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TECHNOLOGY, PUBLIC POLICY, AND THE CHANGING STRUCTURE OF AMERICAN AGRICULTURE*

Over the next 15 years, American farmers will be offered an extensive array of new biotechnologies and information technologies that could revolutionize animal and plant production. The adoption of these technologies will be critical for shoring up the United States' lagging ability to compete in the international marketplace. Indeed, 83 percent of the estimated 1.8 percent annual increase in agricultural production needed to meet world agricultural demand by year 2000 must come from increases in agricultural yields, yields that can only be possible through the development and adoption of emerging technologies.

Yet if current agricultural policies remain in force, this new biotechnology and information technology era will also generate marked changes in the structure of the agricultural sector and of the rural communities that support farming. Some of these changes are already evident: farming is becoming more centralized, more vertically integrated. Large farms, though small in number, now produce most of this country's agricultural output. Operators of small and moderate-size farms, the so-called backbone of American agriculture, are becoming increasingly less able to compete, partly because they lack access to the information and finances necessary for adopting the new technologies effectively. Many such farmers must relocate, change to other kinds of farming, or give up farming altogether. The disappearance of these farm operations is causing repercussions for other businesses in the rural community and for the labor pool in general, which must absorb all those whose livelihood once depended on agricultural production.

Emerging Technologies and the Future Structure of Agriculture

New technologies have historically had significant impacts on structural change. New disease control technologies 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 will make a considerable impact on farm structure, especially by 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 require less capital; information technology will require more.

The new technologies will allow increased control over end-product characteristics, for example less fat per unit of lean in meat animals or a specific color characteristic in corn. This implies that increased homogeneity within an agricultural product may result and that there will be a growing number of end products with engineered characteristics. This would require less sorting or grading to achieve increased homogeneity and a shift toward having more control over the production process so as to achieve homogeneity during production.

An anticipated economic consequence of this increased control over production is an increase in the practice of contracting. Contracting allows husbandry and cultural practices to be monitored and controlled closely during the production process. This greater process control leads to uniform product differentiation.

Biotechnologies will have relatively more important effects on resource concentration than will other technological developments. Even though mechanical technologies will continue to be important, they are not expected to have as important an impact on future structure. In particular, biotechnologies are expected to encourage closer coordination and greater process control in livestock production, permitting more contract livestock production. One example is the potential from these technologies for modifying milk at the farm rather than at the processing plant. This technology holds promise for producing more highly unsaturated fats in milk. If adopted, it would entail close coordination at the producer/first-handler markets and additional process control at the production level.

The biological technologies will encourage coordination in crop production as well. However, the magnitude of change in this area is expected to be relatively less for crops than livestock. Part of the reason is that biotechnologies for livestock production are further

*Excerpted from: Technology, Public Policy, and The Changing Structure of American Agriculture-Summary; Office of Technology Assessment

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advanced. The biotechnology era is expected to encourage closer vertical coordination, with a slight reduction in market access as a consequence. This situation would subsequently lead to fewer but larger farms.

The information technologies are expected to reduce barriers to entry and to increase market access without any significant change in vertical coordination or control at the producer/first-handler level--especially for crop agriculture. Information technologies hold the potential for significantly increasing the amount of information across markets. This impact would be attributable to improved communication of buyers' needs to production-level managers, which should result in more equality between buyers and sellers.

The largest farms are expected to adopt the greatest amount of the new technologies. Generally, 70 percent or more of the largest farms are expected to adopt some of the biotechnologies and information technologies. This contrasts with only 40 percent for moderate-size farms and about 10 percent for the small farms. The economic advantages from the technologies are expected to accrue to early adopters, a large proportion of which will probably be operators of large farms.

Impacts of Agricultural Finance and Credit

The severe financial stress of a large proportion of farmers and the recent regulatory and competitive changes in financial markets have combined to change significantly the financial framework of farming. **The farm of the future will be treated financially like any other business--it will have to demonstrate profitability before a bank will finance its operation.** Managing a farm efficiently and profitably, which will necessitate keeping up-to-date technologically, will be the key to access to credit.

The cost of credit, however, will be higher and more volatile. Interest on loans may be variable rather than fixed. **Moreover, given the concentration in the banking industry, decisions about extending credit more likely will be made at large, centralized banking headquarters far removed from a loan applicant's farm.** Loan decisions will thus be less influenced by the considerations of neighborly good will that frequently shaded decisions of local farm banks.

Congress will have to consider all these factors because the availability of capital will continue to be an important factor in agricultural production in general and in the adoption of agricultural technologies in particular. Readily available capital at reasonable rates and terms, plus technologies that aid profitability, provide a favorable environment for technology adoption. **Emerging technologies, for the most part, will pass the test for economic feasibility.**

The financing consequences of new technologies in agricultural production will probably depend on the relationships between three important factors: 1) the financing characteristics of the new technologies, 2) the creditworthiness of individual borrowers, and 3) the changing forces in financial markets that affect the cost and availability of financial capital. The financing characteristics suggest that most of the new technologies should be financed largely with short- and intermediate-term loans that are part of the normal financing procedures for agricultural businesses. **However, the technical characteristics of the technologies, together with the factors constituting the creditworthiness of individual borrowers, suggest that increased emphasis in credit evaluations will be placed on the farmers' management capacity, on their ability to demonstrate appropriate technical competence in using the new technologies, and on building human capital, where appropriate.** In some cases--particularly for Farmers Home Administration borrowers--significant investments in human capital, with related financing requirements, may accompany new technology adoption. This is consistent with the more conservative responses by lenders to the agricultural stress conditions of the early 1980s. Lending institutions themselves, in turn, must have sufficient technical knowledge and expertise to evaluate these management and credit factors along with other sources of business and financial risks in agriculture. Finally, some forms of new technology involving large investments and having long-run uncertain returns will probably rely more on equity capital for financing.

The changing regulatory and competitive forces in financial markets, including the preference for greater privatization of some credit institutions, means that the cost of borrowing for agricultural producers will likely remain higher and more volatile than before 1980 times and will follow market interest rates much more closely. Similarly, the continued geographic liberalization of banking and the emergence of more complex financial systems mean that the functions of marketing financial services, loan servicing, and credit decisions will become more distinct, with an increasing proportion of credit control and loan authority occurring subregionally and with regional money centers being located away from the rural areas. This will continue to fragment and dichotomize the farm-credit market so that commercial-scale agricultural borrowers will be treated as part of a financial institution's commercial lending activities and small, part-time farmers will be treated as part of consumer lending programs.

The competitive pressures on financial institutions and the risks involved will bring more emphasis on analyzing the profitability of various banking functions, including loan performance at the department level and individual customer level. Innovative lenders will strive more vigorously to differentiate their loan products and financial services, especially for more profitable borrowers, and will tailor financing programs more precisely to the specific needs of creditworthy borrowers. In turn, however, to compete for credit services these agricultural borrowers must be highly skilled in the technical aspects of agricultural production and marketing as well as in financial accounting, financial management, and risk analysis.

In general, most forms of new technology in agricultural production should meet the tests of both economic and financial feasibility, although the structural characteristics of the adopting farm units will continue to evolve in response to managerial, economic, and market factors. The structural consequences of these factors are severalfold:

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1. a continuing push toward larger commercial-scale farm businesses, with greater skills in all aspects of business management;

2. continuing evolution in the methods of entry into agriculture by young or new farmers, with greater emphasis on management skills and resource control and less emphasis on land ownership;

3. the continuing development of a marketing systems approach toward financing agriculture, with more sophisticated skills in marketing analysis by farmers and higher degrees of coordination with commodity and resource markets;

4. more formal management of financial leverage and credit by farmers, with greater diversity of funding sources by farmers and better developed markets for obtaining outside equity capital;

5. further development in financial leasing and greater stability in leasing arrangements for real estate and other assets; and

6. more complex business arrangements in production agriculture that accommodate various ways to package effectively debt and equity financing, leasing, management, accounting, and legal services for the future farm business.

Emerging Technologies, Policy, and Survival of Various Size Farms

The size and, therefore, the survival of farms is affected by several factors. Clearly, there are economies of size in many commodity areas covered by farm policy. **These economies motivate further concentration of resources.** In addition, present farm policy, more than any other policy tool, makes major impacts on farm size and survival. Although very large farms can survive without these programs, moderate-size farms depend on them for their survival.

This study finds that substantial economies of size exist for several major commodities. The commodities include dairy, corn, cotton, wheat, and soybeans. With the exception of corn, economies of size do not exist uniformly in all the production areas studied for these commodities. It should be noted that the analysis considered only technical economies of size. If it had also included pecuniary economies, additional production areas would have been found to have economies of size.

All of the commodity areas except rice will experience substantial gains in yield *as well as* significant economies of size. (No economies of size were found for rice.) Dairy, in particular, leads all commodities in economies of size and production increases from new technologies. These forces will combine to shift over time the comparative advantage in dairy production from the smaller dairies in the Great Lake states and Northeast to the larger dairies in the Southwest and West.

Overall, the combination of future yield increases from new technology and current economies of size in these commodities means that there will be substantial incentives for farms to grow in size. These powerful forces will continue, and may even speed up resource concentration in U.S. agriculture.

This study finds that farm programs, which include Commodity Credit Corporation (CCC) purchases and price and income supports, have major impacts on rates of growth in farm size, wealth, and incomes of commercial farmers. **Large farms increase their net worth significantly more than moderate-size farms under current farm programs and large farms account for a significantly large share of farm program payments.** In particular, price supports provide most of the wealth and growth benefits to large farms.

Removing farm programs reduces the probability of survival more for moderate-size farms than for large farms. **OTA's analyses find that large farms can survive and prosper without farm programs.** And, because these farms account for the vast majority of farm program benefits, significant savings in government expenditures could be realized if large farms were ineligible to receive program payments.

On the other hand, this study finds that moderate farms need farm programs to survive and be successful. Income supports, in particular, provide significant benefits to moderate farms, and the targeting of income supports to moderate farms is an effective policy tool for prolonging these farms' survival.

Those changes in tax policy that would be more restrictive have little impact on farm survival. Increasing the federal tax burden on farmers reduces the average annual rate of growth in farm size uniformly for all farm sizes.

Currently the financial position of many farmers is under severe stress. The situation is serious and may not improve for some time. Two alternatives most discussed by policymakers are interest subsidy and debt restructuring programs. **OTA finds that restructuring debt for highly leveraged farms does not appreciably increase their probability for survival.** The interest rate subsidy substantially increases average net income more than debt restructuring. It is the more effective strategy to ease financial stress. In addition, large farms with high debts are not as dependent on these financial programs for survival as moderate farms are.

Impacts on Rural Communities

The impacts of technological and structural change in agriculture do not end with the individuals who live and work on farms. **A variety of additional consequences are expected at the level of *rural communities*, consequences that directly or indirectly affect farms and farmers.** As with individual farmers, some communities are likely to benefit from change, while others are likely to be affected adversely. Much depends on the type of overall labor force in the community and on the opportunities for labor to move to other employment areas.

Hard-hit communities may need technical assistance to attract new businesses to their areas, to develop labor retraining programs, and to alter community infrastructure to attract new inhabitants. To accomplish these goals, federal policy will have to be complemented by regional and local policies.

Those rural communities that benefit from changes in agricultural technology and structure may do so in several ways. For example, as agriculture becomes more concentrated, some communities will emerge as areawide centers for the provision of new, high-value technical services and products. Likewise, some communities will

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emerge as centers for high-volume food packaging, processing, and distribution. In both cases, the economic base of these communities is likely to expand. However, unless total demand for agricultural commodities increases substantially, centralization of services, marketing, and processing will be like a zero-sum game in many areas. The market centers will benefit at the expense of other communities. Many of the communities that are bypassed will decline as a result of the process of centralization.

Communities also may benefit in those parts of the country in which the number of small and part-time farms is increasing. This phenomenon results in an increase in population in many rural areas and an increase in total income and spending in some of these areas. The increase in small farms may sustain additional retail establishments than would otherwise be the case, since purchases by small farmers may tend to be more from local sources than those by larger farmers. The operators of these farms in many cases subsidize their own production from off-farm income.

Impacts on Technology and Environmental Resource Adjustment

One of the major reasons that American agriculture has been so productive is because technological change has been fostered by the public sector and nurtured by a

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MEASURING NEBRASKA BUSINESS

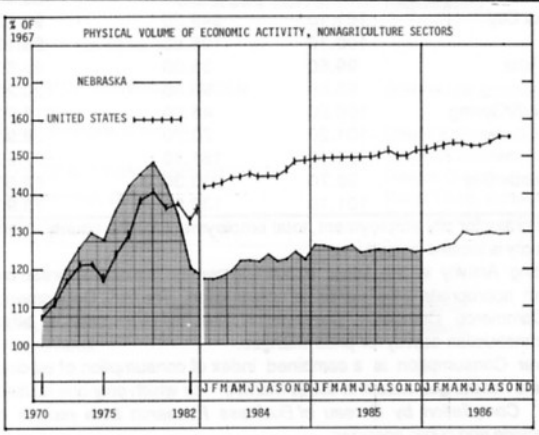
ECONOMIC INDICATORS: NEBRASKA AND UNITED STATES

1. CHANGE FROM PREVIOUS YEAR

October 1986	Current Month as Percent of Same Month Previous Year		1986 to Date as Percent of 1985 to Date	
Indicator	Nebraska	U.S.	Nebraska	U.S.
Dollar Volume	na	na	na	na
Agricultural	na	na	na	na
Nonagricultural	105.10	104.30	104.20	104.40
Construction	85.00	103.30	97.10	106.30
Manufacturing	100.70	96.90	97.50	96.50
Distributive	107.10	106.30	105.30	106.50
Government	108.00	106.50	107.20	106.40
Physical Volume	na	na	na	na
Agricultural	na	na	na	na
Nonagricultural	103.40	102.20	101.80	102.50
Construction	82.70	100.50	94.40	103.40
Manufacturing	102.60	99.30	99.20	98.50
Distributive	105.40	104.70	103.20	104.40
Government	101.50	100.00	102.40	101.60

2. CHANGE FROM 1967

Indicator	Percentage of 1967 Average Nebraska	U.S.
Dollar Volume	na	na
Agricultural	na	na
Nonagricultural	393.10	482.10
Construction	234.20	514.60
Manufacturing	366.00	307.80
Distributive	410.30	573.70
Government	439.60	493.00
Physical Volume	na	na
Agricultural	na	na
Nonagricultural	129.40	154.10
Construction	63.30	139.10
Manufacturing	150.60	123.60
Distributive	124.20	173.60
Government	155.50	149.60



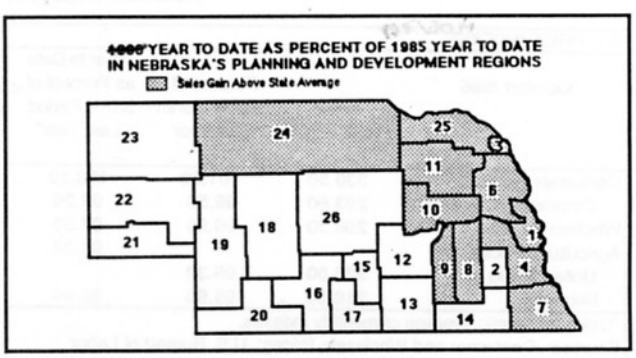
3. NET TAXABLE RETAIL SALES OF NEBRASKA REGIONS AND CITIES

Region Number and City*	City Sales**	Sales in Region**	
	October 1986 as percent of October 1985	October 1986 as percent of October 1985	1986 to Date as percent of 1985 to Date
The State	108.40	111.10	107.50
1 Omaha	110.10	111.70	109.30
Bellevue	105.90		
Blair	99.40		
2 Lincoln	110.20	111.60	107.30
3 South Sioux City	130.40	113.30	109.70
4 Nebraska City	102.00	112.50	109.60
6 Fremont	104.90	113.50	110.10
West Point	114.10		
7 Falls City	103.00	116.00	109.00
8 Seward	120.00	118.10	113.10
9 York	99.60	109.90	111.00
10 Columbus	103.20	117.10	108.60
11 Norfolk	114.00	120.00	111.30
Wayne	120.60		
12 Grand Island	104.90	107.30	105.30
13 Hastings	116.10	115.30	106.90
14 Beatrice	112.20	110.30	107.00
Fairbury	92.00		
15 Kearney	107.10	108.40	107.30
16 Lexington	113.20	109.40	101.80
17 Holdrege	102.60	109.00	104.40
18 North Platte	102.70	104.60	106.50
19 Ogallala	101.60	104.50	102.30
20 McCook	101.10	103.50	101.10
21 Sidney	98.50	91.20	92.60
Kimball	74.20	99.60	104.10
22 Scottsbluff/Gering	104.30	103.50	102.60
23 Alliance	93.40	99.60	104.10
Chadron	112.80		
24 O'Neill	123.60	125.20	115.20
25 Hartington	121.90	125.20	115.20
26 Broken Bow	108.70	112.50	105.00

* See region map below.

** Sales on which sales taxes are collected by retailers located in the state. Region totals include motor vehicle sales; city totals exclude motor vehicle sales.

Compiled from data provided by Nebraska Department of Revenue



profit-seeking private sector. As a result, American consumers have enjoyed a plentiful supply of low-cost food and natural fiber. In addition, agricultural exports have made a major contribution to the overall development of export markets, to the benefit of the general economy. Biotechnology and information technology promise to offer more of the same, with the added bonus of less chemicals used in the production of food--whether for the control of pests, disease, and weeds, or for the production of commercial fertilizer.

Maintaining the productivity and competitiveness of U.S. agriculture in the public interest requires a balance between public and private sector support for technological change. Yet it would be wrong to imply that there are no risks. The conferring of property rights on discoveries of the agricultural research system has shifted the agricultural research balance between the public and private sectors toward the private sector. While the effects of this shift appear to be positive, concerns exist that a substantial portion of the benefits of even public research could be captured by private firm interests. Distribution of these benefits may be so unequally distributed that competitive performance is impaired. In addition, no scientifically acceptable methodology exists for weighing the risks or hazards of biotechnology research. To deal with such issues, the following policy suggestions are made:

* Steps should be taken to secure the public interest on which the USDA and land-grant university agricultural research system has been based. Assurance must be provided that the benefits of publicly supported research and extension are not captured in the form of excess profits by the private sector based on research property rights and increased private sector funding of public research. The effect would be to stifle the process of discovery and the dissemination of new knowledge.

* Major investments must be made to foster the development of human capital that is in a position to cope with the process of rapidly changing agricultural technology. This need extends from the training and development of the most basic biological research scientists, through the extension specialist and county agent, to the farmer who adopts the new technology and the banker who supplies the loan for its purchase.

IMPLICATIONS AND POLICY OPTIONS

The Issue of Farm Structure

This study indicates that the process of structural change in agriculture has already begun. Based on a continuation of current policies, past trends, and future technological expectations, the net result of this structural change could be the development of a farm structure composed of three agricultural classes:

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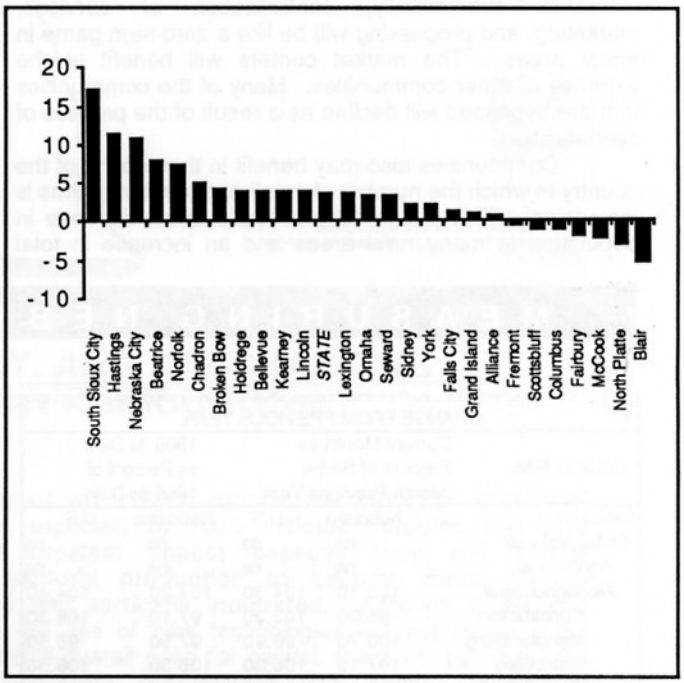
5. PRICE INDEXES

October 1986	Index (1967 = 100)	Percent of Same Month Last Year	Year to Date as Percent of Same Period Last Year*
Consumer Prices	330.50	101.50	102.10
Commodity Componen	283.60	98.50	99.20
Wholesale Prices	298.30	96.90	97.30
Agricultural Prices			95.30
United States	226.00	98.30	
Nebraska	218.00	95.60	95.60

*Using arithmetic average of monthly indexes.
Sources: Consumer and Wholesale Prices: U.S. Bureau of Labor Statistics; Agricultural Prices: U.S. Department of Agriculture

City Business Index
Percent Change October 1985 to October 1986



4. October 1986 CITY BUSINESS INDICATORS

The State and Its Trading Centers	Employment (1)	Building Activity (2)	Power Consumption (3)
The State	99.30	90.30	101.10
Alliance	96.80	258.40	78.50
Beatrice	100.80	136.50	104.40
Bellevue	96.80	153.60	107.70
Blair	96.80	39.00	99.80
Broken Bow	101.00	88.50	90.40
Chadron	97.80	92.80	75.90
Columbus	101.20	45.30	101.50
Fairbury	99.70	119.80	98.00
Falls City	101.20	81.40	96.70
Fremont	100.30	48.30	98.70
Grand Island	101.70	57.60	88.20
Hastings	101.20	197.20	51.40
Holdrege	100.90	146.50	92.00
Kearney	100.50	96.70	92.40
Lexington	99.80	54.00	79.40
Lincoln	97.80	91.40	106.90
McCook	101.40	42.80	85.80
Nebraska City	101.10	649.20	90.20
Norfolk	100.10	106.90	89.10
North Platte	99.60	36.30	83.60
Omaha	96.80	93.30	120.20
Scottsbluff/Gering	100.20	46.00	116.00
Seward	101.20	23.70	108.90
Sidney	100.10	161.10	87.60
South Sioux City	98.70	213.30	88.00
York	101.10	132.50	73.90

(1) As a proxy for city employment, total employment for the county in which a city is located is used.
(2) Building Activity is the value of building permits issued as spread over an appropriate time period of construction. The U.S. Department of Commerce Composite Construction Cost Index is used to adjust construction activity for price changes.
(3) Power Consumption is a combined index of consumption of electricity and natural gas except in cases marked * for which only one is used.
Source: Compilation by Bureau of Business Research from reports of private and public agencies.

1. The ***large-scale farm segment*** would be composed of a relatively small number of farms that produce the bulk of U.S. production. By year 2000 there could be as few as 50,000 large-scale farms producing as much as three-fourths of the agricultural production. This large-scale farm segment would be highly efficient in the performance of production, marketing, financial, and business management functions. Such farms would be run by full-time, highly educated business managers. Barring unforeseen acts of nature, farm operators would be able to predict their chances of making a proft before planting or breeding.

2. The struggling ***moderate-size farm segment*** would be trying to find a niche in the market and survive in an industrialized agricultural setting. The potential for the moderate farm finding that niche is rapidly becoming the center of the farm policy debate. Traditionally highly productive, efficient, moderate-size, full-time farms have been the backbone of American agriculture. It is still true that a moderate, technologically up-to-date, and well-managed farm with good yields is highly resilient. One key to the success of these farms clearly lies in the management factor. But more often than not, management has to be willing to accept a relatively low return on invested capital, time, and effort. With ever-increasing education requirements associated with farming, there will likely be less willingness by successful managers of moderate farms to accept a lower return for their services and for invested capital. Another key to the survival of moderate farms lies in access to state-of-the-art technologies at competitive prices. Cooperatives traditionally have performed that role. But cooperatives by and large are not conducting or funding basic or applied research in biotechnology and information technology. Also, like their predominantly moderate-size farmer members, cooperatives, too, have encountered financial difficulty.

3. The ***small, predominantly part-time farm segment*** tends to obtain most of its net income from off-farm sources. However, this segment is highly diverse. It includes wealthy urban investors and professionals who use agriculture primarily as a tax shelter and/or country home. It also includes would-be moderate farm operators who are attempting to use off-farm income as a means of entering agriculture on a full-time basis. Finally, this segment includes a number of poor, essentially subsistence, farmers who are vestiges of the war on poverty in the 1960s. Such farmers remain a significant social concern that must be dealt with from a policy perspective, although traditional farm price and income policy hold no hope for solving their problems.

Contemporary farm programs have fostered this trend toward three farm-size classes. Payments to farmers on a per-unit-of-production basis concentrate most of the benefits in large farms that produce most of the output. Large farms have been in the best position to take advantage of new technologies arising out of the public sector agricultural research system.

Without substantial changes in the nature and objectives of farm policy, the three classes of farms will soon become two--the moderate-size farm will largely be eliminated as a viable force in American agriculture. In addition, the problems of the small subsistence farm will continue to fester as an unaddressed social concern.

SUMMARY CONCLUSION

The biotechnology and information technology revolution in agricultural production has the potential for creating a larger, safer, less expensive, more stable, and more nutritious food supply. Yet it will exact substantial costs in potential adjustment problems in the agricultural sector and in rural communities. Those costs can be minimized by careful analysis, planning, and implementation. This study is only the first step in that direction.

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