Technology, Public Policy, and the Changing Structure of American Agriculture: A Special Report for the 1985 Farm Bill

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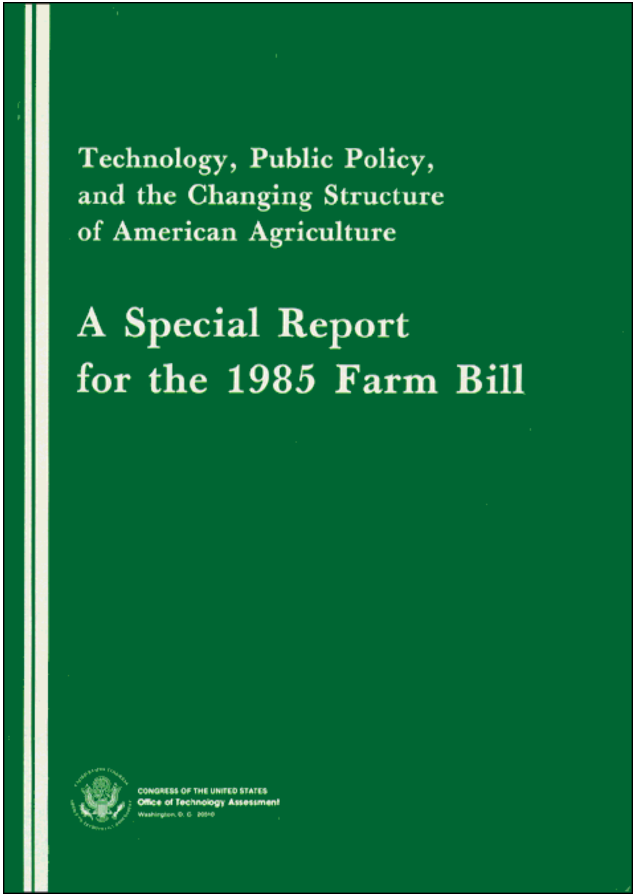

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Foreword

In July 1983 the Technology Assessment Board approved the requests of five congressional committees that OTA conduct a study that would project the most likely picture of U.S. agriculture in 2000 by analyzing the relationships between emerging agricultural technologies, public policy, and structural change in the farm sector. The major concern the committees expressed in requesting the study was the lack of knowledge about the nature and impacts of emerging technologies in combination with public policy specifically as they affect the future direction of agriculture, The committees that requested the study are: the Senate Committee on Agriculture, the Senate Small Business Committee (the Subcommittee on the Family Farm), the Joint Economic Committee, the House Committee on Science and Technology, and the House Committee on Agriculture (the Subcommittee on Livestock, Dairy, and Poultry; the Subcommittee on Department Operations, Research, and Foreign Agriculture; and the Subcommittee on Forests, Family Farms, and Energy).

Although the study will not be completed until late 1985, some findings from the study, provided in this report, are relevant to specific legislation that will shortly be debated and acted upon in Congress (the reauthorization of the Agriculture and Food Act of 1981). Like the legislation, the report focuses on three main policy areas: commodity, credit, and research and extension.

In the course of preparing this report, OTA drew on the experience of many individuals. In particular, we appreciate the assistance of our advisory panel and many workshop participants, as well as the efforts of the project's consultants and contractors, We would also like to acknowledge the help of the numerous reviewers who helped ensure the accuracy of our analysis. It should be understood, however, that OTA assumes full responsibility for this analysis and that the report does not necessarily represent the views of the individual members of the advisory panel.

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Overview

Continuing, rapid advances in biotechnology and information technology promise to revolutionize agricultural production and to alter dramatically the structure of the U.S. agricultural sector. In the next 15 years, 1.5 of the estimated 1.8 percent annual growth in production needed to balance world agricultural supply and demand must come from increases in agricultural yields—yields that will be possible largely through the development and adoption of emerging technologies. While it seems clear that these technologies must be used if this Nation is to compete in the international marketplace, it is also clear that the potential impacts of adopting these technologies have important policy implications for Congress as it begins debate on the reauthorization of the 1981 farm bill,

One impact will be technology's role, under the current policy environment, in creating a surplus of certain commodities in the immediate future. Overall, the agricultural community is expected to experience unpredictable fluctuations in the balance of agricultural supply and demand. For certain commodities, however—notably, dairy products—a substantial potential for further U.S. surpluses exists. The adoption of new technologies coupled with current farm policy will exacerbate that problem. The implication for policy makers is the need for a farm program that more easily allows for adjustments in periods of shortages and surpluses rather than remaining fixed.

Another impact of technology will be its continuing role in changing the structure of the agricultural sector from a system dominated by the moderate-size farm to one dominated by large and very large industrialized farms.[1] Technology has provided the technical means for structural change: mechanization has made it possible for farmers to operate larger farms, and disease control has made it possible to use large-scale confinement feeding. Public policy has provided further incentives, such as price supports and tax incentives, for farmers to expand operations.

The technologies a farmer now needs to remain competitive are costly and complex. Farmers who lack the capital and expertise to adopt new technology early enough to maintain a competitive edge must seek supplementary off-farm income, find some special niche for their products, or give up farming altogether. This last alternative has become a familiar picture for the moderate-size farm, which is fast disappearing from the agricultural scene, As it drops from the middle of the farm spectrum, it leaves small and part-time farms (whose owners earn their primary income elsewhere) clustered at one end and the large farms (whose owners can take advantage of economies of scale) clustered at the other,

This trend has several implications for public policy. First, if a decision is made to slow the decline of the moderate-size farm, policymakers must provide ways for: 1) making new technologies more available to these farms, and 2) providing training in the use of these technologies. Targeting income support to the operators of such farms would also be an effective policy component, although even this measure may not help dairy farmers in some regions.

Second, despite the apparent advantages of operators of very large farms, such operators may need a loan safety net to help them weather price instabilities and the rigors of the world marketplace. Unlike most of their moderate-size counterparts, such farms can survive without income supports.

Third, agricultural policy may have to include ways to help particular groups and regions make the transition to different endeavors. For example, programs to retrain agricultural workers for jobs in other sectors of the economy may be necessary, or farm operators in

[1]For purposes of this study we have defined a moderate-size farm as having gross sales of $100,000 to $199,000; a large farm, $200,000 to $499,000; and a very large farm, $500,000 and over.

a region may need help changing to alternative kinds of farming. The Lake States region, for instance, shows some comparative advantages for switching from dairy production to corn.

Finally, and perhaps most significantly, farm programs must be considered in the context of these strong technological, economic, and institutional forces. Farm programs can merely speed up or slow down these forces of change —they cannot reverse the trends.

While the forces influencing change in the agricultural structure have been identified, they have not primarily been studied in the overall context of farm policy decisions. This report attempts to do just that. It focuses on the following sections of the 1981 farm bill: Title I–Dairy, Title III—Wheat, Title IV—Feed Grains, Title V—Cotton, Title VI—Rice, Title VIII—Soybeans, Title X–Grain Reserves, Title XI–Payment Limitations, Title XIV—Research and Extension, and Title XVI—Credit, Rural Development, and Family Farms.

Chapters 2 and 3 of this report provide background information on technology and structural change and on the procedures followed in the conduct of this study. The remainder of the chapters present the results of OTA'S analysis. The long-run impacts of technology, public policy, and structural changes on rural communities, the natural resource base, and the environment will be addressed in detail in the later full report from this study.

Chapter 2

The New Technologies

Chapter 2

The New Technologies

Technology has made U.S. agriculture one of the most productive in the world. Some of that technology has taken the form of new products—che-rnicals to control pests, drugs to control disease, or sensors and computers that automatically measure moisture conditions and irrigate the field. Other technology has been embodied in new processes—such as the ability to use a computer, to make better economic decisions, or to apply the best combination of cultural practices. The emerging technologies encompass both products and processes, and, like their predecessors, promise to reshape the practice of agriculture.

This chapter provides a brief survey of the emerging agricultural production technologies that could have such an impact and analyzes the effect of various technology development and adoption environments on agricultural food production over the next 15 years,

SURVEY OF EMERGING TECHNOLOGIES

Before the turn of the century, cattle ranchers in Texas may be able to raise cattle as big as elephants. California dairy farmers may be able to control the sex of calves and to increase milk production by more than 10 percent without increasing feed intake. Major crops may be genetically altered to resist pests and disease, grow in salty soil and harsh climate, and provide their own fertilizer. And computers and electronics will be used to increase management efficiency. These are only a few of about 150 emerging technologies in the 28 technological areas that have been identified and evaluated for this study (table 2-1). While it may sound like science fiction, advances in biotechnology and information technology will make these technologies a reality in the next 10 to 20 years,

Table 2.1 .—Emerging Agricultural Production Technology Areas

Animal	Plant, soil, and water
Genetic engineering	Genetic engineering ‘
Animal reproduction	Enhancement of photosynthetic efficiency
Regulation of growth and development	Plant growth regulators
Animal nutrition	Plant disease and nematode control
Disease control	Management of insects and mites
Pest control	Weed control
Environment of animal behavior	Biological nitrogen fixation
Crop residues and animal wastes use	Chemical fertilizers
Monitoring and controlling	Water and soil-water-plant relations
Communication and information	Soil erosion, productivity, and tillage
Telecommunication	Multiple cropping
Labor-saving technologies	Organic farming
	Communication and information management
	Monitoring and controlling
	Telecommunications
	Labor-saving technologies
	Engine and fuels
	Land management
	Crop separation, cleaning, and processing

SOURCE Office of Technology Assessment

Biotechnology

Animal Agriculture

One of the major thrusts of genetic engineering in animals is the mass production in microorganisms of proteinaceous pharmaceuticals, including a number of hormones, enzymes, activating factors, amino acids, and feed supplements. Previously obtained only from animal and human organs, these biological were either unavailable in practical amounts or in short supply and costly.

Some of these biological can be used for detection, prevention, and treatment of infectious and genetic diseases; some can be used to increase production efficiency. One of the applications of these new pharmaceuticals is the injection of growth hormones into animals to increase productivity. Several firms, including Monsanto and Eli Lilly, are developing genetically engineered bovine growth hormone to stimulate lactation in cows. In trials at Cornell University, daily doses of recombinant bovine growth hormone were administered to dairy cows. The hormone, produced naturally by a cow's pituitary gland, was synthesized by Genentech for Monsanto. The results showed that each cow treated with the hormone increased milk production by at least 12 percent without increasing feed intake. Commercial introduction of the new hormone now awaits approval by the Food and Drug Administration (FDA) (Bachrach, 1984; Hansel, 1984).

Another new technique arising from the convergence of gene and embryo manipulations promises to permit genes for new traits to be inserted into the germ lines of livestock and poultry, opening a new world of improvement in animal health and productivity, Unlike genetically engineered growth hormone, which increases an animal's milk production or body weight but does not affect future generations, this technique will allow future animals to be permanently endowed with traits of other animals and humans, and probably also of plants.

In this technique, genes for a desired trait, such as disease resistance and growth, are injected directly into either of the two pronuclei of a fertilized ovum (egg), Upon fusion of the pronuclei, the guest genes become a part of all of the cells of the developing animal, and the traits they determine are transmitted to succeeding generations.

In 1983, scientists at the University of Pennsylvania and University of Washington successfully inserted a human growth hormone gene, a gene that produces growth hormone in human beings, into the embryo of a mouse to produce a supermouse that was more than twice the size of a normal mouse (Palmiter, 1983). In another experiment, scientists at Ohio University inserted rabbit genes into the embryos of mice. The genetically engineered mice, which were 2.5 times larger than normal, ate as much as normal mice (Mintz, 1984).

Encouraged by the success of the supermouse experiments, USDA scientists at the Beltsville Agricultural Research Center are now conducting a new experiment to produce super sheep and pigs by injecting human growth hormone gene into the germ lines of sheep and pigs (Russell, 1984). In this experiment, USDA scientists provide Ralph Brinster of the University of Pennsylvania with fertilized eggs from sheep and pigs at their Beltsville farms. After injecting the eggs with the human growth hormone genes, Brinster returns the embryos to Beltsville to be inserted into the surrogate mother animals.

The experiments of crossing the genetic materials of different species in general and of using the human growth hormone in particular have prompted lawsuits from two scientific watchdog groups: the Foundation of Economic Trends, headed by Jeremy Rifkin, and the Humane Society of the United States. Both charged that such experiments are a violation of "the moral and ethical canons of civilization, " and they sought to halt the experiment. The researchers argued that they are continuing the experiment cautiously and countered that the potential scientific and practical benefits far outweigh the theoretical problems raised by the critics.

I Pharmaceuticals that are proteins.
'Reproductive cells.

The success of the mice experiments indicates that analogous insertion into bovine germ lines of additional bovine growth hormone genes, or of growth hormone genes from larger mammals such as sperm whales or elephants, could yield larger productivity gains than would somatic injections of growth hormones. Moreover, the change in growth would remain a permanently inheritable characteristic, The expression "a whale of an animal" would no longer be just a figure of speech. Probably, however, the growth hormone gene from any animal may be used (not just hormones from very large animals) as long as enough of that hormone is injected to do the job.

Although some scientists may be too optimistic when they predict in 2 years the development of a lo, ()()()-pound cow and the growth of a pig 12 ft long and 5 ft high (Mintz, 1984), these developments are certainly within the realm of possibility in the next 10 to 20 years, However, some of these changes mayor may not be desirable due to economic, environmental, anatomical, institutional, and ethical reasons.

Another technique, embryo transfer in cows, involves artificially inseminating a superovulated donor animal[4] and removing the resulting embryos nonsurgically for implantation in and carrying to term by surrogate mothers. Prior to implantation, the embryos can be treated in a number of ways. They can be sexed, split (generally to make twins), fused with embryos of other animal species (to make chimeric animals or to permit the heterologous species to carry the embryo to term), or frozen in liquid nitrogen, Freezing is of great practical importance because it allows embryos to be stored until the estrus of the intended recipient on the farm is in synchrony with that of the donor. For gene insertions, the embryo must be in the single-cell stage, having pronuclei that can be injected with cloned foreign genes. The genes likely to be inserted into cattle maybe those for growth hormones, prolactins (lactation stimulator), digestive enzymes, and interferon, thereby providing both growth and enhanced resistance to diseases.

[3]Injections into body cells rather than into reproductive cells.
[4]An animal that has been injected with a hormone to stimulate the production of more than the normal number of eggs per ovulation,

While less than 1 percent of U.S. cattle are involved in embryo transfers, the obvious benefits will push this percentage upward rapidly, particularly as the costs of the procedure decrease (Brotman, 1983). One company, Genetic Engineering Inc. (GEI), already markets frozen cattle embryos domestically and abroad and provides an embryo sexing service for cattle breeders (Genetic Engineering News, 1983).

Plant Agriculture

The application of biotechnologies in plant agriculture could modify crops so that they would make more nutritious protein, resist insects and disease, grow in harsh environments, and provide their own nitrogen fertilizer. While the immediate impacts of biotechnology will be greater for animal agriculture, the long-term impacts may be substantially greater for plant agriculture. The potential applications of biotechnology on plant agriculture include microbial inoculums, plant propagation, and genetic modification.

Microbial Inoculums.—Rhizobium seed inoculums are widely used to improve nitrogen fixation by certain legumes. Extensive study of the structure and regulation of the genes involved in bacterial nitrogen fixation will likely lead to the development of more efficient inoculums. Research on other plant colonizing microbes has led to a much clearer understanding of their role in plant nutrition, growth stimulation, and disease prevention, and the possibility exists for their modification and use as seed inoculums,

Recently, Monsanto announced plans to field-test genetically engineered soil bacteria that produce naturally occurring insecticide capable of protecting plant roots against soil-dwelling insects (Journal of Commerce, Dec. 12, 1984). The company developed a genetic engineering technique that inserts into soil bacteria a gene from a micro-organism known as Bacillus thuringiensis, which has been registered as an insecticide for more than two decades. Plant seeds can be coated with these bacteria before planting. As the plants from these buds grow, the bacteria remain in the soil near the plant roots, generating insecticide that protects the plants.

Plant Propagation.—Cell culture methods for regeneration of intact plants from single cells or tissue explants have been developed and are used routinely for the propagation of several vegetable, ornamental, and tree species (Murashige, 1974; Vasil, et al., 1979). These methods have been used to provide large numbers of genetically identical, disease-free plants that often exhibit superior growth and more uniformity over plants conventionally seed-grown. Such technology holds promise for important forest species whose long sexual cycles reduce the impact of traditional breeding approaches. Somatic embryoss produced in large quantities by cell culture methods can be encapsulated to create artificial seeds that may enhance propagation of certain crop species.

Genetic Modification.—Three major biotechnological approaches—cell culture selection, plant breeding, and genetic engineering—are likely to have a major impact on the production of new plant varieties. The targets of crop improvement via biotechnology manipulations are essentially the same as those of traditional breeding approaches: increased yield, improved qualitative traits, and reduced labor and production costs. However, the newer technology offers the potential to accelerate the rate and type of improvements beyond that possible by traditional breeding.

Of the various biotechnological methods that are being used in crop improvement, plant genetic engineering is the least established but the most likely to have a major impact. Using gene transfer techniques, it is possible to introduce deoxyribonucleic acid (DNA) from one plant into another plant, regardless of normal species and sexual barriers. For example, it has been possible to introduce storage protein genes from French bean plants into tobacco plants (Murai, et al., 1983) and to introduce genes encoding photosynthetic proteins from pea plants into petunia plants (Broglie, et al., 1984),

Transformation technology also allows introduction of DNA coding sequences from virtually any source into plants, providing they are engineered with the appropriate plant gene regulatory signals. Several bacterial genes have now been modified and shown to function in plants (Fraley, et al., 1983; Herrera-Estrella, et al,, 1983). By eliminating sexual barriers to gene transfer, genetic engineering will greatly inc:rease the genetic diversity of plants.

Information Technology

Animal Agriculture

The most significant changes in future livestock production due to information technology will come from the integration of computers and electronics into a modern livestock production system that will make the farmer a better manager.

Computers and electronic devices can be used efficiently in animal feeding, reproduction, disease control, and environmental control. The first step toward efficient management will be with electronic animal identification (Muehling and Jones, 1983). Positive identification of animals is necessary in all facets of management, including recordkeeping, individualized feed control, genetic improvement, and disease control. All animals could be identified soon after birth with a device that would last the life of the animal. The device would be readable with accuracy and speed from 5 to 10 ft for animals in confinement and at much greater distances for animals in feedlots or on pasture. Research on identification systems for animals has been in progress for some years, especially for dairy cows. For example, an electronic device now used on dairy cows is a transponder that is worn in the ear or on a neck chain. A feed-dispensing device identifies the animal by its transponder and feeds the animal for maximum efficiency, according to stage of production. It also permits animals in different stages of production to be penned together yet still be fed properly.

[5]Embryos reproduced asexually from body cells.

Feeding systems with sensing devices also detect outdoor temperature so that animals can be fed accordingly. Since the amount of feed-energy an animal needs under various weather situations and at each stage of growth is known, the ability to sense weather information could fine-tune diet preparation.

A rapid analysis of the feedstuff going into the ration will be available at the farm. In formulating a ration, it will be very helpful to get an instant and accurate reading on the calcium, phosphorus, and Iysine contents of the ration ingredients, This will permit a feedback control to adjust the mill and mixer automatically to provide an optimum feed.

The largest potential use of electronic devices in livestock production will be in the area of reproduction and genetic improvement. An inexpensive estrus detection device, for example, would prove profitable in several ways:

- Animals could be rebred faster after weaning and increase the number of litters per year.
- Animals that did not breed could be culled from the herd, saving on feeding and breeding space.
- Time would be saved because breeding would be done faster.
- Embryo transplants would be easier because of better estrus detection.

Another use of information technology is in disease control and prevention (Osburn, 1984). Computers and computer programs are being used at many dairies and swine production units and in the poultry industry. Herd recordkeeping systems for animal health are being developed and refined for various production units. Examples of these programs now in operation include FARMHX in Michigan and similar systems in New York and California (Mather, 1983). These recordkeeping systems may be linked with animal identification systems, including radiotransmitters, as indicated earlier. Examples of the types of information that can be recorded for each animal include production records, feed consumption, vaccination profiles, breeding records, conception dates, number of offspring, listing and dates of diseases, and costs of medicants for treatment or prevention of disease, A review of printouts will allow the manager or veterinarian to analyze quickly a health profile for each animal. Bringing all of this information together will allow the veterinarian and manager of the livestock enterprise to plan for more cost-effective disease control programs and to designate the duties, such as vaccinations and pregnancy examinations, that are to be carried out, These programs are being applied and refined on a few farms. By 1990 many of the more progressive livestock producers will be using these systems, and by 2000 these systems will be widely applied to nearly all of the cost-efficient livestock production units.

Environmental control of livestock facilities is another area where electronic devices can be used. Microprocessors will be used to alleviate odorous gases and airborne dust in ventilation systems.

Plant Agriculture

One of the applications of information technology in plant agriculture is in the management of insects and mites (Kennedy, 1984), Improvements in the design and availability of computer hardware and software will produce tremendous changes in insect and mite management at all levels (research, extension, pest management, personnel, and farmer). To be implemented efficiently, as measured by its contribution to crop profitability, insect and mite management requires the processing of voluminous quantities of information, including: 1) condition and phonological stage of the crop, 2) status of the various insect and mite pests and their natural enemies present in the crop, 3) production inputs into the crop, 4) incidence of plant diseases and weed pests and the measures used in their control, 5) weather conditions, and 6) insect and mite management options. Further, this information must be updated and reviewed at regular intervals, Computers can help superbly in the effective and efficient processing of this information as well as in the design, direction, and analysis of pest management-related research.

The availability at the farm level of microcomputers equipped with appropriate software and having access to larger centralized data bases will greatly speed the transfer of information and facilitate pest management decisionmaking. The advantages, simply in terms of information storage and retrieval, will be tremendous, The ready storage of and access to current and historical information on pest biology, incidence, and abundance; pesticide use; cropping histories; weather; and the like at the regional, farm, and even field level will facilitate the selection of the appropriate management unit and the design and implementation of pest management strategies for that unit.

Centralized, computer-based, data management systems for crop, pest, and environmental monitoring information have been developed and are being evaluated for use on a regional scale by a USDA / Animal and Plant Health Inspection Service regional program. Such systems will provide rapid analysis, summarization and access to general crop summaries, observer reports, pesticide and field management information, reports of new or unknown pests, general pest survey information, and specified field locations with pest severities.

Other software systems designed to facilitate directly the implementation of pest management programs are in use and are continually being improved. The Prediction Extension Timing Estimator (PETE) model (Welch, et al., 1978) is a generalized model for the prediction of arthropod phonological events. PETE is sufficiently flexible to be used for management in many agricultural and nonagricultural systems, For example, it is used as a part of the broader biological monitoring scheduling system (BIOSHED) developed in Michigan by Gage and others (1982) for a large number of pests on a wide variety of crops (Croft and Knight, 1983).

Experiences with these and other software systems have demonstrated their great value and identified areas where improvements are needed. It has also pointed out that the data base from which biological models are developed is limited, Since all biological models are only as good as the biological information upon which they are based, the continued development and improvement of such models for use in integrated pest management (1PM) is contingent on continued high-quality research on the appropriate aspects of plant and pest biology and ecology,

The advantages provided by computer software are tremendous, in terms of improved efficiency and accuracy with which pest management decisions can be made and implemented. There is a great deal of effort currently being devoted to the development of new software and the improvement of existing software. This, in conjunction with the rapid advances being made in computer hardware, provides a powerful force that will lead to dramatic changes in the implementation of 1PM and to increases in the level of sophistication of 1PM, where such increases are desirable.

A detailed description of all technologies examined in this study will be presented in OTA'S full report later this year,

IMPACT OF EMERGING TECHNOLOGIES ON PRODUCTION

To help analyze the impact of emerging technologies on agricultural productivity, OTA commissioned leading scientists in each of the 28 technology areas studied to prepare papers on the state of the art. The papers were valuable resources for workshops conducted to assess the impacts of emerging production technologies. Participants in the workshops—on animal and plant agriculture—provided data on: *1)* the timing of commercial introduction of each technology area, 2) the number of years needed to adopt the technology (by commodity), and 3) yield increases (by commodity) expected from the technology. Workshop participants included physical and biological scientists, engineers, commodity extension specialists, economists, agribusiness representatives, and experienced farmers.

Since the impact of a new technology on agriculture at a given time depends in part on when the technology is available for commercial introduction, workshop participants were asked to estimate the probable year of commercial introduction of each technology under four alternative environments:

1. Baseline environment—assumes to 2000: a) a real rate of growth in research and extension expenditures of 2 percent per year, and b) the continuation of all other forces that have shaped past development and adoption of technology.
2. No-new-technology environment—assumes that none of the technologies identified in the study will be available for commercial introduction by 2000.
3. Less-new-technology environment—assumes to 2000: a) no real rate of growth in research and extension expenditures, and b) all other factors less favorable than those of the baseline scenario.
4. More-new-technology environment—assumes to 2000: a) a real rate of growth in research and extension expenditures of 4 percent, and b) all other factors more favorable than those of the baseline scenario.

The year of commercial introduction ranged from now—for genetically engineered pharmaceutical products; control of infectious disease in animals; superovulation, embryo transfer, and embryo manipulation of cows; and controlling plant growth and development—to 2000 and beyond—for genetic engineering techniques for farm animals and cereal crops. Of the 57 potentially available animal technologies, it was estimated that 27 would be available for commercial introduction before 1990, and the other 30 between 1990 and 2000, under the baseline environment. In plant agriculture, 50 out of 90 technologies examined were projected to be available for commercial introduction by *1990,* and the other 40 technologies between *1990* and 2000.

Historical trend lines of efficiency measurements of crop and livestock production were provided to the participants as a starting point for their assessment of impact on productivity. Through the Delphi process, participants collectively projected the primary impacts of the technologies on each of the nine commodities for 1990 and 2000 under the different environments. Based on the information obtained from the workshops on the year of commercial introduction, the adoption profile, and the primary impacts, OTA computed crop yields and production efficiencies for the nine commodities for 1990 and 2000 (table 2-2).

Projections of Agricultural yield

Under the baseline environment, major crop yields are estimated to increase from now until 2000 at a rate ranging from 0.8 percent per year, for soybeans and cotton, to 1.3 percent per year, for wheat. Wheat yield, for example, is projected to increase from 35.6 bushels per acre in 1982 to 44.8 bushels per acre in 2000 at the rate of 1.3 percent per year under the baseline environment. However, under the no-new-technology environment, wheat yield would increase to 40,8 bushels per acre in 2000 at the rate of 0.8 percent a year. The difference in wheat yield between the two environments, 4 bushels per acre, represents the impact of new technologies.

Under the baseline environment, feed efficiency in animal agriculture would increase at a rate of from 0.4 percent per year for beef to 0.8 percent for poultry, In addition, the reproduction efficiency would also increase, at an annual rate ranging from 0.5 percent, for beef cattle, to 0.9 percent, for swine. Milk production per cow per year would increase from 12,300 pounds (lbs) to 17,563 Ibs per cow in the period 1982-2000. Without new technologies, milk production per cow per year would increase to only 13,700 lbs in 2000; under the

Table 2-2.—Estimates of Crop Yields and Animal Production Efficiency

		No-new-technology environment		Baseline environment		More-new-technology environment	
	1982	1990	2000	1990	2000	1990	2000
Corn bu per acre	115	117	124	119	139	121	150
Cotton lb per acre	481	502	511	514	554	518	571
Rice bu per acre	105	105	109	111	124	115	134
Soybean bu per acre	30	32	35	32	37	33	37
Wheat bu per acre	36	38	41	39	45	40	46
Beef							
Pounds meat per lb feed	0.070	0.071	0.066	0.072	0.072	0.072	0.073
Calves per cow	0.90	0.94	0.96	0.95	1.0	0.95	1.04
Dairy							
Pounds milk per lb feed	0.94	0.94	0.95	0.95	1.03	0.96	1.11
Milk per cow per year (thousand lb)	12.3	13.7	15.7	14.0	17.6	14.2	19.3
Poultry							
Pounds meat per lb feed	0.44	0.52	0.53	0.53	0.57	0.53	0.58
Eggs per layer per year	245	255	260	258	275	257	281
Swine							
Pounds meat per lb feed[a]	0.165	0.167	0.17	0.17	0.176	0.17	0.18
Pigs per sow per year	14.4	14.8	15.7	15.2	17.4	15.5	17.8

[a]The value shown fo,swine feed efficiency for 1982 is the average of national feed efficiencies for the 10 Years Prior to 1982 The national aggregate linear trend of swine feed efficiency is slightly negative and gives a value of ,157 in 1982.

SOURCE. Office of Technology Assessment

more-new-technology environment, production could reach *19,300* lbs.

Projections of food Production

The data obtained from the two technology workshops were used in an econometric model developed by the Center for Agricultural and Rural Development at Iowa State University to assess the collective impact of the 28 areas of emerging technologies on the production of various crop and livestock products.

Table 2-3 shows projections to 2000 of increased production for three major U.S. export commodities (which comprise 60 percent of U.S. agricultural food production exports). Under the baseline environment, corn production is projected to increase at the rate of 1.8 percent per year from 1981 to 2000. However, without the new technologies examined in this study, the rate of growth would be only 1.2 percent. Under the more-new-technology environment, corn production would increase at a much faster rate—2.2 percent per year,

About the same growth rates were obtained for wheat production, which would increase at *1.8* percent per year from 1981 to 2000 under the baseline environment. Under the no-new-technology environment, wheat production would increase at only 1 percent per year,

A more drastic increase in soybean production is projected from now until *2000* regardless of the environment considered. The annual production of soybeans is projected to increase under the baseline environment at an annual rate of *2.8* percent from 1981 to 2000. Without new technologies, the production is still expected to increase at *2,4* percent a year. Under the more-new-technology environment, soybean production would increase at *2.9* percent per year.

In the world marketplace available information points to a series of periodic surpluses and deficits in agriculture over the next two decades (Mellor, 1983; Resources for the Future, *1983).* A Resources for the Future (RFF) study indicates that global balance between cereal production and population will remain quite close to *2000,* indicating vulnerability to annual shortfalls resulting from weather, wars, or mistakes in policy. Over the next *20* years the world will become even more dependent on

Table 2-3.—Projection of Major Crop Production

Crop	Unit	1981	2000 No-new-technology environment	2000 Baseline environment	2000 More-new-technology environment
Corn					
Production	Million bushels	8,136	10,289.0	11,499.0	12,394,0
Growth rate	Percent		1.2	1.8	2,2
Wheat					
Production	Million bushels	2,704	3,273.0	3,825.0	4,063.0
Growth rate	Percent		1.0	1.8	2.2
Soybean					
Production	Million bushels	1,953	3,067.0	3,311.0	3,351.0
Growth rate	Percent		2.4	2.8	2.9

SOURCE Off Ice of Technology Assessment

trade. There will be increasing competition for U.S. farmers in international markets. Much of this increased competition will come from developing countries selling farm commodities as a source of exchange to pay for imports such as oil. Despite this increased competition, exports of grain from North America are projected to nearly double by 2000.

On the other hand, there is another school of thought that believes current studies such as that by RFF have not properly assessed the magnitude and impact of emerging technologies on farm production. Technologies such as genetic engineering and electronic information technology that are available in various forms could mean rapid increases in yields and productivity. While such changes may improve the competitive position of American agriculture, they have the potential for creating surpluses and major structural change—favoring, for example, larger more industrialized farms.

Any conclusion regarding the balance of global supply and demand requires many assumptions regarding the quantity and quality of resources available to agriculture in the future. Land, water, and technology are likely to be the limiting factors as far as agriculture's future productivity is concerned.

Agricultural land that does not require irrigation is becoming an increasingly limited resource. In the next 20 years, out of a predicted 1,8 percent annual increase in production to meet world demand, only 0.3 percent will come from an increased quantity of land used in production (RFF, 1983), The other 1.5 percent will have to come from increases in yields—mainly from new technology, Thus, to a very large extent, research that produces new technologies will determine the future world supply—demand balance and the amount of pressure placed on the world's limited resources.

The OTA results indicate that with continuous inflow of new technologies into the agricultural production system, U.S. agriculture will be able not only to meet domestic demand but also to contribute significantly to meeting world demand in the next 20 years, This does not necessarily mean that the United States will be competitive or have the economic incentive to produce. It means only that the United States will have the technology available to provide the production increases needed to export for the rest of this century.

Under the baseline environment, growth rates in production, which include additional land resources and new technology, will be adequate to meet the 1.8 percent needed to balance world supply and demand in 2000. Under the more-new-technology environment, production could increase at 2,2 percent per year, which would be more than enough to meet world demand. This increased production could, however, point to a future of surplus production. On the other hand, under the less-new-technology environment the production of major crops in 2000 would drop to 1.6 percent per year, a growth rate that would not be able to meet the demand. Under the no-new-technology environment, the annual rate of production growth would be reduced further to 1.1 percent. It should be noted that if the current administration proposal to reduce the agricultural research budget is accepted by Congress, the rate of production growth would be somewhere between 1.1 to 1.6 percent.

Chapter 3

The Changing Character of **the U.S. Agricultural Sector**

Chapter 3

The Changing Character of the U.S. Agricultural Sector

Who will use a new technology is as important a consideration as which technology will be adopted, for the distribution of technology has a considerable impact both on agricultural production and on the structure of the agricultural sector.

The emerging technologies examined for this study will be introduced within a socioeconomic structure that has undergone considerable change in the last 50 years and that promises to continue to change throughout the remainder of this century. This chapter provides a perspective for analyzing technology's distributional impacts on agricultural structure by surveying the characteristics of that structure and noting the past and present factors that define it.

THE PRESENT STRUCTURE OF AGRICULTURE

The heart of agriculture, the farm, is officially defined as a place that produces and sells, or normally would have sold, at least 1,000 dollars' worth of agricultural products per year. So defined, there were about 2.2 million farms in 1982. Farms in that year had an average net income from farming of $9,976 and an average off-farm income of $17,601, for a total of $27,577.

Perhaps the best known characteristic of U.S. agriculture is the trend toward larger but fewer farms. Currently, about 1 billion acres of land are in farms, resulting in an average farm size of about 400 acres. However, this average size has little meaning, since fewer than 25 percent of all farms fall within the range of 180 to 500 acres. Almost 30 percent of all U.S. farms have less than 50 acres, while 7 percent have more than 1,000 acres.

The number of farms reached a peak of about 6.8 million in 1935 and is now approximately 2.2 million. The rate of decline has slowed since the late 1960s, with a loss of about 100,000 farms since 1974.

Employment in farming began a pronounced decline after World War II, when a major technological revolution occurred in agriculture. The replacement of draft animals by the tractor began in the 1930s and was virtually complete by 1960, releasing about 20 percent of the cropland, which had been used to grow feed for draft animals.

The increased mechanization of farming permitted the amount of land cultivated per farm worker to increase fivefold from 1930 to 1980. The amount of capital in nominal terms used per worker increased more than 15 times in this period. Total productivity (production per unit of total inputs) more than doubled because of the adoption of new technologies such as hybrid seeds and improved livestock feeding and disease prevention. The use of both agricultural chemicals and fuel also grew very rapidly in the postwar period. Agricultural production now relies heavily on the nonfarm sector for machinery, fuel, fertilizer, and other chemicals. These, not more land or labor, produced the growth in farm production. The resultant changes have also greatly increased the capital investment necessary to enter farming and have generated new requirements for operating credit during the growing cycle.

One of the best ways to look at changes in the economic structure of U.S. agriculture is in terms of value of production as measured by gross sales per year. Farms can be usefully classified into the five categories of gross sales shown in table 3-1.

Small farms generally do not provide a significant source of income to their operators. This class of farms is operated by people living in poverty and by people who use the farm as a source of recreation.

Part-time farms may produce significant net income but in general are operated by people who depend on off-farm employment for their primary source of income.

Moderate-size commercial farms cover the lower end of the range in which the farm is large enough to be the primary source of income for an individual or family. Most families with farms in this range also rely on off-farm income. In general, farms in this range require labor and management from at least one operator on more than a part-time basis.

Large and very large commercial farms include a diverse range of farms. The great majority of these are family owned and operated. Most farms in these classes require one or more full-time operators, and many depend on hired labor on a full-time basis. Five percent of these farms are owned by nonfamily corporations, a much higher percentage than in the other three classes. In general, the degree of contracting and vertical integration is much higher in these classes.

Table 3-1.—Sales Classes of Farms

Class	Amount of gross sales per year
small	Less than $20,()()0
Part-time	$20,000 to $99,999
Moderate commercial	$100! 000 to $199,000
Large commercial	$200,000 to $499,999
Very large commercial	$500,000 and over

SOURCE: Off Ice of Technology Assessment

Changes in Farm Size and Numbers

Major changes in the structure of U.S. agriculture can be seen in the changes in the number of farms in these classes since the 1969 Census of Agriculture. Inflation in commodity prices has tended to move large numbers of farms from lower sales classes into higher sales classes. Even after the number of farms is redistributed to counteract these nominal changes, the real number of small farms has declined by about 22 percent—a dramatic decline. (Recent reports that the number of small farms has actually increased since 1978 refer to farms that are small in acreage, not small in sales.) The number of part-time farms has also declined by about 18 percent. The number of moderate farms has increased substantially, by about 39 percent, and the number of large and very large commercial farms has increased even more dramatically, by about 43 percent and 53 percent, respectively. Even though the number of moderate farms has increased, the loss of these farms in share of sales and net income to large and very large farms, as shown in the next section, more accurately indicates the changing character of American agriculture.

Changes in Distribution of Saks and Income

Changes in the number of farms do not alone give the whole picture. Changes in the distribution of sales and income are more important and clearly show the direction in which U.S. agriculture is heading. In the sections that follow, sales and income data presented reflect redistributions calculated to adjust for the impact of inflation.

Between 1969 and 1982, sales by small farms declined from 9 to 6 percent. Sales from part-time farms declined from 43 to 22 percent. The market share of moderate farms increased from 13 percent of total sales to 19 percent. In the same period the market share of large and very large farms increased greatly–from 36 to 57 percent.

The most telling changes of all have occurred in the distribution of net farm income. The large and very large farms have not only captured the majority of the market but also controlled or reduced their cost of production. In 1974 these commercial farms had a 47-percent market share and 35 percent of net farm income after adjustment for inflation. In 1982, just 8 years later, with their market share at 54 percent, these farms had 84 percent of net farm income (table 3-2). Very large farms have been responsible for the majority of this growth. This class, which accounts for only 1.2 percent of all farms, increased its real share of net farm income fourfold—from 16 to 64 percent. By comparison, small farms in 1982 had a negative net farm income, and part-time farms had declined from 39 percent in 1974 to 5 percent of total net farm income. Moderate farms have seen a substantial decrease in net farm income, from 21 percent in 1974 to 11 percent in 1982.

It is clear that if these trends continue, small and part-time farms are likely to disappear, to the extent that the operators of these farms depend on them for income. The number of small recreational, or "hobby," farms may increase. Large and very large farms will completely dominate agriculture. The number of moderate farms may continue to increase, but they will have a small share of the market and a declining share of net farm income.

Moderate farms comprise most of the farms that depend on agriculture for the majority of their income. Traditionally, the moderate farm has been viewed as the backbone of American agriculture. These farms appear to be failing in their efforts to compete for their historical share of farm income.

Changes in Sources of Income

Employment and the sources of income of U.S. farmers have changed greatly in the 20th century. These changes occurred at a rapid rate in the 1970s. The largest single source of change was the tremendous increase in labor productivity made possible by technological changes, resulting in a sharp drop in the demand for agricultural labor. During the 1930s the disposable farm income per capita was less than 40 percent of disposable nonfarm income. This income differential resulted in the large migration of the farm labor force out of agriculture and rural areas. This out-migration accelerated after the Great Depression of the 1930s because employment and per capita income opportunities increased considerably outside of agriculture. In general, the marginal productivity of labor was higher outside the agricultural sector from the 1930s to the early 1970s. Therefore, migration of labor from farming to the nonfarm sector contributed to national economic growth.

In the 1970s, the average income differential between farm and nonfarm households nar-

Table 3-2.—Distribution of Farms, Percent of Cash Receipts, Percent of Farm Income, and Farm and Off-Farm Income per Farm by Sales Class, 1982

Sales Class	Value of farm products sold	Number of farms	Percent of all farms	Percent of total cash receipts	Percent of net farm income	Average net farm income	Average off-farm income	Average total income
	Less than $5,000	814,535	36.4	1.2	-2.0	($550)	$20,396	$19,846
Small	$5,000-$9,999	281,802	12.6	1.5	-0.9	(700)	22,498	21,798
	$10,000-$19,999	259,007	11.6	2.8	-0.9	(780)	18,648	17,868
Part-time	$20,000-$39,999	248,825	11.1	5.4	0.2	154	14,134	14,288
	$40,000-$99,999	332,751	14.9	16.4	5.2	3,451	12,529	15,980
Moderate	$100,000-$199,999	180,689	8.1	19.1	14.6	17,810	11,428	29,238
Large	$200,000-$499,999	93,891	4.2	21.0	20.4	48,095	12,834	60,929
Very Large	$500,000 and over	27,800	1.2	32.5	63.5	504,832	24,317	529,149
	All farms	2,239,300	100.0	100.0	100.0	$9,976	$17,601	$27,578

SOURCES: Adapted from *Economic Indicators of the Farm Sector: Income and Balance Sheet Statistics, 1983*, USDA Economic Research Service, 1984, Table 59, using farm number and cash receipts distribution data from the 1982 Census of Agriculture, Dept. of Commerce, Bureau of the Census, 1984.

rowed to about 88 percent, owing to rapid increases in farm prices and a substantial increase in the number of farm jobs available from growth in rural industries. These two factors resulted in a slowing of the rate of outmigration.

In 1982 the average income of farm and nonfarm households was quite close, $27,577 and $28,638, respectively. However, two-thirds of the income of farm households came from off-farm sources. The majority of farm operators today have some off-farm employment.

The average income statistics mask economic problems that exist in the middle of the scale of sales classes of farm operations (table 3-2). Farms in the part-time class, with sales in the range of $20,000 to $99,999, are in serious trouble. About 580,000 farms in this class in 1982 had an average total income of about $15,000. Their average net income from farming was only $2,033. These farms are not large enough to generate much net farm income and have lower-than-average off-farm incomes. In contrast, farmers with sales of less than $20,000 have substantial off-farm incomes and low or negative net farm income. The average off-farm income of these individuals enables them to maintain this way of life.

Those owning moderate farms have sufficient off-farm income to maintain a household. However, this group may be under the most stress. To provide an adequate total income, moderate farm owners must earn almost as much off-farm as on-farm income. Farmers with sales in excess of $200,000 have moderate off-farm incomes and moderate-to-very large net farm incomes. As a group, these farmers are well-off.

Changes in the Structure of Debt in The Farm Sector

At a time when agricultural production has become more concentrated, the structure of debt in the farm sector has also become more concentrated. This process accelerated during the boom years of the 1970s. The size and concentration of farm debt, combined with high production costs and the continuing likelihood of low commodity prices, have led to a great deal of concern about the financial condition of the farm sector. A substantial proportion of the U.S. farm sector is under severe financial stress. Financial *stress* is defined as the perceived inability of the firm or individual to meet cash flow commitments in the form of cash farm expenses, debt repayment requirements, tax payments, or family living needs. This stress can be measured indirectly by use of the debt-to-asset ratio. In general, the distribution of high debt-to-asset ratios is more important than the average debt-to-asset ratio of all farms. The percentage of farms with debt-to-asset ratios greater than 40 percent and greater than 70 percent in January 1984 by gross sales class is shown in table 3-3,

Clearly, debt use is closely related to farm size. To the extent that debt-to-asset ratios show potential financial problems, beginning farmers and operators of larger farms are likely to be in more difficulty than are other farmers,

An important aspect of outstanding debt is the risk of default from the lender's standpoint. If those with the largest proportion of debts to assets are more likely to suffer losses, then there are important risk elements facing agricultural lenders. In January 1984, 24 percent of the total agricultural debt was owed by farmers with over a 70-percent debt-to-asset ratio. Another 32 percent was owed by farmers with debt-to-asset ratios in the range of 40 to

Table 3-3.—Distribution of Farms With High Debt-tomAsset (d/a) Ratios, by Sales Class, January 1984

	Highly leveraged (d/a ratios: 40 to 70"/0)		Very highly leveraged (d/a ratios: over 70°\o)	
Sales class	"/0 of class	No. of farms	0/0 of class	No. Oj farms
Less than $50,000	8.3	123,200	5.0	74,800
$50,000 to $99,999	14.7	44,000	8.7	26,400
$100,000 to $249,999 . . .	18.1	52,800	9.2	26,400
$250,000 to $499,999 . . .	19.0	17,600	12.6	11,000
$500,000 and over	17.4	5,200	15.3	4,500
All farms	11.1	242,800	6.6	143,100

SOURCE U S. Department of Agriculture, 1983 Farm Producllon Expenditure Survey.

70 percent, Thus, over one-half of outstanding debt was owed by operators with debts greater than 40 percent of their assets, This is a matter of great concern for lenders, since poor farm incomes or decreases in asset values will more quickly erode the equity of highly leveraged operators than of high-equity operators (Brake, 1985),

Another useful way to illustrate increasing financial stress is through the recent increases in debt service burdens, This increase can be measured by the amount of interest expense as a percentage of cash receipts after payment of intermediate production expenses, business taxes, wages, and rents. By this measure, the debt burden of U.S. farms was 17 percent in 1975. By 1981 it had reached 35 percent and has been in the range of 34 to 38 percent ever since. This has resulted in substantial reductions in the amount of receipts remaining to pay for the operator's labor, for the owner's equity in the business, for purchases of capital durable goods, and for payments of interest and principal.

The consequences of increasing financial stress can be seen in increasing rates of payment delinquency and foreclosure. For example, Production Credit Association loan charge-offs were under 0.1 percent in 1978 and 1979. By 1983 these charge-offs had risen to 1.2 percent of outstanding loans—an elevenfold increase in 4 years, Similarly, the number of loans in process of liquidation was negligible in the late 1970s. Data on these loans were not even kept in the Farm Credit System. By 1982, loans in process of liquidation approached 1 percent of outstanding loans, and as of March 1984, Production Credit Association loans in the process of liquidation were over 2.5 percent of all outstanding loans,

DEFINING STRUCTURAL CHANGE IN AGRICULTURE

Traditionally, American agriculture has been dominated by farms in which the operators and their families provided most of the labor, made the management decisions, owned part of the resources, accepted most of the production and price risks, bought and sold in the open market, and depended on the farm as their major source of family income. Such farms have been revered since the days when Thomas Jefferson argued for national policies of public land distribution that favored small, independent landholders. In recent years, the dispersed, independent farm, open market system has become less dominant in American agriculture, Major questions are whether this system can compete for world markets and whether society should take steps to halt present trends that are gradually diminishing this system's prominence. Answering these questions entails viewing the causes of structural change—that is, how farm resources are organized and controlled—through economic and noneconomic perspectives.

The Economic Perspective

An economic perspective encompasses concentration and vertical integration in agriculture.

Concentration

Concentration refers to the proportion of production controlled by the largest firms, It is important to consider because the more highly concentrated the market, the greater the potential impact of a firm or group of firms on price.

Concentration of total production in agriculture compared to that in many of the other economic sectors is generally low. As shown in chapter 2, concentration has occurred to the point where in 1982 about 28,000 very large commercial farms—1,2 percent of all farms—produced one-third of the total value of U.S. farm products and accounted for over 60 percent of U.S. farm net income.

However, concentration in land resources is also occurring.[1] Trends in the distribution of harvested cropland according to sales class show that these productive acres are rapidly becoming concentrated in the farms in the large commercial and very large commercial sales classes. Table 3-4 shows the percentage of total cropland harvested by the top two sales classes of farms for the census years *1969* and *1982* and projects them linearly to *1990* and *2000*. If present trends continue, almost half of all cropland will be harvested by farms in these sales classes by 2000.

The degree of concentration varies from commodity to commodity. For example, beef cattle operators with sales over *$500,000* per year in *1982* represented only **0.5** percent of all beef cattle operations and accounted for 55 percent of the total value of cattle sales. The *69* largest of these feedlots produced 21 percent of the fed cattle in *1980* (USDA, *1981).* The largest cattle feeders were also some of the largest feed manufacturers and grain companies,

Higher levels of concentration exist for broilers (chickens). In 1977 the *16* largest broiler producers and contractors controlled about 50 percent of the production (Brooke, *1980).* In vegetable crops, such as lettuce and celery, concentration is comparably high (Brooke, *1980).*

[1] Land resources in the agricultural sector can be viewed in the general category of "land in farms," as defined by the Bureau of the Census, or in the "harvested cropland" category. The acreage of cropland harvested is a more accurate measure of productive agricultural resources than is the general category of land in farms.

Table 3-4.—Historical and Projected Percentages of Cropland Harvested by Farms With Sales in Excess of $200,000

Sales class	Year 1969	1982	1990	2000
$200,000 -$499,000	*12.0*	*25.3*	*27.0*	*32.0*
$500,000 +	*6.0*	11.2	12.0	14.0
Total	18.0	36.5	39.0	46.0

Projection Assumptions:
1 Growth in total harvested acres is linear, resulting in an increase of 2.4 million acres per year.
2 Growth follows the linear trend for the two sales classes and results in an increase of 27 million acres per year for the farms in the $200,000-$499,000 class and of 1 million acres per year for the $500,000+ class.
3 The linear projections are based on the acres harvested by sales classes, adjusted for inflation. Inflation in commodity prices tends to move acres from lower to upper sales classes Since inflation in commodity prices is likely to continue, nominal growth in acreage harvested by these sales classes may be greater than projected

SOURCE Office of Technology Assessment

On the other hand, concentration is still very low for most crop agriculture. Relative to other American industries, where the market share of the four largest manufacturers frequently exceeds 50 percent, concentration in agriculture—even for cattle feeding, broilers, lettuce, and celery—is low. However, attention is drawn to agriculture because of the rapidity with which certain industries, such as broilers and fed cattle, have gone from a diffused to a concentrated and integrated agriculture (Knutson, et al,, *1983).*

Concern exists that if extended over a period of time, the increasing concentration of agricultural production could lead to higher food prices (Breimyer and Barr, *1972).* This would result from increased merchandising and marketing costs, the potential unionization of agricultural workers, and lack of effective competition (Rhodes and Kyle, 1973).

Vertical Integration

Firms are vertically integrated when they control two or more levels of the production-marketing system for a product, Such control may be exercised by contract or by ownership.

Contract integration exists when a firm establishes a legal commitment that binds a producer to certain production or marketing practices. At a minimum, contract integration requires that the producer sell the product to the buyer. Additional commitments may bind the farmer to specified production practices and sources of inputs, While all forms of contract integration have created concern, the greatest controversy exists with contracts that control both production and marketing decisions of farmers. In addition, from a legal perspective, the producer may not even own the product being grown (Knutson, et al., *1983).*

The extent of contract integration is not well documented. Ronald Knutson estimates that all forms of contract integration represented *32* percent of farm sales in 1981 (Knutson, et al., 1983). He makes the following observations on the extent of contracting:

1. Contracting used to be limited to perishable products; now it has expanded to virtually all commodities.
2. Production contracting appears to be associated with commodities where breeding and control of genetic factors play an important role in either productivity determination or quality control.

Ownership integration is a single ownership interest extended to two or more levels of the production-marketing system. It may involve either cooperatives or proprietary agribusiness firms. Knutson estimates that proprietary ownership integration accounts for about 6 percent of farm sales. Some proprietary agribusiness firms such as Cargill (beef), Superior Oil (fruits, vegetables, and nuts), Coca-Cola (oranges and grapefruit), Tysons (broilers and hogs), Tenneco (fruits, vegetables, and nuts), and Ralston Purina (mushrooms) have made substantial investments in agricultural production. In products such as broilers, eggs, cotton, vegetables, and citrus fruits, ownership integration is over *10* percent of total U.S. production (Knutson, et al., 1983).

Cooperative ownership integration is much more prevalent than proprietary ownership integration, accounting overall for 34 percent of farm sales. However, in only 13 percent of cooperative integration is there a legal commitment by farmers to market their commodities or purchase inputs from the cooperative.

The economic implications and concern for structural change of vertical integration are debated. A principal problem in agriculture has been the difficulty of coordinating production with market needs. Vertical integration can make a substantial contribution to satisfying this need. For example, in broilers and turkeys, vertical integration has contributed to the uniform size and quality of poultry sold. It has also contributed to increased efficiency and reduced costs (Schrader and Rogers, 1978).

On the other hand, there are potentially adverse consequences of vertical integration. Contract integration with corporations, and sometimes cooperatives, radically changes the role of the traditional independent farmer. More often than not, the farmer loses control of, if not legal title to, the commodities grown under a production-integrated arrangement. Payment to the grower is largely on a per-unit or piece-wage basis, and not necessarily related to product value.

It has been argued that in the long run, market power in integrated agriculture will become sufficiently highly concentrated that the consumer will pay higher prices for food. However, no definitive conclusion can be made. The above argument fails to take into account efficiency gains from integration. The extent to which these gains could be realized without the development of a vertically integrated system is open to question,

The Sociological Perspective

Many concerns relating to structural change are of a sociological nature, They revolve around the impact of concentration and integration on the institution of the family farm, on rural communities, and on rural institutions,

Concern has been expressed that continuously increasing the concentration and integration will lead to the demise of the family farm as an institution. The term family farm has been associated with the existence of an independent business and social entity that shares responsibilities of ownership, management, labor, and financing. The family farm system leads to dispersion of economic power and has been associated with the perpetuation of basic American values and of the family as an institution, Increased concentration and integration tend to destroy the family farm institution. Very large farms lose many of the characteristics of the traditional family farm because their business and hired labor aspects clearly predominate. Most of the management functions traditionally associated with the family farm institution are removed by integration. With integration the farmer takes on more of the characteristics of a businessman.

Another concern is that concentration and ownership integration reduce the number of farms and make the integrator less dependent on the local community. As a consequence, small rural towns and their social institutions decline or vanish. Recent research conducted in California provides some evidence to substantiate such a relationship. Dean MacCannell (1983) has found that rural communities where a few large and integrated farms dominate are associated with few services, lower quality education, and less community spirit.

Concerns are also expressed about the impact of structural change on the nature of the U.S. political system. Thomas Jefferson visualized the merits of a decentralized political system where power was highly diffused and where every individual had the opportunity for input to public decisions. His philosophy placed a high value on independent farmers and landowners as a means of maintaining a democratic system of government.

Already there has been a marked departure from the decentralized power structure ideal visualized by Jefferson. The question is whether agriculture is basically unique and different from other sectors of U.S. society, as has long been maintained—that is, are there unique social, cultural, and traditional values in having land ownership widely dispersed, or should agriculture join the mainstream where the other economic sectors have long been? As U.S. agriculture continues along the trends laid out in this report, it will increasingly take on characteristics of the nonfarm sector. Some will interpret this trend as progress; others will interpret it as a step backward.

CAUSES OF STRUCTURAL CHANGE

A number of factors have been identified by researchers as causes of structural change. However, there has been no delineation of the relative importance of each factor. One of the objectives of this study is such a delineation. Before moving to that analysis in the following chapters, however, it is important to understand why each of these factors is considered important to structural change.

Most observers of structural change cite three main determinants: 1) technology and associated economies of size, specialization, and capital requirements; 2) institutional forces; and 3) economic and political forces (fig. 3-1). This section briefly defines these forces.

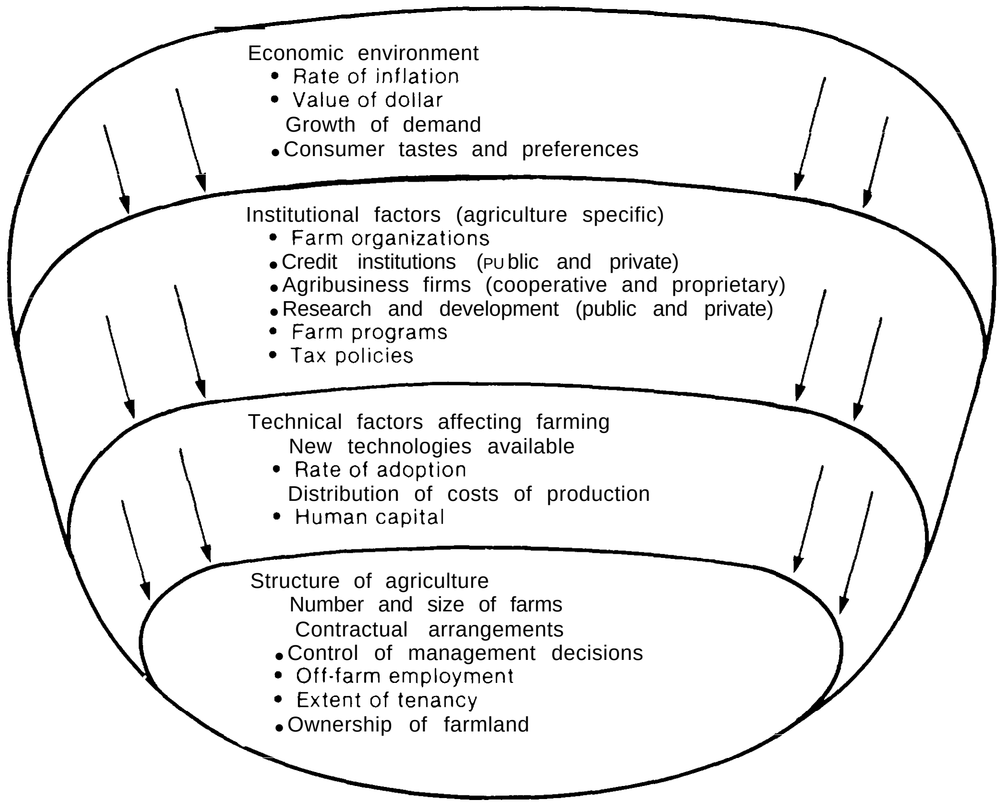
Technological Forces

Certain farmers have a strong incentive to adopt new technology rapidly. The early innovator achieves lower per-unit costs and increased profits, at least for a short time, before other farmers follow his lead. For example, in Washington State a winter wheat farmer with *2,500* acres can reduce average machinery costs by 9 percent per acre by replacing a conventional crawler tractor with a four-wheel-drive tractor. If he also expands the size of his farm to 3,900 acres, he can reduce costs by an additional 18 percent (Rodewald and Folwell, 1977), This nearly 60-percent increase in farm size can be made without additional labor. Once the innovative wheat farmer adopts the technology, other crop farmers generally have two options: purchase a four-wheel-drive tractor and expand the size of their farm or accept a lower net income as market prices for their crops fall. In short, new technology can play an important role in determining acreage and capital requirements. Different farmers have different costs because they use different combinations of inputs, have different management skills, or have different scales of operation.

Economies of Size

The relationship of scale of operation to cost is of particular significance to structure, If costs are relatively the same for all farm sizes,

Figure 3-1 .—Factors Influencing the Structure of Agriculture



SOURCE Off Ice o'Technology Assessment

one would expect all farm sizes to have relatively little incentive to increase in size. In addition, with relatively even costs, consumers would clearly not benefit from increases in farm size. If, on the other hand, costs decline sharply as farm size increases, not only would there be strong incentives for farms to grow in size, but consumers would potentially realize lower prices for food, of at least equal importance to policy makers, if costs decline sharply as farm size increases, efforts to prevent this change from occurring—for example, to preserve the family farm—would not only be difficult but could be counterproductive from a consumer perspective. Smaller farm operators could exist in a cost-declining environment only if they were willing to accept lower returns to contributed labor, capital, and management, and/or had an off-farm job.

Past studies of the relationship between average production costs and farm size support two major conclusions, First, most economies of size are apparently captured by moderate farms. Second, while the lowest average cost of production may be attainable on *a* moderate farm, average cost tends to remain relatively constant over a wide range of farm sizes, Thus, farmers have a strong incentive to expand the sizes of their farms in order to increase total profits.

Earlier studies on economies of size have several limitations. External economies gained from buying and selling in large volumes and from access to credit have usually been ignored. Common ownership of related farm and nonfarm activities has not been considered, There is some evidence that inclusion of such pecuniary economies would lower the average production costs for large farm units and would shift the conclusion about the size of the most competitive farm (Smith, et al., 1984).

Specialization

Technology has also influenced specialization and regional production patterns. Cotton production has moved westward, for example, into areas of broad, flat fields where larger machinery can be used to optimum advantage. Specialization in crop production is also due in part to technology. Farmers who once relied on crop rotation and diversification to conserve soil fertility, prevent soil erosion, and control pests have replaced these practices by chemical fertilizers, insecticides, and herbicides, with questionable long-run effects. They can thus grow one crop exclusively year after year, specializing in commodities that are the most profitable. Similarly, the development of new disease control techniques has given poultry and livestock farmers unprecedented opportunities to specialize. The vertically integrated broiler industry of today would have been impossible without scientific advances in breeding, feeding, housing, and medicine, which have reduced the real cost of broilers by as much as 50 percent over the past 30 years,

These scientific breakthroughs have generally enabled both small and large farmers to specialize more. However, improvements in farm machinery have perhaps been most important in fostering large-scale, specialized operations. A decision to invest in a specialized piece of equipment means that an operator will emphasize production of the commodity for which the machine is intended, quite likely at the expense of some other commodity, And, insofar as a machine is most economical on a particular size of operation, expansion to that size is encouraged. Thus, specialization and farm growth occur simultaneously.

Capital Requirements

Agriculture is one of the most capital-intensive industries in the American economy. The result is high requirements for credit to finance new capital investments, production, or storage.

Technology has made barriers to entry more formidable, The cost of machinery raises capital requirements for beginning farmers. Technologies that allow individuals to farm increasingly larger acreages have added to the competition for land, resulting in high land prices, the single greatest expense in farming today. The average investment in 1980 in a farming operation with gross sales between $40,000 and $60,000 ranged from $350,000, for fruit and nut farms, to over $800,000, for livestock ranches.

Institutional Forces

Institutional factors have their primary influence on the costs of inputs used in production, the prices of products, and the generation of new technology for agriculture. These institutions may be either in the private or the public sector.

The costs of inputs are primarily a function of competition between private sector agribusiness firms. Input costs do not have to be the same for all farmers, Input suppliers may offer farmers discounts for larger volume purchases of fertilizer or chemicals. Likewise, larger scale farmers may receive higher prices for products marketed through the use of crop contracts or futures markets.

Research and Extension Service

New technologies are generated in both the public and private sector. Basic agricultural research is primarily a public sector function performed by the U.S. Department of Agriculture (USDA) and the land grant universities. Applied research functions are shared between the public and private sector, with the private sector dominating development activities. Extension activities assist in evaluating and transferring technological innovations into practice. An integral part of agricultural research and extension policies is the generation of higher levels of training and expertise embodied in human capital, The result is more skilled farmers, agribusinessmen, scientists, and agricultural policy makers.

Research and extension have had differential impacts on farms, farm workers, rural communities, and even entire regions, depending on their characteristics and the type of technology developed, Some technological innovations, particularly mechanical innovations, have favored and hence fostered larger farms. Other technological innovations that could be applied on farms of any size are often first adopted by larger farms (paarlberg, 1981; Perrin and Winkelman, 1976). By being the first to adopt new technologies, larger farms receive greater benefits than those not adopting the technologies (typically, smaller farms).

A major effort of the extension service is to disseminate timely information through public meetings. The topics covered in publications and public meetings are heavily influenced by current research results, Any bias toward larger farms that is embodied in research results would most likely be carried over into meetings and publications.

Even though extension personnel make information available to all farmers, those farmers that make the most use of the research results and extension information can generally be characterized as more innovative, more aggressive, and better managers, usually of larger farms (Paarlberg, 1981). Such farmers are also generally more vocal, providing feedback to research and extension personnel on the usefulness of the information received. Even though no overt effort is made to exclude particular groups, such as operators of small farms, the net result is that many research and extension programs become more oriented toward those select groups that generally avail themselves of the information (Paarlberg, 1981),

This lack of structural neutrality was recognized in 1979 by Secretary of Agriculture Bergland when he questioned the use of Federal funds for research projects having the objective of producing large-scale, labor-saving technology and set up a special task force to investigate the impact of research and extension on structure. At the same time, Congress earmarked research and extension funds for increased work with small farms and for projects involving direct marketing from farmers and consumers, However, no special programs were developed for moderate farms,

The Bergland initiative on research was reemphasized with the change in administration in 1981. It has, however, been rekindled by the announcement of joint initiatives in biotechnology research between private sector companies and universities. Questions have arisen as to whether the primary beneficiaries of the initiatives will be the private sector firms or the initial farmer adopters of the resulting new technology,

Public policy

Many public policies affect the structure of agriculture by influencing resource use, capital requirements, technology development and adoption, freedom of decisionmaking, exchange arrangements, risks, and costs and profits. Some policies are oriented specifically to the farm sector, such as price and income policy (commodity programs). Others affect agriculture directly but are more broadly oriented, such as tax policy. Still others are general—national macroeconomic policy, for example—and affect agriculture indirectly.

Public policies offer viable ways to maintain or alter the structure of the agricultural sector. In this section, areas of public policy involvement that affect the structure of agriculture are briefly examined.

Commodity Programs. -Beginning with the Agricultural Adjustment Act of 1933, a series of commodity programs have evolved to deal with price and income problems in farming. These programs have covered such commodities as wheat, feed grains, cotton, wool, sugar, rice, peanuts, tobacco, and dairy products. To stabilize and increase farm prices and incomes, a variety of program tools have been used: price supports, direct payments, acreage allotments, set-asides, conservation reserves, surplus disposal, and stock accumulation.

There is widespread agreement that these programs, in the short run, held farm incomes above what they would otherwise have been; there is much less agreement about their long-term effects on income. Price stability from these programs has, however, enabled farmers to adopt new and improved technologies.

Commodity programs along with technological advances influence structural change in agriculture through the following mechanisms. Since farmers are price takers, no one farmer can significantly influence the aggregate supply of a commodity and hence the price that he receives. However, the individual farmer can do something about his operating costs. By adopting a new technology an innovative farmer increases productivity and lowers his firm's cost structure. Since price is not affected at the early stage of technology adoption, he reaps a profit. As his cost structure falls, the farmer increases his output at the given price, It is possible that innovative farmers used some of their profits to buy up assests of less efficient neighbors, thus starting the change in the structure of farming. As more farmers realize the benefit of new technology and follow this innovator, the adoption of the new technology becomes widespread. As they do this, aggregate supply increases, and the price of the product declines. After a period of adjustment a new equilibrium is reached at a lower price, a situation in which the innovator no longer receives a profit and in which the laggard adoptors of new technology suffer an economic loss. This dynamic interaction has been referred to as the "agricultural treadmill" (Cochrane, 1958).

Under a commodity program in which the price of the commodity is supported, the same treadmill concept applies. However, under such a commodity program the price does not fall when the aggregate supply increases, because the product price is supported by Government action. Instead, each early adopter continues to reap a profit and seeks to expand output by acquiring the land of his less innovative neighbors. Thus, farm technological advances coupled with Government-supported product prices result in structural change in which productive assests in farming are concentrated in the hands of aggressive, innovative farmers. However, since the total amount of arable land is limited, competition for this land between the innovative farmers causes the price of land to rise, The cost of production will thus rise until a new equilibrium is reached in which the expanded, innovative farmers are back in a no-profit situation while the laggard adoptors end up with a loss. In this case the equilibrium is reached by an increase in land values rather than a fall in product prices.

Tax Policy .—Tax laws and provisions are widely recognized as being a determinant of agricultural structure. There is not agreement, however, about the relative importance of tax policy because of tax policy's interactions with other structural determinants. Some tax laws and provisions can be directly related to structure (i.e., estate and corporate tax law), while others (i.e., investment tax credits, depreciation provisions, capital gains, and cash accounting) are indirectly related and often interact with credit and commodity policies,

In animal agriculture, tax factors such as cash accounting, current deductibility of costs of raising livestock, and capital gains treatment for sales of breeding livestock, together with investment tax credits and accelerated depreciation, influence livestock investments and can affect structure. Tax policy issues in animal agriculture include tax shelter and nonfarm investments, tax provisions as a factor in economies of size, and the legal structure of agriculture, The cattle sector provides one example.

For mechanical technology, current tax laws favor the substitution of capital for labor and may speed the adoption of mechanical systems. Two tax factors are at work: payroll taxes, which increase the cost of labor, and provisions for investment tax credit and accelerated depreciation, which decrease the cost of machinery (Carman, 1983).

The income tax advantages of cattle feeding were packaged as limited partnership syndicates in the late 1960s and early 1970s and sold to nonfarm investors. The growth of nonfarm investment in cattle feeding was closely associated with the movement of cattle feeding out of the Midwest and with the growth of large-scale feedlots in the High Plains area.

Other factors also played a role, but limited empirical evidence suggests that tax-induced investment in cattle feeding through limited partnerships was related to structural change (Carman, 1983),

It is conventional wisdom that tax provisions are an important consideration in the adoption of capital-intensive innovations, since investment tax credit and accelerated depreciation do have a significant impact on after-tax costs. Such innovations include the large four-wheel-drive tractors, circle irrigation systems, minimum tillage systems, and large-scale and improved harvesters.

An important implication can be drawn about structural change from the above discussion. Small farms and very large farms have more off-farm interests against which to offset farm losses than do moderate farms. This could be a significant factor in accounting for the decline of the moderate farm.

Agricultural Credit Policy .—Public policy directly influences the supply of capital to farmers through the Farmers Home Administration (FmHA) of the USDA and the Farm Credit System, which includes the Federal Land Bank, Production Credit Association, and Bank for Cooperatives. The original capital for the Farm Credit System was supplied by the Federal Government, but the system is now wholly owned by its borrowers. However, the Farm Credit System is still accorded agency status, whereby interest costs on its bonds and discount notes are lowered. The FmHA is a Government agency that has a mandate from Congress to make low-interest loans to family farmers who cannot obtain credit elsewhere. The FmHA and the Farm Credit System together account for approximately 40 percent of the total farm debt outstanding (8 and 33 percent, respectively) (Barry, 1983),

The general intent of farm credit policies has been to ensure appropriate capital availability for agriculture. Policies established by these agencies and their attendant programs are thought to have influenced the structure of the farm sector, although the extent of their impact has not been studied thoroughly,

Economic and Political Forces

Agriculture operates in a broader overall economic and political environment. This environment determines the rate of interest, the rate of inflation, and the value of the dollar—all of which influence the costs and prices of farm products, The increased importance of these effects has made macroeconomic policies that influence the overall economic environment within which agriculture operates more important to farmers.

THE DYNAMICS OF STRUCTURAL CHANGE

A study of this type cannot possibly analyze all of the technical, economic, and institutional factors that influence the structure of agriculture. This study therefore concentrates on those factors that appear to be the most critical in affecting structure and that also relate to current farm policy decisions. These factors include:

- The technical factors influencing the costs of production as related to farm size.
- The major farm program elements.
- The institutions that lead to the development and assimilation of new technology.

The factors interact in a dynamic fashion to influence the structure of farming. New technology continuously infused into agriculture is adopted by the most progressive farmers. While the initial adopters assume increased risk in applying a new technology, they generally also gain substantially higher returns. Farm programs that reduce price risk help assure higher returns.

As more farmers realize the advantages of new technology, the adoption process becomes more general. As this happens, supplies increase, with the tendency to force down market prices. If Government policies prevent market prices from falling, surpluses build up, as they have in the dairy industry or did before the payment-in-kind (PIK) program. If market prices fall, Government payments rise.

Wider adoption of technologies also changes the nature of costs as farm size increases. If larger farms are the first adopters, their costs are substantially lower. The laggers in adoption realize much higher costs. By not adopting, they become, in effect, left behind—eventually being either forced off the farm altogether or forced to take an off-farm job. Moreover, the higher returns gained by early adopters of technology encourage them to seek expansion of output by acquiring more land. Given the fixed land base, however, innovative farmers can only grow in size by acquiring the land of their neighbors. Thus, growth and prosperity of large, progressive farmers can only take place by the failure of those who are slow to adopt technology.

These consequences often lead to suggestions of turning off the technological wheels of progress. Such a strategy, however, would have a devastating effect on the competitiveness of American farmers in world markets. Instead of just some people being left behind, the whole American farm system would be left behind.

Chapter 4

Economic Impacts of Emerging Technologies and Selected Farm Policies for **Various Size Crop Farms**

Chapter 4

Economic Impacts of Emerging Technologies and Selected Farm Policies for Various Size Crop Farms

The impacts of emerging technologies will spur many adjustments at the farm level. Policymakers must thus consider several questions as they debate the 1981 farm bill: Who will adopt these technologies and benefit the most from them—the moderate farms, large farms, or very large farms? What set of farm policies in conjunction with technology advance will benefit each size of farm the most? What combination of emerging technologies and farm policies encourages each size of farm to grow or remain at its present size? How important is technology compared to farm policy in determining farm growth? What is the likelihood of a new entrant in agriculture remaining solvent?

To help answer these questions, this chapter and the next will present the findings of an analysis of selected regions in the United States that represent significant agricultural production in the commodities considered in farm policy: dairy, corn, cotton, soybeans, rice, and wheat, Within each production region analyzed, representative commercial farms were identified for each of the three size categories: moderate, large, and very Iarge.1 It was assumed that the technology development and adoption conditions in existence would be those of the baseline environment outlined in chapter z.

Two techniques were used to analyze the effects of selected policy provisions and technology on farms within each region. Information was obtained on resource characteristics, acreages devoted to specific crops, and historic projected yields of crops eligible for farm program provisions. These data were used to develop resource characteristics of the three different farm sizes. Then a simulation model was used to analyze the economic viability and growth potential of each representative farm for selected policy and technology advance scenarios.

The following sections present the representative farms and major findings for the production areas analyzed. Obviously, more areas could have been analyzed, but neither time nor the resources allocated to this study would permit their inclusion. It is expected that the results will apply in broad principle to the major production region of which each area is a part, It is important to remember that the results of this analysis are mainly illustrative. Thus, the relative results for the several farm sizes and for the several alternative policy and technology scenarios are probably more important than any specific numbers generated by the analysis.

[1]Small and part-time farms were not included because these farm operators in general depend on off-farm employment for their primary source of income.

THE CROP FARMS ANALYZED

Corn-Soyboan Farms in the Corn Belt[a]

The North Central Region of the United States produces approximately 50 percent of the total production of corn and soybeans. Representative farms for this region are the three farms from the corn-soybean cash grain area of east central Illinois and the three farms from the irrigated row crop area of south central Nebraska.

The representative farm situations developed and used in this analysis were constructed from two basic data sources: 1) national cost-of-production surveys by the U.S. Department of Agriculture (USDA) in 1978 and 1983, and 2) farm record data collected and analyzed by the Universities of Illinois and Nebraska. The size of representative farms and acreages of owned and rented cropland were developed from the size distributions in the USDA cost-of-production surveys. The very large farms approximate the largest 10 percent of farms in the surveys, the large farms the 70th to 90th percentiles, and the moderate farms the 40th to 70th percentiles.

Financial status, as measured by net worth, debt load (both intermediate-term and long-term), and leverage ratio, differs dramatically from farmer to farmer. Data from the most recent Agricultural Finance Survey were used to depict the beginning financial characteristics for the six representative farms (tables 4-1 and 4-2).

All of the representative farms are well-mechanized production units ranging from 640 to 2,085 acres of cropland, and all farms include a combination of owned and rented land. Of the six representative farms, only the very large units in each area employ full-time workers. The other farms operate with a combination of family and part-time workers, The Illinois farms have all of their cropland devoted to cash crop production of corn and soybeans, The Nebraska farms are cash crop operations that combine both gravity and sprinkler technologies to irrigate corn and a small acreage of soybeans. In addition, they produce a substantial acreage of grain sorghum under a nonirrigated (dryland) regime. Production on this dryland acreage tends to be somewhat riskier than for the irrigated component of their farming operations, but irrigated farming still has some year-to-year yield variability, owing to weather. Although a number of these irrigated corn farms also produce some wheat and/or corn silage, those enterprises have not been included in the analysis.

The crop mix for the Nebraska farms is identical for all three farm sizes: irrigated corn (58.3 percent of cropland acres), irrigated soybeans (6 percent), and dryland sorghum (35.7 per-

[a]These representative farms were developed and analyzed in the paper "Economic Impacts of Selected Farm Policies, Income Tax Provisions, and Production Technology on the Economic Viability of Corn-Soybean Farms in East Central Illinois and Irrigated Row Crop Farms in South Central Nebraska, " prepared for the Office of Technology Assessment by W. B. Sundquist.

Table 4-1.—Financial Characteristics of Three Representative Corn-Soybean Farms in East Central Illinois[a]

	Farm size		
	Moderate	Large	Very large
Cropland acres	640	982	1,630
Acres owned	260	429	458
Acres leased	380	553	1,172
Value of owned real estate ($1,OOO)[b]	900.5	1,480.6	1,538.4
Value of machinery ($1,000)	92.2	104.8	129.0
Long-term debt ($1,000)	126.1	557.4	579.2
Intermediate-term debt ($1,000)	55.3	62.9	83.8
Initial net worth ($l,OOO)[c]	855.4	1,027.6	1,106.4
Leverage ratio (fraction)	0.21	0.61	0.60
Long-term debt/asset (fraction)	0,14	0.38	0.38
Intermediate-term debt/asset (fraction)	0.60	0.60	0.65
Equity ratio (fraction)	0.82	0.62	0.63
Off-farm income ($1,000)	8.2	7.4	7.6
Minimum family living expenses ($1,000)	18.0	20.0	24.0
Maximum family living expenses ($1,000)	36.0	40.0	48.0
Marginal propensity to consume (fraction)	0.20	0.20	0.20

a A family size of four persons was assumed for the purposes of estimating family labor supply and determining appropriate income tax rates
b Includes land and buildings.
c May include assets other than land, buildings, and machinery

SOURCE: Office of Technology Assessment.

Table 4-2.—Financial Characteristics of Three Representative Irrigated Corn Farms in South Central Nebraska[a]

	Farm size		
	Moderate	Large	Very large
Cropland acres	672	920	2,085
Acres owned	302	530	1,042
Acres leased	370	390	1,043
Value of owned real estate ($1,000)[b]	477.7	838.4	1,648.3
Value of machinery ($1,000)	102.7	112.1	183.9
Long-term debt ($1,000)	123.2	102.0	291.1
Intermediate-term debt ($1,000)	40.1	53.7	98.0
Initial net worth ($1,000)[c]	448.3	839.0	1,463.1
Leverage ratio (fraction)	0.39	0.20	0.27
Long-term debt/asset (fraction)	0.26	0.12	0.18
Intermediate-term debt/asset (fraction)	0.39	0.48	0.53
Equity ratio (fraction)	0.72	0.84	0.79
Off-farm income ($1,000)	8.2	8.2	9.7
Minimum family living expenses ($1,000)	18.0	18.0	24.0
Maximum family living expenses ($1,000)	36.0	36.0	48,0
Marginal propensity to consume (fraction)	0.20	0.20	0.20

a A family size of four persons was assumed for the purposes of estimating family labor supply and determining appropriate income tax rates
b Includes land and buildings
c May include assets other than land, buildings, and machinery
SOURCE Office of Technology Assessment

cent). On the Illinois farms, the proportion of corn to soybeans varies only slightly for the three representative farms, with corn planted on 52 to 55 percent of the cropland acreage and soybeans on the balance.

For the Illinois farms, all cropland has the same per-acre value, while the price of cropland on the Nebraska farms reflects the differentials for four categories of land: 1) gravity irrigated, 2) sprinkler irrigated, 3) dryland with irrigation potential, and 4) dryland without irrigation potential. Each of the three Nebraska farms do, however, have the same proportions of gravity irrigation, sprinkler irrigation, and dryland acres.

Wheat Farms in the Southern Plains[a]

Approximately 65 percent of the U.S. wheat production is produced in the Great Plains. For the analysis of representative wheat farms, farms were selected from the Southern Plains region and are representative of wheat farms in western Kansas, eastern Colorado, and the Oklahoma and Texas Panhandle.

The three farms selected for the analysis are the typical moderate farm in the region (1,280 acres), a large farm (1,900 acres), and a very large farm (3,200 acres), The initial financial characteristics for the three representative farms are summarized in tabIe 4-3. The proportion of cropland owned by each farm was obtained from the most recent Agricultural Finance Survey summarized for wheat farmers in western Kansas, eastern Colorado, the Oklahoma Panhandle, and the Northern High Plains of Texas who had real estate debt.

Average long- and intermediate-term debt-to-asset ratios from the Agricultural Finance Survey were used to estimate initial values for long- and intermediate-term debts. All three wheat farms had about the same beginning equity levels (75 percent) (table 4-3). Minimum family living expenses were based on values obtained from a Texas A&M survey that asked for the minimum annual cash expenditure for family living. The Agricultural Finance Survey was used to obtain values of off-farm income for the three representative farm operators.

A typical cropping pattern in the Southern Plains is to irrigate 50 percent of all cropland and to raise wheat on one-half of this irrigated land. Grain sorghum is typically raised on the

[3]These representative farms were developed and analyzed in the paper "Economic Impacts of Selected Policies and Technology on the Economic Viability of Three Representative Wheat Farms in the Southern Plains," prepared for the Office of Technology Assessment by James W. Richardson.

Table 4-3.—Financial Characteristics of Three Representative Wheat Farms by Size in the Southern Plains

Characteristics	Farm size (acres) Moderate	Large	Verv large
Cropland acres owned . . .	640	840	1,400
Cropland acres leased . . .	640	1,080	1,800
Acres of pastureland owned	120	220	360
Value of owned cropland ($1,000)	296.0	388.5	647.5
Value of owned pastureland	29.4	53.9	88.2
Value of machinery ($1,000)	241.9	352.2	477.2
Value of off-farm investments ($1 ,000) . . .	37.3	49.0	53.5
Beginning cash reserve ($1 ,000) . .	10.0	12.0	20.0
Long-term debt ($1;000)" . .	60.2	86.3	143.5
Intermediate-term debt (1,000)	83.2	126.5	171.3
Initial net worth ($1 ,000) . .	470.3	642.3	970.7
Equity ratio (fraction)	0.77	0.75	0.75
Leverage ratio (fraction) ,.	0.31	0.33	0.33
Long-term debt/asset (fraction)	0.19	0.20	0.20
Intermediate term debt/asset (fraction). . ,.	0.34	0.36	0.36
Off-farm income ($1,000) ,.	12.4	9.8	9.0
Minimum family living expenses ($1 ,000).	18.0	20.0	23.0
Maximum family living expenses ($1 ,000). . . .	40.0	50.0	50.0
Marginal propensity to consume (fraction)	0.25	0.25	0.25

SOURCE: Office of Technology Assessment,

other half of the irrigated cropland. Wheat is generally also raised on the portion of the cropland that is not irrigated. This cropping pattern was assumed for all three farms.

Numerous crop share arrangements prevail in the region for leased land. However, these arrangements generally involve the producer paying the landlord about 25 percent of the crop and the landlord paying none of the production and harvesting costs. This crop share arrangement was assumed for all leased cropland.

General Crop Farms in the Delta Region of Mississippi

The Mississippi Delta is an excellent region for analysis of general crop farms. Farms in this area can produce a variety of crops not possible in other parts of the United States. The representative farms in this region produce cotton, rice, soybeans, and wheat (or other small grains).

The three representative farms developed for this study are a moderate farm (1,443 acres), a large farm (3,119 acres), and a very large farm (6,184 acres). Table 4-4 provides a summary of the financial and resource characteristics for the three representative farms. The long- and intermediate-term debt-to-asset ratios for the 1,443-acre farm and the 3,119-acre farm were obtained from USDA's Agricultural Finance Survey and adjusted to reflect the equity levels as reported from a 1983 mail survey of farms

Table 4-4.—Financial and Resource Characteristics for Three Representative General Crops Farms in the Delta of Mississippi, 1983

Characteristics	Farm size Moderate	Large	Verv large
Age or' farm operator-	44	44	44
Family size[a]	4	4	4
Cropland acres owned . . .	533	1,419	3,064
Cropland acres leased . . .	910	1,700	3,120
Acreage of principal crops in 1983:			
Cotton	395	1,088	2,250
Rice	305	574	871
Soybeans.	640	1,190	2,539
Wheat (or other small grains)	82	247	180
Value of owned cropland ($1,000)	799.5	2,128.5	4,596.0
Value of farm machinery ($1,000)	378.9	786.7	1,209.8
Value of off-farm investments ($1 ,000) . . .	129.1	210.3	358.7
Beginning cash reserve ($1,000)	31.9	71.1	141.6
Long-term debt ($1,000) . .	331.4	840.8	1,640.8
Intermediate-term debt ($1,000)	243.8	413.0	574.7
Net worth ($1,000)	748.6	1,921.5	4,047.5
Total equity to assets (fraction)	0.56	0.60	0.64
Long-term debt/asset (fraction)	0.41	0.40	0.36
Intermediate-term debt/asset (fraction). . . .	0,64	0.52	0.48
Off-farm income ($1,000). .	18.3	18.2	36.0
Minimum family living expenses ($1 ,000).	18.0	24.0	30.0
Maximum family living expenses ($1 ,000).	27.0	36.0	45.0
Marginal propensity to consume (fraction) . .	0.25	0.25	0.25

a Values for the age and family size variables assumed for simulating the effects of alternative farm program provisions for the representative farms

SOURCE: Office of Technology Assessment.

[4]These representative farms were developed and analyzed in the paper "Economic Effects of Selected Policies and Technology on the Economic Viability of General Crops Farms in the Delta Region of Mississippi, " prepared for the Office of Technology Assessment by B. R. Eddleman.

in the Delta. These debt ratios are the average for part-owner general crops farms in the Mississippi Delta region that had debt on real estate in 1979. Financial ratios for the largest farm were developed by extending the ratios on a per-acre basis for a 3,457-acre farm, as reported in the most recent Agricultural Finance Survey, and were adjusted by the equity levels reported for the largest farm size group.

The mix of acreages planted in each crop changes by farm size. In general, the acreage planted in cotton and soybeans increased relative to the acreage planted in rice and wheat as farm size increased. The moderate farm planted 73 percent of tillable cropland in cotton and soybeans, while the large and the very large farm planted 89 and 82 percent, respectively, of tillable cropland in cotton and soybeans. In the analysis, as the farm was allowed to grow in size to the next largest farm size, the proportion of cropland planted to each crop was changed to reflect these relative differences in crop mix.

Cotton Farms in the Texas Southern High Plains[5]

Cotton is an important commodity in the United States, and over one-half of the cotton produced can be found in the Southern High Plains of Texas. The three farms selected for analysis are a typical moderate farm in the region (1,088 acres), a large farm (3,383 acres), and a very large farm (5,570 acres). These size farms account for 31 percent of the farms and 62 percent of the cotton lint produced in the Texas Southern High Plains.

Table 4-5 provides a summary of the demographic and financial characteristics for the three representative cotton farms used in the present study. The long- and intermediate-term debt-to-asset ratios for the moderate farm were obtained from USDA's Agricultural Finance Survey. These debt ratios are the average for part-owner cotton farmers in the Texas High Plains who had debt on real estate in 1979.

[5]These representative farms were developed and analyzed in the paper "Economic Impacts of Selected Policies and Technology on the Economic Viability of Three Representative Cotton Farms in the Texas Southern High Plains," prepared for the Office of Technology Assessment by James W. Richardson.

Table 4-5.—Financial Characteristics of Three Representative Cotton Farms by Size in the Texas Southern High Plains

	Farm size		
Characteristics	Moderate	Large	Very large
Age of operator	42	.-	- .
Acres owned	381	1048	3,453:;
Acres leased	707	2,335	2,117
Value of owned cropland ($1,000)	222.4	611.7	2,015.4
Value of machinery ($1,000)	144.5	420.8	713.9
Value of off-farm investments ($1,000)	59.0	110.0	213.7
Beginning cash reserve ($1,000)	16.7	52.0	85.5
Long-term debt ($1,000)	61.1	120.9	488.7
Intermediate-term debt ($1,000)	98.3	203.6	475.4
Initial net worth ($1,000)	275.0	854.8	2,032.3
Equity ratio (fraction)	0.62	0.72	0.67
Leverage ratio (fraction)	0.61	0.40	0.49
Long-term debt/asset (fraction)	0.27	0.20	0.24
Intermediate-term debt/asset (fraction)	0.68	0.48	0.67
Off-farm income ($1,000)	16.0	0.0	0.0
Minimum family living expenses ($1,000)	15.2	29.1	38.0
Maximum family living expenses ($1,000)	50,0	50.0	60.0
Marginal propensity to consume (fraction)	0.25	0.25	0.25

SOURCE: Office of Technology Assessment

POLICY AND TECHNOLOGY SCENARIOS

The three representative farms for each production region were analyzed for the period 1983-92 under alternative policy scenarios. Six farm policy scenarios (including a continuation of the 1981 farm bill), an income tax provision scenario, two financial stress scenarios, a technology option, and a new-entrant scenario were analyzed for each farm. All assumptions and policy values associated with each scenario were held constant across farm sizes to

[6]The current version of the Firm Level Income Tax and Farm Policy Simulator (FLIPSIM V), developed by James W. Richardson and Clair J. Nixon, was used to simulate the three representative farms in each region.

allow direct comparison of their impacts on different size farms. Appendix A contains summary tables of the analysis for each farm size by region.

Farm Policy Scenarios

Current Policy

The current policy scenario involves continuation through 1992 of current income tax provisions and of the price supports, income support, and supply control programs of the 1981 farm bill. In addition, it is assumed that annual mean crop yields for the three representative farms will increase as new technologies are introduced and adopted by farmers in the baseline technology environment. For this policy scenario it is assumed that the following farm policies are in effect:

- The Commodity Credit Corporation (CCC) loan program is available to producers for corn, cotton, rice, sorghum, soybeans, and wheat.

  A 3-year, indirect, farmer-owned reserve (FOR) is available for feed grains and wheat. T
- An acreage diversion/set-aside program is in effect for 1983-85, using the actual acreage reduction levels and diversion payment rates specified for these years.
- A target price-deficiency payment program is available for corn, cotton, rice, sorghum, and wheat in all years.
- The $50,()()0-payment limitation for deficiency and diversion payments is in effect and is effective on the farm as specified.
- Farms of all sizes are eligible to participate in these farm program provisions,

Values for loan rates, target prices, diversion rates, and diversion payment rates for 1983 and 1984 are set at their actual values, expressed in 1982 dollars. Values for these variables for 1985 are set at their respective levels announced on or before September 14, 1984, by Secretary of Agriculture Block. Loan rates and target prices for 1985 are held constant through 1992. No acreage reduction program was assumed to be in effect after 1985.

It was assumed that the following options for depreciating machinery and calculating income taxes are used for the current policy scenario:

- Machinery, livestock, and buildings placed in use prior to 1981 are depreciated using the double declining balance method.
- Machinery, livestock, and buildings placed in use after 1980 are depreciated using an accelerated cost recovery method.
- The operator elects to claim first-year expensing for all depreciable items placed into use after 1980.
- The operator elects to take maximum investment tax credit (ITC) and thus reduce the basis for all depreciable assets placed into service after 1980.
- The operator adjusts crop sales across tax years to reduce current-year taxes.
- The operator may use either the regular income tax computation or income averaging to calculate Federal income tax liabilities.
- There is no maximum interest deduction for calculating taxable income.
- The actual self-employment tax rates and maximum income levels subject to this tax for 1983 and 1984 are used. Announced values for these variables in 1985-86 were used, and the 1986 values were held constant through 1992.
- The operator elects to trade in old machinery on new replacements at the end of each item's economic life.

Results Expected.—Since this policy includes price supports, income supports, and supply control programs to maintain and stabilize prices and farm income at a reasonable level and reduce the price and income risks, it is anticipated that all farms under this program will have a higher probability of remaining solvent over the lo-year planning horizon, have higher net farm incomes, and have stronger financial positions.

[7] The 1977 farm bill established FOR as a 3-year extension of the CCC loan after grain had been in the regular loan for 9 months, Stocks remain in the farm operator's control until the Secretary of Agriculture authorizes release.

Results Obtained:

- Except for Texas cotton farms, all farms in the other four regions had a 100-percent" probability of remaining solvent over the l0-year period. For Texas cotton farms, the probability of survival ranged from 92 percent for the moderate farms to 94 percent for very large farms.
- All farms in four of the five regions increased their absolute net worth by the end of the period with very large farms increasing more than the moderate farms. The two smaller farms in Illinois experienced a loss in net worth over the period, while the largest farm experienced a 14.5 percent increase in real net worth.
- On the average, all three farms were able to grow by purchasing and leasing cropland. Moderate farms grew in size at a faster rate than the very large farms. The moderate and large grain farms grew at approximately the same rate of growth.
- Average annual net farm incomes for all farms substantially benefited by the presence of price and income supports in the current policy. Removal of these program provisions resulted in negative average annual net farm incomes for farms in all regions except Illinois. (Illinois net farm incomes did not fall below zero because a large portion of cropland is devoted to soybeans, and this crop does not receive a deficiency payment.)
- Ratios of net farm income to total Government payments reveal that, across all regions, the moderate farms are more dependent on Government payments to maintain their incomes than are the very large farms.

Price supports

The price supports program is designed to prevent prices from falling below a certain level and to stabilize prices through the CCC nonrecourse loans at established loan rates to farmers. Such loans, plus interest and storage cost, can be repaid within 9 to 12 months when the commodity is sold on the cash market. If the market is not favorable for a farmer to sell the commodity and repay his loan, CCC accepts the commodity in full payment of the loan,

CCC releases its stock to the market when prices are high and withdraws stocks from the market when prices are low, Thus, the program also stabilizes prices.

Results Expected:

- Since price supports stabilize prices and prevent prices from falling below the loan rate, this program should increase farm income and reduce the price risk for farmers.
- All farms should have a higher probability of survival, greater net present value, [a] and higher net farm incomes than they would have had without the program.

Results Obtained:

- price supports increased the probability of survival for all three representative farms in all regions.
- Net farm incomes for these farms also increased with the price supports program. In all regions, the larger the farms, the greater the increase in net farm incomes.
- With increased farm incomes and reduced price risk, all three farms in all regions experienced increases in real net worth with the price supports program.
- Average ending farm sizes were not significantly different as a result of the price support program.

Income Supports

Income supports are accomplished through deficiency payments and the target price. Deficiency payments are paid to farmers to make up the difference between a price determined

[a]The concept of present value is used to help measure the profit potential of an investment decision. Simply put, a dollar today is worth more than a dollar in the future because today's dollar can be invested and can accrue interest. Thus, the present value of a specified amount of money payable at a specified future date is the amount of money that one would have to invest now in order to have that future amount by that future date. In analyzing an investment over several periods, a positive present value would indicate an economically attractive decision; a negative present value would not.

to achieve a politically acceptable income level (target price) and the average market price. Deficiency payments are made on each farm's base acres and farm program yield. The farm program yield is based on each farm's yield history. Target prices were set initially to reflect an average cost of production.

Deficiency payments were initiated to raise and stabilize farmer incomes to the level of the nonfarm population while allowing farm prices to be competitive in the export market. Total annual Government payments (deficiency and diversion) were limited to $50,000.

Results Expected:

- The major impact of deficiency payments should be to increase the income level of producers who participate in the farm program. Since the payments are based on the quantity of eligible production, large-scale producers benefit more than small-scale producers, up to the $50,00()-payment limitation.
- Deficiency payments also reduce income risk for producers, increase their ability to obtain financing, and thus increase the probability of all farms remaining solvent.

Results Obtained:

- The deficiency payment program increased the probability of survival more for moderate Texas cotton farms than for the very large farm. For farms of other regions, the probability of survival was 100 percent, with or without income support.
- Income supports increased net farm incomes substantially for all farms, often moving net farm incomes from negative to positive.
- Income supports enhanced net farm incomes of all farms more than the price support program.
- The presence of the $50,00()-payment" limitation causes the income support program to benefit moderate farms relatively more than very large farms. In contrast, the price support program results in a greater relative advantage for large and very large farms.
- With reduced income risk and greater farm incomes under the income support program, all farms improved real wealth, and average after-tax net present value increased for all farms.
- Income supports increased the average ending farm size for all farms. Average ending farm size increased at a faster rate for moderate farms than for very large farms.
- Removal of the $50,000 limitation on deficiency payments benefited larger farms more than smaller farms. Big winners of this program were big farms in Texas and Mississippi. In Texas, for example, when the $50,0()()-payment limitation was removed, average annual net farm income increased $3,600, $50,000, and $104,000 for moderate, large, and very large farms, respectively.
- Increased farm income strengthened the financial positions of larger far-ins, increasing their ability to obtain more financing. All three representative farms, especially the very large farms, had increased net worth at the end of the lo-year period. For example, removal of the $50,000 limitation increased the ending net worth of the moderate Texas cotton farm by $37,000, of the large Texas farm by $441,000, and of the very large Texas farm by $1,019,000.

supply Control Policy
(Acroage Reduction Program)

The objective of acreage reduction programs is to reduce the quantity produced and thus the supply of a given commodity. Acreage reduction consists of an acreage set-aside and/or acreage diversion that is generally voluntary. Acreage set-aside programs require that participating farmers idle a percentage of their crop base acres so that they are eligible for other program benefits. Acreage diversion programs pay producers a given amount per acre to idle a percentage of their base acres. A farmer's base acres are determined by the production history of the crop.

For this analysis the provisions of the current policy were modified by adding a 15-

percent set-aside with a 5-percent diversion for corn, cotton, rice, sorghum, and wheat in 1986-92. Normal slippage[8] (30 percent for corn and 70 percent for all other crops) and program participation rates were used to estimate the resulting real increase in mean prices for these crops in 1986-92. All other provisions of the current policy were used without change.

Results Expected:

- To the extent that acreage reduction programs reduce production, they reduce supply and stocks and increase prices domestically for those commodities. Higher prices will result in higher total and net incomes for all farm sizes. Farms that participate in diversion payments also benefit from the program through increased cash receipts, up to the $50,000 limit.
- Slippage in the programs reduces the programs' effectiveness, increases the farms' net present value, and increases farm size.
- Higher incomes lead to more disposable income for debt repayment and retained earnings for accelerating farm growth.
- Farm operators' average net present value should increase.
- Faster rates of growth should be experienced by the farms because of increased cash accumulation, repayment capacity, and equity in existing land assets.

Results Obtained:

- Imposing a 20-percent acreage reduction program increased the average net present value and ending net worth for all three farms in all regions except for the large farm in Illinois.
- Imposing a 20-percent acreage reduction to existing farm programs resulted in a 20- to 300-percent increase in net farm income for almost all farms.
- Average ending farm size for all three farm sizes increased relative to the initial farm size.
- Imposing additional supply controls to existing farm programs does not substantially change the rate of growth or ending farm size of all farms. Moderate farms continued to grow at a faster rate than larger farms.
- Eliminating slippage reduced the rate of growth relative to that in the current policy for all three farm sizes.
- The less slippage in an acreage reduction program, the smaller the increase in average net present value for all three farm sizes.

No Farm Program

In the no-farm-program scenario, all farm programs outlined for the current policy were eliminated for all 10 years of the planning horizon. In this essentially free market environment, farm prices and income are very unstable because: 1) production varies, owing to weather and biological factors; and 2) demand for farm products changes. The inelastic nature of supply and demand for farm products makes farm prices particularly unstable. The variability in prices and incomes has both favorable and unfavorable aspects. From a favorable perspective, the movement in prices reflects changes in supply and demand conditions and is a signal for production regarding market needs. However, when prices become highly unstable, the signals may be misinterpreted and mistakes may be made in production and marketing decisions. The result frequently is misallocation of resources. In addition, variability in price and income increases the risk and uncertainty to the farm business.

Results Expected:

- Average farm incomes will be less with no loans or price supports because the floor on prices received for these commodities has been removed, allowing prices to fluctuate freely.
- Net present value will be lower and more unstable than with price and income supports.
- Net worth of farms will decline because the market value of cropland will be less,

[8] Slippage is the difference between the percent of production decrease and the percent of acreage reduced. These two percentages are different because farmers tend to set aside marginal lands in Government programs or intensify the cultivation of remaining land.

since there are no benefits from the programs to be capitalized into the land.

- Farms will have less probability of survival because of increased instability in prices for crops. The impact will be more pronounced for highly leveraged farms that cannot survive without price and/or income support and for smaller farms that cannot survive with high price risk.

Results Obtained:

- Removing all farm programs reduced the probability of survival for all three farm sizes in cotton and wheat regions, relative to the base policy. The probability of survival fell more for the moderate farms in these regions than for the very large farms. For example, in cotton the moderate farm's chance of remaining solvent for 10 years decreased from 92 to 42 percent; the chance for the solvency of very large farms decreased from 94 to 78 percent.
- The probability of having a positive after-tax net present value declined significantly for all farm sizes in each of the four regions except the Mississippi Delta. For example, in the Southern Plains the probability of a positive net present value for the moderate farm declined to about 10 percent. In most cases the very large farms had a higher probability of positive net present value than the moderate farms. The probability of a positive net present value was *100* percent in the Mississippi Delta without the farm program, Qwing primarily to diversification of crop production and the reduced relative yield variability in the Delta compared with that of the other regions.
- Ending net worth declined for all three farm sizes in all regions. In most regions the absolute decline in net worth was greater for the large and very large farms than for the moderate farms. For example, the large and very large Texas cotton farms experienced a $743,000 and $1,100,800 decline in net worth, respectively, from that of the current policy, while the moderate farms' net worth declined $396,800. The ending net worth of the Mississippi Delta farms declined the least of all regions because a significant portion of crop acreage was devoted to soybeans.
- In the absence of farm programs, all three farm sizes continued to grow in all regions, but at a much slower rate than under the current policy. For example, farms in the Southern Plains declined from the current policy on average about 20 percent in ending farm size.

Target Farm Program Benefits

For the target farm program benefits scenario, all farm program and income tax provisions of the current policy were used except that large farms were not eligible to participate in farm program provisions. Farms producing more than 300,000 dollars' worth of program commodities (corn, cotton, rice, sorghum, soybeans, and rice) valued at their localized loan rate were not permitted to participate directly in the program provisions (CCC loan, FOR, target price/deficiency payments, and set-aside diversions). Mean prices and relative variability in prices were not adjusted because a sufficient number of "small" farms were assumed to participate in the farm program for the price support actions of the CCC loan and FOR to function normally.

Results Expected:

- Findings for moderate farms will be the same as the findings for the current policy.
- Large and very large farms exempted from the programs will receive indirect benefits from other farms participating in the programs.
- Compared with the no-farm-program scenario, the following should be observed for large and very large farms:
  - —Net present value will be higher and more stable.
  - —Net worth of these farms will be greater.
  - —Farms will have a greater probability of survival because of the increased stability in prices.
  - –Farms will be larger because of increased income and large repayment capacity.

Results Obtained:

Moderate farms consistently producing less than $300,000 in program crops exhibit the same growth rates, net farm incomes, and ending financial positions as they do under the current policy.

Farms that grow beyond or are initially larger than the $300,000 threshold level of sales experience lower average Government payments, net farm incomes, average net present values, and net worths than under the current policy, owing to targeting program benefits.

The larger the farm, the greater the reduction in average ending acres from the current policy for farms in the Southern plains, Nebraska, and Illinois. Moderate grain farms in these regions experienced no real change in average ending farm size because of their level of total sales being less than $300,000.

Growth rates for the very large farms in Texas and the Delta were similar to those experienced under the no-farm-program option. The moderate and large farms in the Delta experienced reduced rates of growth relative to the very large farms. A similar relationship was observed between the large and very large cotton farms in Texas. The reason for these different rates of growth is that the very large farms in these regions are less dependent on farm programs than are smaller size farms.

Tax Policy Scenarios

The Federal income tax provisions in place for the current policy were made more restrictive in the reduced income tax benefits and base farm program scenario. All farm policy provisions of the current policy were left unchanged. The more restrictive Federal income tax provisions included the following:

- Machinery, livestock, and buildings were depreciated using the straight-line cost recovery method.
- First-year expensing provisions were eliminated for all depreciable items.
- Maximum ITC provisions were eliminated.
- The maximum annual interest expense that could be used to reduce taxable income was $15,600.
- The operator was required to sell obsolete machinery upon dis-position rather than trading it in on new replacements, thus forcing recapture of excess depreciation deductions.

Results Expected:

- Making Federal income tax policies less favorable tends to increase income tax payments by reducing tax deductions. Net cash farm income is not affected directly in the first 4 to 6 years. After that, interest income usually becomes a factor, and higher tax payments the first 6 years reduce cash available for interest income in later years.
- The farm operator will have lower tax deductions and tax credits when machinery is replaced. The length of time machinery is kept will not likely be shortened from the current policy because machinery was replaced based on its normal economic life, not its depreciation life.
- Reducing tax deductions and tax credits will mean greater annual income tax payments, resulting in greater cash flow requirements and reduced ending cash reserves. Net present value will likely be reduced because of lower retained earnings and the slower accumulation of wealth.

Results Obtained:

- Adoption of a more restrictive set of Federal income tax provisions had little impact on farm survival.
- Increasing the Federal tax burden on farmers reduced the average annual rate of growth in farm size about the same for all sizes of farms in each region. Average ending farm size was about 8 percent less than that for the current policy for large and very large farms and about 4 percent less for moderate farms.
- The more restrictive income tax provisions reduced the propensity to grow through purchasing cropland and increased the

propensity to lease cropland for growth. For example, in the Mississippi Delta the growth rate in owned cropland for the moderate farm was reduced to 4 percent, and its rate of growth in leased cropland increased by 49 percent.

- The changes in the tax provisions resulted in reduced annual net farm incomes on all sizes of farms in all regions. The reduction in net farm income was greater for the very large farm relative to the moderate farm because the very large farm had more depreciable items affected by changes in depreciation rules, investment tax credit, and capital gains treatment of sales of used machinery.

Technology Scenarios

To determine the impact of technology on structure, selected farm policy scenarios were simulated, assuming increases in mean yields of crops only from the use of existing technologies. A comparison of these simulated results with the previous farm policy scenarios, which included increases in mean yields from emerging technologies, indicates the impact of new technology on structure. Three policy alternatives were analyzed under these conditions. They were the base farm policy, which continues all provisions of the 1981 farm bill, the elimination of income support provisions, and the elimination of all farm program provisions.

Results Expected:

- Technology advance would have the greatest impacts on wealth accumulation, net farm income, and rate of growth in acres controlled for very large farms that adopted the technology first and had it in use over a longer period of time.
- The greater the increase in productivity through technology advance the greater should be the rate of increase in wealth, net farm income, and rate of growth in acres controlled.
- Technology advance in the presence of price and income support programs would have greater impacts on growth in real wealth, farm acres controlled, and net farm income than it would in the absence of these programs.

Results obtained:

- Farm commodity policies had more effect on the final amount of acres controlled than did technology advance, across all sizes of farms in all regions.
- Technology advance had little impact on the final amount of acres controlled in all regions. Yield-enhancing benefits from emerging technologies increased average final farm size from o to 2 percent in the Delta, Illinois, and Texas and from 6 to 10 percent in the Southern Plains. The greatest increase in farm size occurred on very large farms in the Southern Plains under the current policy scenario because these farms are principally wheat producers, and the greatest increases in yields were predicted by OTA to occur for wheat.
- Small increases in final farm size for the other regions can be explained by the relatively smaller increases in yields (based on the results of OTA workshops for corn, soybeans, cotton, and rice).
- Farms did not exhibit any appreciably larger rates of growth in real wealth and farm size under price and income support programs than under open market conditions. But in the presence of technology advance, annual net farm income increased relatively more under the price and income support program than under open market conditions.
- Flows of new technology for all commodities in all regions were found to increase annual net farm incomes relatively more than real wealth and ending farm acreage across all sizes of farms. Net farm income was increased relatively more for the very large farms than for the moderate and large farms, across all farm policies evaluated.

Implications **for the** 1985 Farm Bill

- Farm programs have major impacts on rates of growth in farm size, wealth, and incomes of commercial farmers.

- Most farm program benefits are capitalized into land values and net worth. Very large farms increase their net worth significantly more than moderate farms under current farm programs.
- Moderate farms are much more dependent on farm programs to maintain their incomes than are very large farms.
- Income supports provide significantly greater benefits to moderate farms than to very large farms. (In contrast price supports provide more wealth and growth benefits to very large farms than to moderate farms.) Targeting of income supports to moderate farms is an effective policy to prolong their survival.
- Very large farms can survive without income supports. A loan safety net may be needed to deal with instability and world competitive environment.

FINANCIAL STRESS AND NEW ENTRANTS SCENARIOS

Financial Stress Scenarios

The financial position of many farmers is under severe stress. As discussed in chapter 3, the situation is serious and may not improve for some time. policy makers are considering various solutions to this problem, Two of the most discussed alternatives are interest subsidy and debt restructuring. To analyze the effects of these two financial bail-out policies, the financial position of the three representative farms in each of the four regions was modified to depict highly leveraged farms. The long-term debt-to-asset ratio for each farm was increased to 55 percent, the intermediate-term debt-to-asset ratios were set equal to 60 percent, and annual interest rates on old loans were increased to their average values for 1980-83.

Interest Subsidy

An interest subsidy is a loan at below-market interest rates. For example, if the Government's cost of money is 11 percent and the Farmer's Home Administration makes loans at 5 percent, there is a 6-percent direct interest rate subsidy. The object of an interest rate subsidy is to reduce the cash expenses for interest costs, thus increasing total net cash farm income. The total cash requirements are reduced, thereby benefiting all farms. The total saving is greater for larger farms because of the total debt being larger on these farms. An interest subsidy for the first 2 years of the lo-year simulation was provided. Interest charges on both long- and intermediate-term debt were set at 8 percent annually for the two years.

The results expected are:

- Higher probability of survival.
- Higher land values, net worth, and average net present value.
- An increase in the equity ratio because current debts are paid and longer term debts are reduced, allowing greater opportunity for the farm to grow in size because of the increased ability to leverage existing equity.

Deb? Restructuring

Debt restructuring refers to the rescheduling of loan commitments. Debt may be restructured by rewriting short- or intermediate-term debt to a long-term basis if the collateral justifies such change, The amount paid per year is then reduced. without sufficient additional long-term collateral, debt restructuring is limited to rescheduling each class of loans—short-, intermediate-, and long-term—over a longer repayment period, Also, if the debt is on a fixed interest rate basis and interest rates have declined, the debt might be rescheduled in part to take advantage of lower interest rates to obtain a longer repayment period. For the highly leveraged farms, debt restructuring was provided through increasing the length of intermediate-term loans by 1 year and by converting a portion of the intermediate-term debt to long-term debt as long as the long-term debt to asset ratio did not exceed 65 percent.

Restructuring debt has the same type of expected effects as interest rate subsidy; however, they differ in their methods. Debt restructuring does not reduce the annual interest payments in the initial period unless long-term interest rates are less than intermediate-term interest rates. Annual principal payments are reduced, thus reducing cash flow needs of the farm operator,

Results Experienced From Financial Stress Scenarios

- Restructuring initial debt for highly leveraged farms failed to increase appreciably the probability of survival for each size of farm in any region except for moderate and large wheat farms in the southern Plains.
- In all regions, the interest rate subsidy strategy substantially increased the survival rate and average net farm income more than did the restructuring of farms' debts.
- Both debt restructuring and interest subsidy policies resulted in increased growth in real wealth (i. e., ending net worth) on the very large farms in all regions.
- Except for Texas cotton farms, the very large farms with high debts in each region are not as dependent upon financial bail out strategies for survival as the moderate and large farms.
- Debt restructuring resulted in less rapid rates of growth in rear wealth than interest rate subsidies on moderate and large farms in the Corn Belt and High Plains regions.

New Entrants Into Farming Scenario

All previous simulations of the effects from the farm commodity policy alternatives were based on representative farms operated by established farm producers. These simulations provide indications of the short-run effects of the alternative farm commodity policy provisions on economic survival and growth characteristics of established farm operations, They do not provide information on the survivability and economic viability of potentially new entrants into farming. To obtain some general notions of the effects of selected farm commodity policies on newly established farming operations, the smallest farm in each region was simulated under the condition that the farm operator was a new entrant.

In this scenario the entering farm operator was allowed to have only minimum equity in owned farmland (30 percent) and farm machinery (35 percent), All farm machinery was considered to have a new machinery cost, and annual interest rates on long- and intermediate-term loans were equal to the 1980-83 averages, The operator was not allowed to have any off-farm investments. Because the farm operator was paying the full cost of all inputs (land, capital, machinery, and labor), these simulations provide an indication of long-run survivability and profitability of the representative farms. Three policy alternatives were analyzed under these conditions for the new entrant. They were the base farm policy, which continues all provisions of the 1981 farm bill, the elimination of the target price / deficiency payments provision of the program (no income support provisions), and the elimination of all farm program provisions,

Results Expected:

- New entrants would be expected to face lower probabilities of survival, slower rates of real wealth accumulation, and slower rates of growth in farm size than would current operators on the representative farms in each region under existing farm legislation. Because both depreciation adjustments on machinery and annual cash requirements for debt repayment on real estate and machinery loans are based on new 1982 costs and current (1980-83) interest rates, annual net farm incomes will be lower for new entrants than for current operators, under existing policy.
- Elimination of income support provisions of the 1981 farm bill will be expected to reduce the probability of survival, rate of growth in real net worth and farm size, and annual net farm incomes of new en-

trants in each region. The greatest impacts would be expected for specialized crop farms producing commodities eligible for target prices and deficiency payments. Elimination of all farm program provisions would be expected to reduce further the rate of growth in real wealth and farm size. Annual net farm incomes for new entrants would be expected to be even lower, particularly on representative farms producing commodities eligible for set-aside and paid diversion provision.

Results Obtained:

- New entrants exhibited considerably lower probabilities of survival under the base farm policy than did current operators for all specialized crop farms. Only the diversified crop farms in Nebraska and the Mississippi Delta exhibited relatively high probabilities of survival for new entrants under current farm commodity policy.
- New entrants experienced much lower rates of real wealth accumulation than did current operators under current policy. In three of the regions—High Plains wheat farm and Nebraska and Illinois crop farms —real net worth after 10 years was lower than initial net worth on the farms, indicating that the new entrant operator had to sell owned cropland to remain solvent. Net farm incomes were negative for all farms, with the High Plains wheat farm experiencing the largest relative decline in annual net income.
- New entrant farm operators in the High Plains wheat and Nebraska and Illinois crop regions were unable to increase farm size over the l0-year period under current farm policy. The Texas cotton farm and Mississippi Delta crop farms experienced considerable growth, 20 and 27 percent, respectively.
- Eliminating the target price / deficiency payments provision of current legislation substantially decreased the probability of survival and ending net worth on all farms. Only the Texas cotton farms exhibited any appreciable growth in farm acreage (about 6 percent).
- Under the policy alternative of no farm programs, none of the farms exhibited reasonable potentials for remaining solvent over the 10 years. Farms in the Texas High Plains, Southern Plains, and Corn Belt had less than a lo-percent probability of survival. Mississippi Delta farms had only a 60-perCent chance for remaining solvent over the 10 years.
- Under the current farm program only the Nebraska and Mississippi Delta crop farms had sufficient returns for new farmers to enter agriculture with a reasonable chance of remaining solvent and making a reasonable return on their investment.
- Elimination of income support, price support, and supply control provisions of current farm policy resulted in new entrant farmers in all four regions facing little chance of surviving and becoming economically viable farming operations.
- Other sources of income, economic assistance, or wealth accumulation will be required for these new entrants to survive economically in an open market farm policy environment.

Implications for the 1985 Farm Bill

- Restructuring of debt for highly leveraged farms does not appreciably increase their probability of survival.
- Interest rate subsidy substantially increases average net farm income more than debt restructuring, It is, therefore, a more effective strategy to ease financial stress.
- Very large farms with high debts are not as dependent on these programs for survival as moderate farms. under either of these programs, very large farms grow significantly in farm size and real wealth.
- New entrants into agriculture will not likely survive even with current farm programs. Other sources of income, economic assistance, or wealth accumulation will be required.

Chapter 5

Economic Impacts of Emerging Technologies and Selected Farm Policies for **Various Size Dairy Farms**

Chapter 5

Economic Impacts of Emerging Technologies and Selected Farm Policies for Various Size Dairy Farms

One of the most controversial policy areas in the 1985 farm bill debate is expected to be in dairy policy—in 1983 a large amount of surplus milk production cost taxpayers approximately $2.6 billion. For that reason, there will be many alternatives proposed to the current dairy program. This chapter examines the current state of the dairy industry, identifies the technologies most likely to affect the industry from 1983 to 1992, identifies policy options most likely to be considered in the 1985 farm bill, and analyzes the effects of these options on moderate, large, and very large dairy farms in major U.S. dairy production regions.[1]

[1] The representative farms were developed and analyzed in the paper "Economic, Policy, and Technology Factors Affecting Herd Size and Regional Location of U.S. Milk Production," prepared for the Office of Technology Assessment by Boyd M. Buxton.

BACKGROUND

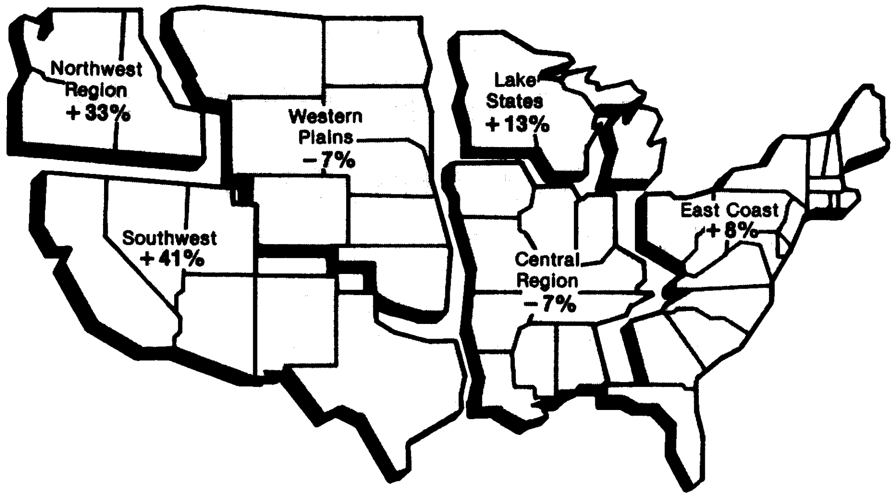
During the 1970s, milk production increased 41 percent in the Southwest region of the United States and 33 percent in the Northwest, while total milk production increased only 11 percent (fig. 1). Much of the increased production came from dairies with more than 500 cows, with herds of 1,500 to 2,000 cows being common. Although 303, 710 farms in the United States reported having milk cows in 1983, less than 5,000 well-managed dairies with 1,500 cows each could have produced all the milk sold commercially that year.

Herd size, technologies employed, and practices used in milk production vary considerably throughout the United States. In May 1983 the average herd size for 120,655 producers selling milk to plants regulated by Federal milk marketing orders was 63 cows per farm (table 5-1). However, the average herd size in each State varied from 49 cows in Pennsylvania to 532 cows in Florida,

The variation in herd size within each State was even more dramatic. Although the average herd size in Florida was 532 cows, the average herd size for the largest 10 percent of the herds in that State was 1,861 cows (table 5-1). Similarly, the average herd size for the largest 10 percent of herds regionally was about 1,700 cows in the Southwest, but only 125 cows in the Lake States region. Generally, dairy herds are much larger in the Southwest, Southeast, and Northwest regions than in the Lake States and Northeast regions.

From the herd size information in table 5-1, 22 dairies were selected to represent existing herd sizes in five major dairy areas (table 5-2), The 200-cow Pennsylvania and 600-cow New York dairies exceed the average size of the largest 10 percent of dairies in those States. However, such larger sized dairies exist in these States and will become more prevalent in the near future.

Figure 5-l.— How the Dairying Picture Has Changed
(percent change in milk production in various regions from 1970-71 to 1980-81)



SOURCE: U.S. Department of Agriculture

Table 5-1 .–Total Producers and Size Distribution of Herds Selling Milk to Plants Regulated by Federal Milk Marketing Orders, May 1983[a]

Region (State)	Total producers (number)	Average herd size (milk cows) for: All farms	Largest 10 percent	Largest 70-89 percent	Largest 40-69 percent	Smallest 40 percent
Lake States:						
Minnesota	9,968	53	116	74	49	30
Wisconsin	24,400	54	133	68	52	28
Northeast:						
Pennsylvania	12,928	49	127	66	44	25
New York	13,374	59	162	81	53	27
Southeast:						
Georgia	962	127	343	181	117	54
Florida	352	532	1,861	931	355	133
Southwest:						
New Mexico	176	333	1,832	433	169	32
Arizona	160	510	1,733	714	433	160
California	13	400	1,640	580	253	110
Northwest:						
Idaho	574	135	607	169	90	34
Washington	1,647	127	418	171	108	46
United States	120,655	63	202	82	54	26

a The 120 655 farms accounted for about 69 percent of all milk produced in May 1963, but excluded most farms in California and other States where there is no Federal milk order,

SOURCE: Boyd M Buxton and John P. Rourke, "Size Distribution of Dairy Farms Marketing Milk Under Federal Milk Orders, " unpublished report, Economic Research Service, U.S. Department of Agriculture, April 1964.

Table 5.2.— Representative Dairies by Region and Herd Size

Region/State	Herd size (cows)	Cropland (acres)	Housing facilities (type)	Sun shades	Feed produced	Silage storage (type)	Total labor (W/e)[b]
Lake States:							
Minnesota .	52	188	Stanchion	No	Most	Upright	2,03
Minnesota .	125	449	Free stall	No	Most	Upright	3.30
Northeast:							
Pennsylvania	52	156	Stanchion	No	Forage	Trench	2.2
Pennsylvania .	125	375	Free stall	No	Forage	Trench	3.8
Pennsylvania .,	200	600	Free stall	No	Forage	Trench	5.54
New York	52	156	Stanchion	No	Forage	Trench	2.21
New York	200	600	Free stall	No	Forage	Trench	5.54
New York .	600	1,800	Free stall	No	Forage	Trench	14.36
Southeast:							
Georgia	200	400	Free stall	Yes	Forage	Trench	4.5
Georgia . .	350	700	Free stall	Yes	Forage	Trench	7.84
Florida ., ...	350	0	Open field	Yes	None	NA	7
Florida	600	0	Open field	Yes	None	NA	11
Florida ., ...	1,436	0	Open field	Yes	None	NA	18
Southwest:							
New Mexico . . .	900	0	Corral	Yes	None	NA	13
Arizona . .	359	0	Corral	Yes	None	NA	7
Arizona .	834	0	Corral	Yes	None	NA	12
Arizona .	1,436	0	Corral	Yes	None	NA	16
California .	550	0	Corral	Yes	None	NA	9
California . .	1,436	0	Corral	Yes	None	NA	16
Northwest:							
Washington .,	140	51	Free stall	No	Silage	Trench	2.96
Idaho	200	400	Corral	No	Most	Trench	5.0
Idaho . .	550	0	Corral	No	None	NA	10.5

[a] Housing types are
- *Stanch/on* A conventional barn with locking stanchions In which cows are Im ı l ked and fed
- *Free* sta// A covered barn w(th Indlvldual stalls In wh{ch cows freely enter and exit
- Open *fie/d* A field where cows are kept that IS large enough to mal ntal n p!ant cover
- *Corra/* A drvlot open pen where cows are kept and fed at a fencel ı ne feeder

b Labor In worker equivalents of 2,500 hours annuall Y

NA—not applicable

SOURCE Off Ice of Technology Assessment

TECHNOLOGIES AND PRACTICES

The technologies and practices assumed for each of the 22 dairy operations were based on discussions with dairy producers, university and Government employees, and equipment representatives. The objective of these discussions was to describe efficiently organized dairy operations that use proven technologies and practices for each specified herd size. Therefore, the dairy operations in this analysis are not the average of what exists, but rather approximate modern sizes and types of operations.

The 52-cow dairies in Minnesota, Pennsylvania, and New York use the conventional stanchion barns for housing and milking cows (table 5-2). For larger herds in the Lakes States, the Northeast, Washington, and Georgia, free-stall housing and milking parlors are assumed.

Cows are kept in open corrals throughout the Southwest and on larger Idaho dairies. Sun shades in the corrals are assumed in New Mexico, Arizona, and California (Southwest), but not in Idaho, Cows are milked twice a day in milking parlors and fed at fenceline bunks from a feed wagon or truck.

Open fields with sun shades are assumed in Florida. one-half acre per cow is provided, allowing fields to remain grass-covered to minimize mud problems. Cows are milked twice a day in a milking parlor, After leaving the milking parlor, they are fed concentrates in a feed barn before being released back to the field. Roughage is fed loose in the open fields,

The source of feed follows the common practice existing in the various States. For New Mexico, Arizona, California, and Florida, most feed is purchased from off the dairy operation. The same is assumed for the 550-cow Idaho dairy, Dairy operations in Pennsylvania, New York, and Georgia purchase most of the concentrates but produce most of the forage used by their dairy herds. All feed is assumed to be produced on-farm for the Minnesota and the ZOO-cow Idaho dairies.

POLICY AND TECHNOLOGY SCENARIOS

Eight representative dairy operations of the 22 presented in table 5-2 were selected to simulate selected policy and technology scenarios. The likelihood of a particular dairy remaining solvent under alternative policies is directly affected by its financial characteristics. A policy change can have quite different implications for the operator of a dairy with a high level of debt than one with a low level of debt. The average financial situation that exists on the eight dairies of the size and location selected are shown in table 5-3. The averages were approximated from the U.S. Department of Agriculture (USDA) farm financial survey.

The eight dairy operations in three regions were simulated for 10 years under the alternative scenarios described below. Seven policy scenarios (including the 1983 base described in a previous section) and two technology scenarios were simulated for each dairy. The assumptions and policy values associated with each scenario were held constant across all dairies to allow direct comparison of their impacts on different size dairies in different regions.

Two financial stress scenarios (interest subsidy and debt restructuring) were evaluated for the Minnesota 52-cow and 125-cow, Arizona 359-cow, and Florida 350-cow dairies, assuming an initial high debt position and assuming a new entrant with high debt position. Each scenario is described below, along with the ex-

[2]The current version of the Firm Level Income Tax and Farm Policy Simulator (FLIPSIM V), developed by James W. Richardson and Clair J. Nixon, was used to simulate the representative farms in each region.

Table 5-3.—Financial Characteristics Assumed for Eight Dairy Operations in Four States

	Herd size in:							
	Minnesota		Arizona	California		Florida		
Financial characteristics	52	125	359	550	1.436	350	600	1.436
Value of:								
Cropland and farmstead ($1,000)	293.4	679.1	39.4	160.0	312.0	262,5	450.0	1,074.0
Buildings ($1,000)	92.7	176.7	192.8	284.4	512.6	87.9	108.9	211.7
Farm machinery ($1,000)	104.1	159.0	120.3	183.1	303.0	114.6	180.0	260.7
All livestock ($1,000)	77.9	181.4	599.6	960.7	2,505.0	525.5	981.4	2,344,3
Off-farm investments ($1,000)	5.5	13.1	0	0	0	0	0	0
Beginning cash reserves ($1,000)	12.0	62.5	89.8	137.5	35.9	70.0	212.0	505.5
Debt:								
Long-term ($1,000)	111.2	213.9	67.3	155.5	288.6	143.7	218.0	475.7
Intermediate-term ($1,000)	57.1	88.5	230.4	308.8	842.4	160.0	243.9	468.9
Initial net worth ($1 ,000)	417.1	969.4	744.2	1,261.3	2,537.5	756.9	1,464.7	3,343.0
Equity ratio (fraction)	0.71	0.76	0.71	0.73	0.69	0.71	0.76	0.76
Family living:								
Minimum ($1,000). ,	20.0	25.0	25	27	30	25	27	30
Maximum ($1,000)	32.0	35.0	30	38	40	30	38	40
Marginal propensity (fraction)	0.3	0.4	0.3	0.4	0.4	0.35	0.4	0.4
Off-farm income ($1 ,000)	0	0	0	0	0	0	0	0

SOURCE Office of Technology Assessment.

pected results and the observed results from the analysis. Appendix B contains summary tables of the analysis for each farm size by region.

Farm Policy Scenarios

Current Policy

The current policy assumes the continuation of the Dairy and Tobacco production Stabilization Act of 1983 through September 30, 1985. The Government stocks of dairy products are assumed to be high enough through 1985 and 1986 to trigger a 50-cent drop in support price on April 1, 1985, and again on July 1, 1985, as specified in the 1983 act.

All features of the 1983 act are scheduled to expire on September 30, 1985. It is assumed that the support price will remain at the 1985 level through 1986, then rise to $13.11 for manufacturing milk through the end of the lo-year simulation period.

Results Expected.—Under current policy, it is expected that a well-managed dairy of average size would about break even after paying expenses and farm overhead and making withdrawals for family living. It is also expected that well-managed dairies in all regions should be able to survive under a continuation of the current program. Farms that are not in a position to realize most of the economies of size in dairying would be gradually forced out of business. In other words, an extension of current policy would force dairies to compete on the basis of cost and efficiency.

Results Obtained:

- All dairies except the 52-cow Minnesota operation were able to increase their real net worth over the l0-year planning horizon. The 52-cow dairy experienced a 54-percent reduction in net worth.
- The larger the dairy, the greater its financial success. Dairies in Florida and the Southwest were more profitable than dairies in Minnesota. The Florida dairy benefited greatly from higher milk prices.
- The 52-cow dairy had the lowest probability of survival (0o percent) due to having the highest unit cost of production. It lost an average of $27,000 annually in net farm income.

A Crop Acreage Reduction Program

The present feed grain program was assumed through 1985. From 1986 to 1992 a 15-percent set-aside with a 5-percent diversion for corn, cotton, rice, sorghum, and wheat was assumed. This program results in dairy feed prices being 9 percent higher than those under current policy.

Results Expected.—Feed cost represents about 50 to 60 percent of total costs per cow. A crop program that results in a 9 percent higher feed cost is roughly equal to a 5-percent reduction in the price of milk. This would have an adverse impact on a dairy's ability to increase net worth, reduce debts, and achieve as high an internal rate of return as under current policy. In the short run, dairies that raise most of their feed would be less directly affected. The probability of survival would most likely be reduced for dairies operating at or below the break-even point under the current policy because they would be unable to absorb the higher feed costs.

Results Obtained:

- The associated higher feed prices had the greatest adverse financial impact on dairies that purchased most of the feed from off the farm. For example, compared to that of the current policy, the average annual net farm income of the 1,436-cow California dairy declined 64 percent from $375,000 to $136,000.
- The probability of survival was reduced for all dairies except the 1,436-cow Florida dairy and the 125-cow Minnesota dairy.
- There was relatively little impact on Minnesota dairies, where most feed is raised on the dairies.

No Crop Programs

There is much discussion of a desire to move to more market-oriented crop programs. Removing all price supports and income supports would increase the variability of feed prices, subjecting the dairyman who purchases feed to greater risk. For this scenario the Commodity Credit Corporation (CCC) loan, farmer-owned reserve (FOR), and target price provisions were eliminated for all years in the planning horizon (1983-92). This increased the variability in feed costs facing dairy operations. The impact of this variability was evaluated.

Results Expected.–Feed prices paid by dairies would be higher in some years but lower in other years. Over time, high and low price years would be expected to balance out, leaving a surviving dairy about as prosperous as under the current policy. However, the cost associated with possible borrowing to tide a dairy over periods of high feed costs might be expected to affect somewhat adversely its ability to retire debt and increase net worth. Dairies under tight financial conditions under current policy would be expected to have a lower probability of survival without crop programs because they would be less able to absorb the effects of periods of relatively high feed prices. This would be less a problem for dairies in a relatively strong financial position under current policy because they would be better able to absorb these shocks.

Results Obtained:

- The increased variability in feed prices, associated with eliminating all crop programs, had little financial impact on all dairies compared with the results under the current policy. Average net present value declined less than 2 percent for all dairies,
- Increased price risk did not reduce the probability of survival for any of the farms.

Fifty Cents Lower Price

All the assumptions of the current policy were retained except that the mean milk prices were reduced 50 cents per hundredweight (cwt) and the variability of milk price is increased. This scenario was included in the analysis because of the current high level of Government stocks and program costs.

Results Expected.—Lower support prices would be expected to affect adversely the dairies' net incomes as well as their survival and growth. The dairies most adversely affected would be those that are already in financial difficulties under the base policy.

Results Obtained:

- All farms were more negatively affected by this policy than by current policy. All farms experienced more losses under this policy in net farm income, net present value, and net worth.
- The largest dairies in each region experienced little reduction in the probability of survival.
- The greatest adverse impact was on the smallest Minnesota dairy, where the probability of survival declined from 70 to 38 percent and the probability of a positive net present value declined from 24 to 14 percent, Other dairies that were adversely affected included the smaller Florida and California farms. Therefore, reduced price supports would force many small dairies out of business.

No Dairy Program

With no dairy program, the price of milk would drop about 8 percent across the regions (about $1/cwt) to the variable cost of production in Minnesota and California as excess stocks and production are eliminated. It was assumed that this would take 4 years. After that, prices were expected to increase 6.6 percent ($0.80 /cwt), equal to the average total cost of production for large-scale dairies in Minnesota and Californians Historical price relationships were maintained,

[3]The variation of milk prices without a dairy price support program was developed from the following study: Cameron S. Thraen and Jerome W. Hammond, *Price Supports, Risk Aversion and U.S. Dairy: An Alternative Perspective of the Long-Term Impacts*, Economic Report ER83-9, Department of Agricultural and Applied Economics, University of Minnesota, June 1983.

Results Expected.—Without a dairy price support program there would be no guaranteed price floor. In some years milk prices would be higher, while in other years they would be lower than under current policy. However, they would still fluctuate about the long-term equilibrium price. Over time, favorable and unfavorable prices should balance out, meaning that the ability of a dairy to increase net worth, repay debt, and achieve a favorable internal rate of return would not be seriously affected. However, the probability of survival for dairies in tight financial situations would be adversely affected.

Results obtained:

- The probability of survival fell for all farms, with the greatest reduction experienced by the moderate and large farms analyzed. The lowest probability of survival was 34 percent for the 52-cow Minnesota dairy.
- Net present value declined significantly for all farms. For example, the very 1arge California dairy experienced a 43-percent decline in net present value and a 27-percent decrease in net worth.
- However, the very large farms were still able to survive in all regions.

Supply Control

All assumptions of the base current policy were retained, except that mandatory quotas were imposed on dairies. Quotas equal to 96,5 percent of a producer's normal production would, over time, be expected to maintain milk prices $1 above those under current policy. Herd size would be reduced about 4 percent in order to reduce milk production 3.5 percent, assuming that poorer-than-average cows would be culled in complying with the quota.

Results Expected.—The financial performance of all dairies would likely be improved as a result of permanently higher milk prices, despite those dairies having to reduce total milk produced within the designated quota. The probability of survival would increase along with a greater ability to reduce debt and increase net worth for dairies existing at the time the program is implemented, However, this economic advantage could be capitalized into the quota value, thereby eroding the advantage for new entrants or producers who would have to purchase quotas to expand milk production.

Results Obtained:

- Probability of survival was increased for all farms of all regions. The 52-cow Minnesota dairy experienced the largest increase in the probability of survival from 70 percent under the base scenario to 92 percent,
- Average net present value increased for all dairy farms. The 52-cow Minnesota dairy increased from negative $77,000 to $22,000,
- Ending net worth was increased for all dairies due to retained earnings and repayment of debt.
- Net farm income for Minnesota dairies was increased by $15,000. These dairies previously had the lowest income.

Tax Policy Scenarios

All assumptions of the current policy were retained except for more restrictive Federal income tax provisions, including the following:

- Machinery, livestock, and buildings were depreciated using the straight-line cost recovery method.
- First-year expensing provisions were eliminated for all depreciable items.
- Maximum investment tax credit provisions were eliminated.
- The maximum annual interest expense that could be used to reduce taxable income was $15,600.
- The operator must sell obsolete machinery upon disposition rather than trading it in on new replacements, thus forcing recapture of excess depreciation deductions.

Results Expected.—These tax policy changes would have an adverse impact on the ability of a dairy to reduce debt, increase net worth, and, if in a tight financial situation, reduce the probability of survival, All tax changes increase the tax liability, reducing the net income of the operation and leaving less for debt retirement and increases in net worth.

Results Obtained:

- Eliminating the tax benefits increased tax liabilities and reduced the net present value and net worth for all farms. These reductions, however, were relatively small —in the range of 1 to 10 percent,
- The increased tax liabilities were not large enough to reduce significantly the probability of survival.

Technology Scenarios

Computer-Controlled Feeding

A technology now available but not widely adopted is individual cow feeding by using computer-controlled feed stalls. with this technology concentrates fed to individual cows can be controlled in total and over time. One experiment suggests that average daily milk production per cow can be increased 2 pounds with a 0.1 percent higher butterfat content without increasing total feed fed to the herd (Wildhaber, et al., 1984). The estimated added investment costs for computer feeding for the three largest dairies were:

Minnesota 125-cow herd	$18,750
Florida 1,436-cow herd	$157,960
California 1,436-cow herd	$157,900

Investment included a neck responder for each cow, a feeder stall with storage and auger feeder, and a computer, It was assumed that this technology would be adopted only by the largest dairies in each region; thus, only three dairies were analyzed.

All other assumptions of the current policy were retained except that allowances were made for added investment and operating costs and for higher average milk production per cow. The gain in milk production was expected to exceed the added cost, giving dairy producers a more favorable financial position,

Growth Hormone

A technology not yet in commercial use but demonstrated in experimental work is bovine growth hormone. Injecting milk cows with this hormone every other day would result in increased milk production. preliminary results are that with this technology, milk production per cow during the last two-thirds of the lactation period is increased 30 to 40 percent without additional feed (about 23 percent annually). The cost for the hormone can be expected to decline since it can probably be produced cheaply.

Injections given every other day and costing $1 each are assumed in this analysis. Combining this cost with increased hauling and other costs of added milk results in about a $185- increase in cost per cow per year. Once again, it was assumed that only the largest farms would adopt, and allowances were made for added cost and yields,

Results Expected

The expected impact of adopting these technologies is to improve greatly the financial performance of the larger adopting dairies. The probability of survival and all measures of financial performance would be improved for the adopting dairies. The disparity in costs and returns for moderate and very large dairies could be significantly increased,

Results Obtained:

- Large increases in net farm income, net present value, and net worth were experienced by the adopting dairies, These increases were significantly larger for the bovine growth hormones.
- Any lag in the adoption of new cost-reducing technologies seriously adversely affected the ability of dairies to compete.

FINANCIAL STRESS SCENARIOS

The assumed beginning financial conditions for four of the eight dairies were changed to reflect high-debt operators and new entrants. Debt load was doubled to reflect high-debt situations. For new entrants all equipment was assumed to be new, which increased both the initial value of the machinery and the total debt load.

Two policies were considered for high-debt dairies. One was to subsidize interest rates on all debt so that the effective rate for all loans paid would be 8 percent rather than the higher rates used in the current policy. The second was to restructure the debt by converting a portion of intermediate debt into long-term loans and/or to extend the length of intermediate-term loans. In the second case, interest rates, total debt loads, and other assumptions of the high-debt dairies remained the same as under current policy.

The impact of higher feed costs and eliminating the dairy price support program was evaluated for new entrants with a high-debt position. The results obtained included the following:

- The probability of survival for any dairy depends greatly on its initial financial position. Dairies and new entrants with high debt had significantly lower probabilities of surviving than dairies with initial financial situations assumed in current policy.
- Neither interest subsidies nor opportunities for debt restructuring greatly improved the chances of high-debt dairy farms remaining solvent.
- The probability of survival for both Minnesota dairies was zero for all policy scenarios. The implication is that high-debt producers in this region cannot survive under even the current dairy policy.

IMPLICATIONS FOR THE 1985 FARM BILL

- Policies and technologies that are favorable for the dairy industry provide greater financial opportunities for large rather than small dairies.
- Policies that adversely affect the dairy industry such as higher feed costs, fewer income tax benefits, and no dairy price support program will negatively affect small dairies more than larger dairies,
- The major advantage enjoyed by larger dairies is more related to the efficiency of operation than to specific dairy policies.
- There will be a continued trend to fewer and larger dairies in all regions. Milk production can be expected to continue to increase in the lower cost regions of the Southeast and Southwest.
- Traditional dairy regions will continue to experience increased competitive pressure from larger scale, more efficient producers in other parts of the United States, Substantial restructuring of dairies in the Lake States and Northeast will be required for them to compete.
- Dairy price supports must be sufficiently flexible to adjust to the increased production and lower costs spurred by technological change. This could be accomplished either by adjusting the price support level to changes in production costs per unit of output or by adjusting the level of CCC purchases.
- Current geographic price alignment systems in Federal milk marketing orders are becoming increasingly outdated. A comprehensive study is needed of changes required to modernize the Federal order system in light of technological changes.

Chapter 6

Agricultural Research **and Extension Policy**

Chapter 6

Agricultural Research and Extension Policy

Much of the success of American agriculture is attributable to the creation of its agricultural research and extension system (Ruttan, 1982; Cochrane, 1958). For well over a century, the public has invested substantial sums of money (currently about $3 billion annually) in agricultural research and extension at Federal and State levels. This investment has been no accident. Several important events have helped make the agricultural research and extension system an integral and longstanding part of U.S. agricultural policy—the first Federal appropriations to agricultural research in 1856, the establishment of the land grant university system in 1862, and the creation of the Federal-State-local extension partnership in 1914 (Knutson, et al., 1983).

The agricultural research and extension system continues to be an important contributor to a plentiful and low-cost food and fiber supply, as well as to the positive U.S. balance of agricultural trade. For the period 1945-79, technological innovations brought about by the system increased agricultural output 85 percent, with no change in the level of agricultural inputs (USDA, 1980).

Agriculture's entrance into the era of biotechnology and information technology raises several questions about the impact of technical advances on the performance of the research and extension system and about how that performance will ultimately affect the structure of agriculture. For example:

- Who gains and who loses from the process of technological change in agriculture?
- Is agricultural research and extension structurally neutral or does it favor the growth of large industrialized farms?
- What are the roles of the various components of the agricultural research and extension system as they relate to technological change in the biotechnology and information technology era?
- what are the implications of increased private sector involvement in agricultural research?
- what are the implications of patents being conferred on biotechnology and information technology discoveries for the social contract under which the agricultural research system was created?
- How is a proper balance to be struck between public and private sector components of the agricultural research and extension system?

These are the major issues that will be addressed in this chapter, The answers are based on previous OTA studies, on an extensive body of literature regarding the impact of technology on agriculture, and on papers commissioned by OTA regarding the status of the agricultural research and extension system as it relates to developments in biotechnology and information technology.

[1]Agricultural research and extension policy issues were identified and analyzed in papers prepared by the OTA research and extension policy workgroup. Authors of the papers were Ronald Knutson, Roy Lovvorn, George Hyatt, and Fred White. This chapter is based on an integration prepared by Ronald Knutson, of the workgroup's findings.

WHO PROFITS FROM TECHNOLOGY CHANGE

The point that technology is one of the driving forces behind structural change in agriculture has perhaps been most clearly argued by Willard Cochrane *(1983)*, who notes that the first adopters of new technology are also the immediate beneficiaries in that their costs per unit of production are lowered and their profits are thus increased. The profits of those firms supplying the products of new technology also increase. In addition, higher profits for the farmers encourage the adopting farmers to expand output—even to the extent of increasing the scale of their farm operation. However, as output expands, prices decline; later technology adopters thus realize less profit. Those farmers who are the last to adopt new technologies may actually be forced either to adopt or to get out of agriculture.

Three important lessons arise from this description of the process of technological change:

- Those farmers who are most aggressive in effectively adopting and applying new technologies are the most likely to survive. Their size or scale of operation thereby influences the structure of agriculture. Likewise, structure is affected to the extent that research discoveries or extension programs favor farm operations of a certain scale. The significance of technology's role in fostering structural change makes it an important factor to consider when designing research and extension programs.
- Research and extension are vital to maintaining the competitiveness and comparative advantage of U.S. agriculture in international trade. Competition in export markets is becoming increasingly keen as countries strive to expand output and export to earn foreign exchange. Throughout the 1970s, exports were the driving force behind farm prices and incomes. A return to agricultural prosperity awaits a resurgence of exports. Growth in export markets cannot be maintained without the benefits of continuous adoption of cost-reducing technologies.
- The ultimate beneficiary of agricultural research and extension is the consumer—domestic and foreign. Larger supplies, lower food prices, and better quality have almost invariably been the main results of agricultural research. This does not mean that research operates contrary to the interest of all farmers; rather, research directly benefits the more progressive farmers. Research is also critical for expanding markets for farm products and for overcoming the constant threat of disease and other vagaries of nature.

The result of these gains and losses has been a handsome rate of return from public investment in agriculture. Rates of return on public investment in agricultural research typically fall in the 30 to 60 percent range (Ruttan, 1982). Rates of return for extension have been estimated to run even higher—particularly in the case of specific extension activities (White, 1984). The high rate of return indicates that agricultural research and extension services have been highly productive.

THE EFFECT OF AGRICULTURAL RESEARCH AND EXTENSION ON FARM STRUCTURE

The impacts of research and extension on farms, farm workers, agribusiness, and rural communities depend on the type of technology developed and the rate of adoption. Some technological innovations, particularly mechanical innovations, favor and hence foster larger farms, Other innovations could be applied on farms of any size, but are often first adopted by larger farms (Paarlberg, *1981;* Perrin and Winkelman, *1976;* White, *1984).*

The extent to which agricultural research and extension affect farm structure has become an item of increasing debate and concern, Jim Hightower (1973) focused and fueled the controversy by concluding that "Agriculture's preoccupation with scientific and business efficiency has produced a radical restructuring of rural America and consequently urban America . , . . America's land grant college complex has wedded itself to an agribusiness vision of automated, vertically integrated and corporatized agriculture, " Hightower's perspective appears to be that agricultural research and extension should be structurally neutral (i.e., not favor one farm size over another), but if it favors anything, it should favor moderate and smaller farms.

The impact of agricultural research and extension on farm structure can best be understood by considering the separate impacts of research, extension, and technological adoption on farm structure.

A research program that is structurally neutral would develop technologies that can be used by any size farm. There is limited evidence about whether the type of agricultural research being conducted by public institutions is structurally neutral (White, 1984). Biological-chemical technologies, the focus of most land grant research, are more likely to be structurally neutral than is mechanical research, which is primarily done in the private sector. Mechanical innovations such as the cotton picker, combine, and mechanical tomato harvester have favored large farms by reducing labor requirements and lowering costs on large farms (Schmitz and Seckler, 1970). The biological-chemical technologies over the past 50 years have accounted for about a doubling of output in most farm commodities–i.e., wheat, corn, rice, and cotton. However, mechanization and economies of size have accounted for a tenfold to twentyfold increase in output, and this has not been structurally neutral. In general, there has been no widespread public recognition of the consequences of such technological developments before their release and widespread adoption (White, 1984).

Dissemination that is structurally neutral entails dissemination of research results by research and extension staff to all farmers. Although the extension service disseminates research results through a wide range of publications, public meetings, and result demonstrations, these means are more readily accessed by the more knowledgeable and better educated farmers, who more often are the operators of larger, more progressive farms. Since the topics covered in publications and public meetings are heavily influenced by current research results, any bias toward larger farms in these results would be carried over into those publications and meetings. On the other hand, one of the criticisms of extension has also been that operators of the larger, more progressive farms are more knowledgeable about the state of the art than are extension staff. This claim is more likely true of county-level staff than of the State specialist staff.

Adoption that is structurally neutral involves the equal willingness and ability of operators of all farm sizes to adopt new technology. Adoption neutrality would be hampered if research and/or dissemination were not structurally neutral. But even when research and extension activities are structurally neutral, adoption may not be neutral because adoption of new technology is dependent on many factors, including the potential profitability of technology, the capital investment required, the natural resources controlled by farmers, the economic environment within which farmers operate, and the technical skills of the farmer.

The structural trend in agriculture is quite clearly toward a bimodal distribution—small and large farms surviving, with moderate farms struggling to exist, Small farms are surviving and even increasing in number because they have off-farm income against which to offset farm losses. Large farms are increasing in number because their operators are more efficient and can purchase inputs at lower prices, sell their products at higher prices, obtain more farm program benefits, and therefore have higher incomes (Smith, et al., 1984].

Considering the number and complexity of these factors, it would be difficult to achieve a farm structure that maintains the moderate farm simply by focusing more research and extension resources on producing and disseminating technologies specifically oriented toward the moderate farm segment. Instead, research and extension activities would have to be integrated into other targeted policy tools to achieve the desired structural goals.

Since dissemination and adoption would appear to be more important than research to structural change, the emphasis in a program to achieve greater neutrality would logically fall on highly applied research and extension functions targeted toward the competitiveness and survival of moderate farms. Such a program would have to:

- Increase public research efforts aimed at developing farming and management systems that allow moderate farms to achieve the same technical or production efficiencies as their larger scale counterparts.
- Provide higher levels of support for farmer cooperative research and educational activities aimed at serving family farm agriculture, With proper orientation, farmer cooperatives should be able to allow moderate farms the same input economies as larger farms.
- Increase emphasis on the use of modern marketing and management tools by operators of moderate farms. An understanding of contracting, futures markets, options markets, and committed cooperatives will be critical to the future survival of the moderate farm system. In addition, moderate farms will have to use state-of-the-art computer information and financial systems. Public research and extension will play the major role in seeing that this knowledge base is developed and reaches farmers.

Reorienting the research and extension system in this manner carries some risk, The competitive position of American agriculture in an open world economy could be jeopardized if, while concentrating on improving the competitive position of moderate farms, technological advances for larger farms stagnated. Therefore, while directing more efforts toward moderate farms, research and extension must continue to foster improvements in production, marketing, and management systems for all farm sizes. Accomplishing such changes would require additional staff, retraining of existing staff, more resources, and a reorientation of existing resources.

RESEARCH, PRIVATE SECTOR, AND EXTENSION ROLES

One of the most important contemporary issues that the agricultural research and extension system has had to deal with is that of establishing both the broad priorities for research and extension and the roles of the components of the research and extension system. Since the passage of the 1977 farm bill, considerable progress has been made in establishing roles and priorities in the various components of the agricultural research system. The Joint Council and the Users Advisory Board, given sufficient time and encouragement to perform, have the potential for dealing effectively with the priorities issue. Positive progress is indicated by the recently reIeased Joint Council Needs Assessment for Food and Agricultural Sciences.

The primary question regarding the roles issue involves the line of demarcation between the U.S. Department of Agriculture (USDA) anci the land grant programs. This issue has been treated quite differently by research and extension. OTA'S agricultural research system study concluded that USDA research should concentrate on those agricultural problems that are important to the Nation and for which no one State or private group has the resources, facilities, or incentive to solve (OTA, 1981).

Such a role can logically be assigned to the USDA Agricultural Research Service and the USDA Economic Research Service. Concentrating only on national and regional problems would represent a marked shift by the Agricultural Research Service from its past decentralization policies involving increasing emphasis on research having a State or local focus.

Private Sector involvement

The land grant university system was established largely because it was concluded that in a decentralized competitive structure, the private sector would not have the economic incentive to provide the level of funding needed to maintain an efficient, viable agriculture. Despite many changes in the structure of agriculture since the founding of the land grant system, this premise went largely unchallenged until the 1970s.

As a result, private sector grants for agricultural research have historically come primarily from foundations such as Ford or Rockefeller and from a small number of grants for university developmental research associated with the introduction of new products. With the advent of biotechnology, the interest of private firms in agricultural research increased sharply. While much of this interest appears to be a spinoff of biomedical human research, substantially expanded resources have also been committed to plant and animal reproduction designed to produce new varieties or to expand the rate of genetic improvement. In addition, increased interest is being shown in developing disease- and insect-resistant plants as well as in more organic methods of pest control.

One of the major reasons for this expanded, private sector interest in agricultural research has been the extension of patent rights to plant varieties and other biological discoveries. These rights, in turn, gave rise to increased private sector interest in supporting university research that could result in profitable, patented discoveries.

The current magnitude of private sector commitment to agricultural research is largely unknown. Studies suggest that it may approach $3 billion (National Agricultural Research and Extension Users Advisory Board, 1983). Approximately half of the amount is spent on production agriculture and half on food production or postharvest technology research. Private sector research resources are obviously devoted to those areas having the highest short-run profit potential. Also, despite recent large increases in private sector agricultural research, questions remain about the long-term willingness of private sector firms to invest large sums of money in agricultural research and about the breadth of such research. As noted previously, private firms have tended to cut back on research first in times of adversity.

The private sector also plays a role in education. For most agribusiness firms, this role is pursued in conjunction with their efforts to promote the products and services that they market. The educational value of these promotional activities relates more to alerting farmers to the availability of new products than to evaluating objectively the performance of those products.

The burden of new product evaluation then falls either on the farmer (through trial and error) or on the extension service (through result demonstration); extension involvement is more efficient. However, the biotechnology era holds potential for increased antagonism between private sector firms and extension because the extension service evaluates the comparative performance of new biotechnological products, a role not always appreciated by firms producing products that have relatively lower levels of performance,

With a few important exceptions, such as integrated pest management (1PM) checkoff programs, the private sector's direct financial support for agricultural extension programs has been limited, but appears to be growing. It might be argued that limited private sector funding is essential for keeping extension education programs objective. Greater dangers may lie more in increased private sector funding of extension than of research. In the funding of both, it is critical to maintain the objectivity and availability of information flows.

Research Involvement

Land grant universities were created to serve the public. The agricultural component of the land grant universities has unique responsibilities to conduct and extend the results of research for the public benefit. Traditionally, those research results have been readily and freely available to the public, since they have no private property or exclusivity rights attached to them. Research results that were to be held in confidence or had proprietary rights attached to them were frowned upon. Policy changes that have occurred over the past 15 years hold the potential for substantially changing this traditional concept of ready and free access to land grant university research. Some changes have already occurred; others may occur very rapidly. In other words, changes in property rights and exclusivity rules may have also changed the very concept of the land grant system.

Questions of how the land grant universities might adjust to the new concept of research property rights and the related opportunities for increased private sector funding have been the subject of extensive study. However, the impact of these factors on the unique nature or "social contract" of the land grant system has received little attention.

Policy changes regarding property rights in agricultural research had their origin in the enactment of the Plant Variety Protection Act of 1970. Previously, patent protection in plants was limited to asexually reproduced material—mainly orchard fruits and ornamental flowers. The Plant Variety Protection Act provided that a breeder of a new, stable, and uniform variety of sexually reproduced plants could prevent other seedsmen from reproducing and selling that variety for 17 years.

Of possibly greater significance was the 1980 landmark U.S. Supreme Court decision, Diamond v. Chakrabarty, which held that the inventor of a new micro-organism, whose invention otherwise met the legal requirements for obtaining a patent, could not be denied a patent solely because the innovation was alive. This decision opened the door for patenting potentially all new products of the biotechnology era.

Since the passage of the Plant variety Protection Act and the Chakrabarty decision, private sector interest in agricultural research has mushroomed. OTA, for example, found that in 1983 there were 61 companies pursuing applications of biotechnology in animal agriculture and 52 companies applying biotechnology to plants. Most of these firms have developed their own in-house research capability, employing molecular biologists, biochemists, geneticists, plant breeders, and veterinarians.

Relationships are also developing between universities and many of these firms. For example, Monsanto has a 5-year, $23.5 million contract with Washington University under which individual research projects are conducted. At Stanford University, five corporate sponsors (General Foods; Koopers Co., Inc.; Bendix Corp.; Mead Corp.; and McLoren Power and Paper Co.) contributed $2.5 million to form the for-profit Engenics and the not-for-profit Center for Biotechnology Research.

Such relationships are not limited to private universities. Michigan State University (a land grant college) created the entity Neogen to seek venture capital for limited partnerships to develop and market innovations arising out of research. The formation of Neogen points up a significant problem being encountered by universities in the biotechnology era. Neogen was formed, in part, for the purpose of retaining faculty members who are getting offers from biotechnology companies, In Neogen, faculty members are allowed to develop their entrepreneurial talent and gain financial rewards while remaining at the university, The formation of Neogen reflects the reality that biotechnology development is resulting in or might result in a substantial drain on university basic and applied research talent. If leading faculty members are not overtly hired away from universities, they may form their own companies or become consultants. The establishment of biotechnology property rights has substantially heightened scientists' interest in private sector employment opportunities. In the process, questions have arisen over who should maintain the property right—the university, the private firm, or the scientist.

In the Washington University-Monsanto case, the university retains the patent rights while Monsanto has exclusive licensing rights. In Engenics, Stanford likewise gets the patent rights while Engenics and its five corporate sponsors receive the royalty-bearing licenses. Neogen will buy patent rights from Michigan State University, while the inventor will get a 15-percent royalty or a stock option in Neogen.

It does not take much imagination to recognize the potentially profound implications of such developments on the land grant university system. While public sector-private sector arrangements were kept previously at arms length, private sector arrangements now integrate business into the university fabric. Questions develop over who controls the university research agenda, the allegiance of scientists to their university employer, the willingness of scientists to discuss research discoveries related to potentially patentable products, and potential favoritism shown particular companies by the university because of its research ties,

The advent of patent rights, exclusive licensing, and private sector investment in public sector research may change the distribution of benefits from land grant research discoveries. These changes warrant direct public discussion and consideration by policy makers. They occur for at least five reasons:

- By exclusive licensing or transferring of patent rights to private firms, the right to use discoveries is no longer freely available—even if information on the discovery itself is freely available.
- Certain individuals and firms are conferred the benefits of specific land grant research, to the potential detriment of others. Prior to the transfer of discovery rights, the benefits were available to anyone who adapted a land grant discovery to commercial usage.
- The costs of the resulting discoveries are internalized in the price of the resulting product. The price the public pays for the product also includes any monopoly rents associated with the conferral of the rights. Society thus pays twice: once for the cost of the research and again for its benefits. Without the conferral of property rights, rents are minimized by competition.
- Private sector-public sector inequities are virtually assured in any granting of research property rights to an individual firm. This occurs because a relatively small private sector investment brings access to a much broader range of current and prior research.
- The existence of patent rights, trade secrets, and confidential information has many potentially adverse implications for extension in terms of the increased burden for product testing, the potential lags in information, and the absence of research information that previously would have been readily available.

The argument does not, however, flow exclusively against the conferral of private sector property rights by the land grants. There are three main counterbalancing arguments:

- With the conferral of private property rights and the associated private sector investment, the quantity of research discoveries may increase. Robert Evenson (1983), for example, found a sharp acceleration in private plant breeding programs after the 1970 Plant Variety Protection Act was enacted into law. Over 1,088 patent-like certificates were granted by February 1, 1983.

- Without land grant university involvement in private sector-funded research, the universities may not be able to retain the top-quality scientists needed to conduct agricultural research on the frontiers of knowledge. In the process, the agricultural research, extension, and teaching programs would all suffer.
- Patent monopoly rights may be necessary to attract the capital investment needed to translate the scientific advances of land grant universities into commercial reality. Without such proprietary protection, new discoveries may not be able to compete for resources to develop marketable products or technologies. The public availability of such products could thereby be affected.

If policy makers want land grant universities to refrain from conferring property rights, it will be necessary for policy makers to provide the level of funding whereby land grant universities can compete with non-land grant universities that confer such rights. This basic decision may be the most important related public policy decision since the land grant system was created. Once the land grant system starts actively competing for private sector grants and conferring licensing rights, there will be no turning back.

Extendon Roles

Available evidence suggests that the progress of the agricultural research community in establishing priorities is more advanced than that of the extension community. The agricultural research community has been widely studied and critically evaluated within and without the system in a series of projects extending back to the mid-1960s. In light of these analyses, the agricultural research system has adjusted the distribution of its resources in recognition of potential advances evolving from biotechnology and information technology.

Similar progress is not apparent in extension. Extension administrators suggest that this is the case because most of the extension planning occurs at the local level through advisory committees. Yet such a system does not obviate the need for setting national plans and priorities. One major congressionally mandated extension evaluation project culminated in a series of reports that concentrated more on past benefits than on future needs, priorities, and required adjustments (Extension Service, *1983).* There is also relatively little reference to the functions or programs of extension in the reports of either the Joint Council or the Users Advisory Board.

Federal extension has also dramatically reemphasized its direct education role in the past 20 years (Hyatt, 1984). Although Federal extension specialists were generally viewed as having a vast subject matter base in their own right and were frequently called upon to engage in staff training and to conduct educational programs, these specialists are viewed today more as program leaders, coordinators, and facilitators. The education function is thus left to State specialists and agents. These changes were at least partially forced by reductions in personnel ceilings and limited appropriations. Regardless of the cause, this change in strategy has not been beneficial to the overall national extension education program, which is left to cope with a lack of progress in national planning and needs assessment and a deterioration in the quality of educational service to the States.

As in research, there are issues of national significance that the USDA Extension Service is better able to deal with educationally than are the States. While ultimately the States must still take the lead in extending educational programs to farmers, the USDA Extension Service can play an important role in making the information and related educational materials available on a timely basis. (For another perspective see Hyatt, 1984.) Currently, this role is being played on, at best, a spotty basis. A key mission of the Federal Extension Service should be to facilitate technology transfer between USDA research agencies and the State extension services as well as between States. If this function is not adequately performed, research agencies become motivated to develop their own outreach programs. The need then is for increased integration of the research and extension function—not greater fragmentation.

To add Federal extension national program leaders who are knowledgeable about the state of the art of technology would be substantially more expensive. Such staff would have to be recognized as national extension coordinators and be provided compensation consistent with that role. Finally, they would have to have access to resources whereby State specialists and researchers coordinated to develop state-of-the-art educational materials that could be used in all States.

The biotechnology era presents some very important challenges to the extension community—challenges that could determine extension's future usefulness as an educational aid to farmers. With renewed emphasis on basic agricultural research, substantial concern arises about whether a gap in applied research will develop, This could occur as applied scientists are attracted into basic research that offers higher rewards, leaving open the jobs in applied research. The potential for such a gap is reduced by increased private sector interest and involvement in biotechnology research and development (R&D). However, as the private sector performs a larger share of the applied research, extension may become even more involved in the evaluation of technologies and products flowing out of the private sector. Without such evaluation individual farmers and ranchers will incur the costs of experimenting to determine which combinations are optimum for use in production. These costs will be converted into a decline in the number of farms (for those who used the wrong input combinations), higher food costs, and reduced competitiveness in international commodity markets.

Substantial challenge is involved in extension's adjusting to this new role. While in some States technology and extension are already deeply involved in the evaluation of new products, in other States product evaluation has been primarily a function of experiment stations. In the future, experiment stations will likely be doing less of this work, and extension's responsibilities will correspondingly increase, Meeting this increased responsibility will entail a larger specialist staff with modern scientific training. Some States may be inclined to forego the responsibility of getting involved in conflict-oriented product evaluation programs. To the extent that this occurs, the usefulness of extension to the farmer will decline.

Many of the technologies on the horizon are exceedingly complex and foreign to many extension staff. In the foreseeable future embryo transplant technology may be as important to the dairy industry as artificial insemination has been over the past three decades. Growth regulators will increasingly be applied in minute quantities to plants to increase productivity. New strains of genetically engineered plants and animals will be entering commercial production channels. Extensive staff training and development will be required at both the specialist and county levels for extension to play an effective role in technology transfer during the biotechnology era. Without such training, extension will play an increasingly less important role in production agriculture. Technology transfer will occur less efficiently with more structural impacts—larger farms will benefit at the expense of smaller farms.

At current funding levels, the most difficult issue facing extension is whether to limit its role and coverage to those functions for which it has the greatest expertise. Without criteria for limiting the role of extension, extension activities might become so dispersed and out of focus that their effectiveness would be impaired. Regardless of whether the problem is related to agriculture or not, extension may be called upon to solve it. It is not possible for extension to be everything to everybody, particularly in times of limited resources.

The Joint Council has not given sufficient attention to the role of extension. As a starting point for defining that role, it must be remembered that the root of extension is research. Similarly, extension is a primary outlet for research, after an appropriate level of product development. Extension is, therefore, delimited by the scientific endeavors of the research components of the agricultural research system, including both the public and private sector components.

The core mission of extension is, therefore, one of developing, extending, and bringing about the use of research-based knowledge. The core source of that knowledge is the agricultural experiment station. Viewing extension in a broader context than this runs the serious risk of reducing its overall effectiveness. This is particularly the case when it is recognized that extension is likely to play an increasing role in filling a portion of the gap between basic research and extension, i.e., applied research. Another dimension of this role problem involves the tendency for the experiment station to become more involved in extension-type educational programs as a way of gaining public recognition and support. Considerable care must be taken not to foster such duplication of efforts.

The 1890 land grant universities have evolved into institutions that have a comparative advantage in studying problems that are unique to small farmers—particularly those that depend on agriculture for a majority of their income. Satisfactory performance of this function requires a recognition of this role and a closer working relationship with the 1862 land grant university in both research and extension programs (Lovvorn, 1984).

IMPLICATIONS FOR THE 1985 FARM BILL

- Granting of property rights and exclusive licensing of technological discoveries have brought the unique nature or “social contract” of land grant universities into question. These new rules may change the distribution of benefits from land grant research discoveries. These changes warrant direct public discussion and consideration by policymakers.
- Progress of the agricultural research community in establishing priorities is more advanced than that of extension.
- The agricultural research system has adjusted the allocation of resources in recognition of potential advances evolving from biotechnology and information technology. Similar progress is not apparent in extension.
- There is a need to address the following extension issues:
  —clientele and mission of extension,
  —organizational structure of the extension system,
  —role of Federal extension service, and
  —need for extension to conduct applied research.
- Research and extension policy is a critical component of agricultural structure policy. For moderate farms to be able to compete, for example, ways must be developed for making new technologies more available to moderate farms and for providing training in the use of these technologies.

Appendixes

Appendix A.-Summary Analysis Tables for Crop Farms

Table A-1 .—Comparison of Selected Farm Commodity and Income Tax Policy Scenarios on Representative Corn-Soybean Farms jn East Central Illinois

Criteria	Alternative Scenarios[a] I	II	III	Iv	v	VI	VII	VII!
Moderate size (640 ;cres):								
Probability of survival . . . . , ...	100,0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Present value of ending net worth ($1 ,000) .,	703,0	743.0	703.0	568.0	593.0	669.0	563.0	719,0
Ending farm size (acres)	902.0	904.0	902.0	824.0	837.0	907.0	834.0	893.0
Annual net farm income ($1,000)	23.2	29.9	23.2	10.2	11.8	19.1	11,1	19.0
Annual government payment ($1,000)	11,6	9.8	11.6	0.7	0,7	8.6	0.0	11.7
Large size (982 acres):								
Probability of survival	100.0	100.0	100.0	100.0	100.0	100,0	100,0	100,0
Present value of ending net worth ($1 ,000)	975.0	970.0	991.0	645.0	693.0	801,0	622.0	852.0
Ending farm size (acres)	1,374.0	1,364.0	1,388.0	1,139,0	1,180.0	1,355,0	1,134.0	1,217.0
Annual net farm income ($1 ,000)	24.3	22.9	26.4	14,3	5.2	8.0	1,1	24,9
Annual government payment ($1,000) . . . . ., .	22.6	16.6	24.3	1,0	1,0	7.8	0.0	21.9
***Very large size** (1,630 acres):*								
Probability of survival ., ...	100.0	100,0	100.0	100.0	100,0	100,0	100,0	100,0
Present value of ending net worth ($1 ,000) .	1,267.0	1,348,0	1,266,0	991.0	1,033,0	1,056,0	1,036,0	1,044,0
Ending farm size (acres)	1,945.0	1,932.0	1,942.0	1,856.0	1,859.0	1,908.0	1,876,0	1,784.0
Annual net farm income ($1,000)	51.8	62.2	52.4	31.1	35.1	34.7	34.8	54.4
Annual government payment ($1,000)	23.6	19.3	25.3	1.7	1.7	0,0	0.0	23.3

Table A.2.—Comparison of Selected Farm Commodity and Income Tax Policy Scenarios on Representative Irrigated Row Crop Farms in South Central Nebraska

Criterl a	Alternative Scenarios[a] I	II	111	Iv	V	VI	VII	VIII
Moderate size (672 acres):								
Probability of survival	100,0	100.0	100.0	92.0	100.0	100.0	90.0	100.0
Present value of ending net worth ($1 ,000) .	670.0	736,0	670.0	260.0	476.0	670.0	264.0	***628.0***
Ending farm size (acres)	921.0	909.0	921.0	882.0	870.0	921.0	808.0	***917.0***
Annual net farm income ($1 ,000) ., ...	26.8	31.0	26.8	–9.8	10.6	26.8	– 11.4	26.8
Annual government payment ($1 ,000)	17.3	14,5	17.3	1.0	1.0	17.3	0.0	17.9
Large size (920 acres):								
Probability of survival	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Present value of ending net worth ($1 ,000) .	1,349.0	1,377.0	1,369.@	739.0	1,084.0	1,180.0	750.0	***1,269.0***
Ending farm size (acres)	1,257.0	1,253.0	1,257.0	1,242,0	1,240.0	1,257.0	1,243.0	1,234.0
Annual net farm income ($1 ,000)	58.4	60.9	57.4	0.1	35.7	37.4	–0.5	***58.9***
Annual government payment ($1,000)	24.1	19.3	23.9	1,3	1.3	15.3	0.0	***24.4***
Very ***large size (2,085 acres):***								
Probability of survival ., ...	100.0	100.0	100.0	100.0	100.0	100.0	100,0	100.0
Present value of ending net worth ($1,000)	2,259.0	2,374.0	2,407.0	1,013.0	1,863.0	1,270.0	1,007.0	***2,072.0***
Ending farm size (acres)	2,375.0	2,383.0	2,384.0	2,167.0	2,280.0	2,197.0	2,128.0	***2,330.0***
Annual net farm Income ($1,000)	118.6	127.3	134.6	1.3	88.0	10,8	–0.1	112.8
Annual government payment ($1,000)	35.9	31.5	49.6	3.0	3.0	0.0	0.0	***35.9***

[a]The Scenar)os are
1—Contlnuatlon of the 1981 Farm BIII and 1983 Federal Income tax provisions
II –A 20° c Acreage Reduc[lon (n 19861992
Ill – No Farm Program Payment Llmltatlon In 1983-1992
IV– No Price Support and No Deflclency Payment In 19831992
V–No Target Price/Deftclency Payment In 1983.1992
VI —Target Farm Program Benefits to farms that produce less t~an $300,000 In program crops
VII—NO Farm Program (n 1983.1992
Vlll —Reduced Income Tax Benef(ts and the Base Farm Program
The Impact of Price Supports can be derived by subtracting Scenario 5 from Scenario 6
The Impact of Income Supports can be derived by subtracting Scenario 6 from Scenario 1
The Impact of Income Supports with a $50,000 Payment Llmltat!on can be found by subtracting Scenario 6 from Scenario 4

Table A-3.—Comparison of Selected Farm Commodity and Income Tax Policy Scenarios on Representative Southern Plains Wheat Farms

	Alternative Scenarios [a]							
Criteria	I	II	III	IV	v	VI	VII	VIII
Moderate size (1,280 acres):								
Probability of survival	100.0	100.0	100.0	76.0	100.0	100.0	48.0	100.0
Present value of ending net worth ($1 ,000)	803.0	1,032.0	811<0	283.0	426.0	761.0	189.0	710.0
Ending farm size (acres)	1,901.0	1,955.0	1,901.0	1,565.0	1,648.0	1,910.0	1,478.0	1,757.0
Annual net farm income ($1,000)	***2.6***	***18.3***	***3.1***	***–33.6***	***–21.4***	–0.9	–41 .6	–8.3
Annual government payment ($1,000)	30.9	31.5	31.6	2.5	2.5	27.7	0.0	29.4
Large size (1,920 acres):								
Probability of survival	100.0	100.0	100.0	50.0	90.0	96.0	32.0	100.0
Present value of ending net worth ($1,000)	1,028.0	1,359.0	1,117.0	294.0	475,0	696.0	179.0	833.0
Ending farm size (acres)	2,765.0	2,890.0	2,755.0	2,234.0	2,339.0	2,618.0	2,093.0	2,499.0
Annual net farm income ($1,000)	9.0	28.5	17.3	–52.5	–34.9	– 17.6	–67.9	–21.8
Annual government payment ($1,000)	39.0	39.1	44.7	4.2	3.7	16.2	0.0	37.3
Very ***large size (3,200 acres):***								
Probability of survival	100.0	100.0	100.0	100.0	100.0	100.0	92.0	100.0
Present value of ending net worth ($1,000)	1,936.0	2,204.0	2,231.0	1,096.0	1,412.0	1,087.0	925.0	1,657.0
Ending farm size (acres)	4,218.0	4,365.0	4,483.0	3,552.0	3,834.0	3,494.0	3,472.0	3,805.0
Annual net farm income ($1,000)	48.9	59.5	78.4	–7.8	15.6	– 13.6	– 25.1	28.1
Annual government payment ($1,000)	44.2	45.0	76.9	5.8	5.9	0.0	0.0	44.1

Table A-4.—Comparison of Selected Farm Commodity and Income Tax Policy Scenarios on Representative General Crop Farms in the Delta of Mississippi

	Alternative Scenarios [a]							
Criteria	I	II	III	Iv	v	VI	VII	VIII
Moderate size (1,443 acres):								
Probability of survival	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Present value of ending net worth ($1,000)	1,651.0	1,757.0	1,881.0	1,106.0	1,134.0	1,059.0	1,070.0	1,533.0
Ending farm size (acres)	2,009.0	2,057.0	2,093.0	1,625.0	1,645.0	1,581.0	1,590.0	1,913.0
Annual net farm income ($1,000)	***38.9***	***92.6***	***64.6***	***– 14.2***	***–6.9***	***– 16.3***	-17.6	***29.9***
Annual government payment ($1,000)	48.2	45.2	75.4	1.9	1.9	0.0	0.0	47.9
Large size (3,119 acres):								
Probability of survival	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Present value of ending net worth ($1,000)	2,940.0	3,280.0	4,418.0	2,482.0	2,537.0	2,433.0	2,454.0	3,139.0
Ending farm size (acres)	3,327.0	3,340.0	3,877.0	3,119.0	3,135.0	3,119.0	3,119.0	3,135.0
Annual net farm income ($1,000)	38.3	65.1	147.9	– 20.6	–8.2	– 28.9	– 25.1	21.8
Annual government payment ($1,000)	49.9	49.1	160.6	4.7	4.8	0.0	0.0	49.9
Very ***large size*** (6, 184 ***acres):***								
Probability of survival	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Present value ofending net worth ($1,000)	5,450.0	6,117.0	7,728.0	5,135.0	5,175.0	4,964.0	5,079.0	5,902.0
Ending farm size (acres)	6,248.0	6,254.0	6,530.0	6,270.0	6,245.0	6,242.0	6,267.0	6,203.0
Annual net farm income ($1,000)	41.8	118.2	277.1	– 19.7	–0.6	– 42.9	– 32.4	5.9
Annual government payment ($1,000)	49.9	49.8	277.9	7.9	7.9	0.0	0.0	49.9

[a]The Scenarios are:

I—Cont!nuatlon of the 1981 Farm Bill and 1983 Federal income tax provisions.
II—A 20°/0 Acreage Reduction in 1986-1992,
III—No Farm Program Payment Limitation in 1983.1992,
IV–NO Price Support and No Deficiency Payment in 1983.1992
V—No Target Price/Deficiency Payment in 1983-1992.
Vi—Target Farm Program Benefits to farms that produce less than $300,000 In program crops.
VII–NO Farm Program In 1983-1992
Vlll —Reduced Income Tax Benefits and the Base Farm Program

The Impact of Price Supports can be derived by subtracting Scenario 5 from Scenario 6.
The Impact of Income Supports can be derived by subtracting Scenario 6 from Scenario 1
The Impact of Income Supports with a $50,000 Payment Limitation can be found by subtracting Scenario 6 from Scenario 4

Table A-5.—Comparison of Selected Farm Commodity and Income Tax Policy Scenarios on Representative Texas Southern High Plains Cotton Farms

Criteria	Alternative Scenarios [a] I	II	III	Iv	v	VI	VII	VIII
Moderate size (1,088 acres):								
Probability of survival	92.0	94.0	94.0	56.0	68.0	92.0	42.0	88.0
Present value of ending net worth ($1 ,000)	564.0	648.0	601.0	242.0	301.0	564.0	167.0	516.0
Ending farm size (acres)	1,558.0	1,635.0	1,648.0	1,216,0	1,274.0	1,558.0	1,213.0	1,565.0
Annual net farm income ($1 ,000)	8.3	13.3	11.9	–28.9	–21.7	8.2	–40.6	–6.0
Annual government payment ($1,000)	26.0	22.2	29.5	1.3	1.1	25.9	0.0	25.8
Large size (3,383 acres):								
Probability of survival	90.0	94.0	94.0	72.0	82.0	86.0	62.0	88.0
Present value of ending net worth ($1 ,000)	1,412.0	1,697.0	1,853.0	931.0	1,055.0	1,191.0	801.0	1,226.0
Ending farm size (acres)	4,289.0	4,455.0	4,577.0	3,748.0	3,857.0	3,985,0	3,649.0	3,965.0
Annual net farm income ($1 ,000)	33.4	53.6	83.3	– 14.8	3.6	12.9	–39.7	– 7.2
Annual government payment ($1,000)	38.0	35.1	83.3	3.2	3.0	16.8	0.0	37.9
Very ***large size*** (5,570 ***acres):***								
Probability of survival	94.0	96.0	98.0	92.0	96.0	88,0	78.0	94.0
Present value of ending net worth ($1,000)	3,027.0	3,489,0	4,047.0	2,367.0	2,645.0	2,287.0	2,066.0	2,583.0
Ending farm size (acres)	6,002.0	6,047.0	6,514.0	5,781.0	5,848.0	5,727.0	5,736.0	5,746.0
Annual net farm income ($1,000)	66.6	100,6	170.6	–3.2	31.0	– 13.9	–40.5	– 15.6
Annual government payment ($1,000)	40.2	39.1	135.8	4.8	4.6	0.0	0.0	40,4

[a]The Scenar!os are
I—Continuation of the 1981 Farm BIII and 1983 Federal income tax provisions
II—A 20°/0 Acreage Reduction in 1986.1992
III–No Farm Program Payment Limitation In 1983.1992
IV—NO Price Support and No Deflclency Payment in 1983.1992
V–No Target Price/Deficiency Payment In 1983-1992
VI —Target Farm Program Benefits to farms that produce less than $300,000 in program crops
VII–NO Farm Program In 1983.1992
Vlll —Reduced Income Tax Benefits and the Base Farm Program
The Impact of Price Supports can be derived by subtracting Scenario 5 from Scenario 6
The Impact of Income Supports can be dertved by subtracting Scenario 6 from Scenario 1
The Impact of Income Supports w!th a $50,000 Payment Llm!tatlon can be found by subtracting Scenario 6 from Scenario 4

Table A-6.—Comparison of Selected Financial Bailout Scenarios for Three Representative Corn-Soybean Farms in East Central Illinois[a]

Criteria	Alternative Scenarios for 640-acre Farm			Alternative Scenarios for 982-acre Farm			Alternative Scenarios for 1,630-acre Farm		
	Ix	x	xl	Ix	x	xl	Ix	x	xl
Probability of survival	80.0	72.0	84.0	88.0	80.0	90.0	100.0	100.0	100.0
Present value of ending net worth ($1,000)	271.0	291.0	299.0	579.0	588.0	654.0	822.0	872.0	831.0
Ending farm size (acres)	653.0	689.0	662.0	1,046.0	1,062.0	1,073.0	1,795.0	1,740.0	1,712.0
Annual net farm income ($1,000)	–0.9	–3.3	3.8	2.0	–3.5	7.8	30.6	27.9	36.9
Annual government payment ($1,000)	8.9	8.9	9.1	19.2	18.9	19.0	23.0	22.8	22.8

Table A-7.—Comparison of Selected Financial Bailout Scenarios for Three Representative Irrigated Row Crop Farms in South Central Nebraska[a]

Criteria	Alternative Scenarios for 672-acre Farm			Alternative Scenarios for 920-acre Farm			Alternative Scenarios for 2,083-acre Farm		
	Ix	x	xl	Ix	x	xl	Ix	x	xl
Probability of survival	96.0	86.0	98.0	100.0	100.0	100.0	100.0	100.0	100.0
Present value of ending net worth ($1,000)	353.0	334.0	387.0	871.0	876.0	893.0	1685.0	1820.0	1714.0
Ending farm size (acres)	822.0	822.0	854,0	1,195.0	1,146.0	1,205.0	2,399.0	2,392.0	2,421.0
Annual net farm income ($1,000)	5.9	2.9	11.3	22.6	16.7	28.2	58.9	77.2	72.1
Annual government payment ($1,000)	16.7	16.8	17.0	23.0	22.6	22.9	36.0	36.0	36.1

Table A-8.—Comparison of Selected Financial Bailout Scenarios for Three Representative Southern Plains Wheat Farms[a]

Criteria	Alternative Scenarios for 1,280-acre Farm			Alternative Scenarios for 1,920-acre Farm			Alternative Scenarios for 3,200-acre Farm		
	Ix	x	xl	Ix	x	xl	Ix	x	xl
Probability of survival	86.0	98.0	100.0	40.0	70.0	80.0	100.0	100.0	100.0
Present value of ending net worth ($1,000)	289.()	408.0	383.0	258.0	399.0	406.0	1,248.0	1,373.0	1,348.0
Ending farm size (acres)	1,434.0	1,549.0	1,552.0	1,994.0	2,058.0	2,118.0	3,779.0	3,978.0	3,891.0
Annual net farm income ($1,000)	–22.5	–21 .2	– 14.3	–37.9	–35.1	–24.1	17.1	12.4	27.5
Annual government payment ($1,000)	25.2	26.4	26.8	34.8	35.2	35.6	43.9	44.1	44.0

Table A-9.—Comparison of Selected Financial Bailout Scenarios for Three Representative General Crop Farms in the Delta of Mississippi[a]

Criteria	Alternative Scenarios for 1,443-acre Farm			Alternative Scenarios for 3,1 19-acre Farm			Alternative Scenarios for 6,184-acre Farm		
	Ix	x	xl	Ix	x	xl	Ix	x	xl
Probability of survival	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Present value of ending net worth ($1,000)	1,563.0	1,656.0	1,545.0	3,237.0	3,431.0	2,968.0	5,259.0	5,840.0	4,990.0
Ending farm size (acres)	2109.0	2,115.0	2,025.0	3,845.0	4,719.0	3,685.0	6,606.0	7,656.0	6,453.0
Annual net farm income ($1,000)	35.5	29.4	37.7	30.1	20.4	33.8	3.7	-14.8	5.4
Annual government payment ($1,000)	48.4	48.4	48.3	49.9	49.9	49.9	49.9	49.9	49.9

[a]The Scenarios are"

IX—Continuation of the 1981 Farm BIII and the 1983 Federal tax provisions for a highly leveraged farm

X—Restructure of debt for a highly leveraged farm.

X1—Irrterest rate subs!dy (buy-down) in the first two years for a highly leveraged farm

Table A-IO—Comparison of Selected Financial Bailout Scenarios for Three Representative Texas Southern High Plains Cotton Farms[a]

Criteria	Alternative Scenarios for 1,088-acre Farm			Alternative Scenarios for 3,383-acre Farm			Alternative Scenarios for 5,570-acre Farm		
	Ix	x	xl	Ix	x	xl	Ix	x	xl
Probability of survival	64.0	66.0	72.0	56.0	50.0	60.0	66.0	64.0	66.0
Present value of ending net worth ($1,000)	304.0	314.0	343.0	604.0	600.0	733.0	1,310.0	1,356.0	1,619.0
Ending farm size (acres)	1,414,0	1,434.0	1,443.0	3,770.0	3,841.0	3,821.0	5,733.0	5,976.0	5,772,0
Annual net farm income ($1,000) ., ...	–5,4	–6.4	1.3	–9.1	–21 .2	6.9	–41 .8	–57.3	–6.3
Annual government payment ($1,000) . .	24.4	24.8	24.7	36.8	36.4	37.2	41.1	41.3	41.6

[a]The scenar!os are
IX —Contlnuatlon of the 1981 Farm BIII and the 1983 Federal tax provisions for a highly leveraged farm
X—Restructure of debt for a highly leveraged farm
Xl—Interest rate subsidy (buy-down) In the first two years for a highly leveraged farm

Table A-n .—Comparison of Selected Policy Scenarios Assuming No New Technology for Three Representative Corn"Soybean Farms in East Central Illinois[a]

Criteria	Alternative Scenarios for 640-acre Farm			Alternative Scenarios for 982-acre Farm			Alternative Scenarios for 1,630-acre Farm		
	X11	X111	XIv	X11	X111	XIv	X11	X111	XIv
Probability of suwival	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.
Present value of ending net worth ($1,000)	699.0	589.0	561.0	862.0	604.0	540,0	915.0	694.0	672.0
Ending farm size (acres)	902.0	837.0	850.0	1,392.0	1,190.0	1,116,0	1,899.0	1,801.0	1,796.0
Annual net farm income ($1,000) . .	23,0	11.7	10.8	23.9	3.3	-0.8	25.3	9.8	6.1
Annual government payment ($1,000)	11,6	0.7	0.0	22.9	1.0	0.0	22.9	1.7	0.0

Table A-12.—Comparison of Selected Policy Scenarios Assuming No New Technology for Three Representative Irrigated Row Crop Farms in South Central Nebraska[a]

Criteria	Alternative Scenarios for 672-acre Farm			Alternative Scenarios for 920-acre Farm			Alternative Scenarios for 2,085-acre Farm		
	X11	X111	XIv	X11	X111	XIv	X11	X111	XIv
Probability of survival	100.0	100.0	90.0	100.0	100.0	100.0	100,0	100.0	100.0
Present value of ending net worth ($1,000)	670.o	475.0	263.0	1,230.0	985.0	671,0	1,812.0	1,388.0	680.0
Ending farm size (acres)	921.0	870.0	808.0	1,257.0	1,221.0	1,226.0	2,402.0	2,240.0	2,107.0
Annual net farm income ($1,000)	26.7	10.6	– 11.4	53.9	30.3	–2.6	77.5	51.0	– 10.9
Annual government payment ($1,000) . .	17.3	0.9	0.0	23.9	1,3	0.0	35.7	3.0	0.0

Table A-l 3.—Comparison of Selected Policy Scenarios Assuming No New Technology for Three Representative Southern Plains Wheat Farms[a]

Criteria	Alternative Scenarios for 1,280-acre Farm			Alternative Scenarios for 1,920-acre Farm			Alternative Scenarios for 3,200-acre Farm		
	X11	X111	XIv	XII	X111	XIv	X11	X111	XIv
Probability of~urvival ., ...	100.0	90.0	32.0	100.0	Z4.O	10.0	100.0	82.0	28.0
Present value of ending net worth ($1,000)	726.0	325.0	134.0	780,0	229.0	81.0	1,131.0	562.0	220.0
Ending farm size (acres)	1,859.0	1,632.0	1,430.0	2,605.0	2,304.0	2,048.0	3,699.0	3,542.0	3,322.0
Annual net farm income ($1,000)	-1,3	–28.9	–46.8	– 10.9	–52.9	–77.1	–2,1	– 45.4	– 85.8
Annual government payment ($1,000)	30.7	2.5	0.0	38.1	3.9	0.0	43.7	5,9	0.0

[a]The Scenarios are
X1I —Conttnuatlon of the 1981 Farm BIII and the 1983 Federal tax provisions, assuming no new technology scenar!o
Xl If—No Target Pr!ce/Deflclency Payment Program, assuming no new technology scenario
XIV— Deflclency plus diversion payments and any other government payments received for government loans and storage costs

Table A-14.—Comparison of Selected Policy Scenarios Assuming No New Technology for Three Representative General Crop Farms in the Delta of Mississippi[a]

	Alternative Scenarios for 1,443-acre Farm			Alternative Scenarios for 3,1 19-acre Farm			Alternative Scenarios for 6,184-acre Farm		
Criteria	X11	X111	XIv	X11	X111	XIv	X11	X111	XIv
Probability of suwival	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Present value of ending net worth ($1,000) ~	1,613.0	1,104.0	1,043.0	2,786.0	2,451.0	2,354.@	5,286.0	4,915.0	4,714.0
Ending farm size (acres)	2,006.0	1,638.0	1,587.0	3,343.0	3,148.0	3,119.0	6,322.0	6,277.0	6,261.0
Annual net farm income ($1,000)	38.6	– 7.3	– 18.3	34.0	– 11.9	– 29.9	15.1	–27.5	–57.7
Annual government payment ($1,000)	48.2	1.9	0.0	49.9	4.8	0.0	49.9	7.9	0.0

Table A-15.—Comparison of Selected Policy Scenarios Assuming No New Technology for Three Representative Texas Southern High Plains Cotton Farms[a]

	Alternative Scenarios for 1,088-acre Farm			Alternative Scenarios for 3,383-acre Farm			Alternative Scenarios for 5,570-acre Farm		
Criteria	X11	X111	XIv	X11	X111	XIv	X11	X111	XIv
Probability of survival	92.0	68.0	42.0	88.0	78.0	60.0	94.0	90.0	76.0
Present value of ending net worth ($l,ooo)	552.o	290.0	161.0	1,325.0	966.0	738.0	2,807.0	2,322.0	1,843.0
Ending farm size (acres)	1,590.0	1,280.0	1,206.0	4,273.0	3,818.0	3,633.0	5,960.0	5,816.0	5,724.0
Annual net farm income ($1 ,000)	7.0	–22.2	–41 .0	25.4	–3.6	–45.5	47.0	0.2	–65.9
Annual government payment ($1,000)	26.3	1.1	0.0	37.9	3.0	0.0	40.5	4.8	0.0

[a]The Scenarios are:
X1I—Continuation of the 1981 Farm Bill and the 1983 Federal tax prowslons, assuming no new technology scenario
XIII—NO Target Price/Deficiency Payment Program, assuming no new technology scenario,
XIV—Deficiency plus dlverslon payments and any other government payments received for government loans and storage costs

Table A-16.—Comparison of Selected Policy Scenarios for a New Entrant on a Representative 640 Acre Corn"Soybean Farm in East Central Illinois[a]

Criteria	Alternative Scenarios for 640-acre Farm: XV	XVI	XVII
Probability of survival	2.0	0.0	4.0
Present value of ending net worth ($1 ,000)	221.0	202.0	197.0
Ending farm size (acres) .	640.0	640.0	640.0
Annual net farm income ($1,000)	–56.9	–61 .1	–62,8
Annual government payment ($1,000)	9.6	6.1	0.0

Table A-17.—Comparison of Selected Policy Scenarios for a New Entrant on a Representative 672 Acre Irrigated Row Crop Farm in South Central Nebraska[a]

Criteria	Alternative Scenarios for 672-acre Farm: XV	XVI	XVII
Probability of survival	84.0	42.0	6.0
Present value of ending net worth ($1 ,000)	187.0	106.0	356.0
Ending farm size (acres) ., . .	674.0	666.0	672.0
Annual net farm income ($1,000)	–19.2	– 35.8	– 56.6
Annual government payment ($1,000)	14.5	1.2	0.0

Table A-18.—Comparison of Selected Policy Scenarios for a New Entrant on a Representative Southern Plains Wheat Farm[a]

Criteria	Alternative Scenarios for 1,280-acre Farm: XV	XVI	XVII
Probability of survival	2.0	0.0	0.0
Present value of ending net worth ($1 ,000)	39.0	26,0	45.0
Ending farm size (acres)	1,280.0	1,280.0	1,280.0
Annual net farm income ($1,000)	-94.2	-103.2	– 121,9
Annual government payment ($1,000)	18.1	7.4	0,0

Table A-19.—Comparison of Selected Policy Scenarios for a New Entrant on a Representative 1443 Acre General Crop Farm in the Delta of Mississippi[a]

Criteria	Alternative Scenarios for 1,443-acre Farm: XV	XVI	XVII
Probability of survival	100.0	76,0	62.0
Present value of ending net worth ($1 ,000)	985,0	395.0	319.0
Ending farm size (acres)	1,830.0	1,459.0	1,443.0
Annual net farm income ($1,000)	-18.8	-76.8	–91 .3
Annual government payment ($1,000)	47.3	2.3	0.0

Table A-20.—Comparison of Selected Policy Scenarios for a New Entrant on a Representative Texas Southern High Plains Cotton Farm[a]

Criteria	Alternative Scenarios for 1,088-acre Farm: XV	XVI	XVII
Probability of survival	50.0	16.0	10.0
Present value of ending net worth ($1 ,000).	235.0	53.0	41.0
Ending farm size (acres)	1,306.0	1,155.0	1,126.0
Annual net farm income ($1,000)	-35.7	–66.5	– 84.9
Annual government payment ($1,000)	***21.7***	2.0	0.0

[a]The Scenanos are
XV —Contlnuatlon of the 1981 Farm BIll and the 1983 Federal tax pro. vlsIons
XVI—NO Target Prtce/Deflclency Payment Program In 19811992
XVII—NO Farm Program In 1983.1992

Appendix B.-Summary Analysis Tables for Dairy Farms

Table B-1 .—Comparison of Selected Commodity Policy, Tax and Technology Scenarios on Representative Dairy Farms in Minnesota[a]

		Alternative Scenanos								
Criteria	Initial situation	Base	I	II	III	Iv	v	VI	VII	VIII
52 cow ***Minnesota dairy:***										
Probability of survival	NA	70.0	68.0	68.0	38	34.0	70.0	92,0	–	—
Present value of ending net worth ($1,000). ,,	417.0	224.0	222.0	223,0	157,0	149.0	221.0	314,0	–	—
Ending equity ratio (fraction)	0.71	0.41	0.41	0,41	0.30	0.29	0.41	0,57	–	—
Annual net farm income ($1 ,000).	NA	–27.0	–27	–27,0	–35.0	–36.0	– 27.0	–15.0	–	—
125 cow Minnesota dairy:										
Probability of survival	NA	100,0	100.0	100.0	100,0	98,0	100,0	100,0	100.0	100.0
Present value of ending net worth ($1!000). ....,	969.0	1,012.0	1,019.0	1,012,0	888.0	872.0	965.0	1,111,0	116.0	1,140.0
Ending equity ratio (fraction)	0.76	0.83	0.83	0.82	0.72	0.71	0.79	0.89	0.92	0.91
Annual net farm income ($1 ,000).	NA	0.0	0.0	0.0	– 18,0	– 19,0	–9.0	15,0	21.0	44,0

Table B-2.—Comparison of Selected Commodity Policy, Tax and Technology Scenarios on Representative Dairy Farms in the Southwest[a]

		Alternative Scenarios								
Criteria	Initial situation	Base	I	II	III	Iv	v	VI	VII	VIII
359 ***cow Arizona daity:***										
Probability of survival	NA	96.0	86.0	96.0	***96.0***	92.0	96.0	100,0	—	—
Present value of ending net worth ($1,000) ,.	744,0	1,404.0	1,018.0	1,399.0	1,334.0	1,098,0	1,325,0	1,7190	—	—
Ending equity ratio (fraction)	0.71	0,94	0.84	0.94	0.94	0.88	0.94	0.95	—	—
Annual net farm income ($1 ,000).	NA	28,0	–32.0	27.0	13,0	–22,0	31.0	93,0	—	—
550 cow ***California dairy:***										
Probability of survival	NA	96.0	76,0	96.0	***84.0***	76,0	***96.0***	98,0	—	—
Present value of ending net worth ($1,000). 1,261.0	1,824.0	1,107.0		1,813.0	1,368,0	1,074,0	1,716.0	2,312,0	—	—
Ending equity ratio (fraction)	0,71	0.90	0.68	0.90	0.79	0.67	0.90	0,94	—	—
Annual net farm income ($1 ,000)	NA	–29.0	– 142.0	–30.0	– 101.0	– 147,0	–30.0	65.0	—	—
1,436 cow ***California dairy:***										
Probability of survival	NA	96.0	92.0	96.0	940	92.0	96.0	100,0	100.0	**100,0**
Present value of ending net worth ($1 ,000)	2,538.0	6,507,0	4,968.0	6,496.0	5,448.0	4,774.0	6,278.0	9,553.0	8,750.0	11,084.0
Ending equity ratio" (fraction)" : :	0.69	0.92	0.89	0.92	0.89	0.88	0.92	0,95	.96	0,94
Annual net farm income ($1 ,000)	NA	375.0	136.0	373.0 _	211.0	99,0	371.0	7980	614.0	1,154,0

[a]The Scenarios are
Base–Contlnuatlon of present policy
I–A 20 percent acreage reduction In 1986.1992–9 percent higher feed costs
II–No crop program
111–Fifty cent per cw1 lower milk price
IV–NO dairy price support program
V–Reduce Income tax benefit program
V1–Milk supply control program
V1l– Computer feeding technology
Vlll– Bovine growth hormone technology

Table B-3.—Comparison of Selected Commodity Policy, Tax and Technology Scenarios on Representative Dairy Farms in Florida[a]

		Alternative Scenarios								
Crltena	In[t[al sltuatlon	Base	I	II	III	Iv	v	VI	VII	VIII
350 cow *Florida dairy:*										
Probability of survival	NA	980	700	960	82	680	920	1000		
Present value of ending net worth ($1 .000)	757.0	1,0090	5780	1,0050	933.0	648.0	911 0	1,3270	–	
Ending equity ratio (fraction)	0.71	085	057	085	074	059	080	093		
Annual net farm Income ($1 ,000)	NA	–8 O	–71 o	–8 O	–17 o	–66 o	–3 o	280		
600 cow *Florida dairy:*										
Probablllty of survival	NA	100.0	88.0	1000	980	840	1000	1000	–	—
Present value of ending net worth ($1 ,000)	1,4650	2,1700	1,5470	2,1690	2,1300	1,6300	1,9960	2,326.0		
Ending equity ratio (fraction)	O 76	094	081	094	091	0.78	092	094		
Annual net farm income ($1 ,000)	NA	330	–62 O	320	300	–46 O	330	630		—
1,436 cow *Florida dairy:*										
Probability of survival	NA	1000	100.0	1000	1000	1000	1000	100,0	1000	1000
Present value of ending net worth ($1 !000)	3,3430	8,6910	7,338.0	8,670.0	7,9420	7,7660	8,396.0	9,9540	10,5760	12,3580
Ending equity ratio (fraction)	O 76	095	0.95	0.95	095	095	095	095	095	095
Annual net farm Income ($1 ,000)	NA	5860	411,0	585.0	5040	4630	5820	7490	7820	1.2860

[a]The Scenarios are
Base—Continuation of present policy
I–A 20 percent acreage reduction in 1986-"99? 9 percent higher feed costs
II–No crop program
III–Fifty cent per cwt lower milk price
IV–NO dairy price support program
V–Reduce income tax benefit program
VI –Milk supply control program
VII–Computer feeding technology
VIII–Bovine growth hormone technology

Table B-4.—Comparison of Selected Policy Scenarios on Representative Minnesota Dairy Farms That Have High Debt or Are New Entrants With High Debt

	Financial Stress Scenarios[a]				New Entrant Scenarios[b]			
Criteria	Initial situation	Ix	x	xl	Initial situation	xii	X111	XIv
52 cow ***Minnesota dairy:***								
Probability of survival	NA	0.0	0.0	0.0	NA	0.0	0.0	0.0
Present value of ending net worth ($1 ,000)	246.0	97.0	93.0	101.0	264.0	138.0	122.0	138.0
Ending equity ratio (fraction)	0.42	0.19	0.19	0.20	0.36	0.21	0.19	0.22
Annual net farm income ($1 ,000)	NA	–57.0	–46	–57.0	NA	–98.0	– 105.0	– 98.0
125 cow ***Minnesota dairy:***								
Probability of survival	NA	0.0	0.0	0.0	NA	0.0	0.0	0.0
Present value of ending net worth ($1 ,000)	554.0	238.0	235.0	235.0	575.0	304,0	298.0	303.0
Ending equity ratio (fraction)	0.44	0.23	0.22	0.22	0.37	0.23	0.22	0.23
Annual net farm income ($1 ,000)	NA	–92.0	– 73.0	–94.0	NA	– 147,0	–163.0	–147.0

Table B-5.—Comparison of Selected Policy Scenarios on Representative Florida and Arizona Dairy Farms That Have High Debt or Are New Entrants With High Debt

	Financial Stress Scenarios[a]				New Entrant Scenarios[b]			
Criteria	Initial situation	Ix	x	xl	Initial situation	X11	X111	XIv
350 *cow* ***Florida dairy:***								
Probability of survival	NA	**26.0**	**42.0**	26.0	NA	22.0	12.0	2.0
Present value of ending net worth ($1,000)	466.0	**334.0**	**391.0**	337.0	527.0	345.0	165.0	180.0
Ending equity ratio (fraction)	0.44	**0.35**	**0.40**	0.35	0.41	0.32	0.15	0.17
Annual net farm income ($1 ,000)	NA	– 101.0	--78.00	- 101.0	NA	– 174.0	–245.0	–230.0
359 cow ***Arizona dairy:***								
Probability of survival$	NA	66.0	70.0	66.0	NA	60.0	38.0	24.0
Present value of ending net worth ($1 ,000)	471.0	760.0	840.0	763.0	528.0	717.0	372.0	262.0
Ending equity ratio (fraction)	0.45	0.64	0.68	0.63	0.42	0.58	0.33	0.27
Annual net farm income ($1,000)	NA	–59.0	–35.0	–60.0	NA	- 102.0	- 182.0	- 194.0

a~ financial Scenarios are:

IX—Continuation of present dairy policy and assuming high debt.
X–Subsidize interest rate so effective rate on all loans is 8 percent
XI–Restructure debt.

bThe new entrant scenarios are.

XI I—Base Policy and new entrant.
XIII – New entrant and no price support for dairy products.
XIV—New entrant and a 9-percent increase in feed costs.

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