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Are American Farmers Better Off as a Result of Technology Gains?

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Commercial farmers remain a primary political force in support of publicly-supported research and educational programs to create productivity gains in crop and livestock production. Have the technical productivity gains brought about by both public and private sector research and educational efforts improved the well being of American farmers? A great number of agricultural scientists believe that they have. Studies have attempted to provide estimates of the internal rate of return and benefit/cost ratios for agricultural research and education. The vast majority of these studies estimate a quite favorable internal rate of return and a high productivity for public-sector agricultural research (Huffman and Just, p. 828). But these studies have focused on rates of return to agricultural research and education for society as a whole, without attempting to determine if these gains accrued to farmers, consumers, or perhaps the agribusiness firms who purchase raw farm commodities from farmers or sell them inputs.[1]

Research and educational activities that lower production costs and improve the productivity of crop and livestock production take place in both the private and public sectors. For public sector investments, much of the impetus for the development of the land grant university system from the 1862 Morrill act was related to the need for improved education designed to enhance the productivity of American agriculture–primarily by increasing the output per unit of labor employed, but also on making other factors of production (i.e. land) more productive as well. Khanna, Huffman and Sandler cite evidence to indicate that if output per unit of input employed is the measuring stick, these activities have indeed been enormously successful. They also provide information on how inflation-adjusted estimates of public expenditures on agricultural research vary by state (p. 272).

Antle and Wagenet indicate that "Government invests about 2.5 billion in agricultural research each year. In return, the public expects to see new science and technology that tangibly improves the quality of life. But the public also perceives that new science and technology often creates new problems and uncertainties that diminish the quality of life. These problems have led some to question the

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[1] For many years the US Bureau of the Census and the USDA have debated the issue of what constitutes a farm. It is not surprising that debate also exists with respect to what constitutes a "commercial" farm or a "family" farm. Think of these terms in the following way. There are two types of farms, those in which the operator and the family members supply most of the labor, called *family farms*, and larger than family-size units in which hired workers who are not family members provide most of the labor. Thus many commercial farms are larger than family-sized. However, for commercial family farms the majority of household income comes from the sale of crops and livestock, farm program payments, or other income directly related to farming. For small non-commercial farms, most of the household income comes from off-farm employment or other non-farming-related sources (a "rural lifestyle" farm), or the total income from agriculturally-related sources provides a standard of living at or below the poverty level in an ordinary production year (a "subsistence" farm).

value of using tax dollars to fund science for science's sake without considering the consequences (p. 1)."

Chennareddy and Jones suggest that "As the United States became more industrialized, an enormous demand for non-farm labor increased non-farm wage rates. The next turn of the sequence was that the scarcity of farm labor created the necessity for labor-saving and capital-intensive farm technology, and the rapid growth in farm technology contributed to further decline in the demand for labor." They argue that the three reasons for the decline in farm labor (and, ultimately, out-migration from farming-dependent rural regions) are (1) the industrialization of the *non*-farm sector that made high-wage urban employment increasingly attractive, (2) tremendous advances in labor-saving and output-enhancing technologies within agriculture, and (3) the price inelasticity of demand for farm products.

Any discussion of the sources and impacts of technological change in US production agriculture almost invariably leads to a discussion of the role that the public sector (primarily colleges of agriculture) has played in developing new farm-level production technologies and in providing educational assistance that ultimately encourages widespread adoption of productivity-enhancing and cost-reducing technologies. This concern rests on closely-held beliefs and values of many agricultural college faculty who believe that the many thousands of individual scientific and educational efforts directed toward increasing farm-level productivity have reaped enormous benefits not only to farmers, but also to consumers and the public at large both in the US and world-wide.

This perspective also has roots in what I have termed the "agrocentric" view of farming and rural economies.[2] Those who espouse the agrocentric viewpoint believe that within rural communities the sale of crops and livestock drives the rural non-farm economy, and, therefore, farming assumes a superior position in supporting other sectors of the rural-non-farm economy. Thus agrocentric faculty of colleges of agriculture would be interested in promoting the increased production and sales of crops and livestock over other feasible possibilities for raising incomes in rural areas, and would encourage increased local processing of farm-level production as a major means of boosting incomes of non-farm rural residents. Agrocentric faculty who believe that technological change in production agriculture boosts crop and livestock production are convinced that the development of new farm-level production technologies that increase output or lower production costs must therefore not only be beneficial to farmers but to rural economies as a whole.

Criticisms have not focused on the possibility that the consequences of widespread adoption of new farm-level production technologies may be different than widely believed, but rather on the possibility that colleges of agriculture are not as engaged as they should be in solving practical problems. A criticism sometimes levied is that college of agriculture faculty are not engaged with the real world and, as a result, devote too much of their energies to solving problems of little economic importance to farmers.[3] I believe that this criticism is unjust. The technical production scientists I have worked with over the years seem totally devoted to and consumed by the task of identifying workable ways that incremental productivity improvements can be achieved in either crop or livestock production. However, I am greatly concerned that many of these same scientists and educators

[2] The term *agrocentric* is derived from the word *ethnocentric*. The term *ethnocentric* is characterized by or based on the attitude that one's own group is superior. An agrocentric view places production agriculture in a superior position within the rural economy and thus largely responsible for driving incomes and employment in the rural non-farm sectors.

[3] Schuh leveled this lack-of-engagement (ivory-tower) criticism in a widely cited article in *Choices*. Beattie, in his presidential address to the members of the American Agricultural Economics Association, argues that colleges of agriculture have faced [allegations of lost focus and mission, of misplaced emphasis, of self serving professors rather than professors serving the needs of their students and society . . . "(p. 1319) but then defends the importance of basic research not immediately directed toward solving practical problems faced by farmers and rural societies.

within agricultural colleges seem only vaguely aware of the social and economic consequences of their successes in increasing agricultural productivity by creating and promoting output-enhancing technologies.

What is Technological Change in Agriculture?

What is technological change in agriculture? Much of what agricultural economists call technological change in production agriculture is embodied in the "state" or characteristics of capital inputs (i.e. the so-called "fixed" inputs such as machinery) employed within the production systems being used. The single most important long-term problem facing US agriculture has been low rates of return to labor employed in production agriculture, rates of return that are below those found in most other sectors of our economy. The story of agriculture in the US throughout the 20th century was one long adjustment process in which excess labor moves to (usually) higher-paying non-farm employment, and increased use of capital (a form of technological change) substitutes for labor. Technological change encompasses not only characteristics of "fixed" inputs, but is also embodied in the "state" of inputs normally treated as "variable" including seed genetics, herbicides, pesticides, fertilizers and the like.

Agricultural scientists sometimes like to think of technological change as including two separate but related economic concepts. New technology can be directed toward either increasing productivity of inputs such as land and labor or toward reducing production costs. An example of a productivity-increasing technological change might be a new piece of machinery that increased the amount of a crop that a single worker could produce annually—for example, a larger tractor or new tillage and harvesting equipment would increase the productivity of the farmer's labor so that the same amount of labor could produce more of a crop.

A technology such as this may not necessarily reduce total production costs on a per-unit basis especially if the equipment is expensive or interest rates are high. Furthermore, the purchase of such larger equipment may provide incentives to the farmer to attempt to find additional land to farm in an effort to spread the costs of the new equipment over a larger amount of output. In particular, technologies that increase the productivity of labor employed in agricultural production have been the driving force in farm expansion and the outflow of farm labor from production agriculture.

But new agricultural technologies can assume a very different form. Suppose a new herbicide is invented by a chemical company that is equally effective at controlling weeds in a crop, but is much less expensive for a chemical company to produce so that the herbicide can be sold to crop producers for one-half the previous cost. The farmer adopting the new pesticide immediately cuts the cost of herbicide in the crop budget by one-half, and believes that the savings that occur will as a result increase the profit from growing the crop by an equivalent amount.

Measuring Technological Change in Farm-Level Agricultural Production

One measure of technological change in agriculture is the USDA data series on farm level productivity. This index was at 0.506 in 1949, but stood at 1.198 in 1994, the last year for which data are currently available (Ball et al). This is a 236-percent increase in farm level productivity. According to Ball, for the same period, 1949–94, the index of prices received by farmers increased from 0.464 to 1.063, a very similar 239 percent rise. The cost of inputs employed in agricultural production rose much faster than either prices received or the technical productivity index, from 0.167 in 1949 to 1.179 in 1994, an increase of some 704 percent.

The increase in the cost of inputs employed in agricultural production probably reflects the fact that technological progress in agriculture almost invariably involves the increased use of inputs purchased off-farm–often from agribusiness firms as increasingly sophisticated capital inputs persistently substitute for labor. The numbers reflect the increased use of

chemical fertilizers, herbicides and pesticides, hybrid and often now genetically-engineered seeds, increased reliance on feed additives and artificial insemination, as well as greater expenditures for state-of-the-art livestock facilities and equipment necessary for efficient production systems. Interestingly, neither the physical output increases nor the prices of crops and livestock in the marketplace have kept pace with increases in input costs.

The Council of Economic Advisors Report (p. 218) suggests that farm-level productivity is increasing by about 2.1 percent annually. Based on $200 billion in annual sales of crops and livestock, this would result in a return to technological progress in farm-level agricultural production of about 4.2 billion dollars per year. In a 1986 study, Braha and Tweeten estimate that each dollar invested in agricultural research and extension produces about $10 in gross benefits or $5 in discounted benefits to society over time. Tweeten obtains an estimate of $21 billion in benefits to public- and private-sector research and education in agriculture ($4.2 billion times 5). He estimates the cost of public and private investments in infrastructure, education, and research and development at $11 billion, yielding a benefit-cost ratio for public and private agricultural research and education of just under 2.

Are Farmers Better Off from Technological Change in Production Agriculture?

In a recent paper, Harl et al. ask the question "Do farmers benefit from technology?" With but one exception their conclusion is that farmers do not benefit. They follow my argument that technologies are output-increasing (such as hybrid corn) or cost-decreasing (such as Roundup-Ready soybeans) or both. They argue that for an output-increasing technology, in the face of inelastic demand, the result is a disproportionate drop in price and in profitability except for early adopters who gain from the technology until adoption boosts aggregate output sufficiently to cause negative economic impacts for producers. They suggest that consumers benefit from increased food supplies and from lower food costs, but producers ultimately are worse off economically.

The exception to the general conclusion of Harl et al. that farmers do not benefit from technological progress is grounded in the adoption cycle. They admit that the relatively small number of farmers who are quickest to adopt a new technology will likely be able to reap some increased profits in the short run, even as commodity prices in the aggregate remain relatively unaffected because of low early-adoption rates. Quick adoption of new technologies by a small number of producers may have the intended effect of raising net incomes of the farmers who are among the first to adopt the technology in the short run.

Harl et al. also argue that the adoption of cost-reducing technologies that increase profit margins in the short run may have the undesired environmental consequence of increasing agricultural production at the margin. Reduced production costs mean that the crop in question becomes profitable on soils and in climates where the crop would have been unprofitable without the technology. In effect, cost-reducing technology extends production into new areas. Thus, output ultimately increases, again with a disproportionate drop in price and in profitability, and again only very early adopters benefit.

Thus land that under the old, higher-cost technology could not be used to profitably produce a commodity now becomes profitable. While this may appear to be desirable from the perspective of the individual farmer, it becomes undesirable from the perspective of production agriculture and perhaps even for society as a whole. As marginal crop land (land which under the old technologies was not suitable for crop production) is brought into production, additional output will be placed on the market, ceteris paribus, lowering world prices for the crop. Moreover, marginal lands tend to be environmentally fragile, increasing erosion from water and wind relative to what would have occurred had the cost-reducing technology not been developed. In adopting the new cost-reducing technology, the individual farmer may be better off in the short run, but in the long run the impacts are

similar to what would have occurred with any other type of new technology.

In a recent paper, Tweeten also addresses the issue of whether farmers in the aggregate benefit from technological progress. In contrast with Harl et al., he concludes that farmers have indeed made real gains from technology adoption over time. Tweeten's conclusion is based on a comparison of changes in the multifactor productivity index (defined as the ratio of the aggregate output of crops and livestock to the aggregate farm production input) to the parity ratio (the ratio of prices received by farmers for crops and livestock to the prices paid by farmers for inputs). He calculates that the parity ratio in 1999 was 36 percent of what it was in the 1910–14 average base year. But over the same time period the multifactor productivity increase 3.94 times its 1910–1914 level. He concludes that farmers have benefitted from new technology because output increased nearly four-fold while the parity price index decreased by less than three-fold (100/0.36 = 2.78). While continuing to suggest that the short-run (less than a few years time) aggregate demand is still inelastic, Tweeten further argues that these empirical calculations provide evidence to support the existence of an *elastic* long-run aggregate demand for agricultural commodities.

My own calculations employing a similar method but using slightly different data series for the time period 1949–1994 do not support Tweeten's conclusions drawn from data going back to the 1910–1914 parity ratio base year. As a measure of agricultural productivity I used the USDA index of farm productivity which is currently available for the period 1949–1994 (Ball et al.). This index stood at 0.4613 in 1949, but was 1.1919 in 1994 (1989 = 1.00). This suggests that the 1994 index is 258 percent of what it was in 1949. I then formed the ratio of the index series of prices of farm output to farm input prices (Ball, USDA). This ratio was 2.7732 in 1949 but only 0.90455 in 1994. In other words, the ratio of prices received to prices paid in 1994 was 32.53 percent (0.90455/2.7732) of its 1949 value. So the ratio of prices received to prices paid declined over three-fold, while the productivity index increased by slightly more than two-and-a-half times. These findings conflict with Tweeten's conclusions and support the argument that between 1949 and 1994 farmers have been harmed rather than helped as a result of technology-induced productivity gains. These findings provide empirical evidence against an elastic long-run aggregate demand for agricultural commodities and in favor of the more traditional argument that agricultural commodities instead face an inelastic demand curve in both the short and long run.

We know that output-increasing technological progress in the production of crops and livestock, while significant, has been less dramatic than the gains that have occurred in most of the other sectors of the US economy. The gross value of farm output was only 2.63 percent of US GDP in 1998, down from over 7 percent in 1973 and over 12 percent in 1950. This is in part because decreases in major agricultural commodity prices that have occurred over time have approximately offset any gains from increases in the volume of crops and livestock being sold as a result of technological progress. If adjusted by the CPI (1982–84 = 100), the 1998 Gross value of agricultural output for the US of 144 billion dollars is little different from the 136 billion dollar figure in 1950. Except in the 1970s, when rising commodity prices fueled increases in farm income, and despite gradually accumulating technological progress, the real gross value of agricultural output has varied little in the last 50 years. The stability of the gross value of farm income over time provides empirical evidence to suggest that the long run elasticity of demand for US agricultural production is at most, −1, or unitary. That is, attempts to achieve gains in income to farmers in the aggregate by increasing the volume of output through innovation and technical change in the long run have been almost exactly offset by deterioration in commodity prices.

The Profitability Question

Some have argued that the goal of technological progress in agriculture is not to help farm-

Table 1. Average Farm Operator Household Income, by Economic Size of Farm, 1991–1997

	Economic Size of Farm (Sales)				
	Less than $50,000	$50,000 to $250,000	$250,000 to $499,999	$500,000 or More	All households
1991:					
Total Household Income	33,822	33,147	71,330	177,910	37,447
Farm earnings	−1,840	13,952	47,333	143,421	5,810
Off-Farm Income	35,662	19,195	23,997	34,489	31,638
1994:					
Total Household Income	38,168	40,758	72,518	155,711	42,469
Farm earnings	−3,522	12,143	50,178	119,929	4,376
Off-Farm Income	41,690	28,615	22,340	35,782	38,092
1997:					
Total Household Income	45,939	54,318	78,592	200,758	52,347
Farm earnings	−3,438	16,142	44,131	164,469	5,989
Off-Farm Income	49,377	38,177	34,460	36,289	46,358

ers produce more, since the consequence of the increased output is a deterioration in commodity prices faced by all producers. Rather, the guiding objective of agricultural research and education in crop and livestock production is to help farmers become more profitable, that is, to keep more of the revenue they receive for selling crops and livestock as bottom-line profit, or net farm income. Technological change in production agriculture over time perhaps could have helped farmers gradually widen their profit margins and keep more of what they sell as net income, but this contention is not supported in the USDA data series on farm income.

A simple way of examining this issue is to look at the question of whether net farm income represents a larger or a smaller share of the gross value of farm output recently than it did 50 years ago. If profit margins are widening over time as a result of technological change, then net farm income as a share of the gross value of agricultural output should also be increasing, as the cost-share comes down. However, USDA data reveal an opposite pattern, as costs relative to the gross value of agricultural output gradually widen not narrow over time and net farm income as a share of gross farm output declines. Nationally, net farm income was only 21 percent the gross value of farm output in 1998, compared with nearly 42 percent in 1950. In other words, in 1998 a farmer would have to sell about twice as much dollar volume of output to have the same nominal-dollar net farm income as in 1950.

In 1983, arguably the worst year for US agriculture in the past 50 years, aggregate net farm income was only about 10 percent of the gross value of agricultural output, although in recent years the ratio has remained at just over 20 percent. Note also that direct government payments are counted as a part of net farm income, although they are not part of the gross value of agricultural output, so rising farm program payments during the 90s were in large measure likely responsible for keeping this ratio at just over 20 percent.

How have farmers adapted to all of this? Gardner, in his 2000 AAEA presidential address, dealt with this issue. He relied on data from the USDA Agricultural Resource Management study (summarized in Table 1) which suggests that farmers have increasingly relied on off-farm employment. In 1997, for US farmers as a whole, income from off-farm employment and other non-farm sources on average represented 88.6 percent of farm-proprietor household income. In every year of the study from 1991 to 1997, the average US farm proprietor selling $50,000 or less lost money from farming activities, but because of income from off-farm sources the household income

was still approximately the same as the average household income for all US households.[4]

The situation was very little different for larger farms. Of those with gross sales between $50,000 and $250,000, off-farm income was the source of over twice as much income as income from the farm, averaging $38,177 in off-farm income versus $16,142 of farm earnings, while total household income for this size category exceeded the average income for all US households (Table 1). Farms above $250,000 in gross sales rely more heavily on income from farming activities. However, even for this class of farms, 1997 household income from off-farm sources is still above $30,000. Only for farms selling more than $500,000 in output does farm income greatly exceed income from off-farm sources. In the past, income generated from farming was spent and re-spent in local communities as the farm economy drove the non-farm rural economy. Increasingly, the situation is reversing, with income from off-farm employment being used to support a farming lifestyle–in a sense, the rural non-farm economy is driving the farm economy.

Farmers who rely on primarily off-farm employment as a source of household income have little incentive to adopt the latest in output-enhancing or cost-reducing technologies, particularly if these technologies require a significant expenditure of start-up capital in order to implement or require labor at hours that would jeopardize income from off-farm employment. Many new technologies require a sizable scale of operation in order to achieve the output-enhancing or cost-reducing benefits and are ill-suited to small-scale, part-time, and/or hobby/lifestyle operations.

Those living on farms or those who once lived on farms may have benefitted from technological change in agriculture, but not in the way envisioned by many agricultural scientists who focus on improving farm-level productivity and reducing production costs. New agricultural technologies have gradually though persistently reduced the amount of labor employed per unit of output employed in agricultural production. Prices for most agricultural commodities declined at a faster pace than the technical productivity of these enterprises increased. At the same time, economic development in many rural areas provided expanding off-farm employment opportunities for many farmers faced with declining revenues and incomes from crop and livestock production. Declining commodity prices provided economic disincentives to continue to rely on commodity sales for a major share of family income: Expanding employment opportunities in the non-farm rural economy provided economic incentives to find full-time off-farm employment, while still enjoying a farm as a rural lifestyle residence. Farm enterprises changed as farmers increasingly sought ways to mesh living on a farm with full-time off-farm employment, away from enterprises such as dairy, and toward enterprises such as beef feeding or even confinement hog and poultry production. For many, living on a farm gradually has become a lifestyle choice rather than an economic necessity.

The trend toward increased off-farm employment as an expanding source of farm family income has long been present both nationally and in the South for moderate-sized farms selling less than $50,000 annually. The USDA data suggest that because of weaknesses in the farm commodity markets, this same trend is becoming increasingly important for larger (commercial as opposed to hobby, lifestyle or subsistence) farms selling between $100,000 and $250,000 of output. Farms in this size category have often been thought of as the core farm and political constituency of colleges of agriculture–that is, commercial but still family-run operations that relied heavily on crop and livestock sales for income and perhaps represented the best market for the technologies and educational efforts of colleges of agriculture directed toward farmers. To the extent that these farmers become less dependent on farm commodity sales for family income, their interest in and support for farm-level pro-

[4] In a 1986 *Choices* article, Thurow (pg 18) argued that the agricultural industry was a tax scam. He noted that in 1982, a net farm income of 20 billion dollars was reported to the IRS as 5 billion in losses. Undoubtedly, farms are still being used as tax writeoffs by farmers large and small.

ductivity-enhancing and cost-reducing technologies and educational programs for improving crop and livestock production as programs run by colleges of agriculture may also decline.

Nationally, in the most recent NASS revisions, total farm numbers are no longer declining even though income from off-farm employment is assuming ever larger importance in the household income of farm families. Counts of farm numbers throughout the US reveal that increases in rural lifestyle farm numbers are now completely offsetting the continuing decline in the number of commercial operations. It is a tribute to the increasing economic strength of the non-farm economy (both the rural economy and in cities near farms) that many farm residents can enjoy the farm lifestyle while having incomes comparable to if not better than those of city dwellers. Technological change in production agriculture has in large measure been responsible for these demographic and workplace shifts.

Are US Consumers Better Off?

Two major trends are now occurring that determine whether or not US consumers are benefitting from technological progress at the farm level. The first trend involves changes in consumer demographics with increased numbers of couples who both work, single-person and single-parent households, and other changes that move away from the traditional concept of a family in which the husband is the income provider while the wife stays at home. These trends have shifted food consumption patterns such that fewer and fewer meals are being prepared or are eaten at home, and of these the items used in meal preparation have an ever lower farm level value. When large numbers of housewives stayed at home and cooked meals for their families, these meals often contained comparatively unprocessed items such as raw meats, flour, and other items that had a high farm-level value relative to retail prices. To the extent that technology in agriculture lowered production costs, these reduced costs were often passed through to consumers in the form of lower food prices.

The second, related trend was the expansion and consolidation of agribusiness firms responsible for converting raw agricultural commodities into what the consumer purchases at the grocery store and in restaurants. Changes in demographics have fueled the growth of these firms, as fewer and fewer meals are prepared at home from basic food items with a high farm-level value. The costs of processing, marketing, and transportation dwarfs the farm-level value of the food item. For a particular food item, if the farm value is but 10 percent of the cost to the consumer, gains in efficiency at the farm level will be little felt by consumers relative to what would have happened if the farm value were 30 or 40 percent of the retail price paid by the consumer. This is even more true for restaurants where the farm-level value is even lower. So consumers who once saw great benefits from farm-level technological progress in the form of lower food prices may now see few benefits.

One way of measuring the extent to which consumers have benefitted from technological change in food production is to examine the ratio of prices for food relative to changes in the overall consumer price index. The USDA has a specially constructed index of food prices that they have compiled, which they believe is superior to the food price indices compiled by the Department of Commerce as part of the CPI. The ratio of the USDA index of food prices to the overall CPI fell in the 1960s, then rose sharply in the early 70s, as farm-level commodity prices increased, but then fell sharply again in the late 70s and early 80s. Since 1985, the ratio has remained almost constant.

To summarize, in large measure consumers no longer appear to be reaping the benefits from technological change in crop and livestock production–at least no longer in the form of lower food prices. The demographic changes (more households comprised of but one individual, more single-parent households) and employment changes (more families in which both husband and wife work full time) have

resulted in increased consumer reliance on more fully-prepared and more highly-processed foods, and gradually increased the proportion of meals eaten away from home. Most housewives working an eight-hour day outside the home are not willing to spend a lot of time in the kitchen preparing meals for their families. As a result, the farm value of the consumed food is declining as other costs comprise an increasing share of the cost of food to consumers. Savings due to improved technology at the farm level will likely not even be noticed by the time the food reaches the consumer.

The second reason relates to the increasing consolidation and market power of agribusiness firms responsible for converting raw agricultural commodities into the form purchased by the consumer. The major food processors operate in an oligopolistic rather than a competitive environment. To the extent to which these firms have market power, these firms have opportunities to retain the benefits of farm-level production technologies for themselves rather than pass any savings forward to consumers in the form of lower food prices.

Are Agribusiness Firms Better Off?

The last 15 years has been a period of rapid consolidation of firms in many parts of agribusiness—farm input suppliers, meat and grain processing firms, and even food retailers. Agribusiness firms often act as oligopsonists in making purchases of raw farm commodities, and as oligopolists in selling to consumers (Sexton). As oligopsonists, agribusiness firms seek the lowest-cost supplies of crops and livestock meeting their needs, and often search out world markets for these supplies. US farmers will be chosen as supply sources only to the extent that quality is adequate and prices are competitive in world markets. With broilers and hogs, many producers may have the option of selling to only one buyer. This sets up the necessary economic conditions for the buyer to take advantage of its monopoly (monopsony) power.

Marketing economists have been looking at the issue of whether or not gains in farm-level efficiencies are being passed forward to consumers. In particular, do processed meat prices reflect what the processor paid for the live animal to the extent this was true some years ago? Carstensen suggests that according to USDA data, the farm-to-wholesale price spreads for pork increased by 52 percent and for beef by 24 percent in the past five years. He further notes that this is exactly the result that theory would predict as an oligopoly develops in both the buying and selling markets for meat products.

Consolidation among food manufacturers continues at a rapid pace. Philip Morris purchased Nabisco and subsequently announced plans to combine it with its Kraft unit and then create a separate publicly-traded food company. Even more recently Kelloggs, the breakfast food company, announced that it was purchasing Keebler, a cookie and cracker maker. The consolidation of food retailers presents a similar set of issues. Krogers has become a nearly nation-wide chain with its purchase of Fred Meyer stores (previously a major chain in the West) even as one-stop discount houses such as Wal-Mart, K-Mart, and Meijers expand grocery sections and compete for sales. The implications of these structural changes for either consumers or farmers are not clear. Grocery chains have sometimes argued that consumers are not "well served" by constant fluctuations in the prices of basic items such as milk, meat, and poultry as a result of changes in farm-level supplies. But maintaining stable prices for these items is an excuse for keeping profit margins high when supplies are strong–something perhaps less likely to occur as large chains operating in national markets compete for market share. Interestingly, consumers routinely deal with rapidly fluctuating gasoline prices and grocery stores routinely adjust fresh produce prices to reflect short-term supply conditions.

Moreover, a decade and more ago the delineation of firms engaged in agribusiness was generally quite clear. All of this has changed in recent years and with mergers and consolidations the distinctions are becoming less and less clear. There has been a blurring of lines

between the agricultural chemicals and the petrochemicals industry with the energy companies engaged in the manufacture of both pesticides and fertilizers. The dividing line between what constitutes a chemical company and a grain processor is becoming blurred as well. Archer Daniels Midland can be thought of primarily as an organic chemical manufacturer that happens to use various grains as inputs to organic chemical production. Another illustration is the use of grain alcohol in motor fuels. Advances in biotechnology exacerbate this trend, as genetically-engineered "designer" crops are developed that have specialized characteristics designed to meet particular needs in chemical manufacturing. Indeed, some in colleges of agriculture have argued for a "biocentric" model in which farmers become producers of large amounts of genetically engineered (designer) biomass, renewable plant materials that could be used as the starting point for many different industrial processes including making fuels and industrial chemicals. This biomass might often be sold to firms such as chemical and energy producers, not firms we normally think of as agribusinesses.

Can it be shown that agribusiness firms are now reaping the benefits of farm technological change at the expense of both farmers and consumers? That is difficult to prove. Agribusiness firms–those that sell inputs to farmers, purchase crops and livestock from farmers or further process and then deliver items more readily suitable for consumer use–have indeed consolidated in recent years. While consolidations have taken place, there is not yet overwhelming evidence to suggest that most agribusiness firms have so far reaped monopoly profits as a result of the consolidation. Food retailing, for example, continues to operate on very low margins in comparison with many other kinds of retail establishments and the large discount chains selling food if anything appear to be more competitive than the small regional food retailing chains they are replacing. In vertically-integrated, contract-based livestock markets, agribusiness firms contracting with farmers have a great potential to apply their monopoly power. A similar threat exists for grain producers as direct contracting of grain with particular genetically-engineered characteristics increases, bypassing the traditional grain marketing and price discovery systems.

But to the extent that direct contracting of both crops and livestock proceeds in step with consolidation and increased monopoly power, the potential exists for the economic rents arising from technological progress to be retained by agribusiness firms rather than being passed back to farmers as higher prices or forward to consumers as lower prices. And this potential is not likely to diminish over time.

Two Visions

To conclude, let me construct two alternative visions for rural places in contemporary American society. The *traditional idealized vision* of rural America consists of prosperous rural communities surrounded by equally prosperous farms. Farm families rely almost entirely on sales of crops and livestock for their household incomes and the success of new production technologies in gradually improving farm-level profitability has made this possible. Farms are increasingly prosperous because they have been willing and able to adopt the latest production technologies developed in both the public and private sectors. In this scenario, production agriculture assumes a primary, superior role and the prosperity of the rural community in large measure is driven by the prosperity of the farms that surround it. Both farmers and rural non-farm people highly support the need for more public-sector efforts to improve the productivity and profitability of farms, for these continuing technological improvements provide the fundamental basis for economic prosperity with the rural economy. Jobs in the non-farm sector tend to be focused on those involving suppling inputs to farmers, or those involving the purchase and further processing of commodities produced on the farm, so those employed in non-farm jobs often feel that they too have an equal state in the prosperity of the farmers in the community.

The *alternative* vision for rural America

consists of a scenario in which rural communities are surrounded by what also appear to be prosperous farms. However, the vast majority of families living on these farms rely decreasingly and often very little on the sales of crops and livestock as a source of income. In fact, in most of these farm families, both the husband and wife hold full-time off-farm jobs that pay steady wages year after year. The children have a horse to ride, and the father owns a nicely restored 1950s John Deere tractor, which is used for handling yard chores. The family is interested in agricultural production, but the well-being of the family ultimately does not depend on it. The town, a few miles away, offers a variety of goods and services to the many prosperous "farmers" in the surrounding area (But if you asked these farmers what they did for a living, they would likely tell you about their off-farm job). The town has been successful in diversifying its economy so that its fate is no longer heavily reliant on the success or failure of the surrounding production agriculture. The community has been able to attract and hold a diversified group of businesses and light industrial plants, so that the economic well-being of most of the people living there depends little on crop and livestock prices nor the weather. In fact, the agricultural extension service is facing increased difficulty in getting farmers to listen to presentations that emphasize improved methods for producing crops and livestock. The farmers complain that such technologies are not well suited to their operations as they are too costly for the size of their operations. Further, some of these technologies, if implemented, would make it more difficult for them to continue working full-time off-farm.

The traditional idealized vision of a farming (production agriculture)-centered rural America, in which non-farm prosperity was largely driven by prosperity on the farm represents the key paradigm that has driven program emphases within colleges of agriculture at most land grant universities through the twentieth century. However, the paradigm is shifting, and the alternative vision of rural America is perhaps the more accurate version of what is now going on in many rural areas.

With increased reliance on off-farm income, fewer and fewer farm families see income from the sales of crops and livestock as critical to their survival. This has implications for the willingness of the farmers to continue to press for more efforts devoted to improving farm-level production technologies. There are further implications for shifts in the emphasis traditionally placed within college of agriculture on improving farm-level crop and livestock production.

Most rural communities no longer depend on production agriculture as a primary force driving the well-being of the non-farm rural economy and thus are not as affected by productivity gains in agriculture as they perhaps once were. The fact that farm families rely heavily on income from off-farm employment is a tribute to the expanding employment opportunities in the rural non-farm economy, as well as in adjacent urban centers. At the same time, the increased reliance on off-farm employment opportunities is an indicator that returns to labor in production agriculture remain on average below the returns to labor in the non-farm economy. In many rural areas income from off-farm employment by farmers and spouses is generating capital which is invested in the farming operation. So in a sense the non-farm economy is driving the farm economy, not the other way around.

Many US consumers no longer see the primary benefits of publicly-supported agricultural research and education in the form of lower food prices but are more concerned about issues such as food safety and environmental protection. To the extent that benefits to consumers exist from agricultural production research, these benefits instead accrue in the form of better quality products, increased food cleanliness and safety, and other similar benefits. At the same time, consumers often also see technical change accruing from genetic engineering as being potentially harmful. This too has implications for research and educational programs within colleges of agriculture.

Increased market power over farmers and

consumers put agribusinesses in a position where they can potentially increasingly retain gains from technological change in agriculture for themselves, neither passing these gains back to farmers nor forward to consumers. The extent to which this is occurring and can be measured is an empirical issue. This also becomes an issue as debate increases over the possible implications of agribusiness funding of agricultural research.

Since inception, land grant universities and colleges of agriculture had a strong focus on doing whatever was necessary to help improve the lives of people. As the years passed in the 20th century, this people-centered focus gradually shifted to be increasingly centered on improving the productivity of crop and livestock enterprises. What began as a means to an end (increasing the productivity of crop and livestock enterprises in an effort to boost farm and non-farm incomes) gradually became an end in itself. Few bothered to address the question of whether or not this increasingly crop and livestock (production-centered) focus did in fact gradually improve the lives of people (farm and non-farm residents) living in rural areas. Agricultural production scientists simply assumed that technical productivity gains made the lives of people better–if producers did not gain then surely consumers would reap the benefits of technology-induced productivity gains. Few agricultural scientists questioned these values and beliefs in part because they were intertwined with the public political support and increased funding for colleges of agriculture.

It is clear now that many of these traditionally-held beliefs about the impacts of technological change in crop and livestock production on the well-being of rural people are myth rather than reality. Most farmers have readily adapted to deteriorating conditions in crop and livestock production by pursuing off-farm employment, leaving primarily a small number of relatively efficient large-scale operations to deal with the risks associated with heavy dependence on crop and livestock production as a source of income. The vast majority of smaller, less-efficient operations cope with these risks through off-farm employment, while decreasingly relying on crop and livestock sales as a family income source.

These changes suggest a need also for dramatic changes in the research and educational programs within colleges of agriculture. Colleges of agriculture need to move away from their current crop and livestock focus and back to their roots which instead focused on the kinds of activities that improve the lives of rural people. These shifts are not going to be easy, given the "lumpy" and specialized nature of human capital inputs in colleges of agriculture and the inherent long-term nature of human capital investments in tenure track positions. Most agricultural economists are quite flexible with respect to moving from one problem area to another, but scientists who deal with technical problems in crop and livestock production usually have highly specialized skills useful in dealing with technical problems faced by producers of a specific commodity. Adapting to changes now taking place in agriculture and in rural areas will be far more difficult for our colleagues in departments tied to crop and livestock production than it will be for many of us in agricultural economics.

But the long-term viability of colleges of agriculture and in particular public funding and political support is heavily linked to our ability to make these changes over time, gradually moving away from a crop and livestock-centered program and toward programs that more clearly centered on improving the lives of people in rural areas, whether they live on a farm or not. To put this in simpler terms, the future of colleges of agriculture is with people, not with pigs.

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