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Impacts of New Agricultural Technology on Real Growth in the US and KY Farm Economy: 1949-1995

by

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Abstract

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David L. Debertin*

It is widely believed that public and private research and educational activities have led to rapid advances in the production of crops and livestock, making farmers far better off than they would have been had these technological advances not taken place. The cash receipts data for the postwar period from 1949 to 1995 for both the US and for Kentucky tell a very different story. Once an adjustment is made in the cash receipts data to account for the effects of inflation, real cash receipts from the sale of crops and livestock in 1995 remain almost exactly where they were in 1949--this despite the massive introduction of productivity-enhancing technologies. Over the same time period, gross sales per farm have risen somewhat, but only because farm numbers were declining at a rapid pace over the same time period. On a per-farm basis, from 1949 through 1970s, real sales of crops and livestock increased at a steady pace, rising rapidly in the late 70s, followed by a decline in the early 80s. Since the mid 80s, in both the US and in Kentucky, the real dollar value of sales of crops and livestock per farm have stalled.

Nationally, a two-tiered structure of agriculture is emerging, dominated on one side by large-scale factory-style production systems catering to specific demands of the marketplace and on the other side by part-time farmers whose primary income comes from off-farm employment. The traditional focus of colleges of agriculture has been to cater to the research and educational needs of mid-size commercial operators--those where income from farming represents most of the household income--who look to colleges of agriculture as a primary source of information about new technologies that could be adopted in an effort to increase productivity, and, hopefully, income. Since income from the sale of crops and livestock represents a small component of the income of many part-time farmers, these farmers are often less likely to be interested in the latest productivity-enhancing technologies compared with farmers who earn most of their income from the sale of agricultural commodities and products. Too, these farmers are likely to be less willing to make investments in the newest capital-intensive, productivity-enhancing equipment, often because such equipment requires a "larger than part-time" scale of operation.

Consumers, of course, have benefitted from these productivity gains in that they are able to purchase certain commodity-like items (flour, hamburger) at the grocery stores less expensively than if the technologies had not been adopted by farmers. But with changes in social and work-related demographics (i.e. wives who work) and an increased emphasis on highly processed prepared foods and foods eaten away-from-home, gains that permit consumers to buy raw hamburger and flour less expensively become less and less important to the family budget over time. These findings have important implications for future public support of research and educational programs aimed primarily at improving agricultural production technologies.

The remainder of the paper focuses on economic explanations as to why real cash receipts to farmers in the aggregate have not grown over the period even in the face of massive physical productivity gains. The simple explanation is that the aggregate demand for crops and livestock is inelastic, and any revenue gains attained as a result of the increase in physical productivity are more than offset by losses due to the impacts of the increased output on market prices.

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Significant long-term gains in the productivity of American agriculture can be largely attributed to the effectiveness of research and educational activities in which benefits have accumulated over a very long period of time (Frink and Horsfall, pg. 56). These gains have been in large measure responsible over time for the declining share of individual and family income spent on food. Khanna, Huffman and Sandler (p. 267) noted in a 1994 article that since 1950, there has been an 83 percent increase in U.S. agricultural output, with only a slight increase in the use of inputs under farmer control. Some authors also argue that the rapid industrialization of American society in the twentieth century occurred in part because workers freed from the need to labor producing crops and livestock were able to find employment in other sectors of the economy, making these sectors more productive than they otherwise would have been (Chennareddy and Jones). These are the "classic" and well-documented arguments justifying the need for continuing public and private sector investments in agricultural research and education.

In this paper I begin by discussing the historical role that agricultural research and education has played in the development of the US economy. I then trace the history of public and private sector technological developments in agricultural and public sector institutions since the early 19th century. The political economy as it affected agriculture from the 1950s to the present day is then reviewed; with a particular emphasis on the long-term impacts of the farm financial crisis of the early 1980s. The impact of colleges of agriculture on the structure of farms is outlined, and some emerging alternative roles for colleges of agriculture are identified. A basic mathematical model illustrating the effects of an output increase on total revenue for a product with an inelastic demand is outlined. Data are then presented to illustrate the impact of increases in the production of crops and livestock on real cash receipts. Impacts of technology on the allocation between fixed and variable costs are discussed and the consequences for small versus large-scale producers are outlined. The paper concludes with a discussion of implications for future public sector funding of agricultural research and education.

Prologue

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

Chennareddy and Jones note 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.

Research and educational activities which 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 focused 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).

Colleges of agriculture in the 50 states, as major producers of public-sector agricultural research and education, in recent years have come under strong criticism. Beattie, in his presidential address to the members of the American Agricultural Economics Association, argues that colleges of agriculture have faced [a]llegations of lost focus and mission, of misplaced emphasis, of self serving professors rather than professors serving the needs of their students and society..."(pg 1319). Despite the criticism that professors in colleges of agriculture sometimes do not devote their efforts to the most immediate problems facing agriculture (Schuh), there is little doubt that colleges of agriculture have had and continue to have major impacts in improving the productivity of crop and livestock production.

My concern is a different one. I am little concerned with the criticism that agricultural professors devote too much of their energies to solving problems of little importance to farmers (the issue that enamored Schuh). Indeed, the technical production scientists I have been involved with 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. Instead, I am greatly concerned that many of these same scientists and educators 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. The assumption by these individuals is simply made that the impacts of productivity-enhancing research and education can only be positive--these productivity gains will for certain make producers better off by raising their incomes. Or perhaps the argument is made that if the public sector through colleges of agriculture fails in its mission to do this productivity-enhancing work, the private sector will do it anyway.

Whether these output-enhancing gains are made from the efforts within the private or the public sector, an ever smaller number of farmers will produce an ever greater share of the output. Paarberg emphasizes that public support for institutions that serve a diminishing number of people will decrease over time, as will the number of land grant colleges. But the rapid decline in farm employment (and potential decline in political support) is in part attributable to the successes of the agricultural research and educational system! Colleges of agriculture may be the victims of their own success. It is not the failures of colleges of agriculture to focus on problems on importance to commercial farmers that will be their undoing. The problems and issues are far more subtle and complicated than those articulated by Beattie and by Schuh.

In a 1992 paper, I noted that "Conflicts between what consumers want and what politically powerful and commodity oriented commercial farmers want will be *the* primary administrative agenda item over the coming decade" (Debertin, p. 47). Later, in a 1993 article I proposed that colleges of agriculture will face some extraordinary difficulties in an effort to build public support from consumers as numbers of commercial farmers decline and the political base of support weakens.

I had already completed a draft of this paper before re-reading the *Choices* articles I wrote several years ago pertaining to the future of land grant universities and the proposed suggestions for needed program re-emphasis. Interestingly, I found that in the years that have passed since writing these articles, my views have not changed on the fundamental issues I raised then. Instead, I am even more convinced that the statements I made then about the future of colleges of agriculture will come true. To certain degree, this article is an extension and amplification of several of the points I made in the *Choices* articles. I have also found data and other theoretically-grounded evidence which support the broad assertions made in these earlier articles.

A Brief History

A short history of how colleges of agriculture at land grant universities evolved into a tripartite mission is illuminating. Initially, with the passage of the 1862 Morrill Act, the education of undergraduate students in improved approaches for producing crops and livestock via scientific agriculture was the goal. Only a few years after the land grant university system had started offering courses focusing on improving agricultural productivity, it became quite apparent that without more technical research (agricultural science) directed toward the development of additional methods for improving productivity, there was little to teach. This led to legislation authorizing the development of agricultural experiment stations via federal funding in the 1887 Hatch act (Lewis), and this act, with amendments, still provides significant amounts of federal money for agricultural research.

By the start of the 20th century, an additional need was becoming apparent. Educating undergraduates--many who would eventually go into farming employing the improved methods then being taught--represented one way of improving the productivity of agriculture. It was soon recognized, however, that education of farmers who were not college students could also result in agricultural productivity gains--and this might be a faster way. Thus, in the early 20th century, the 1914 Smith- Lever act authorized an agricultural extension service nationwide which was designed to disseminate research information developed at experiment stations and help farmers put newly emerging research-based production systems in place (Lewis).

It is widely believed that post World War II era has been the period in which the private sector (frequently in partnership with agricultural researchers at public institutions) has primarily played a significant role in improving the productivity of American agriculture, because much of the attention has been on post-war private sector development of highly selective pesticides, chemical fertilizers, hybrid seeds and the like. But there were other critical private sector developments that occurred much earlier--the 1837 development of the steel "scouring" plow by John Deere (Lubar; Frey), the US patenting of the mechanical reaper in 1834 by Cyrus McCormick (although the basic machine had been invented in 1826 by Patrick Bell in Scotland), and others (Lubar; Frey). Hybrid seed corn development involved a cooperative effort between public-sector research scientists at land grant universities and elsewhere, with major help from private sector companies involved in seed increase and sales. Indeed, cooperation between the private sector and public sector agricultural scientists has a long history, making it difficult for social scientists to measure and compare the importance of private versus public sector efforts in improving agricultural productivity.

Historic Impacts of Public and Private Sector Research and Education

If measured by the physical quantity of output (crops or livestock) produced per unit of labor expended, there is little doubt that the rapid advancement of scientific agriculture through both private and public sector efforts has greatly increased the productivity of agriculture. These agricultural productivity gains have largely been responsible for the transition of the US from a heavily farming-dependent agriculturally-based economy into a modern technology-driven industrialized society. Authors such as Lester Brown now even worry that the ability of new technologies to further increase crop yields are tapering off. Over the past 100 years or more, these technological developments in agriculture have freed vast numbers of American workers from production agriculture, and, as education became increasingly available, permitted these workers to find better, often higher-paying employment in the non-farm sector (Ilg, p. 3). These trends, exemplified by the movement of people away from areas of the US such as the upper Great Plains where farming still represents the single most important economic activity of the region, continue to this day (Goetz and Debertin; Hyde; Margolis).

In making a case for continuing and increased public sector funding of agricultural research and education from tax dollars via federal and state sources, college of agriculture administrators often spend a good deal of time pointing out the vital importance of these historic trends on American society, and, for that matter, on supplying worldwide food needs. It seems only logical to take this argument for justifying additional public sector funding one step further. In seeking political support for increased public sector funding, administrators of colleges of agriculture often stress that this system of continuous improvements in agricultural technologies embodying both public and private research and educational activities in partnership has made farmers as a group better off. These assertions are then broadened to suggest that the work of colleges of agriculture in enhancing the productivity of crops and livestock has had broad-based positive impacts on rural societies as a whole, both farm and non-farm. Put another way, through a productive on-farm agriculture, increased employment opportunities in non-farm rural communities become available.

The Political Economy of Public Support for Agricultural Research and Education

From the 1950s through the early 1970s, agricultural economists were preoccupied with why returns to resources employed within agriculture were so low and what could be done to increase these returns (Heady, pg 744; Tweeten, p. 163.). The view that a degree of government involvement in agriculture was essential to maintain a degree of price stability and assure a comparatively stable supply of basic agricultural commodities was widespread. Government price supports along with acreage allotments and other forms of supply control was deemed important in maintaining a viable economic base of full-time farmers.

Beginning in 1973, there was a strong upward movement in worldwide prices for most agricultural commodities, particularly the major grain crops. No longer was the issue primarily one of attempting to increase returns to labor in agriculture and maintaining a degree of price stability, but rather one of making certain that US farmers were able to produce enough basic commodities to satisfy the burgeoning world-wide demand for food. The politics of the day called for getting the federal government out of agriculture, while focusing on public and private research and education to increase productivity in an effort to satisfy growing world-wide demand. Throughout the latter half of the 1970s, the US inflation rate was increasing rapidly. Land prices were also rising rapidly primarily because grain prices in world markets were rising.

During this period of time, the federal government was encouraging farmers to plant "fence row to fence row" in order to take advantage of strong world markets. The then-secretary of agriculture Earl Butz saw the strong markets as an opportunity to reduce government involvement in setting production quotas and price supports--efforts that had dominated agricultural policies in the 1960s and earlier. Farm management specialists in colleges of agriculture were encouraging farmers to "leverage their assets" to purchase additional land and machinery and to implement he latest output-enhancing production technologies by borrowing money using as collateral already owned land that was now valued at inflated prices. There was a widespread belief among farmers (and perhaps even some farm management specialists) that because "farmland was no longer being made", land prices could do nothing but continue to increase every year.

President Carter named Paul Voelker chair of the Fed in 1979. Voelker saw as critical the need to reduce the inflation rate, which had swollen to double digits under the monetary policies implemented by the previous Fed chair. Prior to this period, many government and university economists believed that government fiscal policy (taxation and spending) was as critical in determining the overall rate of inflation rate as was monetary policy. Voelker used the tools at his disposal and increased short term interest rates while restricting the money supply in an effort to reduce inflation and ultimately achieve price stability. Voelker made believers out of many who had previously been convinced that fiscal policy was of primary (or at least equal) importance in determining the overall rate of inflation. Meanwhile, the worldwide demand for grains that had been so strong in the 1970s weakened. Coincident with the tight-money policies of the late 70s was the cessation of export subsidies to the Soviet Union in response to their invasion of Afghanistan. Another reason for this was that foreigners, observing high interest rates in the US, bid up the price of dollars, and American farm products no longer looked as attractive on world markets.

High interest rates brought about by the restrictive Fed monetary policy in combination with a weakening world-wide demand for grains were devastating for many US farmers. Agricultural economists who only recently had encouraged farmers to leverage their assets now discovered that it was precisely the farmers who had followed their advice who were in the deepest financial difficulty. Land in some of the major grain producing states quickly plummeted to 1/3 its previous value, and farmers who had leveraged their own farmland as collateral to purchase additional farmland at the inflated late 1970s prices quickly found themselves in a negative net worth (bankrupt) situation. Agricultural creditors, now holding collateral that was insufficient to repay debt, were in serious trouble. For example, the Farm Credit Services, a farmer-owned credit cooperative holding the bulk of its portfolio in agricultural loans, was in most serious difficulty, but the banks located in many rural communities faced problems too, and a number of these went under or were merged with other banks that were not in financial trouble. Many of the commercial banks located in rural areas were never as aggressive in making loans to farmers as the Farm Credit Services was in the 70s, and since they held a portion of their portfolios in non-agricultural loans, the were sometimes in somewhat better shape.

It is interesting to evaluate how the farming that emerged out of the financial crisis of the early 80s changed from what was considered the norm in the 1970s. In the early 80s, there was a period of time in which the economic picture looked so bleak that there was even fear that productive farmland would not even be planted to crops. Despise the publicity that farmers who were going bankrupt received in the news media, and even on television and in the movies, most farmers were still is good net worth positions, as historically the average ratio of debt to equity has been quite low in comparison with most owner-run businesses. Interestingly, the farmers who had ignored the advice of the 70s (some of it offered by management specialists in colleges of agriculture) to leverage assets and acquire debt to grow emerged in the best shape. (It made little difference to farmers who owned their own land what it was valued.)

But agriculture did change in fundamental ways as a result of the experience. These include:

1. Greater reluctance to assume large amounts of debt in an effort to grow quickly

2. Increased consideration to minimizing debt by renting rather than purchasing farmland, recognizing that farmland values could go down as well as up, and that these values were highly dependent on the price outlook for agricultural commodities

3. Increased consideration of new financial approaches (ie leasing rather than purchasing major machinery and equipment items) that minimize the amount of intermediate-term debt a farmer must assume in order to operate.

4. Increased interest in various kinds of risk insurance for both prices and yields. For example, contracting directly with buyers at the beginning of a production season; use of options and futures contracts; crop yield insurance, etc.

5. Increased reliance on off-farm part-time or full-time work (perhaps by the spouse) which acts as a form of "income insurance".

Colleges of Agriculture and the Ever-Changing Structure of US Agriculture

Despite their ever declining numbers, farmers who obtain most of their incomes from the production and sale of crops and livestock (sometimes called "commercial farmers" to distinguish them from the so-called "part-time" farmers who live on farms but obtain most of their incomes from off-farm employment rather than from the sale of agricultural commodities and products[1]) remain the chief supporters for increased public funding for agricultural research and extension. The implications of this statement is apparent both from the lobbying efforts that go on in Congress as well in most of the state legislatures. With a few exceptions--primarily these are the colleges of agriculture located in states in the Northeast (Kreahling, Smith and Luloff)--colleges of agriculture continue to devote the bulk of their research and educational resources to activities aimed at improving the technical productivity of this group of farmers. The evolution of the relationship between colleges of agriculture and this group of commercial farmers over the years has been interesting to watch. The willingness of agricultural scientists and educators to work with these farmers over the years stems from the fact that these farmers are of sufficient size, have ready access to capital that may be needed as well as a interest in adopting the newly emerging technologies, whether these come from the public or the private sector, or from a combination of public and private effort.

The structure of agriculture continues to change rapidly in the US. The total value of all agricultural sales was $131.9 billion in 1982, and $162.6 billion in 1992, measured in current (non inflation-adjusted dollars) according to the US Bureau of the Census. In 1982, farms with gross sales of from \$50,000-99,000 produced \$18 billion in output but only \$13 billion in 1992. For those between \$100,000 and \$249,999 in sales the value of sales remained approximately constant--\$32.7 billion in 1982; \$32.9 billion in 1992. But farms in the largest Census size category of over \$500,000 in gross sales increased the total value of output from \$42.7 billion in 1982 to \$74.6 billion in 1992. Even more interestingly, this 1992 sales volume of \$74.6 billion was produced on just 46,914 farms, for an average value of output per farm of \$1.59 million dollars! In a 1995 paper, I outline some major structural changes taking place in Kentucky agriculture (Debertin, 1995).

Agricultural scientists and educators have often been less willing to work with smaller, part-time and "subsistence" farmers because they believe either that these farmers lacked the necessary capital to implement the new technologies, or perhaps even the ability to understand the procedures by which the technology is put in place. In addition, as will be explained in detail later, the benefits of many of the new technologies are not size-neutral--that is, a farm needed to achieve a certain size before the labor or cost savings of the new technology would be apparent. Indeed, the new technologies developed within colleges of agriculture likely have had significant impacts on the structure of agriculture--leading to the continuous loss in farm numbers along with a steady increase in the average size of farms and the volume of output produced per farm. A colleague expressed his reluctance to work with beef cattle producers who have full-time off farm jobs by noting that these producers were so small that even if success was achieved, the output gains would be negligible.

Increasingly in recent years, and with increased controversy surrounding the industrialization of agriculture as an emerging trend (Drabenstott), there is discussion about the possibility that some farmers are "outgrowing" colleges of agriculture and in particular the need for traditional services provided by extension. Drabenstott notes that with agricultural industrialization, "By blurring the lines among the links in the food system, the extension service will have to decide who its customers are" (pg. 19). The results of a recent survey by Successful Farming are reported in Benjamin. That survey found that there were 43 producers in the US with more than 10,000 sows, and that these producers averaged 40,500 sows each. These 43 producers account for 29 percent of all sows in the US, and likely wean 40 percent of all pigs born and raised nationwide (Benjamin, p. 7).

Is it possible for a farm to become so large and successful that the educational and research resources of a college of agriculture are no longer needed? Ikerd, for example, questions whether we should be using public dollars to "promote" agricultural industrialization. This concern first became apparent in the broiler industry, as producers increasingly relied on direct contracts with broiler processors and made an effort to produce broilers exactly as specified by the contract provisions. Broiler contractors assume virtually all of the functions formerly called "management[2]", and the farmer simply supplies the skills and labor (and perhaps part of the capital) to produce the broilers. It is noteworthy that very few states now have more than a token number of researchers or educators within colleges of agriculture who deal with poultry production issues, and since virtually all production is now contracted, there is no need for poultry marketing specialists either. Now a similar concern haunts the hog industry which, as Benjamin explains, is rapidly moving toward large-scale production and marketing not unlike what happened some years ago in broilers. Farmers who are contract producers likely will have little need for the technical production or marketing assistance traditionally provided by colleges of agriculture, and those functions will increasingly be performed by the contractor.

College of agriculture administrators (and faculty) now devote a great deal of energy and concern toward fulfilling the educational and research needs of group of full-time farmers who are large enough to adopt the new technologies but are not yet contracting all of their production through an integrator.

How this will evolve over time is very unclear, particularly if the proportion of output placed under direct contracting increases rapidly. In most states, numbers of farmers who fall into this "middle" group of commercial operators have dropped precipitously in recent years, but most college of agriculture administrators still believe that their political support is vital for the continued survival of public-sector agricultural research and education. And this may indeed still be true. An interesting question is whether or not commercial farmers who rely on contracting for an increasing share of their incomes will remain strong supporters of public-sector research and extension activities by colleges of agriculture.

Some very basic programs that historically have been an important part of what colleges of agriculture do are threatened here. Consider the extension effort through 4-H devoted to the genetic improvement of livestock via livestock judging contests and similar activities. What point is there in teaching young people the skills necessary to judge a class of hogs, for example, if hog production is primarily an activity engaged in by farmers who produce hogs that have been genetically engineered to exactly suit a particular market and whose genetic characteristics are determined by the contractor?

The large contractors are sometimes blamed for driving the trend toward increased industrialization and vertical integration of agriculture. But ultimately these trends are not driven by contractors or farmers but by the demands of the consumer. An increasingly sophisticated consumer demands a high quality, very uniform product. Rhodes refers to this phenomenon as extra-market coordination, a situation in which more information is needed by producers (in this instance, about the subtleties of consumer preferences) than ordinary price signals from the marketplace can provide. No longer can the production system simply deliver the product that is simplest for the farmer to produce, nor will the market tolerate inferior appearance or quality. The vertically integrated contract system increasingly is emerging as the simplest and easiest method by which these increasingly sophisticated consumer preferences can be relayed back to producers via these extra-market coordination mechanisms.

Agricultural scientists and educators in college of agriculture have often been very good at assisting farmers in technical production problems--they have been far less successful in helping farmers read and quickly adjust to changes in consumer tastes and preferences, or in helping farmers make adjustments necessary to cater to rapid shifts in consumer preferences. The vertically integrated systems have an important advantage in their ability to link ever-evolving consumer tastes to the on-farm production system. But this observation in turn raises important issues regarding the long term future of agricultural research and education within colleges of agriculture particularly if the emphasis continues to be that of dealing with management and production problems faced by mid-sized commercial producers by employing traditional (non vertically-integrated) approaches.

Emerging Alternative Roles for Colleges of Agriculture

A case can be made that it is now time for agriculture colleges to move on to other problems--that the period in which primary emphasis is placed on solving technical problems faced by commercial farm operators that dominated colleges of agriculture since the end of World War II is rapidly drawing to a close, even as the private sector assumes an ever larger role. Alternative roles that colleges of agriculture might assume include an increased emphasis on programs dealing with non-farm rural development, socioeconomic concerns of farm and non-farm rural residents, consumer-related concerns such as food safety and issues related to environmental problems, and issues related to the long term sustainability of agricultural production systems. But none of these alternatives currently has the base of political support that the partnership between colleges of agriculture and mid-size commercial farmers has traditionally enjoyed.

While there is talk of increased emphasis on other activities that are in keeping with the rapidly changing rural economy, the discussion usually makes the assumption that these new activities will be added only if new funding becomes available in addition to the funds currently appropriated for conducting the kinds of research and educational activities that the core group of commercial farmers historically have "needed", rather than by redirecting existing funding, scientific and educational efforts away from the mid-size commercial focus and toward these other areas. Only if state and federal dollars are specifically earmarked for these new activities will most college of agriculture administrators make investments--otherwise existing funding largely supports the activities thought to still be valued by the politically important core group of mid-size commercial farmers.

Examples of these "new" activities include

1. Research and educational efforts directed toward broad-based rural development problems aimed at creating employment opportunities, improving incomes and the increasing the quality of life for rural residents, whether they be farm or non-farm[3].

2. Efforts specifically directed toward consumer-related concerns relating to food safety and on-farm production technologies employed.

3. Efforts directed toward dealing with issues related to a concern for the environment, especially as the environment is affected by a wide range of activities that take place within an increasingly industrialized, technology-intensive farming sector.

Sustainability Issues

It is doubtful that colleges of agriculture initially would have directed resources toward sustainable agriculture, had there not been political support and a "push" for federal grant and other issues directed toward sustainability issues. Initially, many faculty and administrators tended to view those involved in the sustainablity issues as a "threat" to the scientific agriculture methods that serious commercial farmers used who represented the core base of support for agricultural research and education. In the late 1980s, this attitude shifted, as increasing numbers of scientists and administrators talked of integrating sustainable agriculture principles into college of agriculture-approved farming systems. (See Lockeretz for a discussion of some of the issues surrounding sustainable agriculture programs in colleges of agriculture).

Would this shift in attitudes about sustainable agriculture by those in colleges of agriculture have occurred as rapidly, or even at all, had federal grant money and other tax dollars not been specifically earmarked for working on sustainable agriculture issues? That is an interesting question. My colleagues in entomology argue that the sustainable agriculture movement actually began much earlier, when efforts going back into the 1970s (perhaps earlier) were directed toward integrated pest management (IPM) programs. They further propose that these IPM programs (and scientists in colleges of agriculture who worked on IPM) deserve some of the credit for the increased focus on sustainability. To a certain degree I agree with their assessment, but I also take note of the fact that federal funds and grant dollars earmarked for IPM programs were available far earlier than funds earmarked for sustainable agriculture. Would the IPM programs have developed in the manner in which they did if these funds had not been specifically allocated for that purpose? Would IPM be seen as threatening to the popular and successful programs that employed frequent applications of chemical insecticides and other pesticides then thought by the best scientists to be "entirely safe."

Rural Development

Rural development efforts have also followed an unsteady path at most land grant universities. What has happened in the last 25 years at the University of Kentucky in this regard is not only illustrative but perhaps also representative of the path that rural development efforts have taken in many other states. In the early 1970s, there was in place at the University of Kentucky a program which employed a number of individuals (generally holding master's degrees) who had as there specific job assignment the task of working with local communities and assisting them with rural development efforts. As any rural development specialist knows, educational work in rural development is quite unlike the educational work that takes place in most other educational efforts.

In the typical situation faced by an extension educator dealing with plant or animal agriculture, the educator assumes the role of the "expert" and suggests a specific production strategy which, if implemented, will solve the farmer's problem, increase the productivity of the enterprise, and presumably make the farmer better off. The specific approach is already known to work, and failure can only occur if for some reason outside the control of the educator the farmer is unwilling or unable to adopt the plan.

As any student of rural development realizes, attempting to adapt this approach to rural development education would be a disaster. In other words, the last thing a rural development educator would want to do is to present to a community a specific plan to "solve" a problem, or to work in an effort to see a specific plan go into effect. Instead, a rural development educator seeks to assist rural community in defining problems and in developing alternative solutions to problems. It is important to note that in order for community development work to be successful, both the problem definition and the alternative solutions must come from the community itself, with the specialist-educator simply acting as a facilitator for the discussion, and occasionally rendering technical assistance in terms of assessing the various impacts the alternatives that are suggested--perhaps also making use of analytical (computer-based or other) tools that otherwise would not be available to the community. *The decisions as to which problems need to be resolved or which alternative strategic plan should be pursued in resolving each problem is for the community, not the educator to make, and educators who attempt to prômote a particular plan are seldom if ever valued by residents of local communities.*

This somewhat fuzzy role for the rural development educator in comparison with counterparts dealing with plant and animal agriculture seems alien and often makes many administrators of colleges of agriculture quite uncomfortable. Administrators regularly evaluate the successes of plant or animal educators by noting whether not farmers believe the proposed strategies are workable and therefore are willing to adopt the strategies being presented. In the case of rural and community development education, evaluating the effectiveness of the educator's work is far more difficult.

I believe that this basic problem was the underlying reason why the then-dean of the UNiversity of Kentucky college of agriculture disbanded the system of rural development education that was then in place. The dean saw local communities as essentially political entities (which they are) and was uncomfortable with a situations where educators could no longer play the role of "knowledgeable expert" in a manner similar to how plant and animal educators did in solving farmers' problems. By the late 1970s this entire structure for rural development education had been abandoned by the University.

Rural development thrived in other ways in the 1970s at Kentucky, however,in part because the federal government was providing earmarked dollars specifically for rural development through the Rural Development Act of 1972 (the so-called Title 12 funds). This made possible experiments in designing some new programs based on the then emerging computer technologies and delivery systems. Within a few years, however, this funding had lost its earmarking (let the states decide for themselves what funds should be allocated toward rural development efforts), and these programs were largely abandoned.

At least within Kentucky, the 1980s marked a decade of decline in rural development efforts. Discussion only reappeared as the outlook for the long run future of tobacco production became increasingly precarious--this due to policy changes brought about by health-related concerns. Interest increased in the need for rural development strategies aimed at providing jobs in rural communities that would "replace" income lost because farmers could no longer make as much money growing tobacco. The issues currently confronting tobacco in Kentucky are not new. An interesting reading is the 1972 book edited by Bordeaux and Brannon, which devotes several chapters to issues very similar to those currently being raised about the future of tobacco in the Kentucky news media.

The 1990s could perhaps be labeled the "value-added" era. College of agriculture administrators, increasingly convinced of the need to promote the importance of agriculture within the state (and national) economy, decided that agriculture would seem more important to policy makers if "value-added" could be increased. Concomitantly, large-scale poultry and hog processing companies were seeking new sites to locate plants, and for a variety of reasons, Kentucky appears to be a prime site.

So suddenly, rural development becomes the vehicle by which value-added processors of agricultural commodities are attracted to the state. At this point, the role for the college of agriculture and for rural development education becomes very murky. On one side, college of agriculture administrators see attracting these kinds of operations as important in an overall political strategy for building the case that agriculture is important to a state's economy and deserves continuing and increasing federal and state tax dollars. On a more micro level, hog production scientists, for example, might see growth in the size of the state's hog industry as beneficial in highlighting the need for good scientific research and education aimed at improving hog production, despite the increased reliance on contracting and large scale production.

But everything quickly becomes more complicated for a number of different reasons, and whether or not successes in attracting such operations to the state translates into political gain for the college becomes less and less clear. Heffernan is concerned about the welfare losses of agricultural industrialization to society and the impacts on rural communities. He raises the important question of who within colleges of agriculture is studying these kinds of problems, particularly when political forces are at work aimed at trying to make the case that agriculture is extremely important to a state economy. These concerns are important enough to raise an issue as to the entire role that the college should be playing in such instances.

A rural development specialist would say "Wait a moment!" Locating a chicken or hog processing facility within a rural area poses a complicated set of concerns--concerns that are at the very heart of what educational work in community development is all about. These concerns relate not only to issues such as the environmental consequences of such a plant, but also a complex array of questions relating to how workers at the plant are to be provided with basic needs and services such as housing and schooling. While these plants create employment, jobs in these plants tend to be comparatively low-wage, high turnover jobs. Many of these jobs will likely be filled by workers who previously did not reside in the community. Whenever in-migration of this sort occurs, the local community is reshaped, sometimes in very unexpected and undesired ways. Whether or not long-time residents benefit in part depends on whether or not there exists a pool of workers already in the area who would be increasing their standard of living by taking employment in the plant. In addition, there are a host of environmental and other concerns that go beyond the plant itself, for example, to the large scale operations supplying the plant. These are complicated questions and issues to say the least--questions which cannot be quickly and readily answered.

And there are also concerns with respect to specifically how these operations will benefit the college of agriculture. Clearly, job opportunities will increase for graduating students interested in management or technical support (genetics, nutrition) positions at the processing facilities and even at many of the large scale production facilities. But other the benefits are less clear. Processors are producing a specific product for market, and rely on their own geneticists and nutritionists to make sure that will happen. (Colleges of agriculture will likely educate many of these, but they will be employed by the company not the University). Producers of chickens or hogs for these operations will rely on the contractor not college of agriculture personnel for the information necessary to produce according to contract specifications. Even the need for, say, a marketing economists has been eliminated, since the contract specifies a specific price regardless of short-term market conditions.

Some Empirical Evidence

This section of the paper provides empirical evidence to suggest that some of these arguments for increased public sector support for technology-based research cannot be justified on the basis of simple calculations done on readily available historic data. In particular, we will show here that in the post-World War II era, a nearly 50 year period for which reliable data are available, these technological gains have resulted in no real growth in the size of the crops and livestock sectors, if the size is measured in real dollars. Instead, the benefits of the productivity gains have largely gone to consumers, who are able to purchase food less expensively than might have been the case had the productivity gains not have taken place.

Basic Food Demand Theory

The statement that the demand for food by those who are both willing and able to purchase it is price inelastic has been a basic teaching within introductory agricultural economics courses for many decades. This statement is ordinarily explained by the rationale that a consumer can only eat a certain amount of food before becoming satiated, or as it was once explained to me, "the aggregate demand for food is price inelastic because people's stomachs are, ultimately, *inelastic*." If the price of food goes down (the expected result of technical productivity gains the production of raw agricultural commodities), consumers will respond to a certain degree by purchasing additional food. But, in the aggregate, there will be only a small percentage increase in the amount of food purchased even in response to a rather large percentage decrease in the price of food. This is the basic interpretation of the inelastic demand. The exact elasticity of demand for food in the aggregate could be empirically estimated. Chennareddy and Jones argue that this inelasticity of demand is ultimately a major reason why labor has moved from the farm to the non-farm sector.

Suppose that the total revenue (TR) function for the firm is

$$TR = PQ$$

Then marginal revenue (MR), or dtR/dQ is

$$MR = dTR/dQ = P + Q(dP/dQ) = P[1 + (Q/P)(dP/dQ)]$$

$$= P[1 + 1/E_d]$$

where E_d is the elasticity of demand.

If the elasticity of demand is negative but inelastic, that is $-1 < E_d < 0$, (as would be the case with an inelastic aggregate demand for food) them Marginal Revenue in response to an increase in output would always be negative. This means that any attempt by farmers to increase the aggregate returns to the farming sector by increasing output in the aggregate would instead result in a decrease in aggregate returns. Assume that R is some aggregate measure of agricultural research and information, and that as R increases, gains in productivity increase Q.

Then,

$$\frac{dTR}{dR} = P(Q)\frac{dQ}{dR} + Q\frac{dP}{dQ}\frac{dQ}{dR}$$

Simplifying

$$\frac{dTR}{dR} = P(\frac{P}{P} + \frac{Q}{P}\frac{dP}{dQ})\frac{dQ}{dR}$$

Therefore

$$\frac{dTR}{dR} = P(1 + \frac{1}{E_d})\frac{dQ}{dR}$$

$$\frac{dQ}{dR} > 0$$

$$P > 0$$

$$(1 + \frac{1}{E_d}) = ?$$

$$if\ -1 < E_d < 0,\ then\ \frac{dTR}{dR} < 0\ !!!$$

Hence, whether agricultural research and education increases or decreases total revenue clearly depends on the aggregate elasticity of demand for crops and livestock. If the elasticity of demand for agricultural commodities lies between zero and -1 (inelastic), then aggregate gross income from the sales of crops and livestock will *always* be reduced as a result of the increase in agricultural research and education.

With increasing industrialization and rising per-capita and family incomes, consumers in the US and in other developed nations spend an ever-decreasing share of their incomes on food. This, in turn, leads to a demand for agricultural commodities within developed nations that becomes gradually more inelastic over time, as food becomes a smaller and smaller share of the consumer's total budget. This is exacerbated by the movement toward eating food prepared away-from-home, and the increasing share of grocery store items purchased that have a low farm-level value.

The trend that makes the farm-level demand for agricultural commodities in developed nations gradually become more inelastic over time can be partially offset by increasing demand for US exports of agricultural commodities, but this will take place only if developing countries have the increasing incomes and willingness to purchase US exports. Most developing nations would prefer to improve their own ability to produce food rather than increasingly rely on exports from the US and elsewhere on a long term basis. The increases in agricultural commodity prices that took place in the 70s were largely attributable to temporary increases in exports to countries that could afford them.

The export "bust" that followed was blamed on factors such as the US embargo of grain sales to the Soviet Union, but reasons for the decline in US exports were far more complex. Much of the decline could instead be atributed to an increasing capacity to produce agricultural commodities in countries who were formerly major purchasers of US agricultural commodities. To illustrate, Saudi Arabia, through massive irrigation projects, became an exporter of wheat, and China became an exporter of soybeans, leading to increased supplies of both grains on world markets and lower world prices.

Supporting Evidence in the Data

Is this simple and basic theory supportable from evidence contained in the data? It is widely believed by administrators of colleges of agriculture and by many agricultural scientists that rapid technological advances in the production of crops and livestock make farmers far better off than they would have been had these technological advances not taken place. If this were true, however, we would be observing gains in cash receipts from the sale of crops and livestock in the aggregate once these returns have been adjusted for the effects of inflation.

Table 1 presents data on cash receipts from the sale of crops and livestock for the US and for Kentucky during the time period from 1949-1995. Once the data are adjusted by the CPI we see that (1) Real cash receipts for the entire US are only slightly higher for 1995 than for 1949, and cash rêal cash receipts for 1951 are actually higher than the 1995 level; and (2) Real cash receipts for Kentucky of 2.008 billion dollars in 1995 are slightly *lower* than the 2.234 billion dollar level in 1949. These data are converted to real terms by using the CPI adjustment with 1982-84 = 1.00. These numbers provide empirical support for the theoretical arguments made above.

Figure 1 illustrates these data in graphical form, and also permits a meaningful comparison of how the Kentucky agricultural economy is faring relative to the entire U.S. Since 50 states constitute 100 % of cash receipts from the sale of crops and livestock, an "average" state would be producing 100%/50 = 2% of the total. The scale on the right hand axis, used for the Kentucky data, is exactly 2 % of the scale used on the left hand side, for the US data. Thus, if the line representing Kentucky just touches the US line, it is an "average" state. If line for Kentucky to rise above the US line, this would suggest that Kentucky is producing greater than a 2 % "average share. However, except for a brief period in the early 80s, sales of crops and livestock in Kentucky have remained somewhat below the 2 % average level. The strength of the Kentucky agricultural sector in the early 80s reflects the strength of the tobacco sector during that period, whereas many of the other states were more negatively affected by weaknesses in grain than was Kentucky. Further, Kentucky agriculture is more reliant on livestock agriculture than many other states and livestock agriculture was less affected that crops agriculture in the crisis if the early 80s. In addition the strength of the horse industry in the early 80s--counted in Kentucky's livestock cash receipts--was a factor.

The fact that cash receipts for the entire US and for Kentucky in real terms in 1995 remain approximately at or even below 1949-51 levels confirms our theory. Despite massive increases in the volume of crops and livestock produced (arising from technology gains via public and private sector research) there are no real increases 1949-95. Of course, there were some short run increases in the mid to late 70s, but the long run pattern quickly re-emerged with the early 80s downturn. As technologically-induced productivity gains reach the market, any increase in revenue arising from the fact that more output is sold is at least if not more than offset by a reduction in price--exactly what would be expected if the demand for agricultural products in the aggregate is inelastic. *It is important to realize that if size is measured in real dollars, neither public nor private sector research or education has made the agricultural sector larger--in the US or in Kentucky, if the size of the sector measured in real dollars rather than in the physical volume of output!*

If not in the aggregate, are there perhaps still gains on a per-farm basis? Is it possible that if the size of the crops and livestock producing sectors is not growing in real terms, could it be that individual farmers are still better off as a result of the productivity gains. The analysis quickly becomes more complicated here, in part because of the changes that the US Bureau of the Census has made in the definition of a farm. The most important of these changes occurred in 1974 (Figure 2). Figure 3 illustrates real sales of crops and livestock per farm in each year for the US and Kentucky divided by the total number of farms. There was a rather steady rise from 1949 to 1973, a period in which the census definition remained constant. Kentucky farms are, on average, considerably smaller than the average US farm. In percentage terms, however, the gains for individual farms over the 1949-74 period for Kentucky were similar to those for the US as a whole. In part because of the 1974 changes in the census definition significantly reducing the farm number count and in part because of the strong performance of the aggregate farm economy in 1974, there was a very strong increase in real sales of crops and livestock per far, and real sales remained abnormally strong until the equally spectacular downturn in the early 80s.

Notice that the US trends, while apparent also in the Kentucky data, are somewhat muted in comparison. This was probably because income from tobacco and from livestock--comparatively important in Kentucky cash receipts tended to be more consistent than income from the sale of grain crops--sources of income that are very important in the national data and which were hard-hit in states such as Iowa, Illinois and Indiana.

The most disconcerting evidence contained in Figure 3 is that for both the US and for Kentucky, since the mid 1980s, real sales of crops and livestock per farm have stalled. Real sales per farm have not returned to the long term positive trend that was persistent in the years between 1949 and 1973. Over the past ten years, there the "average" individual farmer has not sold more real dollars of product!

Cost Structure Impacts

One criticism that could be levied at this analysis is that real cash receipts do not take into account costs of production. Perhaps new technologies have reduced costs of production and thus increased real returns over cost, which, in turn would increase net farm income in the aggregate even as cash receipts remains constant in real terms. I have even heard some agricultural administrators who, having confronted the realities of an inelastic aggregate demand, argue that the focus of agricultural research and education should be (is) to assist farmers in lowering production costs, not to help them increase output. They might accept the argument that increasing output in the face of an inelastic demand could cause aggregate revenue to decline (because of the price consequences of an inelastic demand), but surely, if production costs could be reduced, then farmers in the aggregate would be more profitable and better off.

Unfortunately there are basic flaws in this cost-reduction-as-the-route-to-profitability reasoning that are also solidly grounded in economic logic. Costs of production are as much an *outcome* of a particular technology and set of market conditions as they are a factor. Consider a farmer who is successful in reducing the production costs of, say, corn, resulting in a greater net return per acre. The fact that the production costs are lowered makes the farmland used in growing the corn more valuable. To the extent that other farmers adopt the new technology which reduces production costs, their land becomes more valuable as well. In short, any short-run gains from the cost-reducing technology quickly becomes capitalized into the price of farmland.

A farmer who owns his own land might not regard an increase in the price of owned land as a "bad" outcome of having adopted a new cost-reducing technology, as this will increase the farmer's net worth. A renter may not be nearly so happy. Increases in farmland prices arising from the new cost-reducing technology will soon appear and raise rental prices. Further, the new cost-reducing technology may not be size-neutral--farmers may have to be quite large to take advantage of the technology. This sets up a bidding situation that will tend to speed farm consolidation as well as increase rental and purchase prices for land and other assets. It ultimately places farmland in the hands of operators who are quickest in adopting the cost reducing technology, since they are the ones who will be in the best position to bid the highest. So quickly, the costs once again increase, and the individual farmer--even the farmer who is fastest at adopting the new technology--is no better off than before. This leads to a search for another cost reducing technology and presses farm consolidation forward. The science that led to the cost reducing technology has ultimately had major structural impacts on farming and on the economies of many rural areas (Goetz and Debertin).

Doing an analysis such as this based on net rather than gross cash receipts invariably leads the production economist to ponder the question of what costs *should* be deducted from returns. Comparisons across farms cannot be made because the answer to this question differs for every farmer. However, assume that aggregate net returns (Π) for all farmers is equal to Total Revenue (*TR* or *PQ*) less Total Costs (C). Then,

$$\Pi = PQ - C$$

However,

$$C = C(R)$$

That is, the aggregate cost (C) depends on the particular research-based technology (R) employed. Therefore,

$$\frac{d\Pi}{dR} = P(1 + \frac{1}{E_d})\frac{dQ}{dR} - \frac{dC}{dQ}\frac{dQ}{dR} = 0 \; for \; a \; \max$$

Or (since the firm faces a constant product price) for the individual (nth) farm firm

$$\frac{d\Pi_n}{dR} = \bar{p}\frac{dq}{dR} - \frac{dc}{dq}\frac{dq}{dR} = 0 \; for \; a \; \max$$

where q is the output from the nth farm firm and c is the cost incurred by the nth firm. Thus, dc/dq will vary for farms of different sizes (output levels of q) That is, the costs will not necessarily be constant for all sizes of farm firms. Further, dc/dR ($=dc/dq \cdot dq/dR$) will not necessarily be constant for all sizes and output levels (q). This is critical, for it suggests that the technologies developed through agricultural research are not likely to be scale-neutral. The benefits to firms of such technologies will likely vary depending on the size of the firm. In all likelihood, the vast majority of technologies developed by publicly funded agricultural experiment stations will reduce costs of production to a greater extent on large farms than on small farms.

To see this, suppose that the costs associated with a new technology represent the sum of an initial outlay to implement the technology (fixed costs) plus costs that vary with the output level (variable costs). That is,

$$c_t = c_f + c(q)_v$$

where c_t is total production costs, c_f are costs associated with the initial adoption of the technology that do not vary with output, and $c(q)_v$ are costs which vary with the output level, q.

The farm firm that seeks to adopt a new technology developed either by private or publicly-supported agricultural research must first determine whether such adoption might be profitable for the firm given its current size, or output level q. The profitability of adoption will depend on whether or not the cost of the new technology can be spread over a large enough output. If the output level is too small, given the requisite initial outlay (fixed cost) the new technology might not be feasible even though the variable costs of production might be reduced. Of course, the firm also might choose with the adoption of the new technology to attempt to expand the scale of the operation as a means of spreading the fixed costs of the initial outlay over a larger number of units. Examples include a farmer who purchases high-technology grain harvesting equipment and then decides that in order to fully utilize such equipment (and thus spread the "fixed" costs over a greater quantity of output), additional grain needs to be produced, so additional land must be rented or purchased.

Consider the technologies developed by public and private agricultural research institutions. In reality these technologies exist along a fixed-variable cost continuum, but consider first two end points. Suppose there exists a new technology (call it technology A) which, if adopted, requires virtually no initial (fixed) cost outlay. Assuming that the technology is indeed output-enhancing or cost-reducing in that the costs of production per unit of output are reduced. As a result, the only barrier to adoption of such a technology is a lack of information about its availability and application.

Farmers will benefit from the adoption of such a technology only to the extent that other farmers lack sufficient information to realize that such a technology exists and will reduce production costs. To the extent that this information is not widely known, the farmers who are the early adopters will be able to realize some short-run above-normal (perhaps above zero) profits from the imperfect information situation that exists in the short run.

To the extent that the public and private educational system is effective in disseminating the information, however, other farmers will quickly adopt such technologies, these short-run profits will be eroded, and ultimately, the total revenue to all farmers as a result of the technology adoption will be reduced, according to our mathematical model based on the assumption of an inelastic demand for crops and livestock in the aggregate. That is, farmers will be worse off in the aggregate than if the technology had not been invented at all. This event then leads to a search for another newer technology, and the with process of adoption, short term profits from the information and subsequent adoption is followed by yet another round of income and profit erosion--the so-called technology "treadmill", a term first introduced in Cochrane's 1958 book (see also Tweeten, pg. 169-70).

The large firm capable of taking advantage of new technologies with high initial outlays, however, faces a somewhat different, and more favorable situation, and this ultimately is an explanation as to why agricultural industrialization is proceeding with great speed in certain agricultural enterprises such as hog production. Suppose there also exists another technology (call it technology *Z*) which, if implemented, drastically lowers per-unit production costs. However, adoption of technology **Z** requires a high initial expenditure or cost outlay. Further, in order to warrant the adoption of such a technology and its ability to reduce per unit production costs, the firm must be able to spread the initial outlay over a very large quantity of output.

Under such circumstances, only the largest and most highly capitalized firms will adopt the new technology, for it is only these firms whereby the technology is immediately cost reducing (To illustrate, the 43 hog producers with more than 10,000 sows identified in the *Successful Farming* survey cited in Benjamin). Other, smaller and less well capitalized firms will not find the new technology beneficial and its initial adoption will be impractical because they are unable to spread the initial start-up costs of the new technology over a large enough output level. Simply having information available about the new technology and its benefits will not be sufficient to result in widespread adoption, because, given the firm's size and the capital requirements needed to invest in the technology, it will not lower costs. There are, of course, an entire series of agricultural technologies (these could be labeled technology ***B*** through technology *Y*) that require different levels of initial cash outlay.

For these type Z technologies (and other "near-Z" technologies on our scale), monopoly profits for large farms can and do persist over long periods of time, and because of ready access to capital markets, the large firms generally have a significant edge over smaller operations in implementing the technology. However, this is also the whell-known technological force that drives farm consolidation, as farm firms increasingly attempt to acquire enough land and other resources to make the technologies with the high initial capital outlays feasible within the scale of their operation.

The dilemma agricultural experiment stations face is as follows. Plant and animal scientists often work on developing agricultural technologies with little concern for the potential applicability of such technologies to farms of varying scales of operation (output levels). But the various research activities underway often vary significantly with respect to their potential adaptability for farmers in various size classes. Generally, technologies requiring specialized and large up-front capital investments will hold the greatest appeal to large commercial operations, but be of little use to part-time, small or even medium size units. A simple scoring method could be developed to compare the capital investment requirements for the various proposed technologies.

It at first would seem logical to argue that publicly supported agricultural experiment stations could increasingly focus their primary efforts on the development of new technologies that require little up-front (fixed) cash outlay, leaving the other technologies to the private sector. In other words, colleges of agriculture might redirect their primary emphasis on the development of technologies that could be readily adopted by small-and medium size producers, and let the private sector develop the technologies needed for the large-scale operations. There is an obvious, populist, "appeal to the masses" feel to this entire approach--rooted in 19th century land grant tradition--something that agricultural administrators in most states would be comfortable with and likely embrace.

But important problems remain. First, if such a refocusing takes place, the agricultural experiment stations are ultimately eroding aggregate real farm income. Only to the extent that some farmers--through lack of information--do not adopt these technologies (and therefore lose!) will other farmers ultimately benefit. But every effort within agricultural extension is being made to make certain that publicly-produced information about new agricultural technologies is disseminated as rapidly and as widely as possible. This makes profits to early adopters of low-capital-outlay technologies short-lived at best, and, if they are indeed scale-neutral, large-scale operators will quickly adopt as well, since the information is freely disseminated. Over time public-sector agricultural research will likely have an impact on an ever smaller share of total agricultural output, as large-scale producers continue to produce an increasing share of agricultural commodities, and as they rely ever more heavily on the private sector and their own internal research. The political implications of all of this for continued funding of publicly-supported agricultural are murky at best.

Consumer Benefits and Concerns

Consumers, of course, have benefitted from productivity gains in that they are able to purchase certain commodity-like items (flour, hamburger) at the grocery stores less expensively than if the technologies had not been adopted by farmers. But with changes in social and work-related demographics (i.e. wives who work) and an increased emphasis on highly processed prepared foods and foods eaten away from home, gains that permit consumers to buy raw hamburger and flour less expensively over time become less and less important as a percentage of the total family budget. These findings have important implications for future public support of research and educational programs aimed primarily at improving agricultural production technologies.

Consumers generally have not often been a significant factor in the support of public research and educational programs aimed at increasing productivity and lowering production costs for crops and livestock being produced by American farmers. Consumers see prices for food not as the prices farmers receive for raw agricultural commodities, but rather as the prices paid for the final product sold through the grocery store or at the local restaurant. The increasing number of families in which both adults work--and increased numbers with only one adult income earner--means that less and less time is spent in the kitchen while an ever increasing share of food is eaten away from home in restaurants. Even if the food is still eaten at home, an ever larger share is obtained at a takeout window of a fast food restaurant or delivered directly to the home.

Even the grocery stores have adapted to this trend of less and less time spent preparing meals in the kitchen as the deli and prepared frozen food sections of grocery stores increase in importance while the sections of stores devoted to basic items such as flour and raw unprepared meats become a less and less important component. Note particularly that the sections of grocery stores in which the farm value of the product is high as a percentage of the price paid by consumer are becoming smaller and smaller, even as increased amounts of space are devoted to highly prepared items in which the farm value for the raw commodities used as the basis for the product represents but an insignificant share of the final price paid by the consumer. Since the "marketing margin" (the difference between the farm value of the raw agricultural commodity and the price paid by the final consumer) is affected by so many factors other than the price of the raw agricultural commodity--costs like labor and transportation--for most grocery store items it is unlikely that any reduction in the price of the raw agricultural commodity attributed to agricultural research and education will even be noticed by the consumer. Improvements that reduce costs built into the marketing margin will likely be far more noticeable. Interestingly, there is far more consumer interest in issues such as food safety and quality than in issues related to further reducing costs in the production of raw agricultural commodities.

Epilogue

To a large degree, colleges of agriculture have been victims of their own successes. The efficient development of labor-saving output-enhancing new technologies ultimately freed vast numbers of workers from the agricultural labor force, as well as reduced the number of people who directly benefitted from the technology gains. Over the past 40 years, farmers in the aggregate have not seen real incomes rise as a result of the productivity gains. While it is true that consumers have benefitted from the abundant and cheap food made possible by these output-enhancing labor-saving technologies, in recent years the impact has been muted because of a number of other long-term national trends. For example, rising incomes have meant that fewer and fewer consumers spend a significant share of their food dollar on basic food items with a high farm-level value. The trend toward families in which both adults work has fueled the growth in the number of restaurants and other places where pre-prepared food is available. The further a food item is away from its basic form, the less likely the consumer will notice any savings due to improved efficiency of the production system at the farm level.

Until recently, colleges of agriculture have felt comfortable working on improving farming methods for all but the largest of farm operators. Agricultural industrialization is changing all of this. If the results of the Successful Farming survey cited in Benjamin are to be believed, fewer than 50 of the largest hog producers are accounting for 40 percent of the hog output in the US. Even if publicly supported agricultural scientists could identify technologies that could be helpful to such large scale operations, it is not all clear why the public should be spending scarce tax dollars to help operations of this size.

There are no simple or obvious solutions to these problems. However, it is important to recognize that it is no longer possible to assume that any technology that enhances the productivity of agriculture will automatically lead to an improved well being for farmers, rural people or for society in general. Colleges of agriculture need to quit focusing on improving the productivity of commercial agriculture, and begin to identify problems and solutions that will enhance the well being of rural people--whether they are engaged in farming or not.

Notes

[1]A third category of farmers is sometimes added here, called "subsistence" farmers. These are farmers who rely on the sale of crops and livestock for most of their income, and do not have significant off farm earnings, but lack sufficient size and access to capital necessary to produce enough income to support a family at above a poverty level. The output of the farms in the aggregate represents a very small percentage of the output produced by the commercial farmers. Like part-time farmers, subsistence farmers produce only a small amount of output, but subsistence farmers live in a very different world from mopst part-time farmers.

[2]Some decisions normally considered part of livestock production management include the choice of animals to be fed, the ration to be fed, the time over and weight to which the animals are fed, as well as marketing decisions directed toward getting the best price for the feed animals. In the case of contract production, all of these decisions are part of the contract agreement, and, once signed, the farmer no longer makes these decisions. The contractor is simply paying the farmer a fee for his skills and labor in producing the animals exactly as specified, and there is little if any "farm management" involved other than making the decision whether or not to produce for the contractor. Note here that many of the management decisions that are removed are decisions that agricultural extension has traditionally provided assistance to farmers.

[3]Deavers argues that rural places tend to have specialized economies, low density human settlements and remoteness from large urban centers. A college of agriculture emphasizing rural development would focus on problems facing those living in areas defined by these characteristics, whether they are farm or non-farm. See Deavers for a discussion of "What is rural?"

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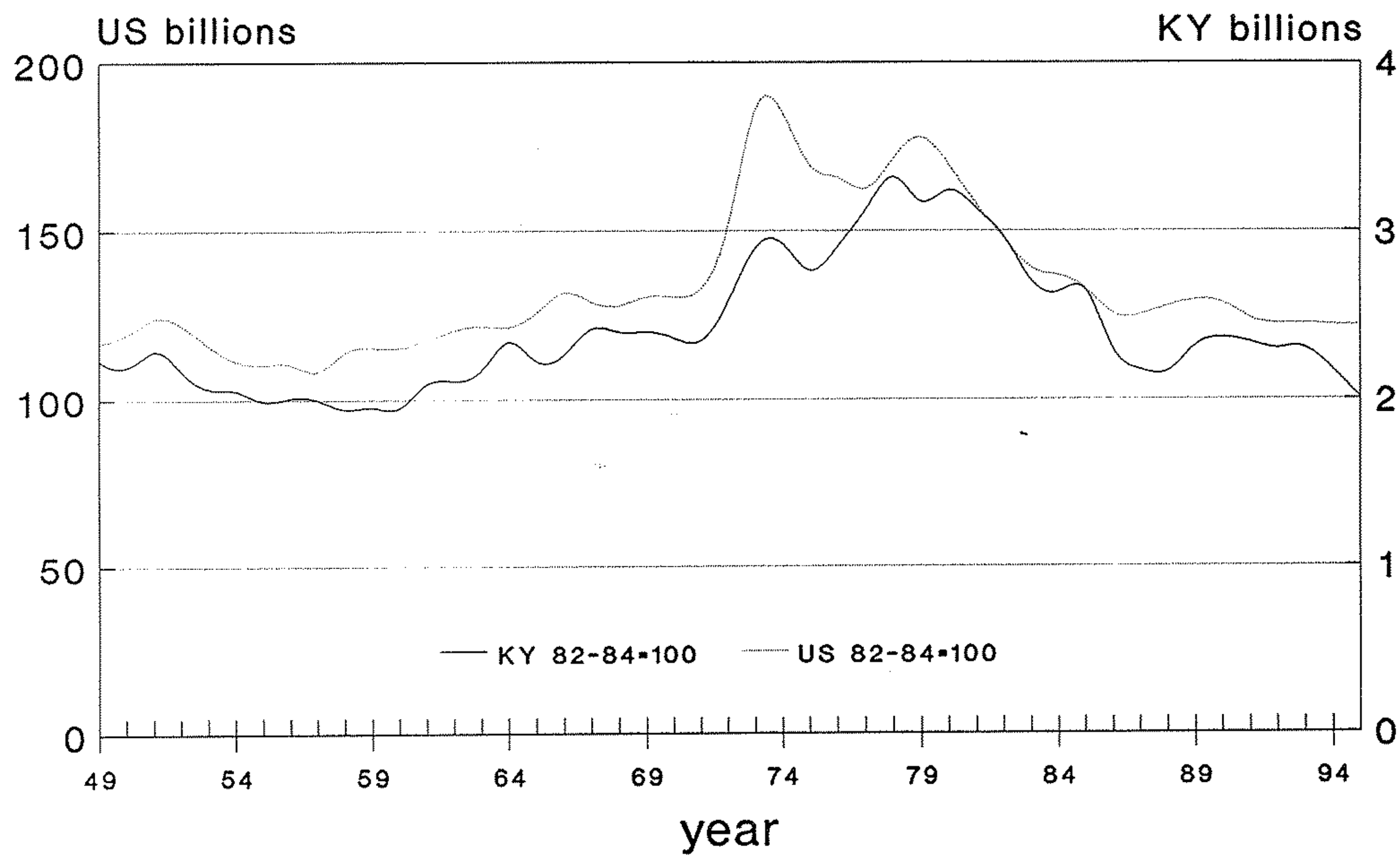
Table 1. Current and Real Cash Receipts from the Sale of Crops and Livestock, US and Kentucky, 1949-1995, (1982-84=100)

Year	CPI 1982-84=100	Cash Receipts Kentucky (Millions)	CPI/100	Real Cash Receipts Kentucky (MIllions)	Cash Receipts US (Millions)	Real Cash Receipts US (Millions)
1949	23.8	531.7	0.238	2234.	27805.	116829.
1950	24.1	511.0	0.241	2120.	28461.	118095.
1951	26.0	622.8	0.260	2395.	32857.	126376.
1952	26.5	570.2	0.265	2152.	32528.	122747.
1953	26.7	545.1	0.267	2042.	31001.	116110.
1954	26.9	559.3	0.269	2079.	29832.	110900.
1955	26.8	525.5	0.268	1961.	29490.	110039.
1956	27.2	550.2	0.272	2023.	30401.	111771.
1957	28.1	565.6	0.281	2013.	29714.	105745.
1958	28.9	553.9	0.289	1917.	33455.	115764.
1959	29.1	575.6	0.291	1978.	33647.	115626.
1960	29.6	560.6	0.296	1894.	34012.	114906.
1961	29.9	640.0	0.299	2140.	35163.	117604.
1962	30.2	633.8	0.302	2099.	36468.	120757.
1963	30.6	650.8	0.306	2127.	37477.	122474.
1964	31.0	755.2	0.310	2436.	37325.	120405.
1965	31.5	685.1	0.315	2175.	39364.	124968.
1966	32.4	724.7	0.324	2237.	43435.	134059.
1967	33.4	826.3	0.334	2474.	42817.	128196.
1968	34.8	826.6	0.348	2375.	44183.	126964.
1969	36.7	886.3	0.367	2415.	48179.	131278.
1970	38.8	920.2	0.388	2372.	50508.	130177.
1971	40.5	927.3	0.405	2290.	52748.	130242.
1972	41.8	1071.4	0.418	2563.	61105.	146186.
1973	44.4	1315.7	0.444	2963.	86886.	195689.
1974	49.3	1464.9	0.493	2971.	92390.	187405.
1975	53.8	1439.4	0.538	2675.	88901.	165245.
1976	56.9	1658.1	0.569	2914.	95355.	167584.
1977	60.6	1879.1	0.606	3101.	96234.	158803.
1978	65.2	2238.4	0.652	3433.	112360.	172332.
1979	72.6	2230.0	0.726	3072.	131529.	181170.
1980	82.4	2728.9	0.824	3312.	139736.	169583.
1981	90.0	2804.6	0.900	3116.	141615.	157350.
1982	96.5	2892.4	0.965	2997.	142561.	147732.
1983	99.6	2644.8	0.996	2655.	136770.	137320.
1984	103.9	2700.3	1.039	2599.	142784.	137424.
1985	107.6	2975.5	1.076	2765.	144114.	133935.
1986	109.6	2422.1	1.096	2210.	135360.	123504.
1987	113.6	2478.8	1.136	2182.	141796.	124821.
1988	118.3	2499.5	1.183	2113.	151243.	127847.
1989	124.0	2921.8	1.240	2356.	160809.	129685.
1990	130.7	3098.7	1.307	2371.	169517.	129700.
1991	136.2	3196.1	1.362	2347.	167863.	123248.
1992	140.3	3194.0	1.403	2277.	171345.	122128.
1993	144.5	3405.9	1.445	2357.	177617.	122919.
1994	148.2	3220.2	1.482	2173.	180775.	121980.
1995	152.4	3059.5	1.524	2008.	185750.	121883.

Figure 1. Real Sales of Crops & Livestock, US and KY, Adjusted for Inflation, 1949-1995



KY scale is 2% of the US scale
2% is an "average" agricultural state

Figure 2. U.S. and Kentucky Farm Numbers
1949-95

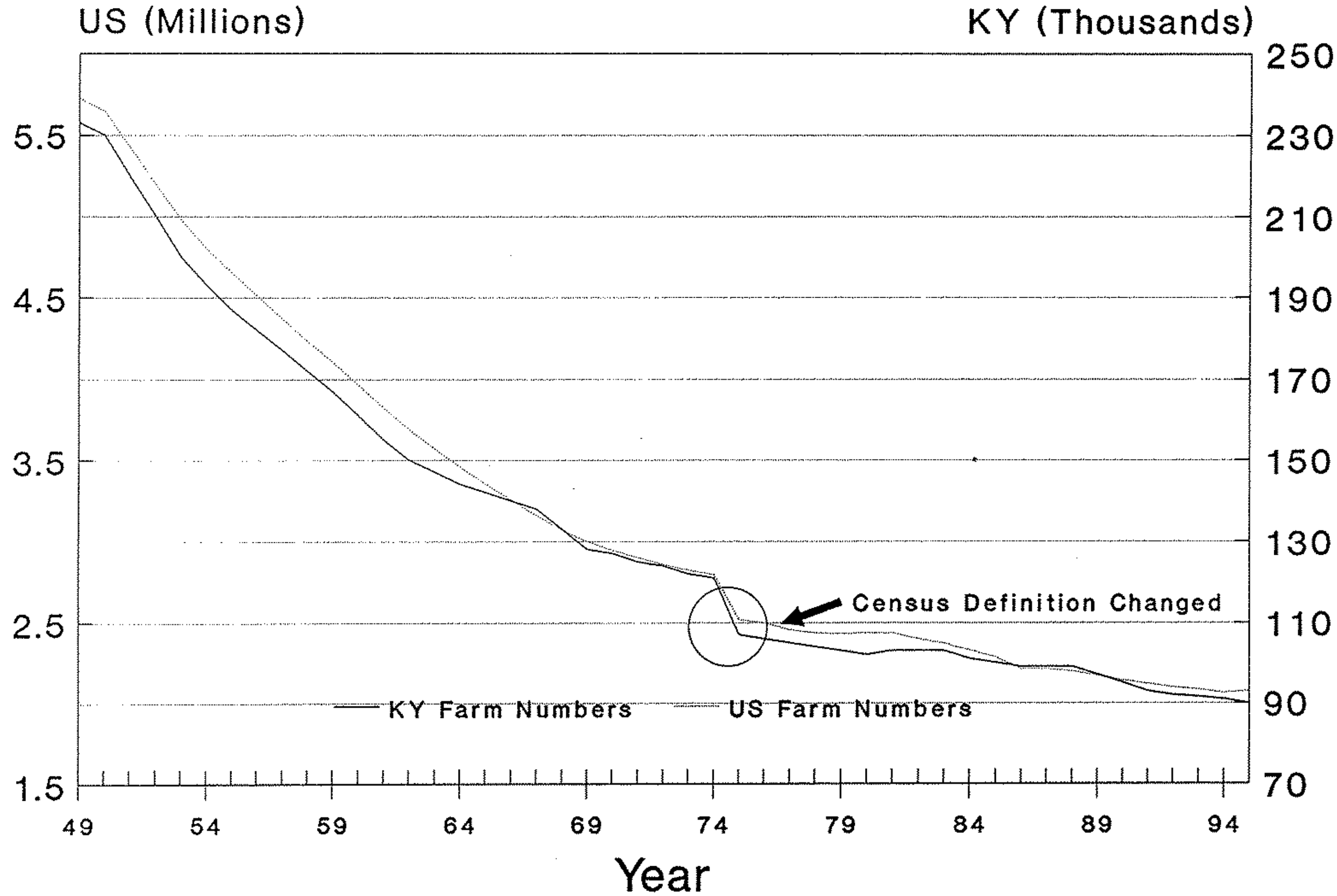


Figure 3. Real Sales of Crops & Livestock Per Farm, U.S. and Kentucky 1949-1995