Part III

Analyses of Technology, Public Policy, and Agricultural Structure

Chapter 6

Emerging Technologies and Agricultural Structure

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Emerging Technologies and Agricultural Structure

New technologies have, historically, had significant impacts on structural change. New disease control techniques gave poultry and livestock farmers unprecedented opportunities to specialize and vertically integrate. Improvements in farm machinery fostered large-scale, specialized farm units.

Like their predecessors, the emerging technologies examined for this study will make a considerable impact on farm structure, especially by year 2000. Biotechnologies will have the greatest impact because they will enable agricultural production to become more centralized and vertically integrated. Although in the long run the use of new technologies will not increase the farmer's overall need for capital, there will be trade-offs: biotechnology will entail less capital; information technology will entail more. This chapter discusses how the emerging technologies are expected to affect these and other elements of agricultural structure.

The chapter evaluates the new technologies' impacts on agricultural structure. It covers: 1) the methodology and assumptions for evaluating the impact of technologies, 2) the analysis of technology's impact on structure, 3) relative adoption rates by size of farm, and 4) relative effectiveness of policy in achieving a structure.

METHODOLOGY

To assess the relationship between technology and structure, OTA conducted a 2-day workshop with a panel of 14 experts.[1] This workshop will be referred to as the Agriculture Structure Group (ASG). The panel members represented abroad range of backgrounds and regions within the United States. (The names, affiliations, and disciplinary specialty of each workshop participant are included in app. C.) A major portion of the first day was devoted to briefings by experts on the 28 previously defined technologies. The initial discussions of the ASG involved the potential impact of these technologies on capital and labor at the farm level and on the structural elements of vertical coordination, market access, and barriers to entry. The second day's discussions were concerned with the distributional impacts of the technologies and the broad categories of public policies that might achieve a predetermined structural changeover time.

*This chapter is based on the results of the workshop as analyzed by Thomas Sporleder in the OTA paper "Agricultural Structure Impacts of Emerging Technologies in American Agriculture" and reviewed by the workshop participants.

The assessment of distributional impacts was by broad category of technologies. The panel members considered both rate of adoption and change in physical output by farm size, focusing on the flow of impacts from various technologies to structure.

As a final item, the ASG addressed the reverse flow-from structure to technology development and adoption. Thus the potential causality between various farm structures and the development and adoption of technology groups was also addressed by ASG.

Group discussion was unstructured except for materials prepared for the ASG that provided an agenda of discussion topics. The Delphi procedure was used to help the group reach consensus about the potential impacts of technology on selected economic variables.

The assumptions made by the work group that applied throughout the assessment of technological impacts to the year 2000 were:

1. Economic variables such as tax policy, in-

terest rates, inflation rates, and prices are held constant at 1984 levels.

z. Impacts of technology groups are assessed separately, assuming that only one technology group exists and is 100 percent adopted in 1984. Thus, potential interaction effects among the technology groups were not assessed.

3. Capital and labor were defined broadly so that they were the only factor inputs in the production process. Capital was defined as all nonlabor, nonmanagement resources, including land, while labor was defined to encompass both management and labor.

4. The focus was production agriculture—farms and ranches. An important element of structure was defined as the number and size of farm firms. Although the group recognized the importance of other levels in the commodity marketing and food distribution channel, the focus remained on the farm level for reasons of manageability.

TECHNOLOGY GROUPINGS

The ASG judged the 28 study technologies to be sufficiently similar in their impacts on market structure to permit assessment of them within groups rather than individually. Thus the technologies were grouped into three broad categories for animal agriculture and four broad categories for plant agriculture (table 6-l).

The biological group essentially consists of technologies that use living organisms or their isolated components for manipulating plant or animal production. The mechanical group encompasses technology development in machinery used to produce and/or harvest the results of crop or animal production. The information group includes the technologies of sensors, controllers, and actuators, along with broad developments in computer technology applicable to the collection and analysis of information for producer-level management decisions.

Whereas the other categories apply to both crop and livestock production, the technologies within the management techniques group apply only to crop production. This group includes technologies that assist in a more optimal, long-term combination of inputs at the producer level, and each involves cultural or management practices.

Table 6-1.—Groups of Technologies Analyzed, by Animal and Plant

Technology group/technologies included
Animal:
Biological.—Genetic engineering, Animal reproduction, Regulation of growth and development, Animal nutrition, Disease and pest control
Mechanical.-Environment of animals, Animal behavior, Crop residues, Animal waste use, Robotics
Information. -Monitoring and control, Communication and information, Telecommunications
Plant:
Biological.—Genetic engineering, Enhancement of photosynthetic efficiency, Plant growth regulators, Plant disease and nematode control, Management of insects and mites, Weed control, Biological nitrogen fixation
Mechanical.—Robotics, Engines and fuels, Crop separation—cleaning—processing
Information.—Monitoring and control, Communication and information, Telecommunications
Management techniques.—Water and soil-water-plant relations, Soil erosion, Soil productivity and tillage, Multiple cropping, Organic farming, Land management

SOURCE: Office of Technology Assessment.

STRUCTURAL ELEMENTS

The structural dimensions assessed for technological impacts were capital and labor, vertical coordination and control, market access, barriers to entry, and regional impacts. These elements are not necessarily the only relevant ones for judging the impact of various technol-

ogies. However, in the interest of manageability of scope and time, these were judged most important.

Capital is viewed broadly as all nonlabor and nonmanagement inputs, including land, while labor was viewed broadly as both management and labor. *Vertical coordination* is defined as coordination of quality, quantity, and timing across producer/first handler markets. *Control* is primarily the ability of producers to exercise authority over production and marketing decisions. *Market access* refers to whether producers have access to most or all buyers at a particular stage of the marketing channel. *Barriers to entry* are defined as the inability, for whatever reason, of new firms to enter a particular industry.

These structural elements are the common ones normally viewed as important in agricultural commodity markets. For any of the structural elements, it is difficult to judge or measure precisely the magnitude of impact from various technologies. Often, the direction of impact (positive or negative) is easier to judge. The procedure used by workshop participants was to discuss direction of impact, then use the Delphi process to judge magnitude of impact within some predetermined range (e.g., O to 10 percent, 10 to 20 percent).

IMPACTS OF TECHNOLOGY ON STRUCTURAL ELEMENTS

The structural elements provide some indication of the potential for a technology group to induce a change in farm size and number over time. The directional impact of the technology groups on each selected structural element is summarized in tables 6-2 and 6-3. The tables apply to both animal and plant agriculture across all technologies.

Capital and Labor

Technology can affect the capital and labor used in production of either animals or crops. The absolute and relative change induced by technology in capital and labor was addressed and is depicted in table 6-3.

Biological Group

Several primary effects of technologies in the biological group on capital were identified. It was assumed that reproduction and genetic engineering technology would be adopted by farmers via contracting for a specialized service. The adoption would slightly reduce (<5 percent) both capital and labor necessary for a given size herd. An example is the expected dramatic savings in time that will result from hiring a specialized service to check a dairy herd for estrus.

Growth hormone technology is also expected to decrease both capital and labor needs slightly in animal production. Animal nutrition and disease control technologies are expected to decrease slightly or have no impact on capital and labor in the long run.

Because both capital and labor are expected to decrease slightly as a result of these biological technologies, no significant change (i.e., <5 percent) is expected in the capital/labor ratio. Capital is viewed as decreasing slightly less than labor, on the average, but this difference is not viewed as significant.

The biological group of technologies is viewed as having a long-run neutral impact on capital input at the farm level, primarily because the majority of these technologies have become available as new plants or seeds. Thus the technology is imbedded into the factor input without a separate purchase of it. Potential price increases in plants or seeds were viewed as being offset by productivity gains.

A slight decrease in labor input is expected from the technologies in this group for plant agriculture. This was expected mostly from the potential for weed, insect, and mite control technologies reducing some labor input to the pro-

Table 6.2.—Potential Directional Impact of Technology Groups on Structural Elements at the Producer Level, by Animal and Plant

Area and technology group	Potential additional direction of impact induced by technology group by year 2000		
	Vertical coordination and control	Market access	Barriers to entry
Animal:			
Biological group	Closer coordination encouraged	Slight reduction	No significant change
Mechanical group	No significant change	No significant change	No significant change
Information group	No significant change	Slight increase	Slight-to-definite reduction
Plant:			
Biological group	Slight encouragement of closer coordination	No significant change	No significant change
Mechanical group	No significant change	No significant change	Slight increase
Information group	No significant change	Increase	No significant change
Management techniques group	No significant change	No significant change	Slight-to-moderate

SOURCE: Office of Technology Assessment

Table 6-3.—Potential Impact of Technology Groups on Capital and Labor at the Producer Level, Assuming Adoption, by Animal and Plant

Area and technology group	Potential additional change induced by technology group by year 2000		
	Capital	Labor	Capital/labor ratio
Animal:			
Biological group	Slight decrease (<5°/0)	Slight decrease (<5%)	No significant change
Mechanical group	Moderate increase (5-10°/0)	Slight decrease (<5%)	Moderate increase (5-10°/0)
Information group	Moderate increase (5-10°/0)	Slight increase (<5°/0)	Moderate increase (5-10°/0)
Plant:			
Biological group	No significant change	Slight increase (< 5°/0)	No significant change
Mechanical group	Moderate increase (5-10°/0)	Slight increase (<5°/0)	Moderate increase (5-10°/0)
Information group	Moderate increase (5-10°/0)	Slight increase (<5°/0)	Moderate increase (5-10°/0)
Management techniques group	Slight increase (<5°/0) ‘	Moderate increase (5-10°/0)	No significant change ‘

SOURCE: Office of Technology Assessment.

duction process. This is also the potential impact of the plant disease and nematode control technologies.

The capital/labor ratio is not expected to change significantly as a result of the technologies in the biological group for crops. The decrease in labor anticipated from some technologies within the biological group is not expected to be important enough to change the capital/labor ratio significantly in the long run.

Mechanical Group

The mechanical group for animals is viewed primarily as housing and lighting control for animals that might influence breeding or growth. The other technologies within this group are viewed primarily as improvements in mechanical methods for crop residue or animal waste processing.

Almost by definition, this technology group is composed of technologies that require capital equipment expenditures if adopted, resulting in a moderate increase (5 to 10 percent) in the amount of capital. Another expected consequence of these mechanical technologies is a slight decrease in labor, primarily because of the potential of these technologies to reduce stress on livestock, which in turn may reduce management input. The decrease in labor for livestock operations, however, is anticipated to be less than 5 percent in the long run. It is further expected that the moderate increase in capital and the slight decrease in labor will increase the capital/labor ratio moderately (5 to 10 percent) for livestock producers.

The adoption of the mechanical technologies group for plant agriculture, as with this technology group for animal production, is expected to result in a moderate increase in capital input. The cost of engines is expected to rise, and engines are expected to have a higher horsepower for the same size. The major technologies in this group are expected to be capital-intensive.

The potential for labor reduction from the technologies for crops is expected to be similar to that for livestock. The expectation is for a slight decrease (<5 percent) in labor input attributable to this technology group. The capital/labor ratio is expected to increase moderately (5 to 10 percent), owing primarily to increased engine costs and small labor reductions. The expectation for the capital/labor ratio for crop production is similar to that for livestock production.

Information Group

The technologies in the information group are viewed as capital-intensive and are expected to have impacts that are similar for both crop and livestock producers. Actuators, sensors, and controllers would require additional capital expenditures for production units such as feedlots, dairy barns, or crop fields. The consensus is that these technologies would require a moderate increase (5 to 10 percent) in capital for either crop or livestock operations.

Because the total amount of data and information available to managers would increase as a result of this technology, a slight increase (<5 percent) in managerial time is expected. The managerial input results from an increase in information that would be generated by the technology. Such information would require more analysis time from managers. This situation is similar for either livestock or crop operations,

The capital/labor ratio is viewed as increasing moderately (5 to 10 percent) as the net result of these technologies. No significant differences are anticipated between livestock and crop production as a result of information technologies. The capital/labor ratio is expected to increase primarily from an increase in capital equipment items used in production of either crops or livestock.

Management Techniques Group

The management techniques group represents various management regimes useful in crop production.

The organic farming technology within this group is viewed essentially as a substitution of mechanical factor inputs (more cultivation) for chemical factor inputs (such as fertilizer or insecticides). This substitution would lead to some capital expenditure decreases and some labor expenditure increases in crop production in the long run.

Other technologies in this group are viewed as relatively more capital-intensive—such as soil erosion, tillage, and general land management. As a result, the net impact of this technology category on capital used in crop production is a slight increase (<5 percent).

Many of the technologies within this group are expected to require additional management input. Almost by definition, the adoption of technologies in this group is expected to demand greater management in the production process. As a result, labor (encompassing management) is expected to increase moderately (5 to 10 percent).

The capital/labor ratio attributable to this technology group is not expected to change significantly. The increase in capital and the increase in labor are expected to be sufficiently similar that no significant change is induced in the capital/labor ratio for crop production in the long term.

Vertical Coordination and Control

The consideration of vertical coordination and control is that if technology induces tighter vertical coordination by an integrator, it may simultaneously induce a shift in control over production from the farmer to the integrator. This, in turn, could affect the number and size of farms in the long run. The poultry industry is an example of a commodity marketing chan-

nel that exhibits relatively tight vertical coordination, loss of producer control, and a consequent shift to fewer but larger production units.

In general, the emerging technologies are expected to allow more control over end-product characteristics. Examples include less fat per unit of lean meat in animals or a specific color characteristic in corn, with the implication that more homogeneity within a type of product may result but that more end products will have engineered characteristics. This situation entails some shift away from sorting or grading as a way to achieve greater homogeneity y and a shift toward more control over the production process.

An anticipated economic consequence of this increased control over production practices will be in the area of contracting. Contracting allows husbandry practices or cultural practices to be monitored and controlled closely during the production process, resulting in productsthat adhere to uniform specifications. Controlled diversity would result from this arrangement. That is, greater process control would lead to uniform product differentiation.

Biological Group

The biological group of technologies is expected to encourage closer coordination in livestock production compared with the situation in 1984. The technologies in this group would encourage greater process control, which would be manifested in more contracted livestock production. One example is swine producers who contract with meat packers to produce pork of uniform specifications and are paid for their labor and facilities at a predetermined fixed rate.

Another example is the potential from these technologies for modifying milk at the cow rather than at the processing plant. This technology group holds promise for producing more highly unsaturated fats in milk. If such technology is adopted, it would require close coordination at producer/first handler markets and additional process control at the production level.

The expectation for this technology group is that it will encourage closer coordination in crop production, as well. However, even though the direction of impact was viewed similarly between livestock and crop production, the magnitude is expected to be relatively less for crops compared with livestock. Part of the reason is that relatively more process control in livestock than in crops is expected from adopting the technologies.

Mechanical Group

No significant change in vertical coordination is expected from the technologies in the mechanical group for either crop or livestock production. The technology for this group is essentially embodied in capital equipment items such as tractors and other machinery. As a consequence, the adoption and use of the technology is a decision made by individual production units, with no real implication for vertical coordination or control.

Information Group

The technologies within the information group are not expected to have any significant impact on vertical coordination or control for either crop or livestock production. The situation for this technology group is similar to that for the mechanical group. Adoption and use of these technologies are decisions of individual farm and ranch managers.

One possible impact from the information technologies on vertical coordination is the potential for the technology to encourage more open markets for commodities rather than contractual arrangements. The technology is viewed as having some potential for coordination across markets without integration. This impact would be attributable to better communication of buyers' needs to production-level managers. This potential is slightly more important for livestock production than for crops.

Management Techniques Group

The technologies in this group are expected to be neutral in impact on vertical coordination and control, again mostly due to individual managers' decisions on adoption and use. Also, this technology group primarily reflects production decisions that are more likely to change quantity of output rather than quality of output.

Market Access

Market access as a structural element of agricultural marketing channels refers to the ability of sellers or potential sellers to gain access to buyers or potential buyers. The extent to which producers have a number of alternative buyers or marketing arrangements for their commodities is the essence of market access. If alternatives are few, market access is low. Foreclosure to participation is not necessary for market access to be low, but it maybe one reason for lack of market access.

Biological Group

The biological group is expected to reduce market access slightly for livestock producers in the long run. This impact is expected because the biological technologies will allow targeting of certain product characteristics to specialized end-use markets, narrowing the range of alternatives for producers adopting the technology. Thus foreclosure to other market segments is one impact expected from the technology.

The impact of the biological group on market access for crop production is expected to be neutral. Even though some potential for market segmentation by end-use characteristics is possible from this technology group, no significant change is expected.

With today's technology of production, there are a number of possibilities for producing specialized crops or for sorting commodities for particular end-use markets. One example is sorting and grading soybeans on the basis of oil yield. For storable commodities, especially, the sorting may well occur after production rather than through exercising process control during production. To the extent this happens, the technology group would have a negligible impact on market access over time.

Mechanical Group

Mechanical group technologies are not expected to have any significant long-term impact for either crop or livestock production. The technologies in this group are viewed as neutral on market access for reasons similar to those for vertical coordination and control.

Information Group

Some differences are expected between plant and animal agriculture from information group technologies. The direction of impact from this technology group is the same for both areas—to increase market access. The magnitude, however, is expected to be relatively more for crop producers.

This technology group encompasses increased information available to managers for both production decisions and marketing decisions. The marketing information component is expected to be important to all farm managers, but relatively more important to crop producers. As marketing information increases among buyers and sellers, improvement in market access is expected. If market information is asymmetrically held by buyers and sellers, the technology should result in more equality among buyers and sellers. The potential significance of this improvement is expected to be slightly greater for crops than for livestock.

Management Techniques Group

No significant change in market access is expected as a result of the technologies within the management techniques group for crops. Again, reasons are similar to those provided under vertical coordination and control.

Barriers to Entry

A variety of barriers restrict the ability of new firms to enter an industry. For example, use of specialized capital-intensive and managerially sophisticated technologies for production within an industry can represent a barrier to new entrants in the long run. Unequal access to information or significant amounts of proprietary information within an industry are also conventionally regarded as discouraging to new entrants.

Biological Group

No significant impact on barriers to entry is expected from the biological technology group for either crop or livestock production. This technology group may increase the level of so-

phistication and/or specialized knowledge necessary for production. However, the expertise necessary would be available to nearly all production units. This expertise is seen as being available through firms that specialize in providing the necessary expertise that may be required for successful adoption and use of the biological technologies. Thus, impact on barriers to entry was viewed as negligible.

Mechanical Group

The impact of mechanical technologies on barriers to entry in the long term is expected to be a slight increase for crop production but no significant increase for livestock production. This difference is attributable to the expected differences in the relative importance of mechanical technologies in the two areas.

Mechanical technologies for crops are viewed as relatively more important and capital-intensive per dollar of output than are mechanical technologies for livestock. The capital-intensive nature of this technology group for crops is expected to impose slightly increased barriers to entry in long-run production.

Information Group

Information group technologies have different impacts on barriers to entry for crop and animal production. This technology group is not expected to change barriers to entry significantly in crop production. However, slight-to-definite reductions in barriers to entry in livestock production are expected from information technologies.

This group holds the potential for significantly increasing the amount of information on markets available to livestock producers without entailing large increases in capital expenditures for adopting the technology. In addition, monitoring and control devices are expected to be relatively more cost-effective for livestock producers than for crop producers. This implies the potential for increased productivity with, perhaps, a lower quality of management. Both the production and marketing impacts from information technologies combine to encourage new entrants into livestock production—or reduce barriers to entry in the long run.

Management Techniques Group

Some portions of the management techniques group are expected to be capital-intensive. For example, land management strategies and multiple cropping are considered to be technologies that will require expanded capital expenditures for adoption. The potential to create an additional barrier to entry from this technology group stems from the capital-intensive nature of the technology. If multiple cropping or land management practices were the norm for crop producers, they would discourage new entrants into crop production in the long run.

RELATIVE ADOPTION RATES BY SIZE

The rate of adoption by size of firm for each technology group was addressed. Adoption rates were estimated for the year 2000, assuming that firms would adopt at least one of the technologies within the group in some significant way (table 6-4). Size categories used for farms were annual sales in 1984 dollars:

1. less than $20,000;
2. $20,000 to $99,999;
3. $100,000 to 499,999; and
4. $500,000 and over.

Relative adoption rates of biological technologies for both plant and animal agriculture are expected to be significantly higher by year 2000 than that for any of the other technologies. This is especially true in the smallest size category of farm. About 40 to 50 percent of the smallest crop production units are expected to adopt at least one technology, whereas 10 to 20 percent of the smallest animal production units are expected to adopt.

This perceived difference in adoption rates between crop and livestock producers is attributable to the form in which the technology will be available for adoption. Many biological technologies available to crop producers are expected to be embodied in seeds, fertilizers, or other in-

Table 6-4.—Percent Adoption Rate of at Least One Technology Within a Technology Group by Year 2000, by Size of Farm

Area and technology group	Adoption rate range (percent), by sales category (1984 constant dollars)			
	<$20,000	$20,000-$99,999	$100,000-$499,999	>$500,000
Animal:				
Biological	10-20	30-40	60-70	80-90
Mechanical	0-1o	10-20	40-50	70-80
Information	0-1o	10-20	55-65	80-90
Plant:				
Biological	40-50	60-70	85-90	90-100
Mechanical	0-1o	10-20	40-50	70-80
Information	0-1o	15-25	55-85	75-85
Management techniques	10-20	30-40	55-65	70-80

SOURCE: Off Ice of Technology Assessment.

put items that normally would be purchased by crop producers. Many crop producers are expected to adopt some simple techniques and information technologies as a normal practice. This accounts for the perception that these will be relatively more widely adopted.

Relative adoption by size is expected to be greatest for larger farms. Generally, 70 percent or more of the largest farms are expected to adopt some technologies from each technology group. This contrasts with only 40 percent for the second largest and about 10 percent for the smallest two categories. The economic advantages from the technologies are expected to accrue to early adopters, and a larger proportion of large farms are anticipated to be the early adopters.

Among the largest production units, biological technologies would be adopted by a relatively higher proportion of producers than would mechanical technologies. Adoption of mechanical technology entails more capital expenditures, whereas the biological technologies were anticipated to be available from a service company on a fee basis. Thus large and small firms may have these biological technologies more readily available to them.

RELATIVE EFFECTIVENESS OF POLICY IN ACHIEVING STRUCTURE

Policies Considered

The potential for achieving a particular distribution of farm size through various broad types of policy was assessed, Eight types of policy were defined regarding their potential use in changing relative size distributions of farms in the future: commodity, tax, credit, research and extension, trade, monetary, fiscal, environmental, and regulatory. The discussion focused on which of these policies might be most useful in achieving some public policy-determined farm structure distribution (number and size of firms). As before, a Delphi procedure was used to rank the relative effectiveness of each of the major policy categories. The relative effectiveness of these policy categories was then assessed by the panel (table 6-5).

Relative Effectiveness

Commodity policy and tax policy are expected to be most effective in achieving a particular size distribution in the future. That is, specific policies under these two broad types could be designed that would either significantly decrease or increase the trend toward fewer but larger production units.

Table 6-5.—Relative Effectiveness of Types of Policy In Attaining a Desired Specific Structure

Policy type by rank order, most to least effective
1. Commodity
2. Tax
3. Credit
4, Macro policy—monetary and fiscal
5. Regulatory
6. Trade
7. Research and extension
8. Environmental

SOURCE: **Off Ice of Technology Assessment.**

Credit and macroeconomic policy are also expected to be effective in changing structure. Environmental policy and policies involving research and extension are expected to be the least effective in changing the size distribution of production units.

Commodity policy is viewed as the single most effective policy category for achieving some predetermined level of size and number of farm firms. For example, if a commodity policy were put in place that had a $10,000 limit on payments, the effect would be to slow or stop the move toward larger farms. Similarly, adopting a commodity policy that has no payment limitation would encourage the trend toward larger size firms. Also, even though commodity policies primarily affect dairy and major crop producers, aspects of commodity policy could be designed to encourage participation. Such items include differential support rates by size of farm. Smaller firms would have higher support levels, thereby encouraging broader participation across all farm sizes.

Tax policy was considered the second most effective policy category for changing the number and size of farm firms to some desired level. The major items discussed were investment tax credits or other tax items that encourage capital to flow into or out of agriculture for tax shelter considerations. Treatment of capital gains, conversion of capital gains, and value-added taxes were considered to be critical items that could influence size distributions.

In the credit policies category, several specific items were considered to be a direct influence on the movement over time to larger size firms. They include interest rates, availability of credit for agricultural production, capital rationing, and subsidized credit.

STRUCTURAL IMPACT ON TECHNOLOGY

The majority of this analysis is directed toward technological impacts on structure. Another area considered by ASG is the potential causality of a particular farm structure on the direction and magnitude of development and adoption of technology. The notion is that structure and technology are simultaneously related through time. Not only will technology influence structure, but structure will influence technology. As a final item, the panel considered the potential relationship from structure to the various technology groups.

The assessment of structure on technology considered each previously defined technology group separately for both animal and plant agriculture. The question addressed by ASG is the direction and magnitude of impact that a bimodal farm structure would have on the development and adoption of the technology groups. The impact is relative to the structure that currently exists. The bimodal distribution assumed to exist for this portion of the assessment was a total of 1.1 million farms, 528,000 in an annual sales category of less than $20,000; 143,000 in a category between $20,000 and $99,999; 120,000 in a category between $100,000 and $499,999; and 309,000 in a category above $500,000. This bimodal distribution has 48 percent of all farms in the smallest category and 28 percent of all farms in the largest category. Thus these two categories account for 76 percent of all farms.

As before, the Delphi technique was employed to gain a consensus on the influence of structure. Overall, the influence of structure on the development and adoption of technology is substantial (table 6-6). A bimodal structure is viewed as having moderate or large increases on development and adoption for each of the technologies for both animals and plants. This is primarily because of the proportion of total farms

Table 6=6.—Potential Directional impact of Farm Structure on Development and Adoption of Technology Groups, by Animal and Plant

Area and technology group	Potential direction of impact induced by bimodal structure by year 2000
Animal:	
Biological group	Moderate increase
Mechanical group	Moderate to large increase
Information group	Moderate to large increase
Plant:	
Biological group	Moderate increase
Mechanical group	Moderate increase
Information group	Moderate to large increase
Management techniques	Large increase

SOURCE: Office of Technology Assessment.

in the largest size category (28 percent in the bimodal distribution compared with less than 2 percent actual in *1982).*

Large farmers have relatively greater adoption rates, and a significant proportion of large farms would also encourage development of various technologies beyond what would otherwise be developed. Differences among technology groups are slight. The greatest impact of structure on development and adoption is the management techniques group for crop producers. Larger crop farms would tend to adopt technologies such as multiple cropping, soil erosion, or tillage practices; or soil-water-plant management techniques considerably quicker than would smaller farms.

SUMMARY AND CONCLUSI0NS

All technology groups are expected to have considerable economic impact on farm structure by *2000,* Biological technologies will have a more important impact than that of the other technology groups. A historical perspective on mechanical technologies is that they have been vitally important in shaping the livestock and plant production structure that existed in *1984.* However, they are not expected to have as important an impact on future structure.

Captal and Labor

For animal production, both the information and mechanical groups are expected to increase capital moderately, with a slight decrease in capital induced by the biological group. Both biological and mechanical groups are expected to generate slight decreases in labor, with a slight increase from information technologies. No significant change is expected in relative capital and labor from the biological group. Moderate increases in capital intensity (the increase in the capital/labor ratio) are expected from both the mechanical and information groups.

For plant production, moderate increases in absolute capital are expected from both the mechanical and information groups, a slight increase from the management techniques group, and no significant change from the biological group. In terms of absolute labor and management, all but the biological group are expected to increase labor slightly to moderately. The only labor-decreasing technology is expected to be in the biological group. No significant change in the relative amounts of capital and labor are expected from the biological or management techniques groups. The mechanical and information groups are expected to induce a moderate increase in capital relative to labor. None of the technologies is expected to induce a decrease in the capital/labor ratio.

Comparison of the technology groups for plant and animal production reveals that, in general, the technologies are expected to be similar in terms of impact on capital and labor. Neither the biological nor management techniques groups are expected to induce any significant change in the capital/labor ratio for plant production. The biological group is not expected to change the capital/labor ratio, whereas all other techniques are expected to increase this ratio moderately in the long term.

Other Structural Elements

The potential direction of the marginal impact induced by the technology groups on vertical coordination and control, market access, and barriers to entry was also assessed. The biological group is expected to encourage closer vertical coordination (i.e., more contracting), with a slight reduction in market access as a consequence. This would subsequently encourage the trend toward fewer but larger farms.

In the opposite direction, the information group is expected actually to reduce barriers to entry and to increase market access without any significant change on vertical coordination or control at the producer/first handler level. The mechanical group is expected to be neutral on all structural elements analyzed.

Expected impactson these structural elements for plant production is similar to that expected for animal production. However, the impact of the biological group on crop agriculture is expected to be less than that on animal agriculture. Less impact on vertical coordination and market access is expected from biological technologies for crops. The management techniques group, a group unique to crops, is not expected to change vertical coordination or market access, but is expected to increase barriers to entry slightly to moderately in crop production in the long run.

The potential for regional shifts from technology was seen as most likely from the livestock biological technology group, particularly as it affects beef production. Biological technologies that increase the efficiency of beef cattle forage utilization may have an important regional dimension. The potential for increasing pasture conversion of beef cattle is likely to favor shifts in production away from the higher opportunity cost of agricultural lands in the Midwest to those in the South and West.

Relative Adoption Rates by Size

Relative adoption rates of biological technologies for both plant and animal agriculture are expected to be considerably higher by year 2000 than they are for any other technology group. This is especially true for small farms.

Relative adoption rates of all technology groups are expected to be greatest for larger farms. Generally, 70 percent or more of the largest farms are expected to adopt some technologies from each technology group. This contrasts with only 40 percent for the middle-size farm units and about *10* percent for the smallest farms. The economic advantages from the technologies are expected to accrue to early adopters; a large proportion of large farms are anticipated to be early adopters.

Policies Effective in Achieving a Structure

Commodity policy and tax policy are the two broad categories of policy that are expected to be most effective in achieving a particular size distribution of farms. Specific policies under these two policy categories could be designed either to enhance or to slow the historical trend toward fewer but larger production units.