Resources & Environment


USDA

Ag Productivity Continues Healthy Growth

The agricultural sector has one of the highest rates of productivity growth among U.S. industries. Agricultural productivity increased at an average annual rate of 1.89 percent from 1948 to 1996. From 1990 to 1996, agricultural productivity increased 2.14 percent per year on average.

Productivity in the agricultural sector over 1948-96 exceeds the 1.3-percent rate for manufacturing—an industry considered to have relatively high productivity. Moreover, the increase in U.S. agricultural output was entirely the result of productivity growth. Output grew at an annual average rate of 1.8 percent, with real expenditures on inputs declining slightly—by about 0.1 percent. In contrast, output increases in many sectors of the economy were largely the result of growing expenditures on inputs. For manufacturing, which is second only to the services sector as an employer in nonmetro areas, only 40 percent of the increase in output growth came from productivity growth.

Productivity captures the growth in output not accounted for by the growth in production inputs. It is most commonly expressed as total factor productivity (TFP), a ratio of total outputs to total inputs, each measured as an index. An increase in the ratio of total outputs to total inputs indicates that more outputs can be produced with a given level of inputs.

Increased productivity improves society's standard of living by producing products using fewer inputs. As productivity levels in one sector of the economy rise, resources are available for use by other sectors. The high levels of agricultural productivity have freed up resources such as labor that would otherwise have been used to meet the food needs of the population.

Increased productivity also improves the standard of living by lowering the real prices of goods and services. Agricultural productivity gains are passed on to the consumer in the form of lower food prices. Other sectors of the economy also have a large effect on food prices— agriculture's share of the food bill is only about 23 percent, with the rest accounted for by processing, packaging, and transporting and other marketing costs. The average annual productivity growth rate of 0.8 percent for "food and kindred products" for 1949-93 was well below agriculture's high levels.

As increased productivity lowers real farm prices, the international competitive position of U.S. agriculture improves. High productivity has been a factor in making the U.S. the world's leading agricultural exporter and in sustaining the trade surplus enjoyed by U.S. agriculture despite a trade deficit for the U.S. overall. The share of U.S. agricultural production exported is more than double that of other major U.S. industries.

Trends in Farm Productivity, Input Use, & Output

The period immediately after World War II, sometimes referred to as the "second American agricultural revolution," ushered in some key technological changes in the sector. This period saw completion of the transition from animal to tractor power and the application of science to farming: use of hybrid seeds, adoption of improved livestock breeding, and the use of more agricultural chemicals, both fertilizers and pesticides. Adoption of many of the practices required additions to the capital complement of farming as well as the development of specialized information systems. Technological developments over the period have allowed agriculture to increase production while using inputs more efficiently.

The 1.8-percent average annual growth in farm *output* over 1948-96 combines a 1.66-percent average rate of growth for livestock products and a rate of 1.84 percent for crops. While cattle and other meat animals represent the largest component of livestock output, poultry and eggs grew the fastest (3.58 percent vs. 1.23 percent for meat animals). Dairy output during 1948-96 grew less than 1 percent per year on average.

Annual output growth rates for crops over 1948-96 have been more variable than for livestock, largely reflecting variation in crop yields in response to weather. The late 1940's through the 1960's, characterized by unusually mild weather, saw unusually stable crop yields. In contrast, weather since the 1970's has returned to the more usual, variable conditions, including the extremes of high temperatures, drought, and early frost in 1983, drought in 1988, and extensive flooding in 1993.

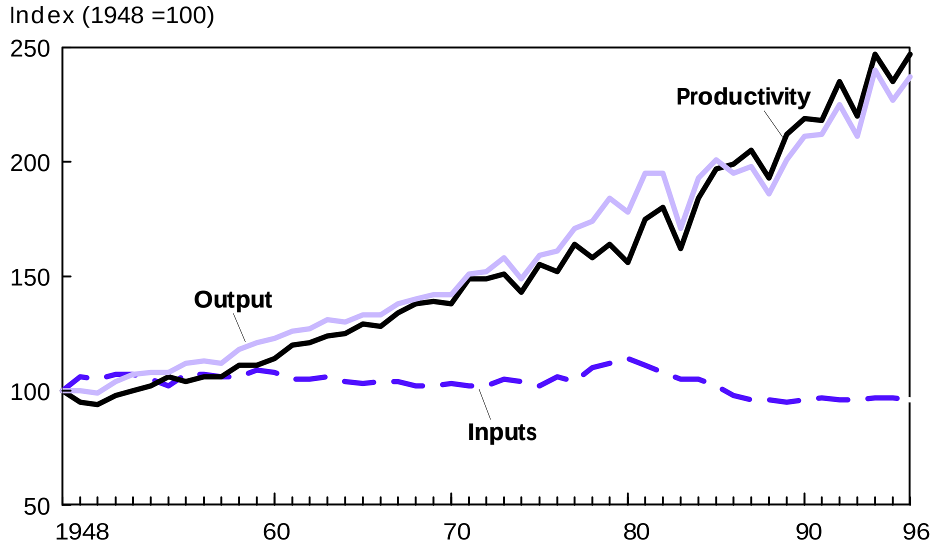
Events other than weather have contributed to variation in overall output growth. In the 1970's, with export demand strong, the average annual rate of growth in agricultural output was 2.25 percent per year. As short-lived concerns over food scarcity in the 1970's gave way to expectations of chronic surpluses in the 1980's (and subsequent farm policy to limit field crop output), output growth slowed to 1.68 percent annually.

Total agricultural *input* use has been fairly stable over much of the period. The highest annual growth rates in input use occurred in the late 1970's. For 1990-96 overall, increases in use of capital (e.g., equipment) and in intermediate inputs (e.g., chemicals, energy, and seed) have been more than offset by a decline in labor input. The measures of input use in agriculture account not only for changing quantities but also changing qualities of major inputs. For example, labor input considers not only the hours worked in agriculture, but the quality of those hours as measured by such characteristics as educational attainment of the workers.

The fairly stable total input level over 1948-96 masks differences among particular inputs. For example, intermediate inputs increased 1.25 percent per year over the period, but energy inputs increased less than 0.9 percent, and pesticides, the fastest growing input category, increased more than 6 percent per year. Synthetic pesticides were just beginning to be used in the late 1940's. By the early 1970's, a significant share of acres in major crop production was being treated. Since the early 1980's, the mix of pesticides has changed considerably. Most notably, pesticides have changed in terms of their ability to kill selected target pests and in their effects on the environment and human health. The pesticides index captures the changing quality as well as the quantity of pesticides.

Labor input in agriculture decreased consistently over 1948-96. In 1948, 7.6 million people were employed in agriculture, compared with 2.9 million in 1996. While the number of workers employed in agriculture and the total hours worked have declined, the quality per hour worked has increased. For example, in 1964, only about one-third of all farmers had completed high school, compared with more than three-quarters of farmers by 1990. The labor input index, which accounts for both number and quality of hours worked, dropped at an average rate of 2.51 percent per year. Adjustment for gains in labor quality lowers the rate of decline in the labor input index.

Productivity Continues To Be the Engine of Growth in Agriculture



Economic Research Service, USDA

On an annual basis, *productivity* growth rates were generally positive during 1948-96. Through the mid-1950's, however, productivity growth was very slow, and at times even negative, as capital and intermediate inputs increased at very high rates, capturing the rapid movement toward mechanization on U.S. farms. Productivity growth was fairly stable through the 1960's. During the 1970's, demand for U.S. exports increased significantly, and many U.S. producers geared up to meet the demand. The average annual rate of growth in productivity during the 1970's, however, was considerably less than in the 1960's, since nearly half of the output growth over this period was accounted for by increased inputs. Growth in intermediate inputs increased 2.5 percent per year on average during the 1970's.

As the sector went through financial restructuring in the 1980's, capital (equipment and land) and intermediate inputs declined, with negative growth rates observed in all major input categories except pesticides. Land area idled in 1983 totaled 80 million acres as a result of acreage reduction and Payment-in-Kind programs. Growth in output averaged only 1.68 percent in the 1980's, but the decline in inputs resulted in fairly high rates of growth in total factor productivity. The 1990's saw a continuation of above-average rates of growth in productivity. Output growth was above average from 1990 to 1996, with input growth, while slightly negative, not as low as in the 1980's.

U.S. productivity growth rates mask variations across States. Over 1960-93, average annual TFP growth in the 48 contiguous States was approximately 2 percent. Most States with TFP growth rates higher than 2 percent were located in the eastern U.S.—the exceptions were the Northwestern States (Washington, Oregon, and Idaho), Utah, and North Dakota.

Five New England States experienced negative rates of growth in real output over the time period. About three-quarters of the 48 contiguous States experienced negative growth rates in input use, the same as the aggregate U.S. trend. Interestingly, most of the top 10 producing States, when ranked by value of farm marketings, did not have TFP growth rates above the U.S. level. USDA's Economic Research Service is currently investigating the reasons for variations in TFP levels by State and is separating productivity into its components—efficiency, technological change, and scale effects.

What Affects Agricultural Productivity?

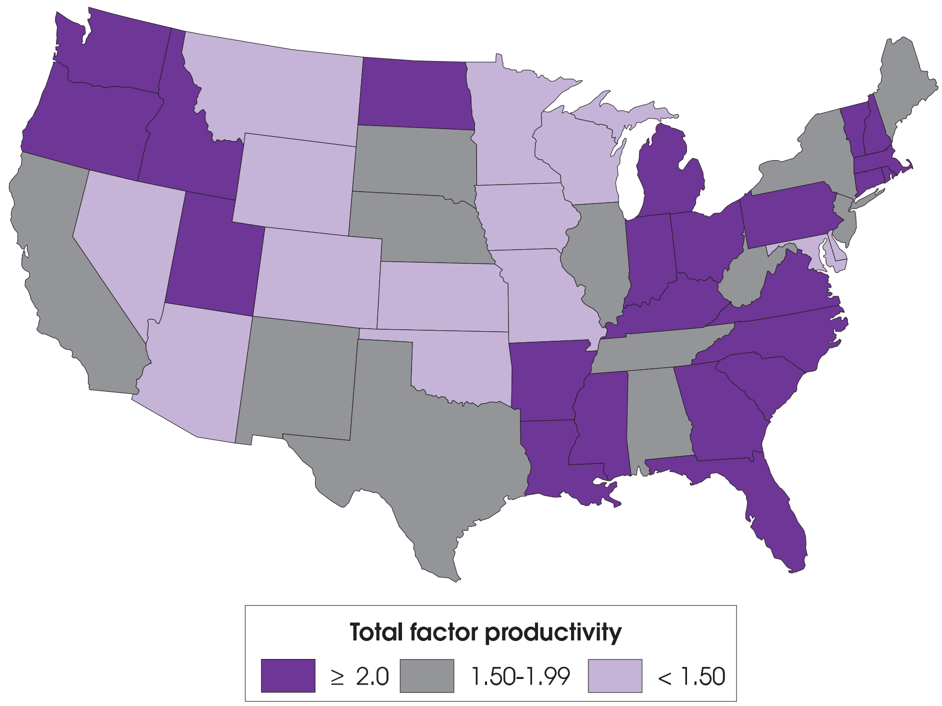
Productivity gains over 1948-96 are the result of an array of factors that include weather, the economy, and public and private investment. Weather is a major, unpredictable external factor in year-to-year productivity. Shocks to the general economy, because they affect relative prices, can in turn affect resource allocations in agriculture. Pressures on relative prices are often cited as an important source of technological innovation in agriculture, through a mechanism known as the "induced innovation concept."

For example, increases in the price of labor relative to the price of capital may induce farmers to substitute more capital for labor. A change in relative prices may also induce private firms (for example, farm machinery companies) to develop new technologies that save on the relatively more expensive input. Economic research has shown that induced innovation forces are particularly strong for inputs that are actively traded, such as fertilizer, but less so for inputs that are less actively traded, such as land.

The social science literature has identified five factors as the key sources of productivity change in agriculture that have implications for public policy. The five are research and development, extension, education, infrastructure, and government programs. Productivity measures provide no information about the separate role of each of these factors. However, an understanding of these factors is of interest because of their potential impact on the components of productivity, and because of the impact of productivity growth on a society's standard of living.

Research and development. Agricultural research is essential not only to increase agricultural productivity, but to keep productivity from falling. For example, yield gains for a particular plant variety tend to be lost over time as pests and diseases evolve that make the variety susceptible to attack. Thus, a large share of agricultural research expenditures is devoted to maintenance research. The results of agricultural research, in addition to higher yielding crop varieties, include better livestock breeding practices, more effective fertilizers and pesticides, and better farm management practices.

States With Highest Farm Productivity Growth Rates Are Concentrated in the Eastern U.S.



Compound annual average growth rates for total factor productivity, 1960-93.
Economic Research Service, USDA

Farmers benefit from agricultural research in the short run because of lower costs and higher profits. The longrun beneficiaries of agricultural research are consumers, who pay lower food prices. Agricultural research also helps the U.S. maintain its competitiveness in world markets.

Agricultural research is performed by both the private and public sectors. Private-sector research focuses mainly on farm machinery, agrichemicals, and food processing. Previous economic analyses have shown that both public and private research have positive effects on agricultural productivity, with public research having a greater impact than private research, particularly in the long run. A number of studies have measured the impact of public agricultural research on productivity and the benefits of public agricultural research relative to the costs. Most studies have found rates of return to public investment of 20 percent to 60 percent.

Private research expenditures have increased dramatically during the past three decades and now surpass those of the public sector. By contrast, the rate of growth in public research expenditures has slowed significantly since the mid-1970's, although demands on agricultural research have expanded to include environmental protection and food safety. There is some evidence that public investment in research increases the amount of private research. To the extent that public research stimulates private research, the returns to public research are underestimated.

Extension. The agricultural production extension system is aimed at reducing the time lag between the development of new technologies and their adoption. A particular research project may take several years to complete, and it takes time for farmers to learn of the innovation. Extension agents disseminate information on crops, livestock, and management practices to farmers, and demonstrate new techniques as well as consult with farmers on specific production and management problems. Extension, unlike research, can have an immediate effect on productivity.

Public extension expenditures have grown little in real terms since 1980. The Federal share of public extension expenditures has fallen steadily during the past few decades. The bulk of extension services is now provided by State and county governments. In some cases, the private sector also provides information to producers on new practices and technologies such as pest and nutrient management practices. Farmers may also consult farmer cooperatives or chemical company representatives for such advice. Empirical evidence on the rate of return to extension is more mixed than for research, with estimates ranging from 20 percent to over 100 percent.

Education. Education is an investment in "human capital" analogous to a farmer's investment in physical capital. In contrast to the more applied focus of extension activities, education provides individuals with general skills to solve problems. Farmers who have more education may be better able to assess and successfully adapt the new technologies. Current measures of labor input account for the changing educational attainment of the farm workforce over time.

Infrastructure. The most obvious example of how public investment in infrastructure might affect agricultural productivity is public transportation. An improved highway system can, for instance, reduce farmers' cost of acquiring production inputs. The decline in overall U.S. productivity in the 1970's was perhaps due in part to declining rates of public capital investment (e.g., highways and streets, water and sewer systems, schools, hospitals, conservation structures, mass transit, etc.). There is evidence that a significant positive relationship exists between infrastructure and U.S. agricultural productivity, although little work has been done to examine the relationship.

Farm Productivity in the 1990's Is Above Average

Index	1948-60	1960-70	1970-80	1980-85	1985-90	1990-96	**1948-96**
Output	1.68	1.48	2.25	2.40	0.97	2.01	1.80
Livestock	2.45	1.62	0.95	0.82	1.33	2.28	1.66
Crops	1.02	1.29	3.20	3.40	0.65	1.81	1.84
Inputs	0.67	-0.48	1.00	-2.28	-1.07	-0.13	-0.09
Intermediate	2.97	1.01	2.47	-2.95	0.33	0.45	1.25
Fertilizer	4.01	1.26	4.73	-5.73	-2.29	-1.46	1.23
Pesticides	11.40	8.68	5.98	0.26	1.44	2.68	6.42
Energy	1.96	1.16	1.85	-4.07	0.42	0.66	0.82
Feed, seed, livestock	2.20	1.59	2.05	-1.95	0.11	-0.64	1.03
Labor	-3.33	-3.36	-2.62	-2.56	-1.27	-0.28	-2.51
Hired	-2.85	-3.71	0.20	-4.46	-1.03	0.00	-2.02
Self-employed	-3.48	-3.27	-3.61	-1.93	-1.31	-0.63	-2.72
Capital	3.22	0.28	1.40	-1.52	-2.57	-0.88	0.62
Durable equipment	4.90	1.28	2.63	-3.47	-5.59	-2.78	0.75
Real estate	0.77	-0.53	0.66	-0.83	-1.26	-0.31	-0.04
Inventories	2.03	1.62	1.96	-1.22	-2.20	1.22	1.05
Productivity	1.00	1.96	1.25	4.68	2.04	2.14	1.89

Compound average annual growth rates for indexes of agricultural output, inputs, and total factor productivity.
Economic Research Service, USDA

Government programs. Government programs affect productivity through the allocation of resources. Farm programs are perhaps the best known example of government involvement in agriculture. Current farm programs generally allow market forces to allocate resources (e.g., amount of land planted to certain field crops), which economists contend is the most efficient method. Tax policy may encourage private firms to invest in innovations and may encourage farmers to adopt the innovations. Enhanced protection of intellectual property rights may increase incentives for private firms to engage in private agricultural research. Regulatory policies affect the rate at which new livestock drugs and farm chemicals reach the marketplace.

Relatively little research has investigated the impact of government programs on agricultural productivity, but some observe a significant positive relationship. For example, high farm prices can encourage substitution of improved capital inputs for labor and increase the rate of new technology adoption. On the other hand, government subsidization of any one sector can have a negative impact on other sectors in the economy.

Prospects & Uncertainties

Research, extension, education, infrastructure, and government programs will continue to affect the productivity of U.S. agriculture. The magnitude of their effects is uncertain because the relationships between these factors and productivity are still not well understood and because of the uncertainty surrounding the level at which society will invest in these growth sources and programs.

Also uncertain is how the agricultural sector will adjust to the planting flexibility provisions of the new farm law, designed to make U.S. agricultural production more market-oriented. While it is still too early to determine, the experience of the 1980's may provide a clue. In that period of economic turbulence in the agricultural sector, U.S. farmers demonstrated a capacity to adjust to changing economic conditions. The question is still open as to whether greater flexibility to adjust production to market signals will result in enhanced productivity.

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