephones</th>
<th>% of all U.S. Homes with Telephones</th>
</tr>
</thead>
<tbody>
<tr>
<td>1902</td>
<td>3%</td>
<td>10%</td>
</tr>
<tr>
<td>1912</td>
<td>30%</td>
<td>31%</td>
</tr>
<tr>
<td>1920</td>
<td>39%</td>
<td>35%</td>
</tr>
<tr>
<td>1940</td>
<td>25%</td>
<td>...</td>
</tr>
</tbody>
</table>

Source: Fisher (1987:8, 19)

In addition to decreasing the isolation and loneliness of the farm populace, the telephone also began to be utilized as a technical system for the dissemination of agricultural information. For example, records of the U.S. Weather Bureau show that in 1904, as many as 60,000 farms in Ohio alone got weather forecasts by telephone (Baker, 1981:18). The telephone was also used as a means of pricing farm inputs and obtaining prices from agricultural markets. In some cases, market reports were

The rate of adoption of the telephone on farms outpaced that in urban areas between 1912 and 1920 due to the ability of the telephone to reduce social isolation, aide in emergencies and serve as a tool for farm business (Fisher, 1987:8-14). However, the percentage of farms with telephones declined between 1920-1940 due to the severe economic conditions of the depression and the lower quality, obsolete technology in rural telephone networks. The rural telephone infrastructure was eventually upgraded in conjunction with the extension of electric power to rural areas by the Rural Electrification Administration (a USDA agency). In 1949, Congress authorized the REA to allocate loans to ensure the availability of adequate telephone service to the largest practical number of rural users (U.S. Congress, 1983:37-38).

In 1872, a patent was issued in the United States in for a primitive version of a wireless telegraph that was invented by a Washington, D.C. dentist named Mahlon Loomis (Baker, 1981:4). However, the private investment necessary to develop Loomis' invention was not forthcoming and the technology for wireless telegraphy was developed in Europe instead.49 In 1896, Guglielmo Marconi was issued the first patent in England for wireless telegraphy. Marconi Wireless Telegraph Company, Ltd. was formed in 1897 and established the first wireless telegraph network. Experiments indicated that the "wireless" worked more efficiently on sea than on land. As the technology evolved, it became a valuable technology in the shipping industry and for naval use (Archer, 1971:53-76).

49 The scientific principles underlying electromagnetic phenomena were uncovered in conjunction with the evolution of telegraphy and the telephone. In 1887, the experiments of German scientist Heinrich Hertz demonstrated that electromagnetic waves could be generated at will. Hertzian waves became the subject of laboratory experiments in many developed countries and it was conceived that they could be used as a medium for telegraph signals (Archer, 1971:55).
The Marconi Wireless Telegraph Company of America was formed in 1899 and wireless telegraphy was established in the United States. Efforts to improve wireless telegraphy focused on extending the broadcast range of telegraph signals across greater geographic distances. In 1901, the first successful trans-Atlantic experiment was conducted by Marconi (Archer, 1971:60-62).

The USDA eventually incorporated both the telegraph and wireless telegraph as a means of more rapidly disseminating agricultural information. In 1920, a telegraph network was established to disseminate USDA market reports to branch market news offices. The reports were then mimeographed at each branch office and mailed to the farm sector. In 1921, a wireless telegraph network was established to disseminate USDA market reports. These reports were broadcast in a special code which could be translated only by designated telegraph operators. The reports were then posted in grains elevators, post offices, feed mills and banks or broadcast over party line telephone networks (Baker, 1981:22-23).

The formation of Cooperative Extension Service (CES) in 1914 via the Smith-Lever Act further extended the outflow of agricultural information from the USDA, LGUs and SAES to the farm sector. During the formative years of the Cooperative Extension Service, agricultural information was disseminated primarily through the office of the county extension agent, who served as broker between the local agricultural community and the larger agricultural system (Dillman, 1986:103). The county extension office served as a location for the acquisition of agricultural information by local farmers and the county extension agent also travelled a circuit of local farm operations. Agricultural bulletins written by the CES also served as an important means of disseminating information.
The success of the wireless telegraph led to experiments focused on attempting to broadcast voice signals over electromagnetic waves. The invention of the audion (vacuum) tube by Lee de Forest in 1907 culminated a series of innovations which led to the development of the wireless telephone, later to be named the radio. In its nascent stages of development, radio was also adapted to naval and shipping use and was popular with hobbyists. The idea of making radio a "household utility" for mass consumption was proposed in 1916 by David Sarnoff. However, the development of commercial radio was delayed until after World War I. By 1920, Sarnoff's proposal was taken seriously. The newly formed Radio Corporation of America (RCA) placed the first order for the mass production of radios with General Electric, and the first commercial radio station was opened under the acronym KDKA by Westinghouse Company on October 27, 1920 in Pittsburgh (Tebbel, 1974).

The radio was quickly adapted to agricultural purposes. The dissemination of agricultural information over the radio was initiated on January 3, 1921 with the broadcast of daily weather reports over the University of Wisconsin's Station 9XM. By 1923, 140 radio stations were licensed and authorized to broadcast both weather and market reports (Baker, 1981:8, 18). The development of the radio provided an ideal medium for the delivery of information to the farm sector as it was of relatively low cost and allowed timely information to be directly disseminated into rural homes. The radio further reduced information float in the dissemination of agricultural information.

Sarnoff first documented his idea in a letter which has become known as the "Radio Music Box Memo." The letter was written to the vice-president and general manager of the Marconi Company, Edward J. Nally, and stated: "I have in mind a plan of development which would make radio a household utility....The idea is to bring music into the house by wireless. The receiver can be designed in the form of a simple "Radio Music Box" and arranged for several different wave lengths, which should be changeable with the throwing of a single switch or pressing a single button....The box can be placed on a table in the parlor or living room, the switch set accordingly and the transmitted music received...This proposition would be especially interesting to farmers and others living in outlying districts removed from cities (quoted in Archer, 1971:112-113).
to the farm sector. As a group, agricultural producers could be more quickly informed of conditions and events in the larger agricultural system compared to the telegraph, printed publications or social interaction.

The radio rapidly became an accepted technology for obtaining information within the farm sector. In 1926, it was estimated by the USDA that nearly one million farm families had radio receivers. With the creation of the Radio Service in 1926, the USDA became involved in the development of agricultural programming. The importance of the radio as an information conduit to the farm sector burgeoned through such programs as "Farm Flashes" and the "National Farm and Home Hour" (a collaboration between the USDA and the National Broadcasting Company). The radio was also incorporated as a tool for extension work. State branches of the Cooperative Extension Service became involved in providing agricultural programs through radio stations owned and operated by the LGUs (Baker, 1981:14, 15, 26-39).

The development of television occurred in conjunction with the growth of radio. Spurred by the invention of the iconoscopic tube by Westinghouse scientist Vladimir Zworykin in 1923, the television was invented in 1925 by Charles F. Jenkins (Francois, 1977:89; U.S. Congress, 1983:45). Experimental television stations were soon created and by 1940, 26 were in operation. The FCC was heavily pressured to allow commercial television broadcasting and on June 17, 1941, the first license for regular television operations was issued to WNBT of New York (Francois, 1977:89-90).

The further development of television was interrupted by World War II. Immediately following the war, the image orthicon tube was invented to replace the iconoscopic tube. This had a revolutionary impact on television programming as the image orthicon tube required significantly less light to activate a television camera which made indoor programming technically feasible. In 1948, the FCC received 300 applications for television stations and over a million televisions sets were sold
(Francois, 1977:90). The era of commercial television was launched and it soon displaced the radio as the most popular form of obtaining entertainment and news within the home.

During the formative years of television, the USDA was subsidized by Congress to develop experimental agricultural television programs. These programs were eventually packaged and distributed to independent television stations. These efforts helped establish agricultural programming for television. In 1963, it was found that 500 out of 654 then-existent U.S. television stations produced a farm program of some kind (Baker, 1981:39-41). Perhaps the greatest contribution of television as a sociotechnical system for the dissemination of agricultural information was its ability to provide visual information in addition to audio. Television did not reduce information float to a greater extent than the radio.

The Application of Computers to Agriculture

Rapid developments in computer technology were occurring along with the development of television. The development of semiconductors by Texas Instruments and Fairchild in 1959 led to the development of integrated circuits which significantly reduced the size and cost of computers (Ide, 1982:41). It was during this period, when computer use was confined to large government, business and educational institutions equipped with mainframe machines, that computer applications for agriculture were first developed. The first application of computers to agriculture was a computer tabulated farm record/management system developed in 1959 at Michigan State University (U.S. Congress, 1983:45).

The development of agricultural applications of computer technology was pioneered by agricultural colleges within the LGU system during the 1960s. Although the computer was being utilized by agricultural scientists, there were few applications of this technology by private farming enterprise. It was not until the advent of the
microcomputer that on-farm computer use became economically viable.

The development of computer applications within the agricultural colleges of the LGUs in the 1960s provided one of several important preconditions for the emergence of information technology-based systems for disseminating information to the farm sector. Another precondition was that the sociotechnical capacity necessary to rapidly disseminate information to the farm sector was available whether in the form of telephone, radio or television networks. Further, these were accepted methods of obtaining agricultural information within the farm sector. Finally, the USDA and CES had well-established roles in disseminating agricultural information as a free public service and had a historical record of subsidizing the development of new technical systems for information delivery.

The Development of Agricultural Applications of Information Technology

The development of agricultural applications of information technology was also pioneered by the agricultural colleges of the LGU system. Their developmental work in agricultural applications of computer technology extended into the development of applications of information technology when time sharing computer systems became feasible. The first agricultural application of information technology for U.S. agriculture was a time sharing system that was implemented by the Cooperative Extension Service at Michigan State University in 1969 entitled TELPLAN (U.S. Congress, 1983:45).

TELPLAN was a statewide system which linked county offices of the CES to a mainframe computer on the Michigan State campus and provided access to software programs designed to solve farm management problems through remote computer terminals. Following TELPLAN, similar systems were implemented by the Cooperative Extension Service at other land grant universities such as CMN at Virginia Polytechnical Institute in 1969, AGNET at the University of Nebraska in 1975 and
FACTS at Purdue University in 1976 (Chartrand and Seidner, 1984).

Under the initial arrangements of these early systems, the county extension agent was the mediator who operated the computer terminal and interpreted the information output for the farmer. The farmer was required to visit the local extension office to get access to this service. In other words, this new technology was integrated into the traditional social arrangements by which extension work was performed and ensured that the organizational structure of extension work was maintained. The development of computerized information networks with direct outreach to the farm sector would later provide an alternative means for agricultural producers to acquire agricultural information via information technology.

Another early application of information technology for agriculture which involved the USDA was the creation of on-line computerized data bases. In 1976, the National Agricultural Library created a computerized data base of bibliographic citations to books, journal and government reports concerning agriculture entitled AGRICOLA. Between 1976-1982, the USDA created a number of additional data bases containing government-generated agricultural information which could be accessed through remote terminals (see table 4.2).

In 1980, the Agricultural Marketing Service (AMS) branch of the USDA upgraded its leased wire market news service by installing a computer network. This network links remote terminals in regional market news office and is used to collect and transmit daily and weekly supplies, prices and other sales information on more than 150 agricultural commodities. This computer-based market news service was also made available to any organizations or individuals willing to pay the subscription costs (Lett, 1983:126).

The development of new applications of information technology during the 1970s provided new sociotechnical systems that could extend computer-based delivery of
Table 4.2

Computerized Data Bases Developed by the USDA, 1976-1982

<table>
<thead>
<tr>
<th>Name</th>
<th>Date Established</th>
<th>Sponsoring Organization(s)</th>
<th>Information Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRICOLA</td>
<td>1976</td>
<td>USDA/NAL</td>
<td>Bibliographic citations to books, journal articles and government reports in the field of agriculture</td>
</tr>
<tr>
<td>CRIS</td>
<td>1977</td>
<td>USDA</td>
<td>Summaries of on-going, publicly-supported agricultural and forestry research in the United States</td>
</tr>
<tr>
<td>FANRS</td>
<td>1978</td>
<td>USDA</td>
<td>Information on federally funded food, agricultural and nutrition programs</td>
</tr>
<tr>
<td>NARS</td>
<td>1980</td>
<td>USDA/CES</td>
<td>Program accomplishment of State Cooperative Extension Services</td>
</tr>
<tr>
<td>National Pesticides Information Retrieval System (NPIRS)</td>
<td>1982</td>
<td>USDA/CSRS, Purdue University</td>
<td>Information on pest control and pesticides</td>
</tr>
</tbody>
</table>

agricultural information beyond the confines of government, business and educational organizations to farms and rural homes. The most important of these systems were videotex and teletext.

The Development of Videotex

Videotex is fundamentally a sociotechnical system for the retrieval of computerized information. Videotex allows information to be accessed from a mainframe or minicomputer and transmitted over telephone lines where it is downloaded to and viewed from either: (a) a videotex terminal (which contains a microprocessor) and television set; or (b) a microcomputer, CRT terminal and/or printer (see figure 4.1). There are three distinct parties involved in a videotex system: the information provider; the provider of the communications network; and the information receiver. The information provider is generally an institution that has made a capital investment in computers and the creation of data base and for a fee or at no charge, is willing to make these facilities available to individuals desiring to access their information.\(^5\)

The actual connection between information provider and information receiver is made via telephone services (whether telephone lines, packet switching networks, gateways, etc.)(Tydeman et al., 1982:5-6).

In addition to subscription and telephone costs, videotex systems can require on-line connect charges and each page of a videotex information file can have an additional charge attached to it. Videotex has the ability to measure its audience and record the number of information transactions requested by each information receiver. These features make videotex especially appealing to those attempting to market computerized information because it provides a variety of sources of revenue and

\(^5\) The creation of a data base requires that information be obtained from a group of information suppliers and then combined and formatted for the computer. If particular information within the data base is "time sensitive" and must be continuously updated, a reliable information supplier becomes even more critical. Thus, most videotex services depend upon a network of information suppliers.
FIGURE 4.1. Technological Components of a Videotex System

instant feedback regarding market size.

Videotex systems are interactive and allow two-way communication between information providers and information receivers. With this capacity, videotex can be used to provide other services in addition to information retrieval. Videotex is the technology that is being used for many of the information technology-based services that have been previously discussed such as teleshopping and telebanking (Fedida and Malik, 1979:81-92; Tydeman et al., 1985:60-88).

Videotex as a sociotechnical system for information dissemination was invented in Great Britain by Sam Fedida, a British Post Office (BPO) research engineer. A field trial of the first videotex system, entitled PRESTEL was initiated in 1976 by the BPO. PRESTEL became commercially available to the British public in 1979. PRESTEL was originally conceived as a means of mass marketing a wide range of information services directly within the home through combining the ubiquitous television and telephone with computer technology (Fedida and Malik, 1979:2-4; Mosco, 1982:10,76).

Following the development of PRESTEL, France, Canada, Japan and many other European countries developed their own similar videotex systems. The model of development used for these systems tended to follow a two-fold pattern: (a) technological development through government subsidiaries; followed by (b) market development and product promotion by the nations dominant telecommunications carrier, e.g., the National Postal Telephone and Telegraph in Europe and Japan and Bell-Canada in Canada (Tydeman et al., 1982:14-15).

As with other information technology-based products and services, the development of videotex in the United States has been largely left to market forces. Therefore, its development has been critically dependent upon private sector investment. The first commercially available videotex-like service in the U.S. was "The Source" which was established in 1979 to provide the retrieval of information
The commercial potential of videotex was recognized during the early stages of its development in the United States. The "videotex revolution" was proclaimed in trade journals and huge mass markets were projected to develop. A substantial number of experimental videotex projects were launched in the early 1980s which drew investment from major U.S. corporations including AT&T, IBM, Sears, Roebuck & Company, J.C. Penney, The Times-Mirror Company, Knight-Ridder Newspapers, CBS, Dow Jones & Company and RCA (Communications News, 1983a; 1983b; 1983c; 1983d; Wall Street Journal, 1984). The inducement for investment was that videotex could be used to deliver information and electronic newspapers, provide teleshopping, telebanking services and the booking of airline reservations -- all within the home.

By 1985, however, it was rapidly becoming apparent that the videotex revolution was faltering. Videotex was not gaining widespread acceptance among consumers and revenues were far below industry projections. Many videotex ventures absorbed major losses and were terminated. Some corporations who failed to recoup their investment completely withdrew their involvement in developing videotex while others scaled back their efforts and adopted a wait-and-see approach (Connelly, 1984; 1985; Harris, 1985b; Wall Street Journal, 1986). Videotex became more of a solution searching for a need rather than a means of a revolution.

Several videotex ventures did manage to successfully establish mass markets. Many of the ventures that failed were high in cost due to the use of technology that would display computerized information in the form of sophisticated graphics. Those that were successful such as Dow Jones News/Retrieval and Compuserve were lower in cost and displayed computerized information in a simple text and data format. The graphics format required special videotex terminals while the text and data format
could use personal computers equipped with modems in addition to videotex terminals. It was found that consumers were unwilling to pay for the higher costs of sophisticated graphics as well as for services that they were not sure they needed (Harris, 1985b).

The videotex revolution has yet to fully materialize in the United States. Retrieval of computerized information is the most successful service and is only very gradually becoming more widespread (Field and Harris, 1986). Businesses have become the primary users of videotex instead of residential consumers (Connelly, 1985). Other services such as teleshopping and telebanking remain available on a limited basis. On a whole, videotex remains in a trial period and it is yet uncertain whether this sociotechnical system for disseminating information will gain acceptance in the United States. Further, the lack of demand poses a threat to the future supply of videotex services as it is uncertain how long the private sector will continue to subsidize the production of unprofitable services.

**The Development of Teletext**

Teletext consists of the broadcast of a computerized information base over the vertical 21 blanking interval of a television signal. The information is received by a special decoder and displayed on a television set (see figure 4.2). Teletext does not permit interactive communication. Information is broadcast in a continuous loop from information provider to information receiver. The information receiver may select what pages of information he/she desires to view, but has no way of communicating with the information provider.
FIGURE 4.2. Technological Components of a Teletext System
Teletext was invented in Great Britain in 1972 by a team of British Broadcasting Company engineers. A market trial of the first teletext system entitled CEEFAX was initiated in 1974. CEEFAX was granted government approval as a commercial system in 1976 (Mosco, 1982:74). Following the development of commercial teletext in Great Britain, other systems were developed in the European Community, Canada and the United States. The first teletext trial in the United States was entitled KSL and was tested in Salt Lake City by Bonneville International in 1978. A number of other systems were subsequently funded and developed by both public sector organizations such as the Public Broadcast Service and the National Science Foundation and corporations such as ABC, NBC, CBS, and Time, Incorporated (Tydeman et al., 1982:40-42).

Information dissemination is the sole service that can be provided through teletext. It has therefore not been considered to have the revolutionary effects of videotex. Its growth as a means of disseminating computerized information has received much less attention compared to videotex. Perhaps the most visible application of teletext is its use in the provision of close captioned television programs for the hearing impaired. Teletext is much lower in cost than videotex as it generally requires only the purchase of a decoder for receiving information and reproducing it on the television screen.

The Blurring of Technology in Videotex and Teletext

The definitions of both videotex and teletext have been blurred as they have undergone technical improvements and new combinations of technological components have been developed. Videotex was originally conceived as involving the provision of computerized services via telephone lines, television and a videotex terminal. As microcomputer technology developed, it was found that a computer keyboard could be used for more sophisticated functions than the simple calculator-like keypad of a
videotex terminal. The stand alone functions of the microcomputer, combined with its use as a means of retrieving information through videotex, provided a much more powerful and useful technology than a videotex terminal alone. The microcomputer and CRT terminal has largely replaced the videotex terminal and television as key technological components in a videotex system.

The growing use of microcomputers by videotex users is credited with mitigating the decline of the videotex industry (Harris, 1985b). Videotex is now defined as any combination of technological components that is used to access on-line computerized data bases over telephone lines or other land line networks (e.g. packet switching networks). Microcomputers have become the predominant means of accessing videotex services and teleshopping and telebanking are currently not provided over most videotex systems.

Teletext has also undergone a number of technological permutations that have blurred its definition. First, alternative teletext systems were developed in which the user has no control over the selection of information to be viewed. Information is broadcast in a continuous loop and it is not possible to freeze individual pages of information on the screen for more detailed examination. Second, teletext decoders were developed for use with microcomputers and other computer-based terminals in addition to television sets. Further, the technology was developed for linking computer printers to teletext systems. Finally, teletext-like systems were developed that utilize radio signals rather than television signals as the medium for transmitting information.

Teletext still does not allow interactive communication even though its technological underpinnings have broadened. Because teletext involves the broadcasting of computerized information, control over access to teletext services can be ensured only by controlling the supply of decoders and/or terminals. This is in contrast to
videotex which requires log-on procedures, computer passwords and access to telephone or other land line networks.

The Development of Videotex and Teletext Systems for Agriculture

Direct computer-based delivery of agricultural information to the farm sector was conceived by Howard Lehnert of the USDA and Harold Scott of the National Weather Service in 1976 as a means of providing better weather information service (Warner and Clearfield, 1982:1-4; Paisley, 1983:155). Support for the idea was obtained from Senator Warren Huddleston of Kentucky in 1977 and a search for funding was initiated. Subsequently, Scott and Lehnert decided that videotex technology would be appropriate for the system.

In 1978, Kentucky was selected as the site for a trial of the proposed videotex system (Paisley, 1983:156). Funding for the experiment was obtained from the USDA/Science and Education Administration, the National Weather Service and the Kentucky Cooperative Extension Service. After a USDA feasibility study, the decision was made to incorporate market information into the data base of the videotex system in addition to weather information. It was further decided to add both state and county level Cooperative Extension Service information as well. Therefore, the experimental videotex system could be used to augment CES programs (Warner and Clearfield, 1982:1-5-1-7, III-6-III-7).

Scott had developed the all-weather FM radio stations for the National Oceanic and Atmospheric Administration and was aware of the limitations of voice-only weather information. For example, it might take two and a half hours to cycle through all weather information that might be potentially relevant to farmers in one locale while an individual farmer might be interested in only several minutes of information. After observing electronic TV games, Scott observed that such technology might be useful for visually conveying weather information (Warner and Clearfield, 1982:1-4).
The experimental agricultural videotex system was entitled "Green Thumb" and field tested in two counties in Kentucky from March, 1980 to April, 1981 by the Kentucky Cooperative Extension Service in conjunction with the Institute for Communications Research from Stanford University (Clearfield and Warner, 1984:285). In spite of numerous technical problems, Green Thumb demonstrated the feasibility and utility of using information technology to disseminate agricultural information directly to the farm sector (Clearfield and Warner, 1984:286-287; Paisley, 1983:159). Green Thumb was one of the earliest videotex trials in the United States and served as a prototype for subsequent agricultural videotex systems. This experiment represented the sole direct involvement of the Federal Government in the development of videotex in the United States (Tydeman et al., 1982:234).

The evaluation of Green Thumb revealed that the videotex system did not become the dominant source of information acquisition among participant farm operators. It was used primarily to augment information acquired through other sociotechnical systems (e.g. print and broadcast media). However, users did ascribe benefits to using Green Thumb over other sociotechnical systems, especially in the acquisition of marketing information. Approximately half of the participants in the experiment reported receiving higher prices for their agricultural products through the use of Green Thumb marketing information (Case and Rogers, 1987:60; Paisley, 1983:15).

In 1982, a field trial of an experimental agricultural teletext system was initiated by the USDA/Agricultural Marketing Service in conjunction with the Public Broadcasting Service. Labeled the Farm Market Infodata Service, this teletext experiment involved broadcasting agricultural information via five public television stations in Tampa, Florida; Springfield, Missouri; Fargo, North Dakota; Denver, Colorado; and Fresno, California. The experimental service was terminated in 1983 after it had demonstrated the technical feasibility of teletext as an alternative method of

Since the termination of these experiments, a growing number of agricultural videotex and teletext systems with outreach to the farm sector have been developed. Organizational support for these initiatives has come from both the public and private sectors. Table 4.3 displays the names of these computer based information systems and their operating organizations.

Within the private sector, commercial videotex and teletext systems have been developed by publishing, communications and electronic information service firms along with a non-profit agricultural cooperative. GRASSROOTS AMERICA is operated by a Canadian conglomerate consisting of a computer time sharing service firm, a bill payment and payroll service firm, a telephone company and an electronic information service firm.

Within the public sector, agricultural videotex and teletext systems have been developed by state branches of the Cooperative Extension Service and public television stations. Several of the older LGU-based systems designed to network county CES offices (AGNET and EXNET) were configured to provide the capability of computerized information delivery directly to the farm sector. Several other CES networks of this type such as CMN at Virginia Polytechnical Institute, FACTS at Purdue University and COMNET at Michigan State University were also configured to allow computerized information retrieval. However, the outreach of these networks remains internal to the CES and access by the farm sector to these information services continues to be largely mediated by county extension agents.

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53 PBS stations received USDA information over telephone lines and then encoded it into public television's captioning system (U.S. Congress, 1983:89).
Table 4.3.

Private and Publicly Operated Agricultural Videotex and Teletext Systems with Outreach to the Farm Sector

<table>
<thead>
<tr>
<th>Name</th>
<th>Videotex Systems</th>
<th>Operating Organization</th>
<th>Name</th>
<th>Publicly Operated</th>
<th>Operating Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGRIDATA</td>
<td>Agrirate Resources, Inc. (a subsidiary of RainTree Publishers Group)</td>
<td>AGRINET</td>
<td>University of Nebraska/Cooperative Extension Service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INSTANT UPDATE</td>
<td>Professional Farmers of America (a subsidiary of Outer Communications, Inc.)</td>
<td>PENPAGES</td>
<td>Pennsylvania State University Cooperative Extension Service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRASSROOTS AMERICA</td>
<td>Grassroots Information Services, Ltd. CyberShare, Comtech, Manitoba Telephone System, Infomart</td>
<td>ETEL</td>
<td>University of Maryland/Cooperative Extension Service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACRES</td>
<td>American Farm Bureau Federation</td>
<td>EXNET</td>
<td>Iowa State University/Cooperative Extension Service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dataline*</td>
<td>Dataline, Incorporated</td>
<td>AGRIVIS</td>
<td>Nebraska Public Television</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>INFOTEXT</td>
<td>University of Wisconsin/Cooperative Extension Service Wisconsin Educational Television</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AGETEXT</td>
<td>University of Kentucky/Cooperative Extension Service Kentucky Educational Television</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>AGRIVIEW</td>
<td>Iowa State University/Cooperative Extension Service Iowa Public Television</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ADVISION</td>
<td>Television Station KWHN, Minneapolis, Minnesota (affiliated with Pioneer Public Television)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Compiled by Author.

*Dataline broadcasts information over an FM broadcast band rather than television and technically is not a teletext system.
The PENPAGES and ESTEL videotex systems along with all of the teletext systems operated by public sector organizations were developed specifically for information delivery to the farm sector. Following the evaluation of the Green Thumb experiment, the Kentucky CES opted to develop a teletext system (AGTEXT) rather than further expand the Green Thumb videotex system.

Agricultural videotex and teletext systems reduce information float below all previously developed sociotechnical systems for disseminating agricultural information (Kendrick, 1983:102). This is attributable to the arrangements for accessing information from agricultural videotex and teletext systems and the technical systems utilized in obtaining information to update the data bases of these systems. The specialized data bases of agricultural videotex and teletext systems can generally be accessed by users at any time of the day. This can contribute toward a smaller lag time between the generation of agricultural information and its dissemination to the public compared to other mass media. For example, agricultural programs on radio and television are broadcast only at particular time intervals while newspapers are distributed on a daily or weekly basis at a particular time. The continuous access to agricultural information provided by videotex and teletext provides the potential of obtaining timely information more rapidly than from these sources.

This underscores the importance of the technical system used in obtaining information for inclusion in the data bases of videotex and teletext systems. The computerized data bases of videotex and teletext systems can be automatically updated through computer networking. This is in contrast to the much slower method of entering information through keypunching. For example, market prices of agricultural commodities in a data base can be instantly updated via computer networking with a computerized commodity quotes service. All that is needed is the correct software program to perform this function.
The speed in which a data base can be automatically updated is dependent upon the contractual arrangements between information suppliers and videotex and teletext services. For example, under one contractual arrangement for obtaining computerized commodity quotes, there must be a ten minute delay between the acquisition and dissemination of market prices via videotex or teletext. Under another more costly arrangement, information on changes in agricultural markets is continuously updated and disseminated -- what is known as "real time" commodity quotes. This illustrates how the benefits of videotex and teletext in reducing information float are especially applicable to time sensitive or "perishable" information which decreases in value over time (e.g. current prices in agricultural markets or weather).

Not all information items in videotex or teletext data bases are continuously updated and are less time sensitive. However, the capability of continuous access still allows this type of information to be accessed more rapidly than other technologies. Given a reliable and efficient technical system for updating their data bases, videotex and teletext can reduce information float in obtaining both perishable and nonperishable agricultural information.54

Problems in Developing the Market for Computerized Agricultural Information Services

Trends within the market for computerized agricultural information largely mirror those in the encompassing electronic information industry. Attempts to commercially market agricultural videotex and teletext services have encountered an unwillingness among consumers to pay for the costs of computerized agricultural information. The restructuring that has occurred within the industry since its inception in the early 1980s suggests that there has been substantial difficulty in developing markets for these services.

54Combined with microcomputers and software for charting historical trends in markets, videotex and teletext can provide a powerful tool in managerial decision making. The merits of this capability are discussed further in chapter 5.
For example, GRASSROOTS AMERICA was originally started in 1984 by a conglomerate entitled Videotex America which consisted of the publishing firm Times-Mirror, Incorporated, and three agricultural cooperatives. (Southern States Cooperative, CENEX and Agway, Incorporated). The agricultural cooperatives eventually withdrew their involvement and the GRASSROOTS AMERICA venture folded. It was subsequently taken over and restructured by the Canadian conglomerate Grassroots Information Services, Ltd. A second independent venture started by Videotex America in 1985 entitled GRASSROOTS CALIFORNIA was also unsuccessful.66

Within the public sector, the ESTEL agricultural videotex service that was started in 1981 and operated by the University of Maryland/CES was discontinued in 1987. A comparative study of users of the EXNET videotex service and AGRIVIEW teletext service operated by Iowa State University/CES revealed that in 1986, only 34 Iowa farmers subscribed to EXNET (Abbot, 1986:1-3).

These events indicate that there has yet to be widespread acceptance within the farm sector of videotex and teletext as sociotechnical systems for the acquisition of agricultural information. However, some agricultural videotex and teletext ventures have been successful. This suggests that there has been a limited acceptance of videotex and teletext within the farm sector. Further, the larger number of these services compared to computerized electronic marketing services (see table 3.6) suggests that computerized retrieval of agricultural information has become a much further established sociotechnical innovation compared to computerized electronic marketing.

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66GRASSROOTS was originally developed in Canada as an agricultural videotex system for Canadian farmers. The GRASSROOTS service was successfully established in Canada. In 1984, GRASSROOTS AMERICA was spun off by Videotex America followed by GRASSROOTS CALIFORNIA in 1985.
Contradictions Underlying the Development of Agricultural Videotex and Teletext Services

The development of agricultural videotex and teletext services reflects a combination of both market forces and government intervention. Within the public sector, the onus of development was passed from the Federal Government to the state level. Decisions to develop these technologies were made in specific states by the state branches of the Cooperative Extension Service.

A potential conflict of interest between private and public operated videotex and teletext services looms on the horizon as the private sector is attempting to expand the market for their information services. Future expansion of demand will be partially dependent on the efforts of the private sector to control the outflow of information to the farm population by displacing public efforts and making private services the primary outlets for agricultural information. However, the privatization of information is in contradiction to the traditional roles of the USDA and Cooperative Extension Service which have long distributed agricultural information as a free public service. The public policy agenda for the private sector is to transform agricultural information into a purchased farm input much like seeds, fertilizer, or pesticides.

This contradiction in interests is not unique to the current situation involving information technology. Rather, this conflict has emerged at different historical periods involving previously developed systems for disseminating agricultural information. For example, an 1872 article in American Agriculturist criticizes then Commissioner of Agriculture Frederick Watts for his proposal to publish monthly USDA reports because this would pose competition to for-profit agricultural journals.

The Commissioner (Watts) proposes to run opposition to the agricultural journals by means of his monthly reports. In referring to the foreign journals received at the Department he says: "They furnish the results of the very latest investigations in entomology, botomy, agricultural geology and microscopy, as well as experiments in agriculture, which could be abridged"
and published in the monthly reports of the Department before they could be reproduced by the agricultural journals of the country". How do our brethren of the press like this (quoted in Rasmussen, 1975:1209)?

In 1963, another controversy arose when Ritter Publications, which owned the *Journal of Commerce* and the Commodity News Service, brought suit against the USDA charging that its efforts in disseminating market information were interfering with private enterprise. Ritter believed that the AMS market news wire service was impinging upon the market for their Commodity News Service. The Federal District Court in Washington ruled that the USDA might continue to disseminate market information as it had been doing, but should not do anything to promote more extensive use of its reports by media broadcasters, such as encouraging them to tap into their market news wire service. This court injunction lasted until 1975 when the Commodity News Service was acquired by a new corporate owner -- Knight Newspapers (Baker, 1981:24).

The primary issue underlying this reoccurring conflict of interest is whether agricultural information should be distributed as a social good by the public sector. Or, should it be a proprietary economic good that should be sold in the marketplace? Both public and private interests were mutually advanced through the historical development of the various sociotechnical systems for the dissemination of agricultural information. As long as the interests of private sector publishing and communications firms were not impinged upon by public sector efforts, a stable division of labor existed between the public and private sectors in disseminating agricultural information. However, once the boundaries of this division of labor were perceived as being encroached upon, conflict occurred.

This conflict has generally been resolved through either shifts in government policy or mutual accommodation and compromise. For example, in response to the suit by Ritter Publications, the USDA deleted a map of the circuits of its teletype network
from its directory of market news services. Therefore, organizations desiring to use the market news wire service would not know where to gain access to the network. One reason the court injunction was withdrawn in 1975, was that the Commodity News Service deemed its technology as being superior to the USDA's in the ability to disseminate market information more promptly (Baker, 1981:24).

The growth and development of information technology-based products and services has provided new means of transforming information into a proprietary good (e.g. videotex and teletext). This has contributed toward the need of developing a distinct Federal information policy. Steps have already been taken that will at least partially mitigate the resurgence of the conflict of interest between the public and private sectors regarding the dissemination of agricultural information via information technology. During the Reagan era, Federal policy has supported the movement toward the privatization of agricultural information and its transformation into an economic good.

**Shifts in Federal Information Policy and the Movement Toward the Privatization of Information**

Due to growing economic importance of information technology, many advanced industrial nations have not only developed their own infrastructures for producing and supplying information technology-based products and services, but have also developed national information policies aimed at maximizing the productive potential of information technology (Smythe, 1982). In the United States, a comprehensive information policy providing direction for both public and private sector initiatives has never been developed. However, a movement focused on restructuring Federal information policy was initiated in the late 1970s which has partially shifted the direction of the information dissemination activities of the Federal Government toward privatization and the accommodation of private sector interests.
During the Carter Administration, there was a movement to reorganize the Federal government's mechanisms for disseminating information and introduce commercial user fees for public documents. This was a result of several forces. First, there was the decision that the number of Federal agencies disseminating public information had grown too large in number resulting in unnecessary duplication and overlap in information being collected and disseminated (Office of Management and Budget, 1978:32204-32205). Second, since World War II, there has been a constant increase in the linkages between the Government Printing Office and private sector printing firms which have been handling an ever greater percentage of government printing contracts. Through the Information Industry Association, the private sector had constantly pressured to become the main distributional channel of government generated information. The principal argument of the Information Industry Association was that government information dissemination should be handled privately and contribute to profit making (H. Schiller, 1981:59-62).

The viewpoint of information as an economic resource was embraced and supported by agencies within the Federal Government. For example, a 1980 statement issued by the National Telecommunications and Information Administration (a branch of the U.S. Department of Commerce) entitled "The Foundations of United States Information Policy" clearly reflects this position in describing the properties of information:

Information is a resource. Like energy, capital, or labor, information is a resource that can be applied to achieve economic, social, or political goals.

Information is a commodity. Information is sold, traded, or otherwise exchanged, frequently for financial or other reward to the person or organization sharing or giving up the information (Bushkin and Yurow, 1980:3).
The drive to privatize government generated information resulted in the drafting of the Federal Publications Act of 1980 which included: (a) a provision that all government information activities be reorganized under single entity entitled the Federal Publications Office (FPO) that would be controlled by the Legislative branch; (b) a provision that production and distribution of information materials may be contracted with the private sector if the service cannot be satisfied by the FPO, or if the contract will result in cost savings to the government; and (c) a provision that all government publications be sold at a price which shall not be less than the cost of production and distribution (U.S. Congress, 1980). Although the act was not passed in the 96th Congress, these policy concepts were influential in shaping subsequent policy initiatives concerning Federal information activities.

Immediately following the ill-fated Federal Publications Act was the drafting of the Paperwork Reduction Act of 1980 which in many ways, reflected the ideas promoted in earlier efforts aimed at reorganizing Federal information activities. The number one stated purpose of the Paperwork Reduction Act was "to minimize the Federal paperwork burden for individuals, small businesses, state and local governments and other persons" (United States Statutes At Large, 1980:94 STAT. 2812). However, there were several other important provisions of the bill which permitted significant reorganization of Federal information activities.

A second important provision of the bill was the establishment of an Office of Information and Regulatory Affairs within the Office of Management and Budget (OMB). The Director of OMB was vested with the authority to "develop and implement Federal information policies, principles, standards, and guidelines and shall provide direction and oversee the review and approval of information collection requests, the reduction of the paperwork burden, Federal statistical activities, records management activities, privacy of records, interagency sharing of information and acquisition and use of
automatic data processing telecommunications, and other technology for managing information resources" (United States Statutes At Large, 1980:94 STAT. 2815).

Activities that were mandated to be carried out by the Director of OMB included: (a) a reduction in the amount of information collected by the Federal Government of 25% over the next two years; and (b) the identification of areas of duplication in information collection requests and the development of a schedule and methods for eliminating duplication. Directors of all Federal agencies were ordered to review and conduct their own information management activities in an efficient, economical manner, ensure that their information systems do not overlap or duplicate those of other agencies, and comply with the information policies, principles, standards and guidelines prescribed by the Director of OMB (United States Statutes At Large, 1980:94 STAT. 2818-94 STAT. 2819).

Another purpose of the Paperwork Reduction Act was "to ensure that automatic data processing and telecommunications technologies are acquired and used by the Federal Government in a manner which improves service delivery and program management, increases productivity, reduces waste and fraud, and, wherever practicable and appropriate, reduces the information processing burden for the Federal Government and for persons who provide information to the Federal Government" (United States Statutes At Large, 1980:95 STAT. 2812-94 STAT. 2813). This provided a coordinating mechanism for the incorporation of information technology into the information management and dissemination activities of the Federal Government.

The Paperwork Reduction Act was signed into law (PL 96-511) by President Carter on December 11, 1980. In essence, it provided a key agency within the Executive branch of the Federal Government with the sole authority to set Federal information policy based on an extremely broad set of guidelines. This provided the leeway for the Reagan Administration to tailor Federal information policy in accordance with their
conservative agenda. The heavy emphasis of the Reagan Administration on paring government programs and privatizing and recovering the cost of government services has been influential in shaping Federal information policy during the 1980s. This is reflected in OMB Circular A-130 entitled "Management of Federal Information Resources" which was issued on December 12, 1985. One of the basic assumptions of this policy statement is the recognition of information as a proprietary economic good.

Government information is a valuable national resource. It provides citizens with knowledge of their government, society, and economy—past, present, and future; is a means to ensure the accountability of government; is vital to the healthy performance of the economy; is an essential tool for managing the government's operations; and is itself a commodity often with economic value in the marketplace (OMB, 1985:3) (emphasis mine).

A second basic assumption is that the Federal Government should rely primarily on the private sector to provide government services.

Although certain functions are inherently governmental in nature, being so intimately related to the public interest as to mandate performance by Federal employees, the government should look first to private sources, where available, to provide the commercial goods and services needed by the government to act on the public's behalf, particularly when cost comparisons indicate that private performance will be the most economical (OMB, 1985:3-4) (emphasis mine).

As part of the overall information policy, Federal agencies are required to: (a) place maximum feasible reliance on the private sector for the dissemination of information products and services; and (b) recover the costs of disseminating the information products or services through user charges where appropriate (OMB, 1985:5). Regarding the use of information technology, Federal agencies are mandated to meet information processing needs through interagency sharing and from commercial sources, when it is cost effective, before acquiring new information processing capacity (OMB, 1985:6).
This trajectory in information policy has resulted in a large volume of information that was previously disseminated through "in-house" government channels now being rechanneled through the private sector. The goal of reducing government information collection and dissemination has been carried out and users fees have been applied to many government publications that were previously distributed free of charge (Demac, 1984:32-34). While these strategies may be more economically efficient for the Federal Government in a time of budgetary deficits, they will result in increasing the cost of information for the end consumer. The cost of private sector dissemination (labor, technology, etc.) must be recovered, whether in the price of the information or through government subsidies.

The privatization of government information services may provide windfall profits to the private sector by virtue of its exclusive control over information generated through public tax revenues. This raises value considerations in that the U.S. public may be forced to pay for access to information generated through tax dollars. The policy orientation of the Reagan Administration toward the privatization of government information services represents a marked departure from the traditional role of the government in disseminating information as a free, public service. Current Federal information policy accommodates the interests of the private sector and facilitates the extension of the concept of information as a proprietary, economic good.

The Privatization of Government Agricultural Information Services

The drive to privatize Federal information services has not been without effect on the system for disseminating government generated agricultural information. The Agriculture and Food Act of 1981 (PL97-98) mandated that all publications arising from USDA agricultural economic research and statistical reporting be provided for a fee deemed reasonable by the Secretary of Agriculture (United States Statutes At Large, 1981:95 STAT. 1273). As a result, many formerly gratis USDA publications (e.g.
economic and statistical reports, Cooperative Extension bulletins) must now be purchased. In 1983, it was reported by the USDA that since the application of users fees, the volume of requests for USDA economic and statistical reports had dropped to 15 to 20 percent of the copies formerly distributed at no charge (Lett, 1983:129). Whether this indicates that the information had little real value or that the decrease is due to the refusal and/or inability to pay is as yet unanswered. However, it is obvious that this formerly free source of agricultural information has been curtailed.

The Food Security Act of 1985 (PL99-198) further extended the application of users fees to encompass software programs and electronic publications in addition to pamphlets, reports and other publications (Glaser, 1985:83). This addition reflects the growth of the utilization of information technology in USDA information dissemination activities. While the growth of private agricultural videotex and teletext systems initially placed the USDA computer-based information dissemination activities in competition with the private sector, the USDA has made it clear that it does not intend to compete. Rather, the USDA intends to augment and encourage the collection and dissemination efforts of both private computer services and LGU-based services operated by the state branches of the Cooperative Extension Service (Lett, 1983:125).

The USDA's information dissemination activities involving information technology clearly reflect the Reagan Administration's information policy. In accordance with this policy, there has been a privatization of computer-based information services. Private sector firms have become the primary outlets for distributing USDA information via information technology. The outsourcing of the USDA's computer-based information dissemination activities to the private sector arose in part from the establishment of an electronic mail network that linked USDA and Cooperative Extension Service offices. In 1981, the provision of this service was contracted to the data processing firm, Dialcom, Incorporated, which was also serving other Federal agencies.
In January, 1982, the USDA expanded the electronic mail service to include access to a number of data bases. One of these data bases includes USDA news releases and current reports. The stated purpose of this expanded service was "to enhance the effectiveness of USDA information distribution by offering farmers and state and local agricultural officials a means of obtaining USDA reports and news releases as soon as they are announced" (U.S. Congress, 1983:76-77). The expanded service was entitled USDA ONLINE. In 1982, Dialcom, Incorporated was acquired by ITT who began to provide the USDA ONLINE service.

USDA ONLINE became an important source of obtaining USDA information for USDA organizations, LGU's, state and county branches of the Cooperative Extension Service, state departments of agriculture, agricultural organizations and news media. Despite the original intent of USDA ONLINE, it has not become an important link for distributing computerized information to the farm sector. Rather, it has become important for disseminating agricultural information within the governance and education sector of the agricultural system and as a wholesale supplier of USDA information to agricultural videotex and teletext services. The latter function is described in a circular distributed by the USDA outlining the agricultural information available from USDA ONLINE:

It (USDA ONLINE) is used by "electronic publishers" of agricultural news and information, who repack the basic USDA information, sometimes adding other information and analysis from other sources, and electronically disseminating the new information product to end users, mainly individual farmers, farm supply dealers, agricultural credit agencies and other agribusinesses (USDA, 1985a).

In 1981, the USDA's Foreign Agricultural Service (FAS) established a cooperative agreement with the University of Nebraska/CES to begin disseminating information through the AGNET videotex service that previously had been distributed only through publications. This experiment was a success and the FAS began adding other infor-
mation to the AGNET system including foreign agricultural trade leads, current news releases, current commodity outlooks and statistical reports (AGNET, 1984:7-10; Lett, 1983:125; U.S. Congress, 1983:51).

Dissension soon arose when other public and private videotex and teletext services demanded the same arrangement instead of having to obtain USDA information through other sources. The decision was then made by the USDA to create a separate electronic information service that would be the sole repository for all USDA perishable information. Types of information that were defined as perishable included USDA market reports, crop and livestock statistical reports, economic outlook and situation reports, foreign agricultural trade leads, export sales reports, world agricultural roundups and USDA press releases (Martin Marietta Data Systems, 1985:1).

In 1984, the provision of this service was contracted to Martin Marietta Data Systems. The service was labeled the Electronic Dissemination of Information System (EDI) and went on-line in July, 1985. EDI was designed to service two primary groups of users. The first group of users consists of organizations and persons in the private sector including news agencies, information distributors, data brokers, farmers and others in the agricultural industry. The second group consists of the Federal Government and their cooperators which include state governments, universities, agricultural agents and others designated by the USDA (Martin Marietta Data Systems, 1985:1). With the creation of EDI, the previous arrangements between the USDA and AGNET were dissolved and perishable information that was previously put directly on DIALCOM was rechannelled through EDI and sold to ITT by Martin Marietta Data Systems.

Other "in-house" sources of disseminating USDA information involving the use of information technology are characterized by partial privatization. For example, the incorporation of computer networking into the AMS market news service involved the
use of leased lines contracted from AT&T. In 1986, this service was contracted to SATPAC, a joint venture owned by Telecom General and Associated Press. With SATPAC, the AMS market news service is now provided through both a satellite network and a packet switching network.

The contractual arrangements between the USDA and ITT and Martin Marietta Data Systems are similar in nature. The USDA subsidizes the cost of data entry and storage. ITT and Martin Marietta Data Systems then distribute the information for the cost of accessing their services and technically are not allowed to charge for the information (although Martin Marietta has a per line charge). In effect, the primary consequence of the privatization of USDA electronic information dissemination activities is that public domain information must be obtained through commercial services with access being sold in the marketplace.

The direct facilitation of commerce represents a markedly different policy orientation compared to that used by the USDA at prior historical points regarding its information dissemination activities. This is illustrated in the development of the "National Farm and Home Hour" radio program in 1928. The program was broadcast by NBC and commercially sponsored by Montgomery Ward. At this time, the USDA was not permitted to disseminate public domain information as part of a totally sponsored program. The program format was structured so that 75 percent of the program was sponsored by Montgomery Ward and 15 percent was unsponsored in which USDA reports were broadcast as a public service (Baker, 1981:24, 29).

The contrast between these arrangements and the current privatization of electronic information dissemination activities underscores a marked shift in public values regarding the role of public domain information in the economy. Rather than

The term partial privatization is used since the actual processing and storage of data is conducted in-house by the USDA. However, a private telecommunications network is leased to disseminate the information to end users.
emphasizing that the public interest can best be served by providing a source of information independent of private interests that is accessible to all. USDA information policy regarding electronic dissemination emphasizes that the public interest can best be served by accommodating the interests of the private sector.

Privatization satisfies the USDA policy of not desiring to compete with the private sector and minimizes the probability of the emergence of a conflict of interest between the public and private sectors concerning the electronic dissemination of agricultural information at the Federal level. Instead, this potential has been shifted to the state level where the videotex and teletext services operated by the state branches of the Cooperative Extension Service are competing with the private sector to establish a customer base within the farm sector. The potential of a conflict of interest exists even though the public sector services must purchase access to USDA electronic information via DIALCOM, EDI or SATPAC in order to provide it to the public.  

A telephone survey of all identified agricultural videotex and teletext services with outreach to the farm sector (see table 4.3) revealed that thirteen of fourteen services distributes USDA information (see table 4.4). The most popular source of obtaining USDA information was SATPAC, which was used by eight of the fourteen services. The second most popular source was DIALCOM, which was used by six of the fourteen services. Only one of the fourteen services reported obtaining USDA information from EDI. The AGNET system operated by the University of Nebraska/CES reported that they initially subscribed to EDI, but terminated their subscription due to its high cost.

57 LGU's and state branches of the Cooperative Extension Service are considered USDA cooperators and generally pay lower fees for access to these services compared to private sector organizations.

58 The telephone survey was conducted in January, 1987.
Table 4.4.

Private and Publicly Operated Agricultural Videotex and Teletext Systems Distributing USDA Information by Source

<table>
<thead>
<tr>
<th>Source</th>
<th>System Name</th>
<th>Distribution USDA Information?</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Sector</td>
<td>AGRIDATA</td>
<td>Yes</td>
<td>EDI, DIALCOM</td>
</tr>
<tr>
<td></td>
<td>INSTANT UPDATE</td>
<td>Yes</td>
<td>DIALCOM</td>
</tr>
<tr>
<td></td>
<td>GRASSROOTS AMERICA</td>
<td>Yes</td>
<td>SATPAC</td>
</tr>
<tr>
<td></td>
<td>ACRES</td>
<td>Yes</td>
<td>SATPAC</td>
</tr>
<tr>
<td></td>
<td>DATALINE</td>
<td>Yes</td>
<td>SATPAC</td>
</tr>
<tr>
<td>Public Sector</td>
<td>AGNET</td>
<td>Yes</td>
<td>DIALCOM, SATPAC</td>
</tr>
<tr>
<td></td>
<td>PENPAGES</td>
<td>Yes</td>
<td>DIALCOM</td>
</tr>
<tr>
<td></td>
<td>ESTEL</td>
<td>Yes</td>
<td>DIALCOM</td>
</tr>
<tr>
<td></td>
<td>EXNET</td>
<td>Yes</td>
<td>DIALCOM</td>
</tr>
<tr>
<td></td>
<td>AGRIVIS</td>
<td>Yes</td>
<td>SATPAC</td>
</tr>
<tr>
<td></td>
<td>INFOTEXT</td>
<td>Yes</td>
<td>SATPAC</td>
</tr>
<tr>
<td></td>
<td>AGTEXT</td>
<td>Yes</td>
<td>SATPAC</td>
</tr>
<tr>
<td></td>
<td>AGRIVIEW</td>
<td>Yes</td>
<td>SATPAC</td>
</tr>
<tr>
<td></td>
<td>AGVISION</td>
<td>No</td>
<td>-----</td>
</tr>
</tbody>
</table>


The privatization of USDA information dissemination activities involving information technology has initiated a restructuring of the organizational system for disseminating government generated agricultural information. With all methods of information disseminating presupposing the use of information technology, the flow of agricultural information from the USDA goes directly to the public or is indirectly disseminated through the state or county branches of the Cooperative Extension Service (see figure 4.3).
FIGURE 4.3. Organizational Flow of Government Generated Agricultural Information Using Conventional Methods of Delivery


FIGURE 4.4. Organizational Flow of Government Generated Agricultural Information Using Information Technology

In the case of information technology, Federal information policy has permitted private sector interests to interpose themselves between the flow of agricultural information from the USDA to the state and county branches of the Cooperative Extension Service and the public (see figure 4.4). A key future issue at the Federal level will revolve around whether information policy mandates that the social relations underlying other sociotechnical systems of information dissemination (publications, social interaction, etc.) be uniformly restructured with those of information delivery via information technology. This would complete the privatization of agricultural information as an economic good.

Another key issue surrounding the privatization of agricultural information is whether the costs of accessing timely information through information technology will prohibit certain groups within the agricultural system from realizing the benefits of information technology and participating in the emerging information society. The utility and applicability of videotex and teletext services extend beyond the farm sector to encompass all other macro organizational sectors within the agricultural system. With the types of information resources and services provided by videotex and teletext, these sociotechnical systems have the potential of becoming the central organizational nodes for the distribution and exchange of information between the industries and organizations comprising the agricultural system.

Many of the government organizations and educational institutions within the governance and education sector and the corporations and economic organizations within the input and marketing and processing sectors already possess the financial and human resources necessary for utilizing information technology. More uncertain is what types of farm operations have the economic resources and technical know-how to adapt to these emerging sociotechnical systems. The extent in which the farm sector utilizes videotex and teletext systems will be heavily dependent upon the degree in
which information technology becomes invaluable to socioeconomic activity in agricultural production.
CHAPTER V

INFORMATION TECHNOLOGY AND ORGANIZATIONAL
SOCIOTECHNICAL INNOVATION IN AGRICULTURAL PRODUCTION

Information technology not only allows the restructuring of linkages between the macro organizational sectors of the agricultural system, but also permits sociotechnical innovation within adopting organizations in each sector. For example, within the input sector, John Deere & Company employs a computer integrated manufacturing (CIM) system in its Waterloo, Iowa tractor works. This system completely assembles a variety of tractor models using a central mainframe computer to provide directions to nine minicomputers located throughout a four building facility. Programmed instructions are provided through the computer network to robots and machines on the shop floor. Daily production runs are scheduled by the mainframe computer on the basis of actual orders received (Zygmont, 1981:31). Due to the use of CIM, the work flow at the Waterloo tractor plant has been significantly reorganized into a more efficient, flexible system compared to the prior production system based upon a more labor-intensive, semiautomatic assembly line.

CIM systems are also being used within the processing and marketing sector for automating the manufacture of processed food products such as baked goods (Melloan, 1988). Electronic data interchange systems are being utilized to link manufacturers with wholesale and retail distributors to create a more efficient production and distribution system for processed food products. Point-of-sale terminals have replaced stand alone cash registers in most major supermarkets chains. These systems allow the
shelf space in each individual grocery store to be allocated more efficiently on the basis of actual consumer demand for processed food products (Geipel, 1986).

Within the governance and education sector, the USDA has progressively incorporated information technology into its activities in compliance with Federal information policy. In addition to being used for the dissemination of information to the public, information technology is also being used to acquire and exchange information within the various organizational divisions of the USDA. Computer networking has been used to link branch offices within a number of the USDA's divisions including the Statistical Reporting Service, Farmers Home Administration, Soil Conservation Service and Agricultural Stabilization and Conservation Service (Dutcher, 1986; Lett, 1983:127; McClellan, 1987). Information technology has not only provided a new sociotechnical system for the exchange of information between the branch offices of these USDA agencies, but has also enhanced their program performance. Agencies can more rapidly gain access to information needed for the implementation of programs.

These applications exemplify the potential effects of organizational sociotechnical innovation resulting from the application of information technology. These include the reorganization of labor processes around the capabilities of information technology and the necessity of new occupational skills for workers and organizational members, i.e., computer literacy and knowledge work. Information technology can accelerate the cycle between the generation and transfer and exchange of information within organizations (Kendrick, 1983). This enhances centralized control over activity within organizations characterized by a complex division of labor.

Information technology can facilitate centralized control over organizational activity in conjunction with spatial decentralization of organizational divisions or branches, i.e., centralized control over multilocalational organizations. For example, the use of computer networking by the USDA's Agricultural Stabilization and Conservation
Service links the agency's 2,800 county offices across the nation with those at the state and national levels (Dutcher, 1986). A joint computer networking project between the USDA's Foreign Agricultural Service and the State Department links 73 agricultural attachés in foreign nations with Washington D.C. via a minicomputer/satellite network. Through this system, domestic and international market data can be instantly obtained for analysis (Lett, 1983:126). These examples underscore the ability of information technology to facilitate the flow of information within organizations regardless of geographic boundaries. This can allow organizational activity to be coordinated more effectively.

There are two basic types of systems of information acquisition and exchange that are crucial for coordinating organizational activity—external and internal (adapted from Masuda, 1981:56). The external information system is concerned with the relationship between a social organization and the external social structure in which it functions while the internal information system is concerned with the essential functions within an organization.

The goals of social organizations are pursued in the context of a larger, encompassing social structure. The acquisition of information concerning the "environmental" conditions within this larger social framework is vital for the effective planning and coordination of organizational activity. The external information system fulfills this function as a sociotechnical system for the acquisition and exchange of information regarding events and conditions within the larger social system in which an organiz-

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Masuda (1981:56) draws an analogy between information networks created from information technology and information systems in living organisms. He specifies two types of information systems within a living organism—environmental and organismic. The environmental information system is concerned with the relation between an organism and the external world while the organismic system is concerned with carrying on the essential functions within the living body of the organism itself. Environmental and organismic information systems can be extended and applied to the level of social organization. Hence, the metaphors external and internal information systems.
The acquisition and exchange of information between organizational members and divisions is also essential for the effective planning and coordination of organizational activity. The internal information system fulfills this function as a sociotechnical system for the acquisition and exchange of information concerning events and conditions within an organization.

It is recognized that external and internal information systems may be overlapping, both in function and physical technology used. However, these categories highlight the importance of sociotechnical systems for the exchange and acquisition of information regarding events and conditions both within and outside an organization for the overall coordination of organizational activity. Information technology provides new physical technologies for external and internal information systems and allows the restructuring of an organization's system for the acquisition and exchange of information. These effects of organizational sociotechnical innovation are being manifested within the farm sector as information technology is being applied to agricultural production.

The Application Of Information Technology To Agricultural Production

Applications of information technology that have been or are currently being developed for agricultural production fall into three general categories on the basis of their functions: (a) information management; (b) telecommunications; and (c) monitoring and control technologies (Office of Technology Assessment, 1986:32). The information management and telecommunications categories refer primarily to the microcomputer, videotex and teletext applications that have previously been discussed. Monitoring and control technologies refer to applications of information technology developed for use in agricultural production processes.
On-farm use of microcomputers is allowing sociotechnical innovation in information management systems within individual farm operations. The ability of microcomputers to process, organize and store information provides the capacity to base farm management on information that hitherto was unavailable or time consuming to manually manipulate into a usable form. Microcomputer hardware appropriate for agricultural use is identical to that used in other industries. Furthermore, many general purpose software packages that are popular in other industries such as spreadsheet analysis and database management are also applicable to agricultural purposes (Office of Technology Assessment, 1986:62-63). These software packages are generally used for such generic business tasks as financial analysis, cost accounting and record keeping. In most cases, the use of microcomputers in information management provides advantages over conventional paper and pencil methods.

The advancement of the agricultural software industry has resulted in the development of software programs that are tailored toward specific needs in agricultural production. For example, software packages have been specifically designed for the management of crops and different types of livestock, the management of the cost and performance of farm machinery and the charting of conditions in agricultural commodity markets just to name a few.60

Another type of software is simulation programs. This type of program allows farm managers to assess possible outcomes from employing alternative managerial strategies. For example, one program of this type allows the assessment of alternative strategies for beef production under various land, energy and economic constraints (Holt, 1985:426). Yet another program allows the calculation of production levels

60These packages are generally capable of storing and analyzing a wide array of data. For example, software packages for livestock management analyze a wide range of factors including levels of performance and yields (e.g. milk or egg production), health factors (e.g. diseases, treatments), fertility factors (e.g. sizes and weights) and breeding histories (Westlake, 1981:164-165).
needed to recoup the investment in alternative models of new machinery (Felling, 1986:46).

Telecommunications applications of information technology provide links for the transfer of digital information between off-farm organizations and farms (Office of Technology Assessment, 1986:65). Videotex and teletext systems currently represent the most common agricultural applications of information technology in this category. The provision of information technology-based services through satellite networks may provide the most economically feasible means of serving farms in extremely isolated areas. AGRIDATA is currently the only videotex service that is alternatively provided via satellite. On-farm earth stations can also be used for accessing teletext services if they are positioned in range of the broadcast signal.

There is a degree of overlap between the information management and telecommunications applications of information technology. Several videotex services such as AGNET and GRASSROOTS provide access to software programs as part of their service. Further, data obtained from a videotex service may be "downloaded" to an on-farm microcomputer for use in a software program. For example, software programs that chart agricultural markets can generally be updated by downloading market prices from a videotex service.

Monitoring and control applications of information technology are directly utilized in a wide range of agricultural production processes for the purpose of increasing efficiency. Some applications are designed to detect certain conditions and report the information to the farm operator while others are designed to function as an automated system. There are three broad categories of monitoring and control applications; (a) remote sensing; (b) computer-automated controls; and (c) robotics. In some cases, these applications are used in combination.
Remote sensing consists of a group of technological systems used to detect, process and analyze reflected and emitted electromagnetic radiation at a distance (Office of Technology Assessment, 1986:66). In essence, remote sensing can be used to detect a wide range of phenomena on the basis of electromagnetic radiation emissions. Information collected through remote sensing is generally transmitted to a computer or other form of computer technology where it is stored, processed and analyzed.

The development of remote sensing for agricultural production has produced a wide range of applications. One is an on-farm weather station which can be used to monitor changes in immediate weather conditions. The placement of remote sensors beneath the soil in cropping areas provides the capacity to monitor soil conditions. For example, levels of soil moisture can be estimated for use in decisions related to land use planning, irrigation or application of inputs. Additionally, remote sensors can be used to detect the degree of insect infestation in cropping areas (Holt, 1985:423).

Remote sensing applications have also been developed to monitor the performance of farm machinery. The fuel efficiency of engines can be monitored as well as the efficiency of machines in performing their tasks. For example, the incorporation of remote sensors into a combine allows levels of grain loss during separation to be monitored. Machinery adjustments can be made more rapidly to minimize grain loss during harvesting (Office of Technology Assessment, 1986:69). Remote sensing also improves on-farm storage of grain. Moisture levels and other conditions within grain

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61 These technological systems include cameras and electronic sensor devices.

62 An example is the Landsat Satellite System which uses remote sensing photography of the earth's surface to detect a wide range of phenomena. Photographs taken by Landsat's cameras are transmitted in digital form down to an earth station where they are then reconstructed and analyzed.
storage facilities can be continuously monitored to ensure that quality standards are
maintained (Holt, 1985:423).

In animal agriculture, remote sensing applications have been developed to monitor
conditions within livestock facilities as well as the physiological conditions of livestock.
Within livestock facilities, conditions such as temperature, humidity, ventilation and
lighting can be monitored. This can ensure that resources such as electricity are util-
ized more efficiently and optimal environmental conditions are maintained for livestock.
Sensors implanted within livestock can detect changes in physiological conditions such
as the identification of cows entering estrus. This particular application can improve
efficiency in livestock breeding (Holt, 1985:423).

Many computer-automated control applications for agriculture are utilized in
combination with remote sensing. For example, computer-automated control systems for
adjusting environmental conditions within livestock facilities work automatically on the
basis of information provided by the remote sensing applications that were previously
discussed. Additionally, computer-automated irrigation systems have been designed to
automatically allocate water to cropping areas on the basis of information on weather
and soil conditions obtained from remote sensors (Office of Technology Assessment,
1986:65). With these types of computer-automated systems, information collected by
remote sensors is transmitted to a central processing unit via radio or land line links.
Programmed instructions are then sent by the central processor to the machinery
needed to perform a particular function (see figure 5.1).

A second type of computer-automated control application that is becoming
established in livestock production is computerized feeding systems. These systems
utilize computer identification of individual animals through a radio transponder placed
in an animal's ear or through a magnetic scanning device which reads information
recorded on a tag placed around an animal's neck. Once an animal steps into a
Example 1. Positive feedback for irrigation control

Field
Soil moisture sensor

Controller
circuitry decides when
field needs
more water
Sends on-off
signal

(+) Additional
water

Actuator
water pump
on flow valve

On-off
signal

Example 2. Negative feedback for temperature control in livestock confinement

Building
Thermometer

Temperature signal

(−) Removes
hot air

Exhaust
fan

Thermostat

On-off signal

FIGURE 5.1. Configuration of Computer-Automated Monitoring and Control Systems for Irrigation and Temperature of Livestock Confinement Facilities

feeding station, it is automatically identified by a computer through signals sent by the radio transponder or magnetic scanning device. Computerized records on the animal are then called up by the central processing unit. Feed is then allocated to the animal on the basis of a number of predetermined factors including previous milk production (in the case of dairy cows), weight, nutrient requirements and time of last feeding. This system can ensure that feed is allocated more efficiently and that each animal is administered an appropriate diet.

Robotics is currently the least developed of the control and monitoring applications of information technology for agricultural production. While already an important technology within input and food processing industries, a workable application of robotics for use in agricultural production has yet to be developed. The first application of robotics in U.S. agriculture may be the robotic tree fruit harvester that is currently being developed at the University of Florida for the purpose of automating the harvest of citrus fruits (R. Harrell, 1986). However, successful development of robotic applications for field crops faces major obstacles such as the development of reliable and accurate optical scanning in conjunction with the ability to overcome the unexpected contingencies that often arise in an uncontrolled outdoor environment (Aldersey-Williams et al., 1986:67). These problems may not be easily overcome. Given the use of a controlled indoor environment, robotic applications may be more appropriate for animal agriculture. Several potential applications have been proposed including the use of robotics to assist in milking, monitoring calving and farrowing and livestock feeding (Holt, 1985:423; Office of Technology Assessment, 1986:67).

The diverse applications of information technology for agricultural production can ultimately be combined into a unified, on-farm, digital information network that will be controlled from a central computer. One possible system architecture involves the use of a local area network (LAN) to link all applications of information technology into a
unified system. However, this is likely to be much more costly compared to the use of a LAN within the typical office setting. This is due to the more extensive spatial dispersion of agricultural production activities which would require a much greater length of LAN cable to link information technology applications (Office of Technology Assessment, 1986:62).

Radio transmission provides an alternative medium for linking applications of information technology with a central computer system. Radio could also be used for linking applications of information technology to the connecting nodes of a LAN. One possible combination of technologies for a unified, on-farm digital information network is displayed in figure 5.2. This system architecture involves the use of a LAN to link monitoring and control applications to a central computer which can also be used for stand alone functions such as spreadsheet analysis. Radio transmission is also used to link remote sensors placed in farm machinery with a connecting node of the LAN. Additionally, satellites, radio and land lines are used for digital telecommunications with off-farm organizations. In the short term, the development of on-farm, digital information networks will involve combining a number of stand alone applications of information technology into a unified system. In the long term, however, fully designed systems may be developed and implemented.

Information Technology And Sociotechnical Innovation Within The Farm Operation

The full development of on-farm, digital information networks will allow sociotechnical innovation within the internal organizational structures of individual farm operations. These networks will allow production processes to be monitored and

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63 The combination of technologies used in an on-farm, digital information network would be dependent upon by the commodities produced by a particular farm operation. For example, specialized livestock producers would not likely use monitoring and control applications of information technology for crop production and vice versa.
FIGURE 5.2. Example of System Architecture for an On-Farm Digital Information Network

controlled from a central location i.e., the farm office. Production and management tasks could then be reorganized around the capabilities of information technology applications. Both the internal and external information systems within a farm operation will be transformed. Information technology provides a more formally organized and efficient sociotechnical system for both internal and external information systems compared to previous sociotechnical arrangements.

Prior to the development of information technology, the internal information system of a farm operation relied primarily upon the farm operator and/or social interaction between the farm operator and his family or hired workers. Information concerning ongoing agricultural production processes was acquired through periodic personal observation and monitoring. Information technology not only automates this process, but also permits continuous monitoring. On-farm, digital information networks will also allow such information to be permanently stored, organized, processed and documented.

Before the advent of information technology, the external information system of a farm operation relied upon social interaction by the farm operator and the mass media. Information on events and conditions within the broader agricultural system were obtained by the farm operator through interaction with persons from off-farm organizations such as extension agents or commodity brokers and through perusing a combination of print and broadcast media. Information technology will augment these sociotechnical arrangements as farm operations can link into videotex and teletext services which will allow important information on conditions and events within the larger agricultural system to be instantly obtained.

It not likely that an on-farm digital information network will ever completely replace other sociotechnical arrangements within the internal and external information systems of a farm operation. For example, studies of users of agricultural videotex
and teletext systems have shown that these sociotechnical systems are being used to augment other information sources (Abbot, 1986:6-8; Gonzalez et al., 1985; Paisley, 1983:158). However, on-farm, digital information networks provide clear advantages over these other sociotechnical arrangements. These advantages can be categorized as the following:

1. **Convenience**—Information on conditions and events within the farm operation and the external agricultural system can be obtained from a single source. Both monitoring and control applications and telecommunications applications such as videotex and teletext are combined into a central computer system.

2. **Speed**—Desired information can be obtained more rapidly. Farm managers do not have to spend as much time searching or waiting for the information they need. Monitoring and control technologies allow continuous monitoring of production processes while videotex and teletext services can be accessed at any time of the day. Information of interest can be obtained instantly through the central computer system.

3. **Timeliness**—The on-farm, digital information network allows access to "real time" information. Monitoring and control technologies continuously provide up-to-date information concerning ongoing production processes. Videotex and teletext systems also allow access to perishable information (e.g. prices in commodity and financial markets) that is continuously updated.

Even as stand alone technologies, monitoring and control applications and telecommunications applications such as videotex and teletext provide these advantages over previous sociotechnical arrangements used in internal and external information systems within the farm operation. The more efficient internal and external information systems allowed by information technology can increase productivity by allowing farm management and production strategies to be adjusted more efficiently in response to changing conditions.

Information technology allows the application of inputs and use of resources to be controlled more efficiently. Changes in financial and agricultural commodity markets can be monitored more effectively. Problems in crop production such as high insect
infestation or low moisture levels can be more readily identified and corrected before they threaten yields. It is the economic efficiencies created through more effective farm management that can make information technology applications indispensable to agricultural production. This will lead to agricultural production processes becoming much more information intensive.

Information has always been an important input during all stages of agricultural production. For example, prior to the planting of crops during a given production year, important information inputs could include information on current agricultural policy and farm programs, prices of inputs and interest rates at banks and credit institutions. If utilizing more sophisticated marketing and financial strategies such as basis contracting, futures options or stock options, marketing and financial information would be an important information input throughout the production year.

Information technology not only provides a more efficient system for acquiring and managing information inputs, but also expands the generation and flow of information within the farm operation. Computer software allows information inputs to be stored, analyzed and formatted in ways not previously possible. Productivity gains resulting from information technology will be dependent upon the ability of farm operators to manage and interpret the expanded flow of information and then adjust managerial and production activities accordingly.

The expanded flow of information may not in itself, provide increases in productivity for all adopters. Rather, those possessing the proper conceptual skills with which to evaluate the information will be most able to capture these productivity gains (Dillman, 1985:21). Therefore, education and knowledge will become even more crucial factors in effective farm management and knowledge work will become a much more indispensable component of agricultural production.
Knowledge work in agricultural production will be augmented by the further development of expert systems and applications of artificial intelligence for agricultural use. These software programs will assist in interpreting information and suggesting possible courses of action to be taken in production and management activities. To some extent, expert systems and artificial intelligence applications will replace mental labor and automate knowledge work. Among the first expert systems for use in agricultural production are PLANT/ds and PLANT/tn which were developed at the University of Illinois for the diagnosis of soybean disease and provision of turf-grass management, respectively (Goe and Kenney, 1988:83; Holt, 1985:426; USDA Extension Service, 1985:11). Another expert system, entitled COMAX, was developed by the USDA’s Agricultural Research Service for use in managing cotton production (Lemmon, 1986).

The increasing importance of knowledge work will heighten the significance of the farm office as an organizational component of the farm operation. As a control and decision making center, conditions within the farm operation and the larger agricultural system will be tracked through the central computer of the on-farm, digital information network. The use of information technology and the increasing importance of knowledge work will change the occupational and skill requirements of agricultural production, possibly leading to increased specialization. This is important because the division of labor within the farm operation is generally less specialized than in other industries.

Within the family farm, the farm operator generally fulfills a wide range of occupational roles including owner, manager and laborer. Management and labor tasks may also be divided between family members and/or hired farm laborers. At the opposite end of the spectrum is the nonfamily, corporate farm which tends to have a

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64 Based upon a particular set of information inputs (e.g. weather conditions), COMAX can be used to project the optimal timing of irrigation, nitrogen application and harvesting of a cotton crop (see Lemmon, 1986).
division of labor that is much more structurally differentiated. This type of farm
operation often involves absentee ownership, a hired farm manager and hired laborers
(Goss and Rodefeld, 1977:25). Additionally, the nonfamily corporate farm may be a
subsidiary or organizational unit of a much larger corporation.

The growth in the importance of knowledge work in agriculture resulting from the
application of information technology will increase the importance and complexity of
the occupational role of farm manager across all farm organizational types. One
possibility is that increasingly specialized management-related occupations may emerge
such as computer software specialists, computer technicians or analysts who focus
solely on particular marketing or financial strategies (e.g. trading futures options).
These specialized managerial tasks may be undertaken by the farm operator or family
members. Alternatively, they may require the hiring of managerial specialists as on-
farm staff or the contracting of management consulting services from independent
service firms. The fact that the predominant source of future productivity gains from
information technology lies in the managerial sphere of the farm enterprise may create
the need for increasing occupational specialization.

The capability of centralized, automated monitoring and control of agricultural
production processes provided by information technology may also lead to the further
displacement of the less than three percent of the U.S. labor force that still works on
the farm. For example, computer-automated irrigation eliminates the need for field
laborers to manually control irrigation systems (Audriac and Beaulieu, 1986:66).
Simultaneously, however, the potential of increased occupational specialization could
mitigate the decline of farm workers by creating new jobs within the farm sector.
Labor employed within the farm sector would be further shifted out of production and
into specialized, management-related occupations. The full effects of information
technology for farm labor cannot yet be forecast. In either case, computer literacy is
likely to become an increasingly necessary skill for those farm workers who remain (Dillman, 1985:13).

The extent of sociotechnical innovation that will ultimately be manifested in agricultural production as a result of information technology is uncertain. This will be dependent upon the extent in which applications of information technology become established in agricultural production.

**The Extent Of Use Of Information Technology In Agricultural Production**

The extent in which the various applications of information technology are currently being used in agricultural production in the United States is unknown. A precise determination is not possible since a nationwide enumeration of on-farm use of information technology applications has never been undertaken. Given what little data is available, only broad extrapolations can be made.

All applications of information technology for agricultural production that have been discussed are technically feasible with the exception of robotic applications. However, technical feasibility does not ensure the development and maintenance of the production, distribution and support infrastructures necessary for adoption and social adaptation to information technology within the farm sector. This will be dependent upon the commercial viability of each individual application of information technology. Sufficient market potential must be perceived as existing for each application in order for the necessary production, distribution and support infrastructures to be developed. Actual demand for information technologies will then influence the maintenance of these infrastructures.

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Although currently far from commercial application, the development of computers that operate on the basis of voice recognition may diminish the effort necessary to become computer literate.
The discussion in this chapter implies that the incorporation of information technology into agricultural production is occurring in a unified process of technological transition. In reality, however, this process is much more fragmented. Applications of information technology that are commercially developed have largely been promoted and distributed on an individual basis. Whether these piecemeal applications can or will be combined into a unified, on-farm, digital information network remains an open question.

Monitoring and control application that have become incrementally established as stand alone technologies include computerized feeding systems and irrigation systems. Other applications such as the use of remote sensing to monitor soil conditions have yet to become commercially viable. The fully computerized farm operation, which integrates diverse applications of information technology into a unified system, has existed only on an experimental basis.

The "Year 2000 Computerized Farm" project involved an experimental demonstration of a fully computerized farm operation at Texas A&M University. This project was funded by the W.K. Kellogg Foundation, The Stiles Foundation, John Deere, Texas Instruments and the Texas A&M Cooperative Extension Service and State Agricultural Experiment Station. The project was initiated in 1984 and demonstrated the feasibility of an integrated system of information technology applications including an on-farm weather station and monitoring and control of farm machinery, buildings and livestock. Private sector firms including John Deere, Texas Instruments and major software vendors were actively involved in designing these applications and had access to developed technologies for commercial production and distribution (O'Brien, 1986). However, even as stand alone technologies, these applications have yet to become widely established in agricultural production.

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66 This was ascertained through personal interviews with representatives from firms manufacturing or assembling these technologies.
Currently, the most widely established applications of information technology in United States agriculture are microcomputers used in combination with videotex and teletext systems. Assessments of on-farm use of microcomputers from both academic and industry sources estimate that between five to ten percent of all U.S. farms own microcomputers (Bradford, 1986; Cox, 1983; Holt, 1985: 424; Spraggins, 1985; Yarbrough and Scherer, 1984:6). It has been estimated that a much smaller percentage (less than 5 percent) use videotex services and on-line computerized data bases (Yarbrough and Scherer, 1984:17). It is likely that the use of teletext services is slightly more pervasive than videotex since it is lower in cost and technically easier to use.

These estimates suggest that the integration of the farm sector into the emerging information society is only in its initial stage. The rapid adoption and social adaptation to information technology that is occurring in other industry sectors in the U.S. economy is not occurring at the same pace in agricultural production. There has been a resistance within the farm sector to adoption and social adaptation to agricultural applications of information technology.

This resistance is attributable to a complex set of factors. For example, the low adoption rate of microcomputers within the farm sector has been attributed to a lack of agricultural software, a lack of awareness among farmers of how computers may be useful for farming, a lack of computer education and literacy among farmers, cultural incompatibility between computer salespersons and farmers, and the lack of disposable income within the farm sector due to the recession in the agricultural economy (Cox, 1983; Goe and Kenney, 1986:126; Spraggins, 1985).

If the farm sector is to integrate into the emerging information society, adoption and social adaptation to agricultural applications of information technology must occur. Despite the low rates of adoption, it appears that microcomputers and videotex or teletext systems will provide the initial foundation for this integration process since
they are currently the most established applications. The successful establishment of all further applications of information technology in agricultural production appears to predominantly hinge upon the extent in which farm operators adopt and socially adapt to microcomputers in combination with videotex and teletext systems. This has several implications.

First, it suggests that the integration of the farm sector into the emerging information society will initially hinge upon the successful application of information technology in management processes rather than production processes. Second, the initial organizational locus of application will be the farm office rather than cropping areas or livestock facilities. Farm operations must internalize the costs of incorporating microcomputers and computerized information systems within the information management activities of the farm office. These costs include: (a) the price of the necessary equipment and supporting services (e.g., microcomputers, modems, communications, software, subscription fees to a videotex service); (b) the education and training necessary for using the technology; and (c) the potential shifts in job responsibilities in using the technology. Conjunctively, farm managers must be able to realize the benefits of using microcomputers and videotex or teletext systems over previous techniques in information management.

The benefits of videotex and teletext within the management activities of farm operations are:

1. **The reduction of labor time in acquiring agricultural information**—videotex and teletext allows agricultural information to instantly acquired at any time of the day and can reduce information float in obtaining perishable information. The amount of time searching for needed information can be reduced due to computer storage and processing.

2. **The reduction of agricultural information sources**—videotex and teletext allow a wide range of information to be acquired in a single source. This can reduce the number of information sources (e.g. journals, radio and television) that need to be consulted to obtain desired information.
3. **More effective scheduling of farm activities**—the instant access to agricultural information and the reduction in information float in obtaining perishable agricultural information can allow farm activities to adjusted and scheduled more effectively in response to changing conditions. For example, the custom weather forecasts designed specifically for agriculture that are available on most agricultural videotex services can allow the optimal timing for crop spraying to be better pinpointed.

4. **The realization of higher prices for agricultural commodities**—Instant access to current market information can allow marketing strategies to be coordinated more effectively. Many videotex systems provide marketing advisory services which provide information on how and when to market agricultural commodities.\(^6^7\) Such information can allow farm operators to realize higher prices for their products through more effective marketing.

5. **The realization of better financial investments**—the instant access to current quotes on stocks and other financial instruments provided by videotex and teletext can allow financial investments to be coordinated more effectively. Farm operators can realize higher returns from financial investments.

An acceleration in the adoption of videotex and teletext will not necessarily ensure that these technologies will be permanently integrated into the technical basis of agricultural production. This will hinge upon social adaptation to these technologies by farm operators. The internalization of the costs and realization of the benefits of videotex and teletext in agricultural production will likely contribute toward social adaptation to these technologies within the farm sector. This can provide the technical foundation for the future creation of on-farm, digital information networks as other applications of information technology for agricultural production are commercially developed that are capable of being linked into a central computer network.

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\(^6^7\) Examples include the American Farm Bureau’s Agrivisor service which is available through the ACRES videotex service and the Professional Farmers of America’s Pro-Farmer service which is available through their INSTANT UPDATE videotex service.
Videotex and teletext currently represent the most established forms of information technology in agricultural production. The integration of the farm sector into the emerging information society will initially hinge upon adoption and social adaptation to videotex and teletext unless other applications of information technology for agricultural production become more predominant. Given the initial significance of these technologies in this integration process, a cost/benefit analysis was undertaken to examine and identify factors contributing to social adaptation to videotex in agricultural production. Such an analysis provides insight into factors which are likely to initially facilitate or constrain the integration of the farm sector into the emerging information society.

As a process of sociotechnical innovation, the incorporation of videotex into agricultural production is in its initial stage as witnessed by the estimated low adoption rate of videotex services. Farm operations that have initially adopted videotex have undergone a trial period in which the costs and benefits of the technology have been evaluated. Failure to realize a favorable cost/benefit calculus has likely contributed to the rejection of videotex. Simultaneously, the realization of a favorable cost/benefit calculus has likely contributed to social adaptation to videotex and its integration into farm management activities.

68 The rationale for selecting videotex is described below.
The costs and benefits of utilizing videotex were outlined in chapter five. The costs include: (a) the price of the necessary equipment and supporting services (microcomputers, communications software, modem and subscription costs of a videotex service); (b) the education and training necessary to use videotex; and (c) the potential shift in job responsibilities within the farm operation for using videotex (e.g. scheduling time within the work day to access videotex services).

The potential benefits of using videotex include: (a) the reduction of labor time in acquiring agricultural information; (b) the reduction of necessary agricultural information sources; (c) more effective scheduling of farm activities; (d) the realization of higher prices for agricultural commodities; and (e) the realization of better financial investments. Data were collected from a sample of farm operators with experience in using agricultural videotex systems in order to examine the relationships between these cost/benefit factors and social adaptation to videotex.

**Defining the Study Area**

The low adoption rates of both videotex and teletext services posed a difficult problem in the ability to identify an adequate sample of farm operations with experience in using either technology for inclusion in the cost/benefit analysis. This problem was ameliorated when the Ohio and Michigan Farm Bureau Federations agreed to participate in the study and identify farm operations in Ohio and Michigan with experience in using their ACRES videotex system.

The selection of Ohio and Michigan as the study area eliminated the possibility of examining users of agricultural teletext systems. At the time of data collection, there were not any teletext systems in operation within the two state area. This limited the cost/benefit analysis to users of agricultural videotex services.
The nature of the agricultural industries within Ohio and Michigan provides an appropriate structural context in which to evaluate social adaption to videotex within the farm sector. Both Ohio and Michigan represent relatively important components of the national agricultural system. Ohio ranked seventh nationally in total farm population in 1980 and eighth in total number of farms in 1982 while Michigan ranked eleventh and sixteenth, respectively (see Table 6.1). Agricultural production in both states is very diversified with a wide variety of crops and livestock being produced. In 1982, corn and soybeans were the most extensively produced crops in Ohio and were grown by 60.6 percent and 49.9 percent of all farms. Cattle was the most widely produced type of livestock and was produced by 48.6 percent of Ohio farms (see Table 6.2).

In Michigan, corn was the most extensively produced crop and was grown by 52.5 percent of all farms. Other cash grains, including wheat and soybeans, were produced by approximately 25 percent or less of Michigan farms in 1982. Cattle was the most widely produced livestock being produced by 43.7 percent of Michigan farms. In general, cash grains and beef cattle are the most extensively produced agricultural commodities within the study area.

In 1984, Ohio and Michigan were among the top twenty states in terms of gross farm income derived from total marketing receipts. Ohio ranked thirteenth nationally with over $3.6 billion worth of agricultural commodities sold. The majority of these sales were derived from soybeans, dairy products, corn and hogs, respectively (see Table 6.3).
Table 6.1.

National Rankings of Ohio and Michigan in Total Farm Population and Number of Farms

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>National Rank</td>
<td>Total</td>
</tr>
<tr>
<td>Ohio</td>
<td>7</td>
<td>272,000</td>
</tr>
<tr>
<td>Michigan</td>
<td>11</td>
<td>178,000</td>
</tr>
</tbody>
</table>


Table 6.2.

Percentages of Farms Producing Selected Crops and Livestock In Ohio and Michigan, 1982

<table>
<thead>
<tr>
<th>CROPS</th>
<th>OHIO</th>
<th>MICHIGAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn for seed and grain</td>
<td>60.6</td>
<td>52.5</td>
</tr>
<tr>
<td>Wheat for grain</td>
<td>37.6</td>
<td>26.3</td>
</tr>
<tr>
<td>Soybeans for beans</td>
<td>44.9</td>
<td>25.4</td>
</tr>
<tr>
<td>Oats for grain</td>
<td>21.0</td>
<td>----</td>
</tr>
<tr>
<td>Vegetable harvested for sale</td>
<td>2.8</td>
<td>6.2</td>
</tr>
<tr>
<td>Dry edible beans (excluding dry timess)</td>
<td>----</td>
<td>10.0</td>
</tr>
</tbody>
</table>

Table 6.3.

Total Marketing Receipts From Agriculture, National Ranking and Principal Commodities Underlying Sales* in Ohio and Michigan, 1984

<table>
<thead>
<tr>
<th>State</th>
<th>Amount of Sales</th>
<th>National Rank</th>
<th>Principal Commodities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohio</td>
<td>$3,611,000,000</td>
<td>13</td>
<td>Soybeans, Dairy Products, Corn, Hogs</td>
</tr>
<tr>
<td>Michigan</td>
<td>$2,777,000,000</td>
<td>20</td>
<td>Dairy Products, Corn, Cattle, Soybeans</td>
</tr>
</tbody>
</table>

*Commodities are ordered by contribution to sales.

Michigan ranked twentieth nationally with over $2.7 billion worth of agricultural products sold. The bulk of these sales were accounted for by dairy products, corn, cattle and soybeans.

A closer examination of these principal income-producing commodities provides further insight into the positioning of Ohio and Michigan agriculture within the national agricultural system. In respect to their primary income-producing cash grains, Ohio ranked sixth in nationwide corn production in 1984 while Michigan ranked eighth. In soybean production in 1984, Ohio and Michigan were ranked fifth and fifteenth, respectively (see Table 6.4).

Table 6.4.

National Rankings of Ohio and Michigan in Production of Principal Income-Producing Agricultural Commodities, 1984

<table>
<thead>
<tr>
<th></th>
<th>CORN</th>
<th>SOYBEANS</th>
<th>WHOLE MILK</th>
<th>CATTLE</th>
<th>HOGS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Million</td>
<td>Million</td>
<td>Lbs. Sold</td>
<td>Millions</td>
<td>Rank</td>
</tr>
<tr>
<td>OHIO</td>
<td>Rank</td>
<td>Bushels</td>
<td>Rank</td>
<td>Bushels</td>
<td>Rank</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>420</td>
<td>138</td>
<td>7</td>
<td>4,695</td>
</tr>
<tr>
<td>MICHIGAN</td>
<td>8</td>
<td>220</td>
<td>32</td>
<td>5</td>
<td>5,230</td>
</tr>
</tbody>
</table>

In dairy production, Michigan ranked sixth in national sales of whole milk in 1984 and Ohio ranked seventh. While cattle is an important source of agricultural income in Michigan, it is not a substantial producer when considered on a nationwide basis. Michigan ranked twenty-eighth in total cattle production in 1984. Finally, Ohio is a relatively important producer of hogs as it ranked eighth in national hog production in 1984.

When considered collectively these data indicate that the two states comprising the study area are relatively important components of the corn and dairy production systems in United States agriculture. Individually, Ohio agriculture is a relatively important component of the soybean and pork production systems while Michigan agriculture is a moderate contributor to the soybean and cattle production systems.

Agriculture in both Ohio and Michigan is typified by the forces of structural change that were discussed in chapter three. Both states have experienced declines in farm population and total number of farms (see Table 6.5).

Table 6.5.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Farm Population</strong> (In Thousands)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio</td>
<td>1,089</td>
<td>853</td>
<td>581</td>
<td>415</td>
<td>272</td>
<td>-75.0</td>
</tr>
<tr>
<td>Michigan</td>
<td>871</td>
<td>695</td>
<td>486</td>
<td>305</td>
<td>178</td>
<td>-79.6</td>
</tr>
<tr>
<td><strong>Number of Farms</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohio</td>
<td>220,575</td>
<td>177,074</td>
<td>140,353</td>
<td>111,332</td>
<td>89,131</td>
<td>66,934</td>
</tr>
<tr>
<td>Michigan</td>
<td>175,268</td>
<td>138,922</td>
<td>111,817</td>
<td>77,948</td>
<td>60,426</td>
<td>58,661</td>
</tr>
</tbody>
</table>

Ohio experienced a 75 percent decrease in farm population from 1940 to 1980 and 60.6% decline in total number of farms from 1945 to 1982. Correspondingly, Michigan sustained a 79.6 percent loss in farm population and a 66.5 percent decrease in farms.

The forces of consolidation that characterize the larger agricultural system were also operative within the study area. The average farm size in both Ohio and Michigan has steadily increased since the post World War II period (see Table 6.6). From 1945 to 1982, the average farm size increased 78.8 percent in Ohio and 78.1 percent in Michigan.

Table 6.6.
Changes in Average Farm Size in Ohio and Michigan, 1945-1982 (in acres)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>OHIO</td>
<td>99</td>
<td>113</td>
<td>132</td>
<td>154</td>
<td>177</td>
<td>177</td>
<td>+78.8</td>
</tr>
<tr>
<td>MICHIGAN</td>
<td>105</td>
<td>119</td>
<td>132</td>
<td>153</td>
<td>183</td>
<td>187</td>
<td>+78.8</td>
</tr>
</tbody>
</table>


These data indicate that the structure of agriculture within the study area is characterized by a declining farm population, a decreasing number of farms, and an increasing average farm size. It is within the context of these forces of structural change that characterize industrialized agricultural production that information technology is being integrated into the technical basis of agriculture.

Identification of Survey Population

The "theoretical" population (Babbie, 1975:142) for the study consists of all farm operations in Ohio and Michigan with experience in using agricultural videotex systems. The theoretical population could not be used in the study because all farm operations within the study area with such experience could not be identified given available
information sources.

A partial identification was accomplished through the arrangement with the Ohio and Michigan Farm Bureau Federations who agreed to provide a sampling frame of farm operations who had experience in utilizing their ACRES videotex system. Thus, the survey population, in contrast to the theoretical population, consisted of all farm operators in Ohio and Michigan with experience in using the ACRES videotex system. The degree of deviation between the survey population and the theoretical population is dependent upon the number of farm operations in the study area with experience in using alternative agricultural videotex systems with outreach to the study area. At the time of data collection, AGRIDATA, INSTANT UPDATE and GRASSROOTS all had market outreach in Ohio and Michigan. Due to the proprietary nature of the information, the private sector firms operating these systems would not release the names or number of their subscribers within the study area. Therefore, the degree of deviation between the theoretical and survey populations cannot be precisely established.

An important factor influencing the composition of the survey population is that the use of ACRES presupposes that the user is a member of the Ohio or Michigan Farm Bureau Federation. This represents a potentially significant institutional factor influencing the adoption of videotex within the study area. That is, the use of ACRES is restricted to the segment of the farm sectors in Ohio and Michigan who identify with the political, economic and social goals of the American Farm Bureau Federation and/or are willing to pay membership dues. As an agricultural cooperative, the Farm Bureau has traditionally consisted of "above average, more prosperous" farmers (McConnell, 1977:150). This is a factor that must be considered when making generalizations from data derived from a sample whose composition is restricted by this institutional constraint.
Sample Design and Sample Selection

At the time of sample selection, only a minute proportion of farm operations within the study area were utilizing the ACRES videotex system. In total, only 295 out of approximately 140,000 farm operations within the study area were subscribing to ACRES. However, 106 farm operators were identified who had previously utilized ACRES but had cancelled their subscription. The names and addresses of the 295 current ACRES users and the 106 ex-ACRES users were utilized as the survey population. The criterion employed in the selection of farm operations for inclusion in the survey was that ACRES must have been utilized for at least one full year of agricultural production (the 1984 production year). Therefore, it could be reasonably assumed that the farm operations would have had sufficient experience with videotex to have evaluated its costs and benefits for their farm operations. Employing this criterion, the survey population was reduced to 370 farm operators which consisted of 274 current ACRES users and 96 ex-users.

The fact that the survey population was small in absolute number brought into question the desirability of drawing a sample, due to the effects of a small sample size on the level of confidence that can be placed in any sample estimates. The level of confidence that can be placed in sample estimates being representative of population parameters is dependent on the absolute size of the sample. This is demonstrated in the calculation of a confidence interval which statistically portrays the space above and below the sample mean in which the population mean is expected to fall (Abrahamson, 1983:203). Confidence intervals are calculated by the following formula:
Confidence Interval = Standard Error of Sample Estimate \times \text{Confidence Level}

\[ = \frac{s.d. \times Z}{n} \]

Where:

- \(s.d\) = the standard deviation of a sample variable
- \(n\) = the sample size
- \(Z\) = the standardized Z score of the level of confidence desired in a sample estimate (e.g., 95% confidence desired, \(Z = 1.96\))

The denominator of the standard error is the sample size. This indicates that the larger the sample, the smaller the standard error and the smaller the range above and below the sample mean in which the population mean is expected to fall. Therefore, the larger the sample size, the greater the confidence that can be placed in sample estimates reflecting their underlying population parameters (McGaw and Watson, 1976:365).

Finsterbusch (1976:120) shows that the range of a confidence interval decreases substantially as sample size increases to 400 sampling units. After this point, increases in sample size up to 1,000 sampling units will only provide very moderate decreases in the range of a confidence interval (see Table 6.7).

Table 6.7.

<table>
<thead>
<tr>
<th>SAMPLE SIZE</th>
<th>LOWER LIMIT</th>
<th>UPPER LIMIT</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>.09</td>
<td>.49</td>
<td>.41</td>
</tr>
<tr>
<td>40</td>
<td>.13</td>
<td>.41</td>
<td>.29</td>
</tr>
<tr>
<td>100</td>
<td>.17</td>
<td>.35</td>
<td>.18</td>
</tr>
<tr>
<td>400</td>
<td>.21</td>
<td>.30</td>
<td>.08</td>
</tr>
<tr>
<td>1000</td>
<td>.22</td>
<td>.28</td>
<td>.05</td>
</tr>
</tbody>
</table>

Source: Finsterbusch (1976:120); Abrahamson (1983:208)

On the basis of these criteria, it was decided that the total population of all 370 farm operations would be targeted for data collection. If the response rate for data collection was less than 100 percent, the group of respondents would theoretically
represent a sample. A high response rate would maximize the confidence that could be placed in estimates from such a sample, provided that there was no inherent systematic bias underlying nonresponse to the survey.

Instrument Construction

A self-administered questionnaire was selected as the instrument for data collection. The "total design method" (TDM) for mail surveys (Dillman, 1978) was utilized in designing the wording, format, and ordering of all questions in the survey instrument. The TDM emphasizes the utilization of simple, precise wording and the avoidance of typical problems such as question bias, double negatives, and double-barreled questions (see Dillman, 1978:95-118).
Additionally, the TDM emphasizes striking a balance among the following four principles in ordering the questions in the survey instrument:

1. Questions that are likely to be perceived as most important by the respondent are placed first;
2. Questions that are similar in content are grouped in content areas;
3. Content areas should be grouped to promote a sense of flow and continuity to the total survey instrument; and
4. Questions likely to be objectionable to respondents should be placed after less objectionable ones or later in the survey (Dillman, 1978:121-125).

The initial draft of the survey instrument was twelve pages long, contained seventy primary questions, eleven contingency questions and six content areas which were ordered as follows:

A. Characteristics of Use and Level of Satisfaction with ACRES;
B. Characteristics of Farm Operation;
C. Marketing Strategies;
D. Attitudes Toward Computer Technology and New Farming Practices and Products;
E. General Characteristics of the Farm Operator; and
F. Economic Returns from Farming.

The survey instrument was reviewed by graduate committee faculty, several agricultural economists, and agricultural specialists from the Ohio Farm Bureau Federation. This review process enhanced the content validity of survey questions by identifying any obvious problems in the wording and format of questions. The survey instrument was then revised and prepared for pre-testing.
Pre-Testing the Survey Instrument

The survey instrument was pre-tested by a mail survey of the 31 farm operators that were excluded from the survey population based on the criterion that they had not utilized ACRES for one full year of agricultural production. The four underlying goals of the pre-test were to ascertain:

1. The average length of time necessary to complete the survey;
2. Whether the wording of all survey questions was clear and appropriate for farmers;
3. If any survey questions might produce a high nonresponse rate due to its content or wording;
4. Whether the response categories to all close-ended questions were mutually exclusive and exhaustive or needed additional response categories.

These four goals could be met by the pre-test sample despite the fact that they had not used ACRES for one full year of agricultural production. Pre-test respondents were given an evaluation sheet along with the survey that asked them to record the number of minutes it took them to complete the survey and comment on any questions that they felt were unclear, did not have appropriate response categories, or were objectionable due to requesting sensitive information.

A 35 percent response rate was achieved in the pre-test. While this is a relatively low rate of response, the information provided was extremely useful for the further revision of the survey instrument. The pre-test evaluations indicated that the twelve page survey took an average of 23.7 minutes to complete. This was an appropriate length of time according to the TDM criteria (Dillman, 1978:55) and suggested that completing the survey did not make overly excessive demands on respondents' time. The evaluations further indicated that several questions had problems in their response categories and several other questions appeared to be requesting the same information. On the basis of these evaluations, the survey
The revised survey instrument was then re-evaluated by graduate committee faculty and agricultural specialists at the Ohio Farm Bureau Federation which resulted in the final draft. The final survey instrument remained twelve pages long, retained the identical ordering of content areas, but now consisted of 67 primary questions and 13 contingency questions (see Appendix A).

**Research Design**

An unweighted cross-sectional survey design was employed in the study (McGaw and Watson, 1976:345). Due to the limitation of this design in measuring relevant study variables at only one cross-section in time, the analysis of the costs and benefits contributing to social adaptation to videotex in agricultural production is reliant upon ex post facto evaluations.

It is recognized that patterns of social behavior may be temporary and subject to change which cannot be identified using a cross-sectional survey design. However, the ability to measure relevant study variables at one point in time through a cross-sectional design will provide some insight into the nature of the relationships between the costs and benefits of utilizing videotex and social adaptation to videotex in agricultural production within the study area. Such data also provide a base for ex ante assessments of the potential significance of these relationships over time.

**Method of Data Collection**

Data were collected through a mail survey. This method was selected due to the relatively dispersed spatial distribution of the survey population which rendered personal interviews and a telephone survey economically impractical. The mail survey

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60 It is unweighted due to every element in the survey population having an equal chance of being included in the sample.
was implemented using TDM guidelines. These guidelines mandate that the initial mailing of the survey include the questionnaire in an 8-1/4" by 12-1/4" booklet form, a personally signed cover letter (see Appendix B) and a business reply, return envelope (Dillman, 1978:160-180). After the initial mailing, the TDM requires the following sequence:

**One Week:** A post-card reminder is sent to everyone (all respondents). It serves as both a thank you for those who have responded and as a friendly and courteous reminder for those who have not;

**Three Weeks:** A letter and replacement questionnaire is sent only to nonrespondents. Nearly the same in appearance as the original mail out, it has a shorter cover letter that informs nonrespondents that their questionnaire has not been received and appeals for its return;

**Seven Weeks:** This final mailing is similar to the one that preceded it except that it is sent by certified mail to emphasize its importance. Another replacement questionnaire is enclosed (Dillman, 1978:183).

In implementing the mail survey, all steps of the TDM sequence were followed with the exception of the final step of sending a second follow-up mailing via certified mail. This step was omitted due to the high cost of its implementation. Therefore, only one follow-up mailing was sent three weeks after the initial mailing. In place of the final mailing, a reminder notice to return the survey was entered into the data base of the ACRES videotex system. Therefore, any respondents logging onto the system would automatically see the reminder notice. It was reasoned that this technique would be more effective than a certified letter which might be perceived as an annoyance by respondents.

**Response Rate**

Two hundred fifty of the 370 respondents in the survey population returned usable questionnaires. This resulted in an overall response rate of 68 percent (see Table 6.8). A 71 percent response rate was achieved among the current ACRES users while 58 percent of the ex-users returned usable questionnaires. Proportionally, ex-users were
slightly under-represented compared to the survey population. Ex-users made up only
22 percent of the respondents (56/250) while comprising 26 percent (96/370) of the
survey population. The higher response among the current users is partially attribu-
table to the reminder notice that was inserted into the database of the ACRES
videotex system. Ex-users would not have been exposed to this "electronic" reminder.
Former ACRES users who were dissatisfied with their experience would also likely have
less interest in participating in the survey. Given the response rate, the total group
of respondents represents a 68 percent sample of the survey population.

Table 6.8.
Response Rates to Mail Survey by State and Subscription Status

<table>
<thead>
<tr>
<th></th>
<th>Ohio</th>
<th>Michigan</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Stratum (current ACRES users)</td>
<td>71%</td>
<td>70%</td>
<td>71%</td>
</tr>
<tr>
<td></td>
<td>(82/115)</td>
<td>(112/159)</td>
<td>(194/274)</td>
</tr>
<tr>
<td>Second Stratum (ex-ACRES users)</td>
<td>66%</td>
<td>52%</td>
<td>58%</td>
</tr>
<tr>
<td></td>
<td>(29/44)</td>
<td>(27/52)</td>
<td>(56/96)</td>
</tr>
<tr>
<td>Total</td>
<td>70%</td>
<td>66%</td>
<td>68%</td>
</tr>
<tr>
<td></td>
<td>(111/159)</td>
<td>(139/211)</td>
<td>(250/370)</td>
</tr>
</tbody>
</table>

On a statewide basis, Ohio respondents had a response rate of 70 percent
compared to a 66 percent rate for Michigan respondents. However, the Michigan
segment had a larger absolute number of current ACRES users than that of Ohio (112
compared to 82).

Sample Characteristics

The farm structural characteristics of the sample were compared with those of the
1982 Census of Agriculture for the two state area in order to gain insight into how
farm operations utilizing the ACRES videotex service correspond to the total
agricultural industries in each state. The average farm size for both the Ohio and Michigan segments of the sample was found to be much larger than the average farm size in each state (see Table 6.9).

The mean farm size in the Ohio and Michigan segments of the sample is 828.6 and 1061.9 acres compared to their respective state means of 177 and 187 acres. Farms of 500 acres or more accounted for 69.7 percent of the Ohio portion of the sample and 81.2 percent of the Michigan portion. In contrast, farms of this size accounted for only 7.5 percent and 8.1 percent of all farms in their respective states in 1982. Further, 75.5 percent of the Ohio portion and 89.8 percent of the Michigan portion had gross farm incomes over $100,000. Only 10.1 percent and 11.3 percent of all farms in each state had this magnitude of sales in 1982. These data indicate that farms utilizing the ACRES videotex system within the study area tend to be the larger, well-financed farm operations of each state's farm sector.
Table 6.9.
A Comparison of the Farm Structural Characteristics of the Study Sample and the 1982 Census of Agriculture for Ohio and Michigan

<table>
<thead>
<tr>
<th></th>
<th>MICHIGAN 1982 Census</th>
<th>Sample Date</th>
<th>OHIO 1982 Census</th>
<th>Sample Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farms by Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-9 acres</td>
<td>4.6</td>
<td>0.0</td>
<td>7.2</td>
<td>0.0</td>
</tr>
<tr>
<td>10 to 49 acres</td>
<td>24.4</td>
<td>0.0</td>
<td>21.6</td>
<td>0.0</td>
</tr>
<tr>
<td>50 to 179 acres</td>
<td>39.8</td>
<td>3.6</td>
<td>41.4</td>
<td>1.9</td>
</tr>
<tr>
<td>80 to 499 acres</td>
<td>23.1</td>
<td>15.2</td>
<td>22.3</td>
<td>28.4</td>
</tr>
<tr>
<td>500 to 999 acres</td>
<td>6.3</td>
<td>40.6</td>
<td>5.9</td>
<td>37.6</td>
</tr>
<tr>
<td>1,000 to 1,999 acres</td>
<td>1.6</td>
<td>32.6</td>
<td>1.4</td>
<td>26.6</td>
</tr>
<tr>
<td>2,000 acres or more</td>
<td>0.2</td>
<td>8.0</td>
<td>0.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Average Farm Size</td>
<td>187.0</td>
<td>1061.9</td>
<td>177.0</td>
<td>828.6</td>
</tr>
<tr>
<td>Gross Farm Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$2,500 or less</td>
<td>23.4</td>
<td>0.0</td>
<td>21.9</td>
<td>0.0</td>
</tr>
<tr>
<td>$2,500 to $9,999</td>
<td>28.1</td>
<td>0.0</td>
<td>27.8</td>
<td>0.0</td>
</tr>
<tr>
<td>$10,000 to $39,000</td>
<td>24.9</td>
<td>1.5</td>
<td>26.4</td>
<td>4.7</td>
</tr>
<tr>
<td>$40,000 to $99,999</td>
<td>12.3</td>
<td>8.6</td>
<td>13.7</td>
<td>19.6</td>
</tr>
<tr>
<td>$100,000 to $199,999</td>
<td>6.7</td>
<td>28.5</td>
<td>6.7</td>
<td>29.9</td>
</tr>
<tr>
<td>$200,000 to $499,999</td>
<td>3.8</td>
<td>39.4</td>
<td>2.9</td>
<td>32.7</td>
</tr>
<tr>
<td>$500,000 or more</td>
<td>0.8</td>
<td>21.9</td>
<td>0.5</td>
<td>13.1</td>
</tr>
<tr>
<td>% of Farms Using Full-Time Hired Labor*</td>
<td>12.7</td>
<td>60.0</td>
<td>9.4</td>
<td>39.4</td>
</tr>
<tr>
<td>Tenure of Operator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Owners</td>
<td>60.5</td>
<td>8.8</td>
<td>59.5</td>
<td>6.4</td>
</tr>
<tr>
<td>Part Owners</td>
<td>33.3</td>
<td>87.6</td>
<td>29.2</td>
<td>87.2</td>
</tr>
<tr>
<td>Tenants</td>
<td>6.2</td>
<td>3.6</td>
<td>11.3</td>
<td>6.4</td>
</tr>
<tr>
<td>Farming Status*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full Time</td>
<td>51.3</td>
<td>88.5</td>
<td>49.7</td>
<td>83.5</td>
</tr>
<tr>
<td>Part Time</td>
<td>48.7</td>
<td>11.5</td>
<td>50.3</td>
<td>16.2</td>
</tr>
</tbody>
</table>

* Both of these indicators were measured in the survey using different definitions than those used in the Census of Agriculture. Full time hired labor in the survey was defined as a worker employed 200 days or more while the Census of Agriculture definition was 150 or more days of employment. A part time farm operator in the survey was defined as a farm operator who is employed 100 or more days in off-farm employment while the Census of Agriculture definition was 50% or more of labor time spent in off-farm employment. Thus the sample figures for the percentage of full time labor is possibly underestimated while the percentage of part time farmers may be overestimated compared to the census distributions.
Further indicators of financial scale are found in the data on tenure and use of hired labor. The vast majority of sample rents additional land for production as 87.2 percent of the Ohio portion and 87.6 percent of the Michigan portion are part owners of the land they use in production. In addition, 39.5 percent of the Ohio sample portion and 60 percent of the Michigan portion utilize full time hired labor in agricultural production. Both of these indicators suggest that the farm operations utilizing ACRES require greater amounts of financial capital.

Full time farm operators who depend upon farming as their primary source of income accounted for 83.5 percent of the Ohio portion of the sample and 88.5 percent of the Michigan portion. Thus, very few part time farm operators within the study area have likely adopted videotex as a technology for information acquisition and management.

The information management attributes of the sample indicate that farm operators with experience in using ACRES tend to be information intensive in their farm management practices. Farm operations within the sample tended to use a number of information sources in combination that involved both social interaction with off-farm organizations and the use of mass media. Consultation with buyers of agricultural commodities was the most popular information source involving social interaction and was used by 57.5 percent of the total sample (see Table 6.10). The most popular mass media source was farm magazines, used by 75.3 percent of the sample. This was followed by the use of commercial newsletters (e.g., Doane’s, Pro-Farmer) and radio, which was used by 68 percent and 63.9 percent of the sample, respectively.
These data indicate that the ACRES videotex system is being used to augment, rather than completely replace other sources of agricultural information. Farm operations within the sample used an average of 4.3 sources of agricultural information excluding ACRES. These findings are consistent with other studies concerning the information management attributes of users of agricultural videotex and teletext systems (see Abbot, 1986:6-8; Gonzalez et al. 1985; Paisley, 1983:158).

Most users of ACRES tend to access the videotex service frequently as 52.5 percent of all current ACRES users were found to use the videotex service at least once a day (see Table 6.11). Further, an additional 30.8 percent accessed ACRES several times a week. These data indicate the utilization of videotex tends to be a frequent information management activity within the farm operations that subscribe to the ACRES service.
Table 6.11.

Frequency of Videotex Use Among ACRES Users
(Percent distribution)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Several times a day</td>
<td>14.1</td>
</tr>
<tr>
<td>Once a day</td>
<td>38.4</td>
</tr>
<tr>
<td>Several times a week</td>
<td>30.8</td>
</tr>
<tr>
<td>Once a week</td>
<td>8.6</td>
</tr>
<tr>
<td>Several times a month</td>
<td>3.2</td>
</tr>
<tr>
<td>Once a month</td>
<td>1.6</td>
</tr>
<tr>
<td>Several times a year</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Both market and weather information were perceived as important inputs to the farm operations within the sample. In total, 77.5 percent of the sample perceived market information as a very important input to their farm operations while 52.4 percent perceived weather information as a very important farm input (see Table 6.12). Overall, 98 percent of the sample perceived market information as being at least a somewhat important input to their farm operations while 89.9 percent perceived weather information as being at least a somewhat important farm input.
Table 6.12.
Perceived Importance of Market and Weather Information as Farm Inputs (percent distribution)

<table>
<thead>
<tr>
<th>Information Type</th>
<th>Perceived Importance</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>Very Important</td>
<td>77.5</td>
</tr>
<tr>
<td></td>
<td>Somewhat Important</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td>Of Little Importance</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Not Important</td>
<td>0.4</td>
</tr>
<tr>
<td>Weather</td>
<td>Very Important</td>
<td>52.4</td>
</tr>
<tr>
<td></td>
<td>Somewhat Important</td>
<td>37.5</td>
</tr>
<tr>
<td></td>
<td>Of Little Importance</td>
<td>8.9</td>
</tr>
<tr>
<td></td>
<td>Not Important</td>
<td>1.2</td>
</tr>
</tbody>
</table>

In sum, farm operators within the study area with experience in using the ACRES videotex service tend to operate large, well-financed farms and depend upon farming as their primary source of income. Further, they tend to be information intensive in their management practices as they tend to consult a number of sources of agricultural information and perceive market and weather information as important farm inputs. The sample data indicates that the early adoption of videotex within the study area has been primarily restricted to the upper stratum of large farm operations that employ information intensive management practices. Agricultural videotex systems are not being used extensively within the study area by smaller farm operations, regardless of the intensity of their information management practices. This suggests that any economic benefits from videotex technology will be restricted to large farm operations within the study area.
Testing for Nonresponse Bias

In order to ascertain whether the 68 percent sample was representative of the survey population, selected characteristics of survey respondents were compared with those of nonrespondents to determine whether there was any systematic bias inherent in the sample. Such a comparison provides an indication of whether confidence can be placed in sample estimates being approximately representative of population parameters or whether they will be systematically biased due to a particular segment of the survey population not responding to the survey. The amount of bias is dependent upon the proportion of nonresponse and the difference between the means of relevant variables for the response and nonresponse groups (Cochran, 1977:361).

Due to the general difficulty in obtaining information about nonrespondents, data on only a portion of the nonresponse group could be procured. Data were obtained on 34 out of the 120 nonrespondents (28 percent) which were all from the Ohio portion of the sample. Therefore, only the response and nonresponse groups from the Ohio portion of the survey population could be compared. While not allowing a complete determination of the absence or presence of nonresponse bias in the sample, such a comparison would provide an indication of whether this problem might be present.

The response and nonresponse groups of the Ohio portion of the sample were compared on three farm structural characteristics: farming status, acres farmed, and gross farm sales in 1984.\(^70\) A two-tailed, t-test (Blalock, 1979:228) was utilized to test

\(^{70}\)Farming status was measured on a nominal basis with full time and part time farming status categories being treated as separate dummy variables. Acres farmed, and gross farm sales were all measured on an ordinal basis using the following ranked categories:

(a) acres farmed - (1) 50 (2) 50-99 (3) 100-259 (4) 260-499 (5) 500-999 (6) 1000
(b) gross farm sales - (1) $2,500 (2) $2,500 to $4,999 (3) $5,000 to $9,999 (4) $10,000 to $19,999 (5) $20,000 to $39,999 (6) $40,000.
the differences of the means of the three farm structural indicators for the response and nonresponse groups. This would provide an indication of whether the nonresponse group of the Ohio portion of the sample significantly deviated from the response group on the three farm structural characteristics. Significantly different means would suggest the possibility of systematic bias in the sample data.

Using the .05 level of significance as the criterion by which to reject the null hypotheses, the t-tests revealed that there were no significant difference between the two groups relative to the three farm structural characteristics (see Table 6.13). Since the proportion of part time farm operators in each group was dependent upon the corresponding proportion of full time farm operators, it was not necessary to conduct a t-test between the former set of proportions because the resulting t-value would be the inverse of that for the latter set (t=1.28 instead of -1.28).

Table 6.13.

<table>
<thead>
<tr>
<th>Results of Two-Tailed, T-Tests, Between the Response and Nonresponse Groups of the Ohio Sample on Selected Farm Structural Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Response Group</strong></td>
</tr>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>Proportion of Full Time Farm Operators</td>
</tr>
<tr>
<td>Acres Farmed</td>
</tr>
<tr>
<td>Gross Farm Sales</td>
</tr>
</tbody>
</table>
The nonresponse group was found to have a slightly greater proportion of full time farmers, a larger average farm size and a slightly smaller average volume of gross farm sales. However, these differences were not significant. These findings suggest that for the Ohio portion of sample, there is a low probability of nonresponse bias in relation to the structure of the farm operations comprising the Ohio portion of the survey population.

Because data were not available on the nonresponse group of the Michigan segment of the sample, the potential of nonresponse bias being present in the sample cannot be entirely ruled out. However, given that the Ohio segment of the sample subsumes 44 percent of the total sample, there is a high probability that this sample proportion is representative of the survey population in relation to farm structure.

While the structure of the agricultural industries in Ohio and Michigan are similar in many respects, inferences about the similarity of the nonresponse stratum of the Michigan segment of the sample compared to the remaining portion of the survey population cannot be drawn since the survey population represents such a minute proportion of the farm population in the study area. However, since the ACRES videotex information service is a relatively high cost input (approximately $1,000 or more per annum), it is likely that the Michigan nonresponse group consists of well financed farm operations and is similar at least in relation to gross farm sales.

Despite the lack of complete information on the total nonresponse group in the sample, the lack of nonresponse bias within the Ohio portion of the sample reduces the probability of nonresponse bias in the total sample. This heightens the confidence that can be placed in the representativeness of sample estimates.
Measurement of Cost/Benefit Variables

Social adaptation to agricultural videotex systems was treated as a dummy variable with 1 representing adaptation and 0 representing nonadaptation. Respondents were assigned a value on this variable based upon their subscription status. It was assumed that respondents who had utilized ACRES for one full year of agricultural production and had continued to use it as the time of data collection had socially adapted to videotex since they continued to allocate economic and human resources for its use. Conversely, it was assumed that respondents who had discontinued use of ACRES by the time of data collection had not socially adapted to videotex.

It is recognized that many of the specified cost and benefits associated with the use of agricultural videotex systems have an underlying interval level measurement, e.g., minutes saved in collecting agricultural information or income gained from realizing higher prices for agricultural commodities. However, it was reasoned that attempting to measure these factors at the interval level would result in the problem of proposing questions that are too demanding of respondents (see Dillman, 1978:108). Thus, respondents would likely have difficulty in providing precise values to questions designed for such measurement which would promote measurement error. Moreover, given that the method of data collection is a self-administered questionnaire, proposing questions that are too demanding could additionally elicit a higher rate of nonresponse.

Since it can be more reasonably assumed that respondents would know whether or not they had realized a particular cost or benefit from utilizing agricultural videotex, all cost/benefit factors were measured nominally by yes/no response categories. Therefore, the measures are "perceptual" in nature rather than direct measures of costs and benefits. Cost factors were measured by asking respondents whether: (a) the subscription costs of ACRES are too high for the benefits received from using it; taking the time to learn to use a computer to access ACRES was an inconvenience; and
(C) taking the time out of the day to access ACRES disrupts their work routine (see questions A-17, A-19 and A-20 in appendix A). It is assumed that these questions are reflective of the costs of using agricultural videotex systems, i.e., the price of subscribing to ACRES, acquiring the technical skills necessary to use microcomputers and the potential reorganization of work activities necessary to use videotex. Responses to these questions were treated as dummy variables with 1 representing "yes" and 0 representing "no". A positive response to any of these questions was deemed indicative of the perceived failure to internalize a particular cost.

Benefits were measured by asking respondents whether they perceived that their use of ACRES allowed: (a) a reduction in labor time in collecting agricultural information; (b) the more effective scheduling of farm activities; (c) the realization of higher prices for agricultural commodities; (d) the realization of better financial investments; and (e) a reduction of agricultural information sources (see questions A-12, A-14, A-15, A-16 and A-21 in appendix A). Responses to these questions were treated as dummy variables with 1 representing "yes" and 0 representing "no". A positive response was deemed indicative of the perceived realization of a particular benefit.

The decision to measure these factors at the nominal level was based on the assumption that such measurement would result in less measurement error and a higher rate of response, albeit at the cost of less precision in the scale of measurement. Given the small size of the survey population, the necessity of maximizing the rate of response and the method of data collection, this was deemed a reasonable exchange. An additional significant factor was that the ability to test hypotheses would not be diminished due to the availability of appropriate statistical techniques for variables measured at the nominal level.
**Statement of Hypotheses**

It is hypothesized that all cost variables will be significantly related to social adaption to agricultural videotex systems. It is additionally hypothesized that these relationships will be negative in direction. The perceived failure to internalize a particular cost of agricultural videotex should decrease the probability of social adaptation to agricultural videotex systems.

It is hypothesized that all benefit variables will be significantly related to social adaptation to agricultural videotex systems. It is additionally hypothesized that these relationships will be positive in direction. The perceived realization of a particular benefit should increase the probability of social adaptation to agricultural videotex systems.

**Data Analysis**

The hypotheses were tested using multivariate logistic regression analysis. Adaptation/nonadaptation to agricultural videotex systems was treated as the dependent variable and regressed on all perceived cost/benefit factors. Logistic regression analysis is an appropriate statistical technique for dichotomous dependent variables and estimates the probability that an individual case will make a specific choice (in this case, continue to use videotex) given knowledge of a single or set of independent variables (Pindyck and Rubinfeld, 1981:287).

Multivariate logistic regression analysis was deemed an appropriate statistical technique for testing the hypotheses because it: (a) would estimate probabilities of individual farm operations socially adapting to videotex given different combinations of cost/benefit factors; (b) would calculate parameter estimates to assess the significance and relative contribution of each cost/benefit factor in influencing the probability of social adaptation to videotex; and (c) would test the overall goodness of fit of the cost/benefit model. This would provide an indication of the models theoretical utility.
in explaining the process of social adaptation to videotex in agricultural production.

Logistic regression (also known as logit) provides a viable alternative to ordinary least squares (OLS) regression analysis in cases when the dependent variable is a dichotomous measure. While its extensive popularity within the social sciences makes OLS regression the most appealing statistical technique to use, the use of this technique with a dichotomous dependent variable inherently involves the violation of several of its underlying assumptions.

By restricting the range of values of the dependent variable in OLS regression to 0 to 1, the assumption that the dependent variable must be a continuous measure is obviously violated. This restricted range of values means that in solving the regression equation \( Y = a + bx + u \), the predicted value of the dependent variable \( P(Y) \) is interpreted as the probability that an individual case will have an observed value of 1 on the dependent variable. The restricted range of the dependent variable inherently involves the violation of the assumption that the error term \( u \) must be homoscedastic or exhibit constant variance across all values of the independent variable \( x \) for all observations.

Observation in which \( P(Y) \) is close to 0 or 1 will have relatively low variances in relation to \( u \) while observation with \( P(Y) \) closer to .50 will have higher variances (Pindyck and Rubinfeld, 1981:276). Therefore, \( u \) will inherently be heteroscedastic which results in a loss of efficiency of the parameter estimate \( b \). An additional outcome of this problem is that estimates of sampling variances will not be correct and any significance tests or confidence intervals calculated for the parameter estimate \( b \) based on these sampling variances will not be valid (Aldrich and Nelson, 1984:13-14).

An additional problem arising from using OLS regression with a dichotomous dependent variable is that the potential exists for individual cases to have predicted
values of the dependent variable (P(Y)) outside the 0-1 range. This occurs because the range of observed values of the independent variable (x) is not restricted. For example, the regression model associates a probability of 1 with all extreme, larger values of x no matter what their differences in absolute magnitude. If the sample data contains a larger number of cases with extreme values of x (large or small), not only can predicted probabilities fall outside the 0-1 range, but also the potential exists for biased slope estimates that are either overestimated or underestimated, depending on the joint distribution of y and x (see Pindyck and Rubinfeld, 1981:277-278).

One means of overcoming these problems is to transform the original model in such a manner that P(Y) will fall between the 0-1 range for all values of X. Further, since the dependent variable is interpreted as the probability of an individual case making a specific choice, the concept of probability should be utilized as the basis of this transformation (Pindyck and Rubinfeld, 1981:280). One means of accomplishing such a transformation is through the use of the cumulative logistic probability function which is the underlying basis of logistic regression analysis.

The transformation to a logistic regression model involves two primary steps that eliminate the constraints of the OLS regression model with a dichotomous dependent variable. The first step is the transformation of the dependent variable from a predicted probability between 0 and 1 to the ratio Pi/(1-Pi) where Pi=P(Y=1). This eliminates the constraint that Pi must be less than or equal to 1. The next step is the transformation of both sides of the regression equation into a natural logarithmic base. This transforms the observed values of the independent variable (x) into a

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71 A proposed solution to this problem is to truncate values of P(Y) outside the 0-1 range to values close to 0 and 1 such as .001 and .999. However, this clearly results in biased predictions.

72 The base of natural logarithms is approximately equal to 2.718 infinity (Aldrich and Nelson, 1984:31-32). In effect, the transformed dependent variable in the logistic regression model is simply the logarithm of the odds that a particular choice will be made.
probability ranging from 0 to 1 while the dependent variable becomes \( \log \left( \frac{\pi}{1-\pi} \right) \). This eliminates the constraint the \( \pi \) may not be any real number from negative to positive.

By itself, the ratio \( \log \left( \frac{\pi}{1-\pi} \right) \) is not interpretable in an intuitively appealing manner. Through the use of antilogarithms and algebraic manipulation, the ratio can be transformed back into a probability with a value ranging between 0 to 1. This is accomplished through the following formula:

\[
\pi = \frac{1}{1 + e^{-(a+bx)}}
\]

Where:

- \( e \) = the antilogarithm of the inverse of the predicted value of the dependent variable.

\( \pi \) is interpreted as the probability that an individual case will have an observed value of 1 on the dependent variable. In effect, logistic regression is one means of overcoming the inherent problems associated with the use of an OLS regression model with a dichotomous dependent variable while providing a predicted probability that satisfies the 0-1 constraint.

An additional advantage of selecting the logit model over OLS regression is that its assumptions are comparatively much less stringent. The assumptions are as follows:

1. \( Y \in [0, 1], i = 1, ..., N \)
2. \( P(y = 1) = \frac{1}{1 + e^{-(a+bx)}} \)
3. \( Y_1, Y_2, ..., Y_n \) are statistically independent
4. No exact or mean linear dependencies exist among the independent variables (Aldrich and Nelson, 1984:49; Pindyck and Rubinfeld, 1981:287).

The first assumption is that the dependent variable must take on only two values, 0 or 1, across all cases. The second assumption refers to the concept of "specification" which has several underlying dimensions. First, it is assumed that all
relevant independent variables are included in the model and the probability of an individual case having an observed value of 1 on the dependent variable is a function of these relevant independent variables that have been transformed from a natural logarithmic base as was previously discussed.

A second dimension of specification refers to the nature of the relationship that is assumed to exist between the dependent and independent variable(s). Unlike the OLS regression model which assumes that a linear relationship exists between the dependent variable (y) and the independent variable (x), the logistic regression model assumes that a nonlinear relationship exists between y and x. The trace line portraying this relationship takes the form of the logistic curve (sigmoid) which assumes that $P(Y=1)$ will increase only slightly for low and high values of $x$ while increasing substantially for middle range values of $x$.

The third assumption of the logistic regression model is that all observations on the dependent variable must be statistically independent. That is, the observed value of the dependent variable for any case must not be a function of, or determined by, the observed values of the dependent variable for any other cases. The fourth assumption is that there must not be a severe multicollinearity problem among the independent variables if a multivariate model is specified.

**Testing the Assumptions**

Since logistic regression was selected as the method of data analysis, it is important to examine whether the sample data meet the assumptions of the statistic in order to determine whether the outcome of the analysis is likely to be statistically sound. The first assumption is easily met since the dependent variable is a dichotomous measure with 1 representing social adaptation to agricultural videotex and 0 representing nonadaptation. All cases in the sample were assigned a value of 1 or 0 depending upon their behavioral choice.
It is extremely difficult to determine whether the second assumption has been met by the sample data. In most cases, it is never known whether all relevant variables have been specified for inclusion in the model until after the analysis has been conducted. The desire to construct parsimonious models that are easily interpretable usually results in the actual value of the error term being greater than zero. Since this particular research problem has not hitherto been examined, relevant variables have not been identified through previous research. Therefore, the logistic regression analysis is primarily exploratory with the goal of: (a) unveiling significant cost/benefit factors contributing to social adaptation to videotex in agricultural production; and (b) testing the validity of the cost/benefit model.

There is a high probability that the sample data meet the third assumption of the logistic regression model. The major proportion of sample observations on the dependent variable are likely to be statistically independent. It is possible that a proportion of the farm operators in the sample may communicate with one another which could have influenced their decisions regarding the use of videotex. However, given the spatial dispersion of the farm operations in the sample over a two state area, it is highly unlikely that a large proportion the sample has communicated with one another regarding their experiences with videotex. Therefore, any confounding effects are likely to be minimal.

Since the cost/benefit model is a multivariate model, the final assumption that there must not be any extreme multicollinearity among the independent variables is applicable. Therefore, bivariate correlations between all independent variables were calculated to assess the degree of multicollinearity. Using Phi\(^7\) as a measure of

---

\(^{7}\)Phi is utilized in 2 x 2 contingency tables and ranges from 0 to 1 with 0 indicating statistical independence and 1 strict perfect association. Phi is calculated by taking the square root of the Chi-square value divided by the sample size (see Reynolds, 1977:27).
strength of association, it was found that there was no extreme multicollinearity among the independent variables (see Table 6.14).

The strongest correlation between any pair of independent variables was .459 which is moderate in magnitude. All other correlations were found to be relatively weak. The lack of strong correlations among the set of independent variables suggests that the fourth assumption of the logistic regression model is not severely violated by the sample data. Therefore, parameter estimates should not be severely attenuated due to multicollinearity.

Estimation of the Logistic Regression Model

Parameters for the logistic regression model are generally estimated through the method of Maximum Likelihood Estimation (MLE) instead of Least Squares Estimation (LSE). The fundamental difference underlying these two methods of estimation is their contrasting theoretical objectives. The goal of LSE is to find parameter estimates that minimize the sum of squared differences between the observed and predicted values of the dependent variable over all N cases. In contrast, the objective of MLE is to find parameter estimates that imply the highest probability or maximize the likelihood that the distribution of the dependent variable in the sample would have been obtained. MLE is generally selected over LSE in the logistic regression model due to the more desirable statistical properties of MLE parameter estimates.

Parameters estimated for the logistic regression model through LSE are inefficient in addition to being nonlinear due to the use of the cumulative logistic probability function (Aldrich and Nelson, 1984:88). Parameters estimated through MLE are also nonlinear, but exhibit the asymptotic attributes of efficiency, unbiasedness and normality (Aldrich and Nelson, 1984:53; Pindyck and Rubinfeld, 1981:311).

Further, these properties have been found to hold true in smaller samples satisfying the condition of N-K=100, where N is the sample size and K is the number of
Table 6.14.

<table>
<thead>
<tr>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>X4</th>
<th>X5</th>
<th>X6</th>
<th>X7</th>
<th>X8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
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<td>.459</td>
<td>.308</td>
<td>.286</td>
<td>.297</td>
<td>.097</td>
<td>.189</td>
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<td>.293</td>
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<td>.220</td>
<td>.042</td>
<td>.129</td>
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<td></td>
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<td>.233</td>
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<td>.047</td>
<td>.113</td>
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<td></td>
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<td>.007</td>
<td>.021</td>
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<td>.045</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td>.103</td>
</tr>
</tbody>
</table>

Where:

X1 = The reduction of labor time in acquiring agricultural information
X2 = More effective scheduling of farm activities
X3 = The realization of higher prices for agricultural commodities
X4 = The realization of better financial investments
X5 = The reduction of agricultural information sources
X6 = Subscription costs of ACRES are too high for benefits received
X7 = Learning to use a computer to access ACRES was an inconvenience
X8 = Taking time out of work day to access ACRES disrupts work routine
parameters to be estimated (Aldrich and Nelson, 1984:53). Due to these underlying reasons, MLE was selected as the technique for estimating the parameters in the logistic regression analysis.

The cost/benefit model was tested through the SAS LOGIST software program which calculates a logistic regression model using the MLE technique. The LOGIST program provides all the statistical information necessary for testing the hypotheses. However, instead of using the standard t-statistic\textsuperscript{74} for testing the null hypothesis that a parameter is zero, LOGIST uses a maximum likelihood Chi-square statistic which is calculated through the following formula:

\[ \chi^2 = \left( \frac{b}{se} \right)^2 \]

Where:

- \( b \) = the MLE parameter estimate
- \( se \) = the standard error of the parameter estimate.

LOGIST also calculates a partial r coefficient for each parameter estimate which is similar to a partial correlation coefficient. These coefficients can be used to assess the relative contribution of each independent variable in influencing \( P(Y=1) \) regardless of sample size (F. Harrell, 1986:271).

In order to test the overall goodness of fit of the model, LOGIST calculates a likelihood ratio Chi-square statistic which tests the joint hypothesis that all parameter estimates except the intercept are zero. This is calculated through the following formula:

\[ C = 2(\log L_0 - \log L_1) \]

Where:

- \( L_0 \) = the maximum value of the likelihood function if all parameters except the intercept are zero.
- \( L_1 \) = the value of likelihood function for the full model as fitted.

\textsuperscript{74}The t-statistic, also known as the t-ratio, is calculated by dividing the parameter estimate by its standard error.
While not provided by the LOGIST program, several other indicators of goodness of fit were calculated that are approximate analogs to the $R^2$ coefficient of determination in OLS regression. The first quasi-$R^2$ measure is proposed by Aldrich and Nelson (1984:57) and is calculated by the following formula:

$$R^2 = C/(N+C)$$

Where:

- $C$ = the Chi-square statistic for the overall fit of the model
- $N$ = the sample size

The second $R^2$ approximation is proposed by Pindyck and Rubinfeld (1981:312) and is calculated through the same formula as the $R^2$ coefficient in OLS regression. That is:

$$R^2 = 1 - \frac{ESS}{TSS}$$

Where:

- $ESS$ = the sum of the squared differences between the observed and predicted values of the dependent variable
- $TSS$ = the sum of the squared differences between the observed value of the dependent variable and its mean.

There is considerable controversy among statisticians regarding the validity of these coefficients. Therefore, caveats must be observed in interpreting these coefficients as the virtual equivalents of the $R^2$ coefficient in OLS regression.

**Confounding Factors Affecting the Internal Validity of the Cost/Benefit Model**

At the time of data collection, farm operations within the sample were being subjected to the forces of a severe recession in the agricultural economy. One effect of a recession is the limitation of disposable income within segments of the farm sector. Given that videotex is a relatively high cost method of obtaining agricultural information (approximately $1,000 or more per annum for ACRES) compared to other sociotechnical systems, it is expected that a proportion of ex-users have discontinued their use of ACRES due to economic constraints of the recession, regardless of the internalization of other costs and realization of benefits. Individual farm operations
that have discontinued use of ACRES due to the economic constraints of the recession, despite internalizing other costs and realizing the benefits of agricultural videotex systems will reduce the goodness of fit of the logistic regression model.

Findings

The means of the independent variables indicate that there is no problem with limited dispersion which would severely restrict the probability of a relationship between an independent variable and the dependent variable being significant in the logistic regression model. Given that all independent variables are dummy variables and are measured in the same units, their means are comparable and represent the proportion of the sample that perceived that they realized a particular benefit or failed to internalize a particular cost. The largest means of the set of independent variables were those of benefit variables. Seventy-nine percent of the sample perceived a reduction in labor time in acquiring agricultural information from using videotex while 74 percent perceived that they realized higher prices for agricultural commodities (see Table 6.15). In addition, 49 percent of the sample perceived that they realized better financial investments, 40 percent were able to schedule farm activities more effectively, and 39 percent was able to reduce the number of agricultural information sources needed to acquire desired agricultural information from using videotex.

Among the cost variables, the means revealed that only a small percentage of the sample perceived that they did not internalize the costs of learning how to use computer technology to access videotex services (12 percent) and reorganizing their work schedules to access videotex (22 percent). However, 45 percent of the sample

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76 Dispersion refers to the relationships between the mean, minimum value and range of an independent variable and is calculated by subtracting the minimum value from the mean and dividing by the range. When the dispersion coefficient for an independent variable falls below or above the .05 to .95 range, the variable has limited dispersion and has little chance of having a significant relationship with the dependent variable in a logistic regression model (F. Harrell, 1986:270).
### Table 6.15.
Means of the Independent Variables in the Cost/Benefit Model
(N=233)*

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MEAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$</td>
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<tr>
<td>$X_2$</td>
<td>.40</td>
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<tr>
<td>$X_3$</td>
<td>.74</td>
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<tr>
<td>$X_4$</td>
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</tr>
<tr>
<td>$X_5$</td>
<td>.39</td>
</tr>
<tr>
<td>$X_6$</td>
<td>.45</td>
</tr>
<tr>
<td>$X_7$</td>
<td>.12</td>
</tr>
<tr>
<td>$X_8$</td>
<td>.22</td>
</tr>
</tbody>
</table>

Where:

- $X_1$ = The reduction of labor time in acquiring agricultural information
- $X_2$ = More effective scheduling of farm activities
- $X_3$ = The realization of higher prices for agricultural commodities
- $X_4$ = The realization of better financial investments
- $X_5$ = The reduction of agricultural information sources
- $X_6$ = Subscription costs of ACRES are too high for benefits received
- $X_7$ = Learning to use a computer to access ACRES was an inconvenience
- $X_8$ = Taking time out of work day to access ACRES disrupts work routine

*These means were computed with 17 of the 250 total sampling units deleted due to missing values.
perceived the subscription costs of ACRES as being too high compared to the benefits received.

The multivariate logistic regression analysis revealed that the reduction of labor time in acquiring agricultural information, the realization of higher prices for agricultural commodities, the realization of better financial investments, the reduction of agricultural information sources and the perception of the subscription costs of ACRES as not being too high compared to the benefits received were all significant factors in increasing the probability of social adaptation to videotex in agricultural production (see Table 6.16). All of the significant benefit factors were positively related to social adaptation to agricultural videotex systems as was hypothesized. The one significant cost factor was negatively related to the dependent variable as was hypothesized.

The more effective scheduling of farm activities, the inconvenience of having to learn how to use a computer to access ACRES, and the disruption of work routines from accessing ACRES were not significantly related to social adaptation to agricultural videotex systems. Further, these independent variables were not related to the dependent variable in the hypothesized direction. The benefit of scheduling farm activities more effectively was negatively related to social adaptation to agricultural videotex systems. The costs of the inconvenience of having to learn to use computer technology to access ACRES and the disruption of work routines from accessing ACRES were positively related to the dependent variable.

The partial $r$ values indicate that the reduction of agricultural information sources and the reduction of labor time in collecting agricultural information had the strongest relative effects in increasing the probability of social adaptation to agricultural videotex systems. This was followed by the perception of the subscription costs of ACRES as not being too high compared to benefits received, the realization of higher prices for agricultural commodities and the realization of better financial investments,
Table 6.16.

Results of the Multivariate Logistic Regression Analysis for the Cost/Benefit Model (N=233)*

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Beta</th>
<th>Standard Error</th>
<th>( \chi^2 )</th>
<th>P</th>
<th>Partial r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
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<td>1.32</td>
<td>.25</td>
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<tr>
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<td>10.32</td>
<td>.00</td>
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<tr>
<td>X2</td>
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<td>0.00</td>
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<td>4.11</td>
<td>.04</td>
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<tr>
<td>X4</td>
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<td>X7</td>
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<tr>
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<td>.534</td>
<td>0.99</td>
<td>.32</td>
<td>.000</td>
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C = 96.91  8 d.f.  P = 0.0
(1) \( R^2 = .294 \)  (2) \( R^2 = .447 \)

Where:

X1 = The reduction of labor time in acquiring agricultural information
X2 = More effective scheduling of farm activities
X3 = The realization of higher prices for agricultural commodities
X4 = The realization of better financial investments
X5 = The reduction of agricultural information sources
X6 = Subscription costs of ACRES are too high for benefits received
X7 = Learning to use a computer to access ACRES was an inconvenience
X8 = Taking time out of workday to access ACRES disrupts work routine

*17 of the 250 total sampling units were deleted from the analysis due to missing values. Seventy-seven percent (180) of the units were current ACRES users while 23% (53) were ex-ACRES users.
respectively.

The model Chi-square statistic (C) was 96.91 with 8 degrees of freedom and was significant. This indicates that, overall, the cost/benefit model fits the sample data. The first quasi-$R^2$ coefficient was .294 while the second was .447. These coefficients suggest that the goodness of fit of the model is likely moderate at best.

The logistic regression model was re-estimated controlling for respondents who had discontinued use of ACRES due to experiencing a cash shortage during the agricultural recession. This provides insight into whether the potential restrictions on disposable income due to the agricultural recession had an effect on the internal validity of the cost/benefit model. The ability to control for this confounding factor was dependent upon the accurate identification of farm operations within the sample that had discontinued use of ACRES due to experiencing a cash shortage.

Ex-users of ACRES were asked to list the primary reason that they stopped subscribing to the ACRES videotex service. Respondents who directly stated that a cash shortage was their primary reason for stopping subscription to ACRES were eliminated from the sample. Additionally, respondents who reported a negative net farm income prior to stopping subscription and who stated that the primary reason for stopping subscription was that the cost of ACRES was too high were also deleted from the sample.

In total, 14 cases within the sample met these conditions. The elimination of these cases reduced the sample size to 219 farm operations. This consisted of 82 percent (180) ACRES users and 18 percent (39) ex-ACRES users. The logistic regression model was then re-estimated.

The re-estimated logistic regression model revealed no changes in the pattern of significant and insignificant relationships between the dependent variable and the independent variables (see Table 6.17). However, the partial $r$ values indicate a change in the relative magnitude of the effects of the significant independent variables in
Table 6.17.
Results of the Multivariate Logistic Regression Analysis for the Cost/Benefit Model Controlling for Respondents Who Discontinued Use of Videotex Due to Cash Shortages (n=219)*

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Beta</th>
<th>Error</th>
<th>$x^2$</th>
<th>P</th>
<th>Partial R</th>
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<tr>
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<td>X4</td>
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<td>.02</td>
<td>.127</td>
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<tr>
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<tr>
<td>X6</td>
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<td>3.76</td>
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</tr>
<tr>
<td>X7</td>
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<td>.789</td>
<td>0.42</td>
<td>.52</td>
<td>.000</td>
</tr>
<tr>
<td>X8</td>
<td>0.079</td>
<td>.611</td>
<td>0.02</td>
<td>.90</td>
<td>.000</td>
</tr>
</tbody>
</table>

$C = 99.60$  
8 d.f.  
P = 0.0

Where:

X1 = The reduction of labor time in acquiring agricultural information  
X2 = More effective scheduling of farm activities  
X3 = The realization of higher prices for agricultural commodities  
X4 = The realization of better financial investments  
X5 = The reduction of agricultural information sources  
X6 = Subscription costs of Acres are too high for benefits received  
X7 = Learning to use a computer to access ACRES was an inconvenience  
X8 = Taking time out of workday to access ACRES disrupts work routine

*14 cases within the stratum of ex-ACRES users were found to have discontinued their use of ACRES due to cash shortages. These cases were deleted and the logistic regression model was re-estimated using 219 cases rather than the 235 cases used to estimate the initial model.
influencing the probability of social adaptation to agricultural videotex systems.

The partial r values indicate that the perceived realization of a reduction in labor time in collecting agricultural information had by far the strongest relative effect in increasing the probability of social adaptation in the re-estimated model. This was followed by the reduction of agricultural information sources, the perceived realization of higher prices for agricultural commodities, the perceived realization of better financial investments and the perception of the subscription costs of ACRES as not being too high compared to the benefits received, respectively.

The changes in the partial r values of the benefit variables in the re-estimated model compared to the initial model indicate that the effects of a reduction in labor time in collecting agricultural information, the realization of higher prices for agricultural commodities and the realization of better financial investments increased in magnitude while the effect of a reduction in agricultural information sources decreased. This suggests that ex-users of ACRES who discontinued use due to cash shortages had the tendency to perceive that they realized the former three benefits while not realizing the latter.

The effect of the perception of the subscription costs of ACRES as being too high for the benefits received also decreased in the re-estimated model. This suggests that the ex-users of ACRES that were eliminated from the sample perceived the cost of ACRES as being too high despite the tendency of realizing one or more of the significant benefits. This likely reflects their cash shortage situation.

The model Chi-square for the re-estimated model increased to 99.40 with 8 degrees of freedom and was significant. This indicates that the re-estimated model fits the sample data. The first quasi-R² measure increased to .312 and the second measure to .534. All of these indicators suggest that the goodness of fit of the cost/benefit model was improved. The changes in the quasi-R² measures indicate that the degree of
improvement in the goodness of fit could be anywhere from 6 percent (.312-.294) to 19 percent (.534-.447/.447). The improvement in the goodness of fit of the re-estimated logistic regression model suggests that the internal validity of the cost/benefit model was being slightly confounded by the effect of the agricultural recession on the disposable income of at least 6 percent (14/233) of the sample.

Utilizing the re-estimated parameters of the logistic regression model, it was found that farm operations that realized all four of the significant benefits and did not perceive the subscription cost of ACRES as being too high had a predicted probability of social adaptation to agricultural videotex systems of .997. In contrast, farm operations who realized none of the significant benefits and perceived the subscription cost of ACRES as being too high for the benefits received had a predicted probability of social adaptation of .119.76

Discussion

The multivariate logistic regression analysis identified four benefits of agricultural videotex systems that are significantly related to social adaptation to this technology in agricultural production. The significant benefits fall into the general categories of information management, marketing and financial management. Out of all cost variables, only the cost of the ACRES videotex service was significant. These findings suggest that social adaptation to videotex services within the study area partially hinges upon the ability of farm operators to realize the benefits of videotex in information management, marketing and financial management while internalizing the financial costs of the videotex service. However, the ability to realize these benefits

76These predicted probabilities are based on the conditions that the single insignificant benefit variable was not realized (scheduling farm activities more effectively) and that the two insignificant cost variables were internalized (learning to use a computer was not an inconvenience and the use of ACRES did not disrupt the work routine of the user). Given that the two insignificant cost variables were positively related to social adaptation to agricultural videotex systems, the failure to internalize these costs slightly increased P(Y).
and internalize the financial costs likely presupposes several conditions.

The realization of the benefits of agricultural videotex in information management presupposes that adopting farm operations are information intensive in their management practices. That is, they actively seek and obtain agricultural information from a wide range of sources for use in coordinating management decisions. Farm operations with information intensive management practices would be most able to realize the benefits of videotex in saving labor time in collecting agricultural information and reducing the number of agricultural information sources needed to obtain desired information. The survey findings regarding the use of information sources by the farm operations within the sample support this assumption.

The realization of the benefits of agricultural videotex in marketing and financial management presupposes that adopting farm operations require timely information needed to coordinate marketing and financial strategies. Farm operations vary in the sophistication of marketing and financial strategies they employ on the basis of a number of factors including farm size and commodities produced (Cramer and Heid, 1983:149-150). Not all farm businesses employ more sophisticated marketing strategies such as hedging their commodities on the futures market. Nor do all employ financial investment strategies such as investing in stocks and other financial instruments. Among those farm businesses that do employ sophisticated marketing and financial strategies, there is undoubtedly variation in their ability to employ such strategies effectively and maximize their economic returns. Farm operations with the greatest ability to effectively employ marketing and financial investment strategies would be most able to realize the benefits of videotex in allowing the realization of higher prices for agricultural commodities and better financial investments.77

77While an attempt was not made to measure ability to effectively employ marketing and financial strategies in the survey, the types of marketing strategies used by farm operations in the sample were measured. It was found that many farm operations in the sample employed multiple pricing strategies in marketing their primary and/or secondary income-producing commodity. Additionally, 35.2 percent of
The perception of the cost of videotex service as not being too high for the benefits received presupposes that adopting farm operations have the available financial capital necessary to purchase access to the service. It also presupposes the ability to realize one or more of the significant benefits. In regard to the financial dimension, large, well-financed farm operations would obviously be more likely to have the disposable income needed for the substantial subscription costs attached to most agricultural videotex services. This is supported by the sample data. However, with the economic conditions of the agricultural recession, even a proportion of the large, well-financed farms in the sample lacked the disposable income necessary to continue subscribing to the ACRES videotex service.

The significant cost/benefit variables reflect two underlying factors: (a) knowledge work ability; and (b) financial resources. All four of the significant benefits reflect the concept of knowledge work. That is, the acquisition of information, the processing and organization of information into knowledge and the application of that knowledge in order to optimally coordinate the marketing of agricultural commodities and financial investments. Farm operators possessing these knowledge work abilities prior to utilizing agricultural videotex would more easily adapt to its use given the proper technical skills to use videotex (e.g. computer literacy). Videotex systems facilitate knowledge work by providing a more efficient technical basis for acquiring, processing and organizing information. In turn, however, the employment of videotex in knowledge work is mediated by possession of the financial capital necessary to

the sample hedged their primary income-producing commodity on the futures market during the 1984 production year. 24 percent hedged their secondary income-producing commodity on the futures market. These findings suggest that a moderate proportion of farm operations within the sample tended to employ more sophisticated marketing strategies. In regard to financial investment strategies, 23.6 percent of the sample engaged in speculating on the futures market.

This is not true in all cases. Several of the videotex services provided by the state branches of the Cooperative Extension Service such as PENPAGES at Pennsylvania State University or EXNET at Iowa State University are provided at little or no cost.
access videotex services.

While exact figures could not be obtained, it is likely that one percent or less of all farm operations within the study area had adopted videotex at the time of data collection. The small size of the survey population indicates that the farm operations within the sample represent a proportion of the initial adopters of videotex systems within the study area. The characteristics of the sample show that the proportion of the initial adopters represented by the sample tend to be large, well-financed farm operations. This pattern is likely influenced by the high cost of videotex, the restrictions on disposable income within the farm sector due to the recession in the agricultural economy and the institutional constraint of necessary membership in the Farm Bureau in order to access ACRES. However, regardless of these factors, the sample characteristics imply that in the short term, any economic advantages resulting from the use of ACRES (realization of high prices for agricultural commodities and better financial investments) will be restricted to large farm operations within the study area.

The findings from the logistic regression analysis indicated that there is considerable variation within the group of large farm operations in the sample in relation to their abilities to realize the significant benefits and internalize the financial costs of videotex. This suggests that the economic advantages resulting from agricultural videotex will not only be inequitably distributed between classes of farms based on size, but also within the class of large farms within the study area.
The significance of any economic gains from employing videotex in agricultural production lies in the extent of their magnitude. The critical issue is whether the economic gains accorded to those able to realize the benefits of agricultural videotex are of the magnitude that they provide a major comparative advantage in the ability to remain competitive in U.S. agriculture. Economic gains resulting from the use of videotex in agricultural production should ultimately be manifested in increased farm income. Respondents within the sample were asked whether they perceived their use of ACRES as increasing their farm income. Contingent upon an affirmative response, respondents were asked to estimate the magnitude of these income gains. Overall, 60.5 percent of the sample indicated that their use of ACRES increased their farm income.

Out of those respondents that indicated that ACRES increased their farm income, only 71.4 percent could estimate the exact monetary value of these income gains. Estimated gains ranged from $100 to $40,000 with a mean gain of $5,853. While these estimates undoubtedly contain measurement error, they do provide insight into the potential economic gains to be derived from videotex.79

The benefits of agricultural videotex in marketing and financial management are sensitive to economies of scale. Farm operations producing and marketing a larger volume of agricultural commodities and/or possessing greater financial capital will derive greater economic gains from realizing these benefits. Given that the use of videotex within study area is primarily restricted to large, well-financed farm operations, this technology will in the short term, contribute toward the trend of income concentration and a bipolar structure of farms.

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79Given the complexity of the set of factors affecting economic outcomes in agricultural production, it is difficult to precisely sort out the exact independent economic effects of videotex from those of other factors affecting this process.
The findings from the survey indicate that adoption of videotex systems within the study area is occurring at a very gradual pace. There has not been a movement to rapidly incorporate this technology into agricultural production. Further, out of those farm operations that have adopted agricultural videotex systems, there has been a failure among a substantial proportion to socially adapt to the technology. Out of the 401 farm operations that were initially identified as having experience in using the ACRES videotex system, 26.4 percent (106) discontinued their use of the technology.

Given this rate of rejection of the technology, the process of social adaptation to agricultural videotex systems is likely to be very gradual in pace. This brings into question the proposition that videotex will be the "leading edge" technology that will stimulate the use of other applications of information technology in agricultural production and spearhead the farm sector into the emerging information society. Agricultural applications of information technology that are affordable to a wider range of farm operations and/or place less reliance on the knowledge work abilities and computer skills of individual farm operators could supersede videotex in this role.
CHAPTER VII

FUTURE IMPLICATIONS AND CONCLUSIONS

The term "informediation" has been used to describe the proliferation of information technology throughout all sectors of advanced industrial societies (Valaskakis, 1984:6). The research findings suggest that there is an imbalance in the extent of informediation across all sectors in the agricultural system. Information technology has become integral to the production of goods and services by organizations in the input, marketing and processing, and governance and education sectors. Further, as part of the office automation movement, information technology has become essential in administrative processes for the overall coordination of activities by adopting organizations.

The use of information technology is viewed by some observers as critical to the ability of U.S. manufacturing and service firms to compete in the conditions imposed by the emerging global economy (Cohen and Zysman, 1987:130-193; Quinn and Gagnon, 1986). Shifts in the global economic order and the rapid growth of the Japanese

80 Applications of information technology for manufacturing involving technologies such as CAD/CAM and robotics can reduce production costs, improve the quality of products and provide greater flexibility in production. For example, small batch production and greater product diversity can be accomplished at nearly the same cost as mass produced items. Computer-automated manufacturing machinery can easily be reprogrammed to perform other tasks and produce a variety of products. This is not easily accomplished on a semiautomatic assembly line system (Jaikumar, 1986). Greater flexibility allows firms to more easily adapt production to shifts in demand as weak products can be discontinued and new products introduced more rapidly. This is becoming increasingly necessary in a competitive global economy with shifting markets. As previously noted, information technology has also become critical in the provision of such services as banking and finance, transportation, legal services, and wholesale and retail trade.
The economy have created a sense of urgency concerning the need to rapidly incorporate information technology into the technical basis of goods and services production.

It ostensibly appears, however, that this sense of urgency is not widely shared within the farm sector relative to the need to incorporate information technology into agricultural production. The low rate of adoption of commercially developed applications of information technology for agricultural production suggests that there is a widespread belief among farm operators that information technology is not immediately critical for remaining competitive in agricultural production. Further, the capacity of increasing productivity in production, marketing, and financial management has not provided a sufficient motivating force for the adoption of commercially developed applications of information technology. Even though it cannot be substantiated with statistical data, it is very likely that the farm sector is lagging far behind other sectors of the agricultural system in adoption and social adaptation to applications of information technology.

The lack of commercial development of a number of the technically feasible applications of information technology for agricultural production (e.g., remote sensing applications, on-farm, digital information networks) indicates that these technologies are presently viewed as marginal investments by manufacturers. That is, an adequate market would not likely be developed and/or there is a perceived lack of demand for these technologies within the farm sector.

As exemplified by agricultural videotex systems, informediaiton is being driven primarily by supply-push factors rather than actual demand by farm operations for information technology-based goods and services (the extensive role of technology in market economies). It is unclear how long producers will continue to attempt to create markets within the farm sector for goods and services that the majority of farm
operations may currently be unable to afford and/or not sure they need. A continuation of the lack of demand for these products and services will inhibit the growth and development of the production, distribution, and support systems necessary to accelerate informedia­tion within the farm sector. The future expansion of markets for commercially developed information technology-based goods and services for agricultural production will be shaped and influenced by a wide range of factors.

One factor that has clearly inhibited informedia­tion in the farm sector has been the recession in the agricultural economy. Since the early 1980s, the farm sector has undergone the most severe economic recession since that of the 1920s and 1930s. A large number of farm operations have been foreclosed and rural communities have deteriorated. There have been recent signs of recovery in the agricultural economy. This can help generate the disposable income necessary for a larger proportion of farm operations to purchase information technology-based goods and services.

Another important factor that will influence the extent of adoption of information technology applications for agricultural production is the cost of information technology-based goods and services. The majority of these goods and services are currently high cost agricultural inputs. Therefore, in the short term, their use will be inhibited regardless of overall conditions in the agricultural economy. Many smaller farm operations may not wish to risk capital investments in technologies whose benefits are unclear and/or are dependent upon the acquisition of technical skills and knowledge work abilities by the farm operator.

Improvements in efficiency in producing information technology-based goods and services could eventually lower their cost, assuming that such a pricing policy is desired by the firms producing them and such improvements are technically feasible. It is highly likely that the cost of information technologies will decline, only if based on the fact that the miniaturization of microelectronics components has yet to run its full
course. The decline in the cost of information technology-based goods and services for agricultural production could make them more affordable across all sizes of farm operations.

The expansion of markets for information technology-based goods and services for agricultural production is also dependent upon perceptions within the farm sector regarding the costs and benefits of information technology. As previously noted, cost considerations include not only the price of the equipment and supporting services, but also the acquisition of technical skills necessary to use computer technology effectively.

The acquisition of computer skills by agricultural producers has been and will likely continue to be a very gradual process. The low adoption rate of microcomputers indicates that there has likely been a lack of interest and/or resistance among farm operators to acquiring these skills. It is highly probable that the growth of computer literacy within the farm sector will largely be an intergenerational process. Computer education has become an integral component of the curriculum in agricultural colleges and increasingly in primary, secondary and vocational education. The predominant proportion of the next generation of America's farm operators will likely be computer literate and have a high level of awareness of the benefits of information technology. An awareness of the benefits of information technology applications for agricultural production can contribute to the initial adoption of information technology-based goods and services within the farm sector. However, the research findings indicate that at least in the case of agricultural videotex systems, the subsequent realization of these benefits in practice is related to the process of social adaptation or continued use of the technology. Farm operations that failed to realize the benefits of agricultural videotex in information management, marketing, and financial management tended to discontinue use of the technology.
The variation in the ability of farm operators to realize the significant benefits of agricultural videotex systems indicates that there is a degree of difficulty attached to the realization of each benefit. As was previously discussed, this is likely related to the information management practices and knowledge work abilities in marketing and financial management of each individual farm operator. The lack of ability of a proportion of farm operators to realize the benefits of videotex or other applications will likely inhibit the extent of social adaptation to information technology within the farm sector.

Short Term Scenario for Informedia\ion within the Agricultural System

The slow pace of informedia\ion within the farm sector and the nature of the conditions inhibiting the acceleration of this process suggest that the integration of the farm sector into the emerging information society will continue to be a very gradual process. It is highly likely that the farm sector will continue to lag behind other sectors of the agricultural system in adoption and social adaptation to applications of information technology. Manufacturing firms, service firms, and organizations within the input, marketing and processing and governance and education sectors are proportionally more likely to incorporate applications of information technology into their activities at a more rapid pace than the farm sector.

Information technology has become more indispensable to manufacturing, the provision of services, government and education compared to agricultural production. There is comparatively a greater demand for labor by the firms and organizations comprising the input, marketing and processing and governance and education sectors, especially those that are part of the expanding U.S. service sector. Computer literacy has already become a necessary requirement in a large number of occupations within the industries and organizations comprising these sectors. A comparatively much
greater proportion of the U.S. labor force with computer skills is seeking employment within the input, marketing and processing and governance and education sectors. In effect, a greater proportion of firms and organizations within these sectors possess the labor skills and financial resources necessary for social adaptation to information technology compared to the farm sector.

The demand for labor in agricultural production is declining as the size of the labor force employed within the farm sector continues to shrink. Computer literacy has not yet become a necessary requirement for occupations in farming. The development of computer skills within the farm sector is primarily dependent upon the procurement of training by farm operators rather than attracting and hiring trained, off-farm labor.

Even though the farm sector will likely continue to lag behind other sectors of the agricultural system in integrating into the emerging information society, the findings from this research indicate that the integration process will likely be led by large farm operations that possess the financial resources and knowledge work abilities necessary to utilize and realize the benefits of established applications of information technology. The economic advantages provided to these farms, such as more effective marketing and financial management, should initially facilitate the trend toward income concentration and a bipolar structure of farms. This has several important policy implications.

Policy Implications

The emergence of information technology in U.S. agriculture highlights and brings greater focus to the role of information as an input in agricultural production. Applications such as videotex and teletext provide more efficient technical systems for the dissemination and acquisition of timely information needed to more effectively coordinate decision making. The capacity of these systems to facilitate more effective
marketing and financial investments suggests that computer-based information delivery is a potentially significant technology for agricultural production.

The privatization of computerized agricultural information restricts access by farm operations to those with the ability to pay. The data from the survey of agricultural videotex users suggests that the market mechanism may not necessarily be the most efficient means of ensuring access for all sizes of farm operations, given the high cost of videotex services. An important future policy consideration is the development of appropriate technological systems for computer-based delivery of agricultural information that are affordable across all sizes of farms.

Teletext can provide such a low cost, affordable system. The major financial costs for users are the purchase of a television set and decoder for receiving broadcasts of computerized information. It appears critical to ensure that the current infrastructure of teletext systems operated by public television stations and state branches of the Cooperative Extension Service be maintained. The development of agricultural teletext systems in agricultural regions of all states could provide a base level infrastructure for low cost, computerized information delivery to the farm sector. In cases where state branches of the Cooperative Extension Service have opted to develop videotex systems instead of teletext, it is important that state or Federal subsidies be provided to ensure that these services are low cost. Public sector videotex and teletext services could be used as a means of ensuring that computer-based delivery of agricultural information is affordable for all sizes of farms. Farm operations desiring to subscribe to private sector services (that could offer a wider range of services and information) would be free to do so.

An interrelated policy issue concerns the extension of the emerging digital telecommunications infrastructure into rural America. Much like the Rural Electrification Administration was used as a means of upgrading the rural telephone system, a
similar program is needed to upgrade and extend the digital telecommunications infrastructure into all regions of rural America. Rural businesses and homes deserve the same access to the high fidelity and wide range capabilities of modern digital telecommunications systems as their urban counterparts.

Satellite systems provide the most feasible technology for reaching remote sectors of rural America. Satellite networks subsidized by individual states are currently being implemented to augment rural education programs (Bransford, 1988). These could be expanded to include agricultural teletext or videotex services. An alternative would be the creation of a nationwide satellite/teletext or videotex network operated by the USDA that could be augmented at the state level to provide more localized information.

A major obstacle facing such policy initiatives is the current lack of demand for agricultural teletext and videotex services and modern digital telecommunications systems by the farm sector. Agitation from the farm populace for such technology and services is critical for such policy initiatives being proposed by state and Federal legislators. How long it will be, if at all, before such agitation is forthcoming remains an open question.

A policy initiative designed to use public sector teletext and videotex services to ensure access to low cost, computer-based information delivery for all sizes of farms heightens the potential conflict of interest with private sector organizations attempting to market such services to the farm sector. This conflict underscores the need of a policy that distinguishes what types of agricultural information should be distributed as a public versus a private good. This issue has never been clearly addressed, although the privatization of USDA computerized information dissemination activities clearly favors private distribution of public domain agricultural information.
A distinction between what types of agricultural information should be distributed as a public versus private good should be based on a determination of what quality, quantity and types of information is needed for all facets of agricultural production, marketing and financial management. Such a determination, however, poses an extremely complex problem.

The findings from this research suggest that farm operations tend to utilize an array of different information sources and vary in their abilities to employ this information for economic gain. This raises the theoretical question of whether there is a base level of information that is necessary for the production of each agricultural commodity. Public sector services could be restricted to distributing basic agricultural information while private sector services could distribute specialized information and analysis (e.g., market advisory services) in addition to basic information.

Access to computer-based delivery of agricultural information, the extension of the digital telecommunications infrastructure into all regions of rural America, and the trend toward the privatization of agricultural information are all critical issues facing the farm sector as it gradually integrates into the emerging information society. The policies that are created to address these issues, or the lack of policy, will ultimately influence this integration process. The development of a digital telecommunications infrastructure to provide low cost, computer-based delivery of agricultural information to all farms will allow smaller farms to realize the benefits of information technology. This can contribute to smaller farm operations remaining economically competitive. The outcomes of these policy issues will be influenced by whether the maintenance of a farm structure dominated in number by smaller family farms remains a desirable social goal in the United States.
Implications of Information Technology for the Spatial Organization of Agricultural Production

The ability of information technology to facilitate the coordination of activity of multilocational organizations is likely to have a future impact on the way the agricultural system is spatially organized. Information technology facilitates centralized control over spatially decentralized organizational units. This can contribute to geographic shifts in control over agricultural production. The capacity to transcend geographic boundaries and monitor and control agricultural production processes via information technology could facilitate the growth of large farm conglomerates with spatially dispersed production operations.

In this capacity, information technology has the potential of facilitating the further expansion of farms beyond larger centralized tracts of land to spatially dispersed tracts that could be selected on the basis of climatic conditions, fertility, and other factors. Land mapping through the use of remote sensing and the development of computerized data bases of land use patterns makes such a selection process technically feasible.

The growth of multilocational farm operations could not only transform the spatial organization of agricultural production within the United States, but at the international level as well. Information technology has the potential of facilitating the further growth of multinational agricultural production as "offshore" production could be more easily coordinated. This could become an increasingly attractive alternative to agricultural producers wishing to circumvent trade barriers that currently exist in the European Community and Japan among other nations.

The current potential of information technology to facilitate a shift in the spatial organization of agricultural production within the United States is limited. The gradual pace in the adoption of information technology within the farm sector indicates that
multilocational agricultural production is not a strategy that can likely be effectively employed by a large number of independent farm operations.

Many food processing corporations with integrated production and processing operations are already engaged in multinational agricultural production. Their use of information technology would further facilitate this process. Within the United States, however, the number of nonfamily, corporate farms in the farm sector remains small. Therefore, it appears that any shifts in the spatial organization of agricultural production within the U.S. through the growth of multilocational farm operations are likely to be very gradual.

Implications of Information Technology for Further Organizational Restructuring of the Agricultural System

The acceleration of informedia­tion and a more encompassing role of information technology within the agricultural system has the potential of making certain organizations superfluous in the future. Within the input sector, this could include a proportion of rural banks and retail sales firms. Within the marketing and processing sector, this could include a proportion of agricultural commodity brokers and marketing organizations. The use of information technology to provide teleshopping, telebanking and electronic marketing services creates this potential. This potential is heightened if farm operations could gain economic advantages through bypassing local service firms and organizations to obtain these services from nonlocal firms at a lower cost via information technology. Whether or not an organization would become superfluous through this process would be influenced by the ways it incorporates information technology into its provision of services.

The growth of private sector computerized information services and the further privatization of government information services could lead to a restructuring of the functions of the Cooperative Extension Service (CES). This will hinge upon whether
private sector interests are able to interpose themselves between the direct flow of information from branches of the CES to the farm sector. Thus far, the private sector has only been able to surround the direct flow of computerized information between the CES and the farm sector. That is, the flow of computerized information from the Federal branches of the USDA has been redirected through private sector service firms. Further, privately-held electronic agricultural information services for the farm sector are competing with those provided by the CES to develop a customer base within the farm sector. The role of CES as an information conduit to the farm sector is being encroached upon both vertically and horizontally by the private sector in relation to computer-based information delivery.

The CES has already recognized that it will increasingly be asked to distribute informational and educational materials through private electronic publishers and that it must keep pace by using information technology for program delivery (Hussey, 1985). The maintenance of the present structure of extension work will be influenced by the ways in which the division of labor between the public and private sectors regarding the dissemination of agricultural information is ultimately structured. Further privatization could necessitate that all CES information be rechanneled through private service firms for distribution to the public.

It has been proposed that the maintenance of the Cooperative Extension Service as a social institution may be dependent on its future ability to redefine its goals to meet the needs of specialized, nonagricultural interest groups (Dillman, 1986). With the shrinking farm population and the further privatization of computerized agricultural information services, this proposition may hold true as rural America integrates into the emerging information society.
An application of information technology that has potentially significant implications for the reorganization of agricultural production is electronic data interchange (EDI). As previously outlined, EDI uses computer networking to link manufacturers with wholesale and retail firms. The flow of current sales data within and between firms allows each stage of goods production and distribution to be coordinated more effectively. For example, manufacturers are able to schedule production runs on the basis of actual consumer demand. This reduces waste resulting from the production of surplus goods that consumers will not buy.

EDI would be beneficial to the farm sector for coordinating agricultural production. The dominant production strategy in industrialized agriculture has been the mass production of large volumes of one or several primary commodities (e.g., corn and soybeans). This strategy is undertaken with the risk that government subsidies and market prices will provide an adequate rate of profit. This has inevitably led to conditions of overproduction and the lowering of prices for agricultural commodities.81

The transfer of sales data from manufacturers and distributors in the food processing industry to the farm sector via EDI could allow agricultural producers to be better informed of patterns of domestic and international demand for food products. Agricultural production could be more effectively coordinated in response to shifts in demand. While EDI is being used to link manufacturers of processed foods with wholesale and retail distributors, these networks have yet to be extended to include linkages with the farm sector.

The possibility of EDI systems that link agricultural producers with other stages of the food production and distribution system is currently remote due to the slow pace of informediaiton within the farm sector. Another obstacle is that manufacturers

81Depressed market prices due to overproduction and the build up of massive stocks of surplus commodities were central to the recent agricultural recession.
would not likely agree to participate in an EDI system if it ultimately led to increases in prices of unprocessed agricultural commodities due to the more efficient planning of production by the farm sector. Under these conditions, EDI systems would most likely be limited to independent farm operations under contract to food processing corporations along with corporate owned farms. Even though EDI could greatly benefit the farm sector through allowing the more efficient planning of agricultural production, EDI systems that link agricultural producers are not likely to be developed anytime soon. It is, however, a useful strategy that should be considered for the future.

Conclusions

The findings from this research indicate that the proliferation of information technology throughout the agricultural system is contributing toward substantial change. However, the locus of this change is outside the farm sector and does not concern agricultural production. Instead, this change primarily involves the manufacture of technological inputs for farming, the provision of services inputs for farming, the marketing of agricultural commodities, the manufacture of processed food products and services involved in the distribution of processed foods. Therefore, the constellation of change processes that have been entitled the transition to the information society are initially affecting all stages of food production and distribution that precede or follow agricultural production.

The process of adoption and social adaptation to applications of information technology for agricultural production has been very gradual in pace. The farm sector appears to be lagging behind other sectors of the agricultural system. The findings from this research suggest that any immediate changes in agricultural production resulting from information technology are likely to be concentrated within a narrow range of farm operations.
The research findings indicate that information technology is allowing a restructuring of the macro organizational linkages of the agricultural system. The most coalescent change has been a restructuring of the sociotechnical system for the dissemination of agricultural information and the trend toward the privatization of agricultural information. Other changes that could result from such applications as electronic marketing, telebanking and teleshopping largely remain possibilities that may or may not be realized to a significant extent. This indicates that the integration of the agricultural system into the emerging information society is still in its initial stage. The total range of possibilities provided by information technology for restructuring organizational linkages within the agricultural system is yet to be seen.

The key theoretical issue underlying these changes is whether agriculture in the emerging information society represents a marked departure from that of industrial society which has characterized much of the twentieth century. Information technology can allow a further shift of labor out of agricultural production, although this is by no means assured. As has been reiterated throughout this study, it can allow further organizational restructuring. Information technology will change the nature of agricultural work, demand new labor skills, and change patterns of social interaction.

All of these changes, however, represent changes of degree. They do not represent changes of a utopian-like transformation as is often espoused by advocates of the information society. In essence, U.S. agriculture in the emerging information society will not be markedly different in substance from agriculture in industrial society, despite the appearance of technical and social change that may suggest otherwise.

The primary significance of information technology rests in its ability to increase the efficiency of organizations for operating under the conditions imposed by the emerging global economy. Businesses and organizations within the input, marketing and
processing and governance and education sectors of the agricultural system are well on their way to adapting to these conditions. The critical issues facing the future are whether the use of information technology in agricultural production will become critical for remaining competitive in the global economy and what steps will be necessary to accelerate social adaptation to information technology within the farm sector.
PLEASE TRY TO ANSWER EVERY QUESTION BECAUSE THE ANSWER FROM EACH QUESTION IS NECESSARY IN ORDER TO HELP US HAVE THE FULLEST POSSIBLE UNDERSTANDING OF THE CHARACTERISTICS AND OPINIONS OF FARMERS WHO ARE USING OR HAVE USED ACRES. SELECT OR GIVE THE ANSWERS WHICH YOU BELIEVE ARE MOST TRUE FOR YOU, WHETHER YOU ARE A CURRENT SUBSCRIBER OR EX-SUBSCRIBER. WE NEED TO KNOW YOUR RESPONSES TO EVERY QUESTION.

This questionnaire is intended only for farm operators. Farm operators are persons who are actively involved in day-to-day management and work on a farm.

SECTION A: Characteristics of Use and Level of Satisfaction With ACRES

First we would like to ask you some questions about your use of ACRES and other sources of information you use on your farm. Also, we are interested in how satisfied you are with ACRES as an information source.

A-1. Are you currently subscribing to ACRES? (Circle the number of your answer)

1. YES → skip to A-2

2. NO

A-1a. What are the reason(s) you quit subscribing to ACRES? (Check all that apply. If you check more than 1, please rank the reasons in order of their importance.)

- THE INFORMATION OFFERED BY ACRES WAS NOT SPECIFIC ENOUGH FOR MY FARM OPERATION TO BE USEFUL
- THE INFORMATION OFFERED BY ACRES WAS NOT UP-TO-DATE ENOUGH TO BE USEFUL FOR MY FARM OPERATION
- THE INFORMATION OFFERED BY ACRES WAS NOT ACCURATE ENOUGH TO BE USEFUL FOR MY FARM OPERATION
- THE INFORMATION OFFERED BY ACRES DID NOT PROVIDE ANY ADVANTAGES OVER OTHER INFORMATION SOURCES I USE —— Why?
- I DON'T LIKE WORKING WITH COMPUTERS
- ACRES DID NOT HELP MY FARM OPERATION BECOME MORE PROFITABLE
- THE BENEFITS GAINED FROM USING ACRES WERE NOT WORTH MY INVESTMENT
- THE COST OF USING ACRES IS TOO HIGH
- USING ACRES IS TOO DIFFICULT —— Why?
- HAVING TO DISRUPT MY WORK ROUTINE TO USE ACRES WAS TOO INCONVENIENT
- LOCAL TELEPHONE LINES PROVIDED POOR TRANSMISSION OF DATA
- THE ACRES SYSTEM WAS NOT RELIABLE ENOUGH
- I FOUND ANOTHER COMPUTER-BASED INFORMATION SERVICE THAT I LIKED BETTER THAN ACRES —— Which one?
- OTHER ________
A-2. In 1984, what method did you use when placing telephone calls to use ACRES?

1. USE THE WATS LINE SERVICE — skip to A-3
2. USED REGULAR TELEPHONE SERVICE

A-2a. What was your average cost per month for telephone calls to use ACRES?

$ __________

A-3. In 1984, how often did you normally use ACRES to obtain information?

1. ONLY SEVERAL TIMES DURING THE YEAR
2. ONCE A MONTH
3. SEVERAL TIMES A MONTH BUT LESS THAN ONCE A WEEK
4. ONCE A WEEK
5. SEVERAL TIMES A WEEK
6. ONCE A DAY
7. SEVERAL TIMES A DAY

A-4. How important is market information to the operation of your farm?

1. NOT IMPORTANT AT ALL
2. OF VERY LITTLE IMPORTANCE
3. SOMEWHAT IMPORTANT
4. VERY IMPORTANT

A-5. Where did you obtain your market information in 1984? (Check all that apply)

____ ACRES __________ USDA NEWSLETTERS (grain, livestock, etc.) __________ FARM MAGAZINES
____ RADIO __________ BUYERS (elevators, stockyards) __________ COMMERCIAL NEWSLETTERS (Doanes, Pro-Farmer, Top Farmer, etc.)
____ TELEVISION __________ OTHER FARMERS
____ NEWSPAPERS __________ MERCHANTS & SALESMEN __________ OTHER __________
____ COOPERATIVE EXTENSION AGENTS __________ MARKETING SERVICE (federal or state)

A-6. Out of the sources of market information you checked in question A-5, which were the 3 most important to your farm operation?

1. __________
2. __________
3. __________
A-7. Do you think that ACRES market information (not including Agrivisor) helped you increase your farm income in 1984?

1. NO —— skip to A-3
2. YES

A-7a. How did it help you? (Check all that apply)

- I got higher cash prices for my products
- I got higher returns from forward contracts
- I got higher returns from hedging
- I saved money in purchasing farm inputs (feedgrain etc.)
- I got higher returns from speculating (Speculating means placing a futures contract on a commodity without having the commodity on your farm to back up the contract)

- OTHER

A-7b. How much money do you estimate that you gained from using ACRES market information (not including Agrivisor)?

$ __________

A-8. How important is weather information to the operation of your farm?

1. NOT IMPORTANT AT ALL
2. OF VERY LITTLE IMPORTANCE
3. SOMewhat IMPORTANT
4. VERY IMPORTANT

A-9. What sources of weather information did you use in 1984? (Check all that apply)

- ACRES
- ALL-WEATHER RADIO
- NEWSPAPERS
- AM OR FM RADIO
- TELEVISION
- OTHER

A-10. Out of the sources of weather information you checked in question A-9, which were the most important to your farm operation?

1. ______________________
2. ______________________
3. ______________________

A-11. Was ACRES weather information more helpful compared to other sources of weather information you use in operating your farm?

1. NO —— skip to A-12
2. YES

A-11a. How was it more helpful? ________________________________
A-12. Does using ACRES save you time in collecting the agricultural information you need in operating your farm?
1. NO
2. YES

A-13. Is the ability to access ACRES at any time a convenience for you when you collect the agricultural information you need?
1. NO
2. YES

A-14. Has using ACRES allowed you to do a better job of scheduling your farm activities?
1. NO
2. YES

A-15. Has using ACRES made it easier for you to sell your products at the best price?
1. NO
2. YES

A-16. Has using ACRES helped you to make better financial investment decisions?
1. NO
2. YES

A-17. Are the subscription costs of ACRES too high for the benefits you receive from using it?
1. NO
2. YES

A-18. Are the telephone costs from using ACRES too high for the benefits you receive from using it?
1. NO
2. YES

A-19. Was having to take the time to learn how to use a computer to access ACRES an inconvenience for you?
1. NO
2. YES

A-20. Does having to take time out of your day to access ACRES disrupt your work routine?
1. NO
2. YES
A-21. Since using ACRES, do you utilize fewer sources of information than you did before subscribing to ACRES?

1. NO  skin to A-22

2. YES

A-21a. What information sources did you quit using?

- Radio
- Television
- Newspapers
- Cooperative Extension Agents
- USDA Newsletters
- Buyers (elevators, stockyards)
- Other Farmers
- Commercial Newsletters (Doanes, Pro-Famer, Top Farmer etc.)
- Merchants & Salesmen
- Marketing Service (Federal or state)
- Farm Magazines
- Other

A-22. Next, we want you to compare ACRES with all other sources of agricultural information you use and evaluate how satisfied you are, overall, with ACRES on the following characteristics (Please circle the number that best represents your level of satisfaction with ACRES):

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Accuracy of Information Obtained</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Timeliness of Information Obtained (how up-to-date the information is)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Cost of Information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Ability to Obtain the Specific Information You Need</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Ease in Obtaining the Information You Need</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A-23. Videotex information systems such as ACRES have the capability of being expanded to include many more services besides retrieving information. It is possible that in the future, ACRES could be expanded to include such services as telebanking, teleshopping, electronic mail, and telemarketing. Please check the services that you would be willing to use in the future.

- Telebanking (banking through ACRES)
- Teleshopping (purchasing farm inputs such as pesticides and fertilizer through ACRES)
- Electronic Mail (sending letters through ACRES instead of the postal system)
- Telemarketing (marketing your products via ACRES)
- Electronic Brokerage Service (placing futures and options orders via ACRES at a discounted rate)
A-24. In the space provided below (or on separate sheets of paper) please indicate if there are any information items or data bases that you would like to see added to the ACRES menu so that ACRES can better meet your information needs.

SECTION B: Characteristics of Farm Operation

Next, we want to know about specific characteristics of your farm operation.

B-1. In 1984, were you a single family farm operator or did you farm in a partnership or as part of a corporation?

1. FAMILY FARMER
2. FARM IN PARTNERSHIP
3. FARM IN CORPORATION
4. OTHER

B-2. How many permanent or full-time workers did you employ on your farm in 1984? (A permanent or full-time hired worker is one who works 200 days or more on your farm during the year)

________ FULL-TIME HIRED WORKERS

B-3. What is the total acreage of land you operated in 1984? (If you farm in a partnership or corporation, include only your share)

________ ACRES

B-4. Of the total acres you operated in 1984, how many did you own?

________ ACRES

B-5. Of the total acres you operated in 1984, how many did you rent?

________ ACRES

B-6. Of the total acres you operated in 1984, how many were cropland and how many were pasture?

________ ACRES OF CROPLAND
________ ACRES OF PASTURE

B-7. Check you major farm enterprise (the one from which you obtained the most farm income in 1984).

____ CASH GRAIN  ____ VEGETABLES  ____ SHEEP
____ DAIRY  ____ SUGAR  ____ FRUIT
____ BEEF  ____ POULTRY  ____ OTHER
8-8. Check the other crops and/or livestock that you raised on your farm in 1984.

___ CASH GRAIN ___ VEGETABLES ___ SHEEP
___ DAIRY ___ SHINE ___ FRUIT
___ BEEF ___ POULTRY ___ OTHER

8-9. Do you have an on-farm accounting system to manage your finances or do you hire a Certified Public Accountant or outside agency to perform this task?

1. USE C.P.A. OR OUTSIDE AGENCY - skip to 8-10
2. HAVE AN ON-FARM ACCOUNTING SYSTEM
3. I USE BOTH 1 AND 2

8-9a. What method of on-farm accounting do you use?

___ MANUAL SINGLE ENTRY SYSTEM
___ MANUAL DOUBLE ENTRY SYSTEM
___ ENTER DATA DIRECTLY INTO A COMPUTER AND USE AN ACCOUNTING SOFTWARE PACKAGE

8-10. What records do you keep on your farm? (check all that apply)

___ BALANCE SHEET ___ MACHINERY PERFORMANCE RECORDS
___ CASH FLOW STATEMENT ___ FEED/FORMULATION RECORDS
___ CHARTING OF MARKETS ___ PESTICIDE MANAGEMENT RECORDS
___ CROP/LIVESTOCK PRODUCTION ___ SOIL FERTILITY ANALYSIS
___ RECORDS ___ CROP/LIVESTOCK PROFIT ___ OTHER
___ PROJECTIONS

SECTION C: Marketing Strategies

We want to know about the strategies you used to market the two main cash products you sold in 1984 (the two products which provided the majority of your farm income). In the spaces provided in questions C-1 and C-3, please (a) list the product sold; (b) check the marketing strategy(ies) used; and (c) list the percentage of the total product sold that was assigned to each strategy.

Example:

| PRODUCT | MARKETING STRATEGY | % OF PRODUCT
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CORN</td>
<td>CASH ON DELIVERY 4</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>FORWARD CASH CONTRACT</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>COMMODITY OPTION</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DELAYED PRICING</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BASIS CONTRACT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OTHER</td>
<td></td>
</tr>
</tbody>
</table>
C-1. What was your strategy for marketing the product which provided you the most farm income in 1984?

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>MARKETING STRATEGY</th>
<th>% OF PRODUCT Assigned to Each Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CASH ON DELIVERY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FORWARD CASH CONTRACT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COMMODITY OPTION</td>
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<tr>
<td></td>
<td>DELAYED PRICING</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BASIS CONTRACT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OTHER</td>
<td></td>
</tr>
</tbody>
</table>

If the above listed product is a cash grain, please also answer question C-1a. Otherwise, skip to C-2.

C-1a. Did you sell the majority (more than 50%) of the grain at harvest or store it for later sale?

1. SOLD AT HARVEST  
2. STORED FOR LATER SALE

C-1b. Did you store the majority (more than 50%) on your farm or in an off-farm elevator?

1. ON-FARM
2. OFF-FARM ELEVATOR

C-2. Did you place a futures contract on the listed product in conjunction with the cash position(s) you checked in question C-1?

1. NO  
   skip to C-3
2. YES

C-2a. What percentage of the product was hedged under the futures contract?

%  

C-3. What was your strategy for marketing the product which provided the second largest proportion of your farm income in 1984? (If you marketed only 1 product in 1984, skip to question C-5)

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>MARKETING STRATEGY</th>
<th>% OF PRODUCT Assigned to Each Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CASH ON DELIVERY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FORWARD CASH CONTRACT</td>
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<td></td>
<td>COMMODITY OPTION</td>
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<td></td>
<td>DELAYED PRICING</td>
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<tr>
<td></td>
<td>BASIS CONTRACT</td>
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<td></td>
<td>OTHER</td>
<td></td>
</tr>
</tbody>
</table>

If the above listed product is a cash grain, please also answer question C-3a. Otherwise, skip to C-4.

C-3a. Did you sell the majority (more than 50%) of the grain at harvest or store it for later sale?

1. SOLD AT HARVEST  
   skip to C-4
2. STORED FOR LATER SALE

Answer C-3b
C-3b. Did you store the majority (more than 50%) of the grain on your farm or in an off-farm elevator?

1. ON-FARM
2. OFF-FARM ELEVATOR

C-4. Did you place a futures contract on the listed product in conjunction with the cash position(s) you checked in question C-3?

1. NO  skip to C-5
2. YES

C-4a. What percentage of the product was hedged under the futures contract?

C-5. Did you speculate on the futures market in 1984? (Speculating means placing a futures contract on a commodity without having the commodity on your farm to back up the contract)

1. NO
2. YES

C-6. Overall, how many futures contracts did you trade in 1984?

FUTURES CONTRACTS

SECTION D: Attitudes Toward Computer Technology and New Farming Practices and Products

Next, we would like to ask your opinions on computer technology and new farming practices and products. First, the questions on computer technology (Circle the answer which best describes your opinion for each of the following questions).

<table>
<thead>
<tr>
<th>Amount of agreement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>D</td>
<td>B</td>
<td>A</td>
<td>SA</td>
</tr>
</tbody>
</table>

D-1. Computer technology helps me manage my farm more effectively. SD D B A SA

D-2. Computer technology has enabled me to make more effective decisions in managing my farm. SD D B A SA

D-3. Using a computer to help solve management problems is not a very efficient way of doing things. SD D B A SA

D-4. Computer technology has allowed me to manage my finances more effectively. SD D B A SA

D-5. For the amount of money I've spent, computer technology has provided very few benefits in managing my farm. SD D B A SA
D-6. Computer technology has helped increase the efficiency in which I produce agricultural products.  SD D B A SA

D-7. Computer technology has not had much of an impact in improving the way I run my farm.  SD D B A SA

D-8. Computer technology has helped increase my ability to effectively solve farm management problems.  SD D B A SA

D-9. By using computer technology for farm management, I waste a lot of valuable time.  SD D B A SA

D-10. Using computer technology in farm management has provided few advantages.  SD D B A SA

D-11. Computers are a real nuisance to work with.  SD D B A SA

D-12. Computer technology has helped me perform management tasks more quickly.  SD D B A SA

D-13. Some people are more familiar with computers than others. We would like to know how well acquainted you are with computers and how they work. For the following 6 pairs of words, please circle the number which best describes how well you are acquainted with computer technology.

To me, computers are:

<table>
<thead>
<tr>
<th>very unfamiliar</th>
<th>somewhat unfamiliar</th>
<th>a little unfamiliar</th>
<th>a little familiar</th>
<th>somewhat familiar</th>
<th>very familiar</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
<td>+2</td>
</tr>
<tr>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
<td>+2</td>
</tr>
<tr>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
<td>+2</td>
</tr>
<tr>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
<td>+2</td>
</tr>
</tbody>
</table>

Next, we would like to know your opinions on trying new agricultural products and practices. (Please circle the answer which best describes your opinion for each of the following questions)

<table>
<thead>
<tr>
<th>SD = I strongly disagree</th>
<th>D = I disagree</th>
<th>A = I agree</th>
<th>SA = I strongly agree</th>
</tr>
</thead>
</table>

D-14. I enjoy experimenting with new agricultural products or practices.  SD D B A SA

D-15. Generally, I am never one to try new products of practices unless I see results.  SD D B A SA

D-16. I prefer to wait until a product or practice has been established for some time before trying it for myself.  SD D B A SA

D-17. I usually try new agricultural products or practices before other farmers do.  SD D D A SA
D-18. As a rule of thumb, I do not use new agricultural products or practices until I hear about them from farmers who have tried them. SD D B A SA

D-19. Once I have made a choice on the type of product or practice that fits my farm operation, I am likely to use it regularly without trying new products or practices that are developed. SD D B A SA

SECTION E: General Characteristics of the Farm Operator

Next, we would like to ask some questions about yourself.

E-1. How many years have you been a farm operator? (Write the number of years you have been farming or the year you started farming, whichever is easier for you)

YEARS (or) SINCE ___

E-2. What year was the principal farm operator born?

19___

E-3. Did the principal farm operator work more than 100 days in non-farm work in 1984?

1. NO

2. YES

E-4. How much education does the principal farm operator have?

1. NO FORMAL EDUCATION 6. SOME COLLEGE

2. SOME GRADE SCHOOL 7. COMPLETED COLLEGE

3. COMPLETED GRADE SCHOOL 8. SOME GRADUATE WORK

4. SOME HIGH SCHOOL 9. A GRADUATE DEGREE

5. COMPLETED HIGH SCHOOL

E-5. Who is the primary user of ACRES on your farm?

1. THE PRINCIPAL FARM OPERATOR

2. A HIRED FARM MANAGER

3. THE PRINCIPAL FARM OPERATOR'S SPOUSE

4. THE PRINCIPAL FARM OPERATOR'S CHILDREN

5. OTHER

E-6. How much formal computer-related education does the primary user of ACRES have? (check all that apply)

NO MATCH: COMPUTER SEMINAR(S) COLLEGE COMPUTER COURSES

HIGH SCHOOL COURSE(S) COURSE(S) OFFERED BY A COMPUTER STORE OR VENDOR
SECTION F: Returns to Farming

Agricultural information systems such as ACRES have the potential of increasing profitability by helping farmers make effective decisions. Because we have little information on how much farmers with different sizes of operations are using ACRES, we are asking you some further questions which are important to the study. We would like to remind you that this information, along with all your other answers to this survey, will never be identified as yours.

F-1. In 1934, what was your approximate gross farm income? (Gross farm income is your total farm income before subtracting farm expenses. If you farm in partnership or in a corporation, include only your share in your answer. Circle the number of the category that applies.)

1. $2,499 OR LESS
2. $2,500 TO $4,999
3. $5,000 TO $9,999
4. $10,000 TO $19,999
5. $20,000 TO $39,999
6. $40,000 TO $69,999
7. $70,000 TO $99,999
8. $100,000 TO $149,999
9. $150,000 TO $199,999
10. $200,000 TO $499,999
11. $500,000 OR MORE

F-2. In 1984, what was your net farm income? (Net farm income is gross farm income minus expenses.)

1. COSTS EXCEEDED INCOME IN 1984
2. BROKE EVEN
3. $2,499 OR LESS
4. $2,500 TO $4,999
5. $5,000 TO $9,999
6. $10,000 TO $19,999
7. $20,000 TO $49,999
8. $50,000 OR MORE

F-3. In 1984, what percentage of your total assets was your debt?

1. 0%
2. 1 - 25%
3. 26 - 50%
4. 51 - 75%
5. 76+ %

Thank you for taking the time to fill out the questionnaire. Your contribution to this effort is greatly appreciated. If you would like a summary of the results, please write "copy of results requested" on the back of the questionnaire. A copy will be sent to you as soon as the survey is completed and a summary is drawn up.
APPENDIX B
An increasing number of farmers are using computer-based information systems such as ACRES to obtain agricultural information. You, as an early adopter and consumer of this new technology, will help influence the extent and ways in which these systems will ultimately be used. However, there is little existing data on the characteristics and opinions of farmers who are using or have used agricultural information systems. Such data are extremely valuable for determining the impact that information systems are having on agriculture as well as for planning for the future to ensure that these systems meet the needs of farmers.

The Department of Agricultural Economics and Rural Sociology at Ohio State University in conjunction with the American, Ohio, and Michigan Farm Bureau Federations is surveying farmers who are currently subscribing or have subscribed in the past to the ACRES system. Your farm operation was drawn in a random sample of subscribers and ex-subscribers of ACRES from Ohio. In order that the results truly represent the characteristics and opinions of subscribers and ex-subscribers in Ohio, it is important that each questionnaire be completed and returned. This is your chance to express your opinions on the positive and negative aspects of the ACRES system and how it can be improved.

You may be assured of complete confidentiality. The questionnaire has an identification number for mailing purposes so we may check your name off the mailing list when your questionnaire is returned. The answers will not be identified as yours. The results of the survey will be made available to Farm Bureau officials and agricultural scientists at Ohio State. You may also receive a summary of the results by writing "copy of results requested" on the back of the questionnaire. I, Richard Goe, the Project Director, would be most happy to answer any questions you might have. My telephone number is (614) 422-9076.

Thank you for your assistance in making this project a success.

Sincerely,

Richard Goe
Project Director

Enclosure
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