Agricultural Research, Productivity, and Food Commodity Prices

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The long-term downward trend in real food prices reflects agricultural productivity growth fueled by public and private investments in agricultural R&D, among other things. Slower rates of agricultural productivity growth since 1990 imply a slower rate of decline in real food prices. An acceleration in agricultural R&D spending may be required to restore productivity growth rates and prevent a longer-term food price crisis.

Over the past 50 years and longer, growth in the supply of food commodities has outpaced the growth in the effective market demand, driven by substantial increases in population and per capita incomes. Consequently, the real (deflated) prices of food commodities have steadily trended down. The past increases in agricultural productivity and production, and the resulting real price trends, are attributable in large part to technological changes enabled by investments in agricultural research and development (R&D). Evidence is beginning to emerge of a slowdown in the long-term path of agricultural productivity growth. This mirrors a progressive slowing down in the growth rate of total spending on agricultural R&D and a redirection of the funds away from farm productivity that began 20–30 years ago. In this short article we document the slowdown in growth of agricultural productivity and grain yields and thus a slowdown in the long-term downward trend of real food commodity prices, and we link those developments back to shifts in funding for agricultural R&D.

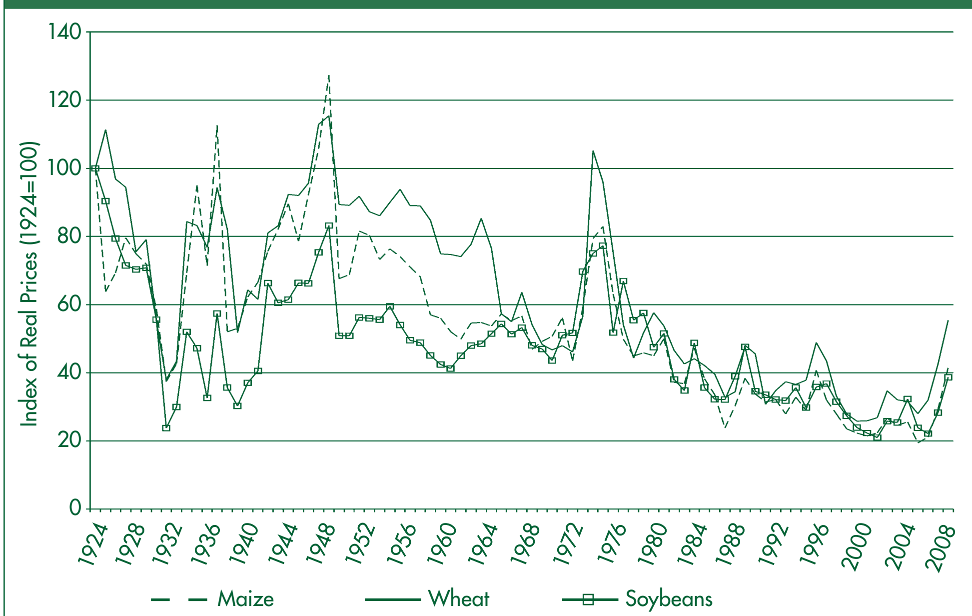
Price Trends and Their Possible Causes

Using U.S. commodity price indexes as indicators of world market prices, Figure 1 shows the price indexes for wheat, maize, and soybeans over the period 1929 to 2007, expressed in real terms by deflating by the index of prices paid by farmers. (Rice was omitted to improve the clarity of the plots. The rice prices follow a similar overall pattern to the commodity prices shown here.) In real terms, grain prices trended up generally (albeit with some major fluctuations during and after the Great Depression) from 1929 through the end of World War II, after which they trended generally down.

The period since World War II includes three distinct sub-periods. First, over the 20 years 1950–1970, prices for rice, maize, and soybeans declined relatively slowly while wheat prices declined fairly rapidly. Next, following the price spike of the early 1970s, over the years 1975–1989, prices for all four grains declined relatively rapidly. Finally, over the years 1990–2005, the rate of price decline slowed for all four grains. Toward the end of the period, but still before the onset of the recent price spike that became evident after 2005, the rate of decline of real prices slowed even more—in fact, from 2000 forward, prices increased in real terms for rice, soybeans, and wheat.

Figure 2 shows some comparable price indexes for U.S. field crops, specialty crops, and livestock products over the period 1949–2004. Panel a shows the nominal indexes, and panel b shows the same price series deflated by an index of prices paid by farmers for inputs. Real prices received by farmers for all crop categories trended down, but at different rates. Over the period 1949–2004, in real terms prices for field crops fell by 64.5 percent, prices for livestock fell by 42.7 percent, and prices for specialty crops fell by 5.3 percent

Figure 1. Real U.S. Prices of Maize, Soybeans, and Wheat, 1924–2008



Source: Compiled by the authors as described in Alston, Beddow, and Pardey (2009).

(8.6 percent for vegetables, 3.0 percent for fruits and nuts, and 0.2 percent for nursery and greenhouse products).

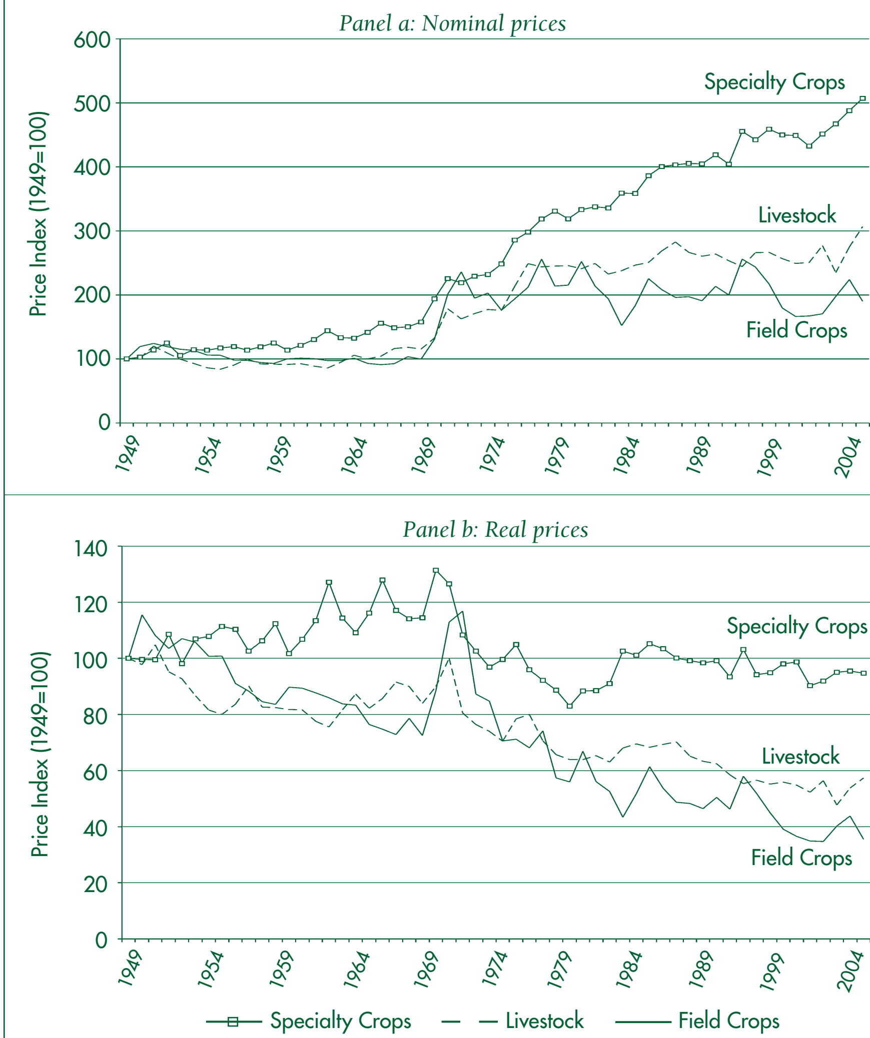
U.S. and Global Crop Yields

Various measures of agricultural productivity growth show some consistent patterns in terms of secular shifts, including indications of a recent slowdown in growth, that mirror the corresponding patterns in relative prices. Table 1 documents the remarkable growth in yields for selected U.S. crops over the long run—beginning in 1866 for wheat and corn, 1919 for rice, and 1924 for soybeans. Between 1866 and 2007 average yields of maize increased by a factor of six, while wheat yields increased by a factor of 3.5. Over the past 100 years, rice and soybean yields grew by a factor of 3.9. For all four crops, most of the yield gains occurred in the latter half of the 20th century. The annual average rates of growth for rice, wheat, and maize since 1950 were typically one to two percentage points greater than the previous longer-run rates of growth—which spanned the period 1866–1949 for wheat and maize and 1919–1949 for rice.

However, we see evidence of a slowdown in U.S. crop yield growth during the 1990s and the first decade of the 21st century. With the exception of soybeans, rates of yield growth during the 17 years, 1990–2007 were significantly below the rates that prevailed during the 40 years, 1950–1989: maize yields grew at an average rate of 1.50 percent per year over 1990–2007 compared with 2.85 percent for 1950–1889; wheat yields grew at an average rate of 0.15 percent per year during 1990–2007, compared with 1.75 percent for 1950–1989; and the rate of growth in rice yield was also substantially slower during 1990–2007 than during 1950–1989.

Table 2 reports average global yields for maize, rice, and wheat (in metric tons per harvested hectare) since 1961

Figure 2. U.S. Prices of Specialty Crops, Field Crops, and Livestock, 1949–2004



Source: Compiled by the authors as described in Alston, Beddow, and Pardey (2009).

(the earliest year for which global yield estimates are reported by the U.N. Food and Agriculture Organization, whence most of these data were drawn). Separate estimates of average growth rates of yields are reported for developing countries, developed countries, and the world as a whole, for two sub-periods: 1961–1989 and 1990–2006. For all three crops, in both developed and developing countries, average annual rates of yield growth were much lower in 1990–2006 than in 1961–1989. The growth of wheat yields slowed the most

Table 1. Rates of Growth of U.S. Average Yields for Selected Crops

Period	Crop Yield Growth			
	Maize	Wheat	Rice	Soybeans
	percent per year			
1866–2007	1.30	0.92	n/a	n/a
1900–2007[a]	1.58	1.12	1.55	1.60
1900–1949[a]	0.63	0.35	0.69	2.83
1950–2007	2.43	1.58	1.90	1.14
1950–1989	2.85	1.75	2.27	1.02
Post-1990	1.50	0.15	1.37	1.16

[a] *Rice yields start in 1919, soybeans in 1924.*
Source: Calculated by the authors as described in Alston, Beddow, and Pardey (2009).

Table 2. Rates of Growth of Global Average Yields for Selected Crops

Group	Maize		Wheat		Rice	
	1961–89	1990–06	1961–89	1990–06	1961–89	1990–06
	percent per year					
World	2.21	1.59	2.78	0.55	2.19	0.97
Developing	2.53	1.92	3.76	1.43	2.34	1.01
Developed	2.50	1.67	2.41	–0.13	0.77	0.73
Western Europe	3.65	1.74	3.25	0.86	0.33	0.53
Eastern Europe	2.62	2.45	3.29	–1.27	–0.61	3.63
North America	2.20	1.43	1.58	0.19	1.87	1.35

Source: Calculated by the authors as described in Alston, Beddow, and Pardey (2009).

and, for developed countries as a group, wheat yields actually declined over the 1990–2006 period. Global maize yields grew during 1990–2006 at an average rate of 1.59 percent per year compared with 2.21 percent per year for 1961– 1989. Likewise, rice yields grew at less than 1.0 percent per year after 1990, less than half the average growth rate for the pre-1990 period.

Land, Labor, and Multi-factor Productivity

In 2002, in aggregate terms, U.S. agriculture produced more than five times the quantity of agricultural output produced in 1910. The 1.82 percent per year increase in output over 1910–2002 was achieved with only a 0.36 percent per year increase in the total quantity of inputs. Consequently, between 1911 and 2002, U.S. agricultural land productivity (output per unit of land) increased by a factor of 4.4, labor productivity increased by a factor of 15.3 and, accounting for all measurable inputs, multi-factor productivity increased by a factor of 4.1. Impressive as the long-run productivity gains undoubtedly are, they mask a more recent slowdown in the rates of productivity increase. Prior to the 1950s, U.S. land, labor, and multi-factor productivity grew comparatively slowly (Table 3). The average rates of productivity growth picked up considerably during the subsequent four decades 1950–1989, averaging 4.11 percent per year for labor productivity, 1.88 percent per year for land productivity, and 2.11 percent per year for multi-factor productivity. A third phase, beginning in 1990 (and, in this instance, running to 2002, the last year for which our productivity estimates are currently available), saw a sharp downturn in the rates of growth of all three productivity measures. Notably, during the period 1990–2002 labor productivity and multi-factor productivity grew at half, or less than half, the corresponding rate for the period 1950–1989.

A similar slowdown is evident in global measures of land and labor productivity growth during the post-1989 period compared with the preceding three decades. Among the world's top 20 producers (according to their 2005 value of agricultural output) after setting aside the large and in many respects exceptional case of China, land and labor productivity growth slowed significantly in the post-1989 period (Table 4). Across the rest of the world (i.e., after setting aside the top 20 producing countries), on average, the slowdown is even more pronounced. For this group of countries, land productivity grew by 1.83 percent per year during the period 1961–1989 but only 0.88 percent per year thereafter; labor productivity grew by 1.08 percent per year prior to 1990 but barely budged during the period 1990–2005.

Research Spending

The increases in agricultural production and the resulting real price trends over the past 50 years and longer are attributable in large part to improvements in agricultural productivity achieved through technological changes enabled by investments in agricultural R&D. Similarly, the recent slowdown in productivity growth reflects an earlier slowdown in the growth rate of total spending on agricultural R&D and a redirection of the funds away from farm productivity. From 1951 to 2006, in inflation-adjusted terms, total U.S. public spending on agricultural research grew by 1.84 percent per year; but from 1981 to 2006, spending growth slowed to only 0.45 percent per year. Similar shifts in agricultural research spending have been observed in at least some other countries.

Worldwide, public investment in agricultural R&D increased by 35 percent in inflation-adjusted terms between 1981 and 2000—from an estimated $14.2 billion to $20.3 billion in real (year 2000) international dollars. It grew faster in less-developed countries and the developing world now accounts for about half of global public-sector spending—up from an estimated 41 percent share in 1980. However, developing countries account for only about one-third of the world's total agricultural R&D spending when private investments are included, and agricultural research intensities (expressing agricultural R&D spending as a percentage of agricultural gross domestic

Table 3. U.S Agricultural Productivity Growth Rate by Period, 1911-2002

	Productivity		
Period	Labor	Land	Multi-Factor
	percent per year		
1911–2002	3.00	1.64	1.56
1911–1949	2.38	1.42	1.24
1950–2002	3.50	1.87	1.86
1950–1989	4.11	1.88	2.11
Post-1990	1.59	1.58	1.01

Source: Alston, Anderson, James, and Pardey (2009).

product) in developing countries are generally static and remain much lower than in the developed countries.

A notable feature of the trends was the contraction in growth of support for public agricultural R&D among developed countries. While spending in the United States increased in the latter half of the 1990s, albeit more slowly than in preceding decades, public agricultural R&D was massively reduced in Japan (and also, to a lesser degree, in several European countries) towards the end of the 1990s, leading to a reduction in the rate of increase in developed-country spending as a whole for the decade. More recent data, where available, reinforce the longer-term trends. Specifically, support for publicly performed agricultural R&D among developed countries is being scaled back, or growing more slowly, and R&D agendas have drifted away from productivity gains in food staples towards concerns for the environmental effects of agriculture, food safety and other aspects of food quality, and the medical, energy, and industrial uses of agricultural commodities. Given the role of international spillovers of agricultural technology, a continuation of the recent trends in funding, policy, and markets is likely to have significant effects on the long-term productivity path for food staples in developed and developing countries alike.

Assessment

The hundreds of country-specific studies reported in the professional agricultural economics literature reveal a strong association between agricultural productivity improvements in a given year and spending on agricultural research and extension over the previous 30 years and more. We suspect that substantial shares of the slowdown in productivity growth observed during the past decade or so are attributable in significant part to a slowdown in the rate of growth in spending on agricultural R&D during the previous decade or two. The observed shifts in that research spending away from productivity-oriented research would serve to amplify the slowdown in productivity growth. Thus, the slowdown in R&D spending is likely to have contributed to the current high commodity prices, though other factors were responsible for most of the recent rapid increases. An implication of our analysis is that a restoration of the growth in spending on agricultural R&D may be necessary to prevent a longer-term food price crisis of a more enduring nature.

Table 4. Growth in Agricultural Land and Labor Productivity Worldwide, 1961–2005

Group	Land Productivity 1961–1989	Land Productivity 1990–2005	Labor Productivity 1961–1989	Labor Productivity 1990–2005
Developing Countries	2.60	3.00	1.60	2.56
excl. China	2.47	2.29	1.49	1.49
Developed Countries	1.71	0.27	3.81	2.89
World	2.04	1.84	1.12	1.37
excl. China	1.93	1.20	1.23	0.42
excl. China & USSR	1.93	1.58	1.14	0.73
Top 20 Producers	2.08	2.18	1.14	1.78
excl. China	1.98	1.38	1.32	0.63
Other Producers	1.83	0.88	1.08	0.07

Source: Calculated by the authors as described in Alston, Beddow, and Pardey (2009).

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For additional information, the authors recommend:

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