

Structural Change in the U.S. Agriculture

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Five major driving forces shaping the U.S. agricultural structure are discussed separately. Specifically, technological innovation, trade, and rural development play the central roles in dictating the current structure of agriculture. Changes in composition of choice of labor force activities, such as farm size and number, choice of labor force activities, sources of farm labor, distribution of income/output, land control and ownership, environmental quality, and types of commodities grown, are explicated. Other important issues related to structural change, such as investment in human capital and uncertainty, risk management, and information systems, are also discussed in this paper.

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Recently, structural changes in agriculture have received considerable attention in the United States. The principal concern has been with declining farm numbers, the bimodal distribution of large and small farms, concentration of production on large farms, and the increasing number of part-time farmers.

Factors affecting farm structural changes include technological innovation, government policies, the credit lending system, international markets and floating exchange rates, rural development, and so on. The composition of the agricultural structure can be characterized by farm size and numbers, choice of labor force activities, sources of farm labor, income and output distributions, land ownership and control, environmental quality, and commodity mix. In particular, research efforts have been devoted intensively to changes in farm size and number.

The purpose of this paper is to examine the causes of structural changes in the U.S. agricultural sector, to review the change in each composition of its agricultural structure, and to discuss future research needs in this issue. While Taiwan looking for mechanization and modernization in the agricultural sector, the past U.S. experience might offer some insight into the future structural change in Taiwan's agriculture.

The paper proceeds as follows. First, five major forces shaping the U.S. agricultural structure are discussed. Although the impacts of these five forces are interwoven, they are discussed separately for explanatory purposes. Secondly, changes in the composition of the U.S. agricultural structure are explicated. Thirdly, other important issues related to structural change are discussed. Finally, conclusions are presented in the last section.

I. Causes of Structural Changes

Five major driving forces of structural changes in the U.S. agricultural sector are discussed below. They include technological innovation, government policies, credit and lending system, international trade, and rural development. These five major structural factors will be analyzed in this paper to determine their actual roles in the structural change process.

Although more than half the number of farms were lost during the past four decades, there is a consensus that declines in farm numbers will be more modest in the future and the

nature of structural change will be different (Stanton, Tweeten, 1991). In particular, biotechnology, rural development, and trade liberalization will be of increasing importance in dictating the future structure of agriculture.

1. Technological Innovation

Technological change is one of the important forces which alter the agricultural structure; it has also resulted in important changes in rural America, such as increases in farm size and decreases in farm number. Skees and Swanson(1988) examined the impact of new technologies upon farm structure and found that labor-saving technologies had a substantive influence on the trend toward large-scale farms in the South between 1969 and 1978. Machinery has reduced the amount of labor necessary in many farming operations so that one worker can farm more land. Technological innovation thus provided an incentive for farm expansion.

Since agriculture is a relatively competitive industry, profit maximization induces farmers to adopt new technologies and to expand output to remain competitive. As a result, change towards labor saving and capital intensive technology has led to significant economies of size. Previous experience suggests that farmers gained more from adopting new technologies early. Farmers who did so at a latter stage were usually just trying to survive.

A central objective of the studies in structural change is the assessment of the economic and social impacts of new technological developments. New technology will change the production function and therefore the cost function. Estimating the production and cost functions, and their changes will allow us to measure technological change.

Recently, with consumers' growing concerns about food safety and environmental quality, biotechnological development has received increasing attention because of its potential impact on the entire agricultural industry. For instance, it would influence production costs and outputs, resource allocation, quality of inputs, location of production, environmental quality and externalities, food safety, and consumption patterns of consumers. Adoption of cost-reducing biotechnology will increase the ability to compete in the international markets. Study of impacts of new biotechnologies on the change in agricultural structure would provide

an extremely important area for future research. However, lack of reliable data in this area may be the main obstacle in addressing these problems empirically. In addition, emphasis should be placed on risk management, risk assessment for adopting new technology, and decision making under uncertainty/risk.

2. Government Policies

Government policies influence the development and adoption of new technologies in very important ways. When government policies provide incentives for the adoption of technologies, the procedure of adoption of new technologies will be sped up. For instance, price supports reduce risk and, thus, encourage investment in new technologies and farm growth. As price supports are bid into asset values, they cause asset values to be overpriced for new farmers. This then causes new farmers financial stress. Existing farmers use their current operations to finance purchases from exiting farmers. Thus, commodity programs have exacerbated the bimodal structural distribution by encouraging farmers with larger operations to expand and by providing profit margins suitable to maintain smaller part-time farms.

In addition to commodity programs, many macroeconomic policies also influence the agricultural structure. For instance, tax policies have encouraged farm overexpansion. Macroeconomic policies, such as monetary and fiscal policies, of the 1970s led to low real interest rates, high rates of inflation, and low value of the dollar. These factors and a growing export market also contributed to the farm expansion in the 1970s. Macroeconomic policies of the 1980s led to high real interest rates, lower inflation rates, and high value of the dollar. These factors led to a devaluation in land values as well as high debts and created financial problems for farmers in the 1980s.

3. Credit Lending System and Financial Stress

Credit lending systems can affect the structural changes in a different way. Overexpansion in credits in the 1970s and falling land prices in 1980s contributed to the financial crisis in the 1980s. The credit system was overly willing to provide credit, causing excessive expansion in capital and in farm output, and leading farmers to borrow excessive amounts in the

1970s. In other words, the credit lending agencies such as Farmers Home Administration (FHA) and the government policies contributed to farm size expansion in the 1970s and the financial crisis in the 1980s, although FHA also saved many farms from financial failure in the 1980s (Tweeten and Huffman; Tweeten, 1991).

Further studies of the impact of financial stress on changes in the farm sizes can contribute to an improved understanding of the change in agricultural structure.

4. International Trade

U.S. agricultural markets have experienced a tremendous change over the past three decades. International markets are increasingly important in influencing the rural agricultural economy in the United States. Agricultural markets are heavily influenced by world events that are difficult to anticipate. As a result, world markets provide a significant element of risk and uncertainty.

During the 1950s and early 1960s, rapid growth occurred in agricultural productivity, resulting in agricultural trade surpluses. With domestic markets growing very slowly, international markets provided expansion possibilities for farmers. Expectation of persistent high agricultural prices in the 1970s also contributed to the expansion in production and farm size.

Current trend is clearly toward free trade under the GATT (General Agreement on Tariffs and Trade). Trade liberalization implies U.S. agriculture will have to compete in world markets without the supports of many government programs, such as price support, quota, tariff, or export subsidies. Information is a key factor for success when facing such complicated markets.

International competition may force the U.S. agricultural industry to invest more in both physical capital and human capital to stay in a competitive position. This may further encourage farm sector industrialization. Meanwhile, since farmers face more risk and uncertainties, risk management will become more important for agribusiness firms as well as family farms.

In short, trade sped up the industrialization process in the agricultural sector over the past three decades. It will continue to affect the agricultural structure in a significant way.

Since the current trend is toward free trade, its effects on structural changes cannot be ignored in the coming years, especially, during a period of dramatic change in Eastern Europe and the Soviet Union. Free trade without government commodity programs would drive those less efficient farmers out of farm business. Research is needed to forecast the impacts of trade liberalization on structural change and the adjustment process of displaced farm families.

5. Rural Development and Off-Farm Income Opportunity

During the past fifty years, rural America has generally experienced a transition from dependence upon agriculture to reliance on manufacturing and other activities. While the importance of agriculture as a source of rural employment and income declined, rural development provided off-farm employment and income opportunities to complement the farming sector in the rural areas where farm resources are underemployed.

The Census of Agriculture of 1987 showed that small farms and rural residences accounted for 85 percent of all farms and farm families received most of their net family income from off-farm jobs (Tweeten, 1991). Due to the increasing significance of off-farm income to small farm families, policies for rural development are increasingly important. Rural development might be able to ensure the future of small farms.

Rural development influences farm structure in various ways, such as decreasing farm size, increasing farm land price, increasing farm family income, decreasing dependence on government payments, and decreasing financial risk. Studies also suggest that farmers who are more risk averse are more likely to take off-farm jobs. Farmers who live in a higher population growth rate region, in a larger and more diverse nonfarm sector, or close to metropolitan areas are also more likely to work off-farm. Empirical studies which test these hypotheses will provide us with a better understanding of changes induced by rural development.

For those farmers who have nearby off-farm job opportunities, taking off-farm jobs and decreasing labor intensive operations could increase the family income and maintain the farm business. On the other hand, for those farmers who do not have nearby nonfarm em-

ployment opportunities, expanding the farm business is the most practical way to increase farm income. "There are fewer alternative opportunities for the use of farmer's labor in farming counties, thus there are incentives for farmers to expand their farms to achieve fuller employment and higher income" (Carlin and Saupe, 1990). Thus, rural development further encouraged the bimodal structural distribution in the past two decades.

Unlike the traditional thought, recent research suggests that rural communities and farm structure are interdependent and that farm well-being depends on rural communities more now. However, there are few empirical studies that examine this two-way relationship between rural development and farm well-being. One reason might be the lack of reliable data. The other reason might be the difficulties of quantifying rural development as to its effects on structural change.

II. Composition of Agricultural Structure

Dimensions of agricultural structure include the number of farms, farm size, choice of labor force activities, farm labor, distributions of output and income, land control and ownership, environmental quality, types of commodities grown, and so on. Each composition will be discussed separately below. Often changes in agricultural structure feature declines in total farm numbers with increasing numbers of part-time farmers. The emphasis has been placed on the bimodal distribution of many small and few large farms.

A recent study by Tweeten (1991) shows that "the rate of decline in farm numbers has been slowing for some time in part because the pace of technological change has slackened and because small farms with full-time operators have nearly completed their adjustment out of agriculture". Stanton (1991) reaches a similar conclusion that the rapid decline in farm numbers that occurred between 1950 and 1969 could never happen again.

Regarding the types of business organization, census data show that sole proprietorship dominates both farm numbers and value of sales although its importance has declined over the past three decades. Meanwhile, corporations which are held by farm families are increasingly important. Percentage of total value of sales changes from 14.2 to 25.6 for corporations and from 67.8 to 56.3 for sole proprietors between 1969 and 1987. However, it only changes from 17.4 to 17.1 for partnership (Stanton, 1991).

1. Farm Sizes and Numbers

The trend toward a bimodal distribution of small and large farms has been the center of discussions in structural changes in agriculture. A few large farms account for most output, and small, mostly part-time, farms dominate farm numbers.

The root cause of this dual structural distribution has been with technological change and farm size expansion and their immediate consequences of labor displacement. Thus, some farmers expanded their farms and others sought off-farm income opportunities while reducing the scale of their operations.

Due to the growing divergence in local farm sectors, Census data need to be interpreted more carefully. For instance, Carlin and Saupe(1991) note that the small farms concentrate in the South whereas the large farms concentrate in the Western Corn Belt and Plains states.

The study of farm size has focused on economies of scale, optimal size, and its distributions. Markov chain models are used frequently to describe and project changes in the numbers and size distribution of agricultural firms. Many researchers have examined the causes of size changes in the agricultural sector. Discriminant analysis and logit analysis are often used in identifying the responsible factors. Farm sizes can be measured by acres or sales. Lack of comparable definitions of farm size has also created a problem for comparison. It needs a consistent definition of farm size, such as small, medium, or large, for comparisons among different studies.

2. Choice of Labor Force Activities: Full-Time, Part-Time, or Exit From Farming

With the adoption of labor-saving technologies and decline in employment opportunities in the agricultural sector, the availability of off-farm income opportunities, and the existence of financial stress, one major adjustment has been the reallocation of labor between farm and nonfarm labor market. As a result, the number of part-time farmers with off-farm income has been increasing rapidly.

The phenomenon of part-time farming is important to consider in discussing major policy issues in agriculture and rural development. Over time, most research has placed the emphasis on explaining why some farmers seek off-farm work while others do not. Huffman (1980) provided a theoretical model for farm labor supply decisions on full and part-time farms. Gould and Saupe (1989) and Huffman and Lange have further examined off-farm employment decisions.

However, special attention should be directed to empirical studies of the differences among part-time and full-time farm operations in production costs and efficiency, resource allocation, demand for inputs, investments in new equipment, and control over land.

Moreover, the issue of exit from farming has not been discussed until recently. Recent research, especially in the Economic Research Service of USDA, has centered on this issue. Yet, no theoretical model explains the decision on exit farming so far. Since the operators who left farming included a large number of retirees, there is also a need for studies in retirement decisions and in new entrants.

3. Farm Labor: Hired vs. Family Labor

Hired labor and family labor are two distinct components of agricultural labor markets. The transformation in agricultural labor markets, arising from adoption of labor-saving technologies and nonfarm labor policy, dramatically reduced the number of farm workers. Another factor was the rising value of human time, which has also continued to transform the labor market.

Due to the rapid change in technology, the accumulated farming experience is less valuable than formal education. As a result, the difference in productivity between hired labor and family labor is narrowed. Thus, hired labor is of increasing importance to agricultural production and is expected to compose more than half of farm labor force in the future (Stanton, 1991). Most hired workers are young male and work only seasonally for large farms which grow vegetables, fruits, and nuts. Foreign illegal workers may account for 10 to 15 percent of all hired farm labor (Barse and Schaub, 1991). Often they supply cheaper hired labor and are seen frequently in the common border between the United States and

Mexico. Thus, one critical issue in farm labor is the immigration policy.

Since few numbers of large farms account for most agricultural output, hiring cheaper and effective labor becomes a practice of survival for large farms in the process of industrialization. In addition to seasonal jobs, agribusiness firms also hire permanent workers. For large farms, increasing the productivity of those permanent hired labor through job training programs is essential for survival. In addition, providing information of local labor market conditions for both individuals and firms would also reduce the transition costs.

Further studies in the importance of hired labor for large farms is necessary for understanding the industrialization process of agricultural sectors. The effects of structural changes, either changes in sizes or changes in the choices of labor force activities, on the amount of hired labor need to be examined more closely in future research.

4. Net Income Distributions

Another major change in the agricultural structure is the change in the income source for farm families. From the trends in the increasing number of small part-time farmers, one observes that more and more farm families in the U.S. depend on nonfarm sources for supplementing farm income. What impacts exist of the alternative sources of income on the inequality of the distribution of total household income? Is the total income for part-time farm households more evenly distributed than for full-time farm households? Studies for full-time and part-time farm households in the comparing the income distribution and variables affecting it will help us in identifying the roots of inequality and will have important policy implications. For instance, if increasing off-farm income reduces the inequality of the income distribution, then rural development policies that are designed to increase the availability of rural nonfarm employment opportunities should be reinforced. As a result, farm families which desire to maintain their farming operation could benefit from the off-farm income opportunities. Education could also be significant for small part-time farmers as they use non-farm income to supplement their low farm income. Income inequality may be reduced if off-farm income could narrow the income gap between farm and non-farm families. Further studies in this area are needed.

In addition, there are few empirical studies examining the various income sources in determining the distribution of total income and changes in the income distribution. Gould and Saupe(1990) examined the various sources of income inequality for farm families among a panel of southwestern Wisconsin farm households between 1983 and 1987. They found an increase in farm-related income would increase the inequality of the distribution of household income, while an increase in off-farm income could reduce the income inequality.

The dual structural distribution of large and small farms and the increasing concentration of production on larger sized farms will also influence the income and wealth distribution. Research is needed to examine whether this trend results in increasing income inequality among farm families. If so, studies in the redistribution of income and wealth in the agricultural sector might be necessary.

5. Land Ownership and Control

Land is an important factor of agricultural production. Unlike other factors such as capital, labor, and management, land is an immobile resource and its opportunities are more restricted.

Studies of absentee ownership, concentration of ownership, and land tenure patterns can provide information about the effects of structural changes on farm lands. Farms which get larger need to acquire more farm land either by leasing or purchasing. On the other hand, farms which get smaller will have idle farm lands to rent out or for sale.

The 1987 Census of Agriculture showed that about half of all farmland is owned by retired farm operators or their spouses and farm families still control most farm real estate assets (Tweeten, 1991). Tweeten concludes that the current trend is toward partownership among commercial farmers and full-ownership among small farms. Further studies are needed in analyzing the effects of the farm land values and its changes on the size changes.

6. Environmental Quality

Environmental issues are receiving increased attention. Issues like soil conservation, water quality, and agricultural chemicals are central to many environmental and food safety

concerns. For instance, soil loss from erosion can decrease the productivity potential of cropland as well as intensify air and water pollution problems. Overuse of agricultural chemicals, such as toxic pesticides and chemical fertilizers, not only endangers the food safety but also induces more environmental damage.

However, there is only limited research examining the impact of a bimodal structural distribution on the environment and natural resources. Will the trend toward fewer but larger farms have unfavorable consequences of soil conservation? What are the impacts of land tenure pattern on soil conservation, chemical use, and water quality? Compared to owner/operators, are renters less likely to practice soil conservation methods or do they simply rent higher quality land with fewer conservation problems? Are full-time farmers better at protecting the natural resources than part-time farmers? Studies in these issues will provide us with a better understanding of changes in environmental management induced by structural change.

Further research is needed to determine if there are differences in soil conservation and agricultural chemical uses among different sizes of farms and different types of land ownership groups. These types of empirical analyses can offer some insight into land ownership impacts on environmental quality. The provided information could be useful for formulating more effective policies in reducing environmental damage. In addition, decision making models for managing the environment by employing the dynamic optimization techniques, such as optimal control and calculus of variations, will provide us a better understanding of changes in practices. Moreover, risk assessment of new biotechnology such as the extent and likelihood of potential damage to the environment would also be an important contribution to the research of this area.

7. Commodity Mix

Among the composition of agricultural structure, commodity mix is expected to change most as free trade and removal of government-supported programs are expected in the future. In particular, those farmers who are heavily subsidized by government programs would be expected to exit or change their commodity mixes to survive. How to reduce the cost of the transition of those displaced farm families will be an important issue in the future.

According to the 1987 Census of Agriculture, large farms predominate in the production of fruits, vegetables, and horticultural crops and cattle. Medium and small family farms predominate in production of grains, hog, and dairy (Tweeten, 1991). Since government-supported crop, livestock, and livestock products are concentrated on small and medium size farms, the groups most likely to be hard hit by the free trade policy will be small and medium size farms. Educating those farmers who are heavily subsidized by government programs in changing their commodity mixes is one way to prevent future failures of those farmers. How technological change and future trade policy affect the commodity mix is a key issue.

III. Other Relevant Issues for Future Research

1. Human Capital and Management Skills

Investment in human capital can improve the skills and productivity of the labor force. It may take many forms, e.g., schooling, health care, and job training programs. The most important form of general human capital is investment in schooling (education). Meanwhile, on-the-job training is the most important source of acquiring specific human capital. On-the-job training can be provided by the hiring farms or land-grant universities through extension service programs. In short, different skills, different amounts of schooling, and different amounts of training will affect the labor quality. Nonetheless, return to education is expected to be higher than farm-specific human capital such as accumulated farming experience partly because the latter depreciates faster in the face of the rapid technological change.

As the trend is toward fewer large farms, improvement in the quality of hired labor will be critical for large farms to stay in a competitive position in both domestic markets and world markets. In addition, investments in human capital could make both full-time and part-time better off by improving the management skills and increasing farm sales, and raising off-farm income.

Empirical studies of the effects of investment in human capital on changes in productivity and management skills should be encouraged. If investment in human capital increases the productivity in either farm sectors or non-farm sectors, a further study is needed to exam-

ine whether it can mitigate net income inequality between full-time and part-time farmers, if income inequality exists. Sumner and Leiby(1987) studied the influence of human capital on size and growth among dairy farms between 1977 and 1982.

2. Uncertainty, Risk Management, and Information

The farmer's response to uncertainty and risky situations also helps explain how and why structure changes. Several types of uncertainties are important to the agricultural sector. Three types are discussed most often, i.e., price uncertainty, yield uncertainty, and technological uncertainty. While market and price uncertainty arises from fluctuations in weather and national economic conditions, weather, insects, diseases, and other biological pests may cause production and yield uncertainty. Other uncertainties may arise from fluctuations in interest rates, floating exchange rates and international markets, or imperfect information. One way to mitigate the price and yield uncertainties is to participate in the future markets, options, or crop insurance to obtain a form of price insurance or yield insurance.

Consequently, research on the formulation of price and yield expectations is important to the analysis of structural change. Studies of the value of information, such as weather or future prices, would also contribute to understanding of the adjustment process in that the information available to the farmer is often incorporated into the formulation of price or yield expectation. In a survey of Iowa farm household, Tweeten and Huffman(1980) found fewer sources of information and extension information were used by a smaller share of the small farmers than by larger farmers.

In summary, information is important for decision makers in reducing uncertainties and risks. Thus, gathering more information or improving information systems may be another way of risk management. Providing farmers with valuable information and educating them through extension service can also help farmers manage risk better. There is also a need for studies to examine the effects of those risk management strategies on structural change and to examine the differences in sources of farm business information by farm size or commodity mix to develop an efficient way in distributing information to different farmers. Simulation will be a useful tool for decision makers in the face of uncertainty and risk.

3. Adjustment Process and Consequence of Structural Changes

Since adjustment problems always exist, the minimization of adjustment costs should not be excluded from our discussions. Studies of changes in income distributions, productivity, assets, debts, sources of total household income, and the status of financial stress are important when discussing the adjustment process and the consequence of structural changes in agriculture.

Sonka(1980) discussed the impacts of fewer and larger farms on rural communities. The consequence of structural change he discussed included non-farm employment generation, farm land value changes, and rural developments. Study of consequence of structural change can help us achieve the desired agricultural structure.

4. Longitudinal Data Needs for Future Research

Data from the Census of Agriculture are aggregated to the county level and do not provide information on adjustments that individual farmer made. Thus, one limitation for future research is the lack of national and individual state farm-level panel data sets. Without such data sets, we are unable to draw inferences about farmers' responses to structural change and to make comparisons among states.

Stanton (1991) has a similar concern that it is difficult to project the size distributions and to analyze the problems of exit and entry without individual farm data. In considering agricultural structure issues, farm-level longitudinal data sets are critical in understanding adjustments and monitoring the changes in agricultural structure. However, national survey data may be less useful due to growing rural and farm diversity. Thus, each state may also need to develop its own survey to satisfy the specific needs of its state.

IV. Conclusions

The current structural changes in agriculture feature dual structural distribution, declines in farm numbers, and increased in the dependence on off-farm income for small part-time farmers. Five major driving forces shaping the agricultural structure are discussed in this paper. First, technological innovation is the most important force. Due to labor saving technology, farm sizes expanded and job opportunities were reduced in agriculture. Second, government policies like price supports reduced risk and thus encouraged expansion in production. Macroeconomic policies, such as low real interest rates and the depreciation of the U.S. dollar, also contributed to farm size expansions in the 1970s. Third, overexpansion in credits further encouraged farm expansions in the 1970s. This, and falling land prices in the 1980s, resulted in a financial crisis in the 1980s. In addition, international markets provided expansion possibilities and sped up the industrialization process. Finally, rural development has provided off-farm income opportunities to absorb the displaced farm labor, saved farmers from financial crisis, and enabled them to remain in agriculture. In combination, these five forces dictate the current structure of agriculture. Biotechnology, rural development, and trade liberalization will play particularly important roles in determining the future structure of agriculture.

The composition of agricultural structure includes several dimensions such as number of farms, farm size, choice of labor force activities, sources of farm labor, distribution of output/income, land control and ownership, environmental quality, commodity mix, etc. Each dimension needs to be analyzed in depth to better understand farm structural change. More attention should be directed to the issues of off-farm income, rural development, distributions of income, hired labor, new entrant to and exit from farming, land tenure patterns, and environmental quality.

As the agricultural sector is expected to confront more uncertainty and risk, providing farmers with valuable information and improving the quality of the available information systems would help them in reducing risk. In addition to adopting new technology, investment in human capital, especially high quality education, is also essential for increasing their adap-

live ability in the face of rapid technological advance.

Moreover, farm-level longitudinal data are needed to understand adjustments and to monitor changes in the agricultural structure for the purpose of future research. Comparable definitions for farm size and part-time farming also need to be clearly defined for the purpose of comparisons among studies. Modelling decision making processes under uncertainty or risk would help explain why and how structure changes as well. Thus, research on the formulation of price and yield expectations is also important to the analysis of structural change. Finally, in order to quantify the structural change, to identify the responsible factors for the change, and to test hypotheses, discrete-choice models, limited dependent variables, and longitudinal data analysis will be useful.

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