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Shifting Ground: Food and Agricultural R&D Spending Worldwide, 1960-2011*

Philip G. Pardey[1], Connie Chan-Kang[1], Jason M. Beddow[1] and Steven P. Dehmer[2]

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[1] International Science and Technology Practice and Policy (InSTePP) Center at the University of Minnesota, 1994 Buford Ave., St. Paul, Minnesota, USA. [2]HealthPartners Institute for Education and Research, Minneapolis, Minnesota, USA. Jason Beddow died suddenly (April 2016) as this paper was being finalized.

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Historically unprecedented shifts in the global geography make up of food and agricultural R&D are large and likely consequential for global food and agriculture futures.

The future path and pace of agricultural productivity growth and global food supplies are inextricably intertwined with investments in food and agricultural research and development (R&D).[1] But the lay of the global food and agricultural R&D land is changing. Our analysis of public spending on food and agricultural R&D over the past 50 years indicates that for the first time in modern history, middle-income countries (especially China, India and Brazil) are investing more in food and agricultural R&D than rich ones. The numbers also suggest that private-sector spending on agricultural R&D is closing in on the spending by the public sector, and that the gap between investment by rich and poor countries is increasing.

The recent rise of agricultural R&D spending in the rapidly growing middle-income countries is not at all representative of developments elsewhere in the world. In many of the world's rich countries, agricultural productivity growth took off around the middle of the 20th century.[2] But in more recent years the pace of that growth has slowed along with spending on food and agricultural R&D. For a number of these countries, inflation-adjusted spending on public food and agricultural R&D has even begun to decline, so that simply sustaining past productivity gains will be increasingly problematic, let alone reviving the rates of agricultural productivity growth required to help feed an ever-growing global population. Much of the world's population growth in the decades ahead will be in the low-income countries, including south Asia and, especially, sub-Saharan Africa.[3] But in many African countries public support for food and agricultural R&D is fragile and faltering, and private-sector investments are minimal.

The lags between investing in food and agricultural R&D and realizing the productivity consequences of those investments are long: matters of decades not months or years.[4] These long lags give added significance to today's agricultural R&D investment decisions that will cast their productivity shadows through to 2050 and beyond. So what do we know about past and present patterns of investment in food and agricultural R&D and what might they portend for the future of food and agriculture worldwide?

Constructing the Long View

Given these long R&D lags, developing an informed sense of these research-cum-agricultural productivity consequences requires decades of data. Our view of prospective food and agricultural futures are informed by a revision and major update of the food and agricultural R&D spending component of the International Innovation Accounts maintained by the University of Minnesota's International Science and Technology Practice and Policy (InSTePP) Center. This update reflects the culmination of the work of many people over many decades and includes direct contact with more than 60 respondents from government and scientific agencies all over the world. Extensive details on the construction of this data series are available online (link to InSTePP website), but in short, they include new and revised estimates of publicly performed food and agricultural R&D for 158 countries for over 50 years (1960-2011) and all-new global estimates of privately performed food and agricultural R&D for the past three decades (1980-2011).

Historic Transitions

Looking back half a century, our new data show we are in the midst of an historic transition. The rich countries' share of global investments in food and agricultural R&D continues to fall. Global gross domestic public and private expenditures on R&D directed to food and agriculture (ag R&D) totaled $69.3 billion (2009 PPP dollars, and similarly throughout this Comment) in 2011, around 5.0% of the overall $1,397 billion invested worldwide in all forms of R&D that year.[5] Around 54.8% of the world's 2011 ag R&D took place in rich countries, down from 68.9% in 1980. The middle-income countries accounted for 43.4% of the ag R&D in 2011, which marks a substantial rise compared with their 28.7% global share in 1980. The shift in the public component of these expenditures has been even more dramatic; in 1960, rich countries accounted for 55.9% of public ag R&D, but by 2011, public-sector spending in middle-income countries overtook that in rich countries, with 49.8% compared to 47.3% of the total, respectively.

The rate of growth in rich-country public ag R&D peaked in the 1960s and 1970s and has fallen since, with an inflation-adjusted growth rate averaging just 0.8% per year from 2000-2011. Collectively, the middle-income countries began outspending the rich countries on public ag R&D in 2010, when spending is measured in purchasing power parity (PPP) terms. Part of the ground shift is that in more recent years (and especially since 2002), historically important agricultural research countries including

the United States, the United Kingdom, and Australia began cutting back on (inflation-adjusted) public spending on food and agricultural R&D, thus abating the accumulation of public agricultural research capital in these countries that occurred throughout most of the 20th century.[6] In contrast, growth in inflation-adjusted public agricultural R&D spending accelerated to 5.8% per year from 2000-2011 for the middle-income countries, compared with an average of 3.8% per year for the 1960-2000 period. In rich countries, public agricultural R&D spending grew by just 0.8% between 2000 and 2011."

Changing Private and Public Roles

Historically, the preponderance of the research in food and agriculture was carried out by public entities (universities and government agencies), but that is no longer so for the rich countries where 52.5% of the research is now done by private firms (versus 42.4% in 1980). The middle-income countries (and among them, notably China, Brazil and India) are also gaining ground on the rich countries both in terms of their global share of private ag R&D (15.7% in 1980 increasing to 35.5% in 2011) and the private-sector share of their own domestic ag R&D (19.0% in 1980 increasing to 36.8% in 2011). The recent rapid growth in investment in private food and agricultural R&D in China is noteworthy—especially research carried out by state-owned agri-businesses such as CNDAC (China National Agricultural Development Corporation) and COFCO (China National Cereals, Oils and Foodstuffs Corporation) but also privately listed companies such as the WH Group, the Yili Group, and the China Yurun Food Group.

This shifting global ground reflects two reinforcing developments. One, the accelerating growth of domestic private R&D capacity in (at least some, and generally the larger) middle-income countries directed to crop genetics, farm machinery, food processing and other relevant business segments, and two, the relatively recent offshoring of R&D endeavors into rapidly growing middle-income countries by multi-national firms headquartered in the rich countries.

The broadly shifting global geography of publicly versus privately performed food and agricultural R&D stems from changes in the underlying structure of the food and agricultural economies across countries and the political economy in which those sectors are positioned. There is a tendency to think of private food and agricultural R&D—such as by companies like Monsanto, Pioneer-Dupont, Syngenta, John Deere and BASF—as being mainly investments in research on agricultural chemicals, crop breeding, and machinery. Important as those companies and areas of innovation are, research targeted to the

food, beverages, and tobacco subsector—involving companies such as PepsiCo, Kraft-Heinz, Nestle and General Mills—accounted for 43.9% of the rich-country private food and agricultural R&D total in 2011. Typically, more-developed countries—i.e., those with higher per capita GDPs (gross domestic products)—consume a larger share of their food away from home, and an increasing share of that consumption is on processed foods.[7] For these post-farm, consumption-oriented reasons one might expect relatively more of the world's private food-oriented research to be conducted in the richer countries, where the appropriable returns from those investments are likely to be higher. Farmers in more-developed countries with generally better access to input (and output) markets tend to use the purchased inputs arising from private R&D more intensively than do farmers in poorer regions of the world, and this also incentivizes more private participation in farm-oriented agricultural R&D in richer markets.

The Rich and Poor Divide: Cents on the Dollar

While the rank order of the top spending countries has been shaken up, the dramatic divide between rich and poor country public spending on food and agricultural R&D persists, and in some key dimensions, it is widening. In 1980, for every dollar of ag R&D spent in high-income countries, just 3.5 cents was spent in the low-income countries, roughly the same rich-poor country R&D spending relativities we see three decades later. When the spending gap is evaluated on a per capita basis, the sizable and growing gap is especially pronounced, and expanding. In 1980, the rich countries invested $13.25 per person on public food and agricultural R&D compared with $1.73 per person among the poor countries on average (a gap of 665%). By 2011, the per-capita spending gap for public ag R&D had widened to 1,072%: $17.73 per person among rich countries versus just $1.51 per person by the poor countries.

The rich-poor country divide is even more pronounced when it comes to private-sector spending on food and agricultural R&D. For every dollar of private ag R&D spent in the high-income countries, there was a meager 0.8 cents of private ag R&D spent in the low-income countries in 2011. Moreover, in 2011 the rich country agBERD to agPERD ratio was 1.10. Thus while private firms spent, on average, $1.10 for every public research dollar in the rich countries, private investment in poor countries was a mere 15 cents for every public dollar of food and agricultural R&D.

This speaks to the enormity of the task in building robust institutional structures that foster effective public and private sector participation in markets that serve poor-country agriculture. On the

flip side, it also speaks to the need to be watchful about a waning public sector role in food and agricultural R&D in rich counties given the continuing, if not increasing, need for risky, long-term basic and typically less appropriable R&D, which is the more natural domain of the public sector.

Implications

While the geography of global food and agricultural R&D spending has shifted dramatically over the past several decades—so that where in the world that research is carried out has changed markedly (and seemingly at an accelerating pace)—this research remains concentrated in just a handful of countries. The top 10 counties (now including a mix of high- and middle-income countries such as China, India, Brazil) accounted for 61.5 percent of ag R&D worldwide in 2011. The bottom 100 ranked R&D countries —home to 21.5% of the world's population and including 28 (all but one) of the world's low-income countries—invested just $4.5 billion (2009 PPP $) (11.9% of the 2011 world total) in agGERD. Therein lies one of several major challenges in the years ahead: specifically, how to get the relevant agricultural innovations into the hands of the world's poor farmers so they may feed themselves and also help feed the increasingly urbanized populations even in these poorer parts of the world.

Most of the world's food and agricultural R&D occurs in countries that produce most of the world's agricultural produce. There the innovation challenges are equally pressing but different. Many of these countries have historically high agricultural productivity levels. To simply maintain present productivity levels requires persistent investment in maintenance R&D to tackle the ever-changing climate, pest and disease pressures that act to undermine past productivity gains. To achieve even higher levels of productivity to feed a growing, increasingly richer, and more urbanized global population is also a challenge, and to do that while simultaneously sustaining (and in some cases rehabilitating) the fragile natural resource base that underpins agriculture is doubly difficult.

The future is uncertain—and especially so for a risky business like R&D—but if present trends continue, it is a pretty sure bet that the landscape of global food and agricultural R&D in the middle of the 21st century will look very different from the lie of the agricultural R&D land at the dawn of this century. Whether or not the contours of this new global R&D landscape are sufficient for the challenges that lie ahead is an open question. The rise of food and agricultural R&D in the rapidly growing middle-income countries, and the increase in private participation in food and agricultural R&D in parts of the planet are encouraging developments. But this is set against a more recent retreat from (public) food and agricultural R&D in many rich countries and a continuation of comparatively low levels of

investments in many poorer countries. Rapidly regaining lost R&D ground for these parts of the world is an obvious first-order task if we are to be sure of sustainably feeding the world to 2050 and beyond.

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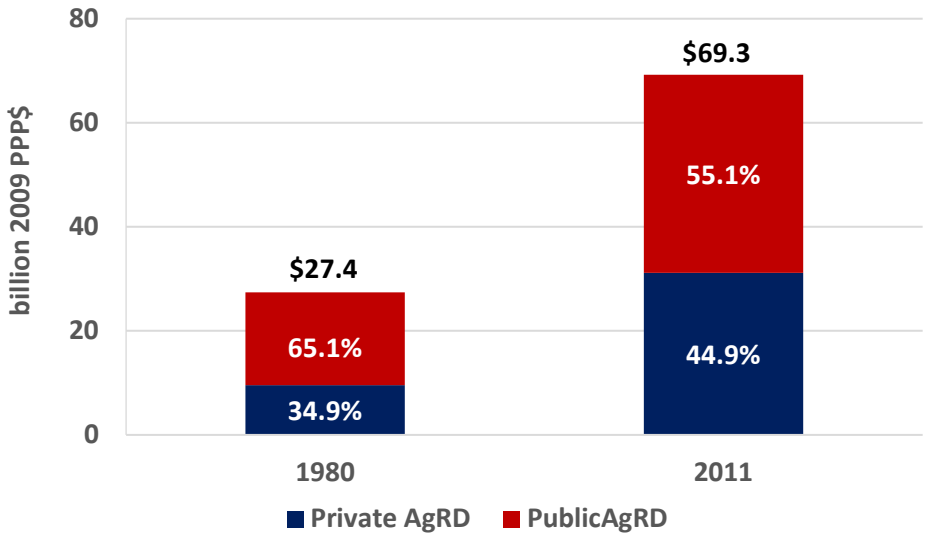
Shifting public-private shares, 1980 and 2011

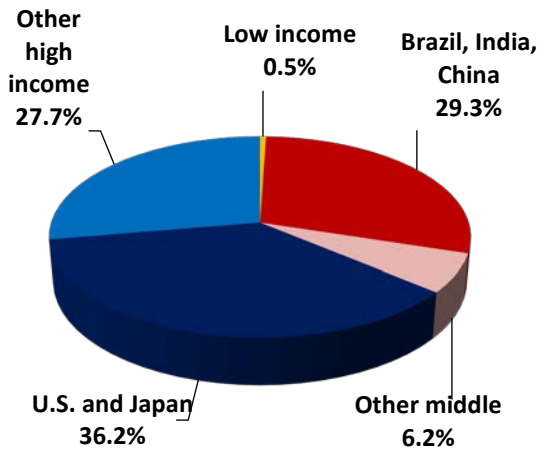


Source: InSTePP R&D Accounts, version 3.5.

Notes: Countries from the Former Soviet Union and Eastern Europe are excluded from the time series because of limited data; the public agricultural R&D series includes 130 countries; the private agricultural and food R&D series includes 128 countries as there were no data available for Guam and U.S. Virgin Islands.

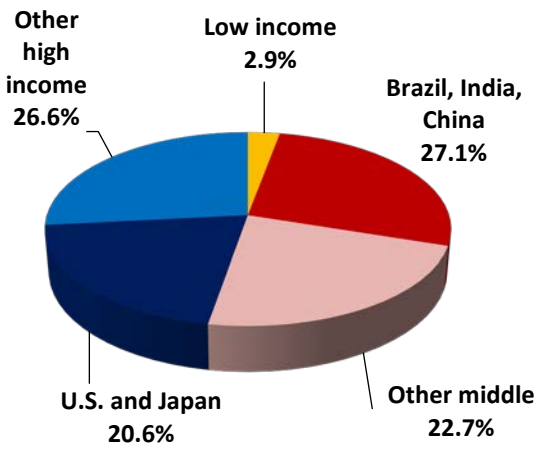
Global food and agricultural R&D by income group, 2011

Panel a: Private sector



$31.1 billion (2009 PPP$)

Panel b: Public sector



$38.1 billion (2009 PPP$)

Source: InSTePP R&D Accounts, version 3.5.

Notes: Countries are grouped into income classes using contemporary World Bank schema.

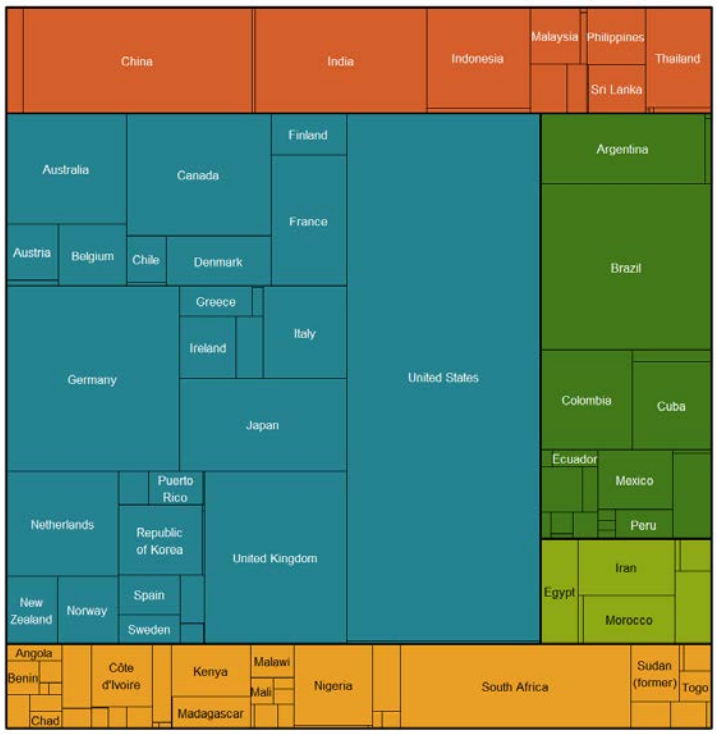
Global food and agricultural R&D by income group, 1980 and 2011

	Private ag R&D				Public ag R&D			
	1980		2011		1980		2011	
	Amount	Per capita	Amount	Per capita	Amount	Per capita	Amount	Per capita
	(million 2009 PPP$)	*(2009 PPP$)*	*(million 2009 PPP$)*	*(2009 PPP$)*	*(million 2009 PPP$)*	*(2009 PPP$)*	*(million 2009 PPP$)*	*(2009 PPP$)*
Low income	63	0.18	165	0.22	593	1.73	1,112	1.51
Middle	1,498	0.54	11,065	2.41	6,374	2.30	18,995	4.14
High income	7,992	9.75	19,899	19.58	10,863	13.25	18,022	17.73
Total	9,553	2.43	31,129	4.91	17,830	4.53	38,129	6.02

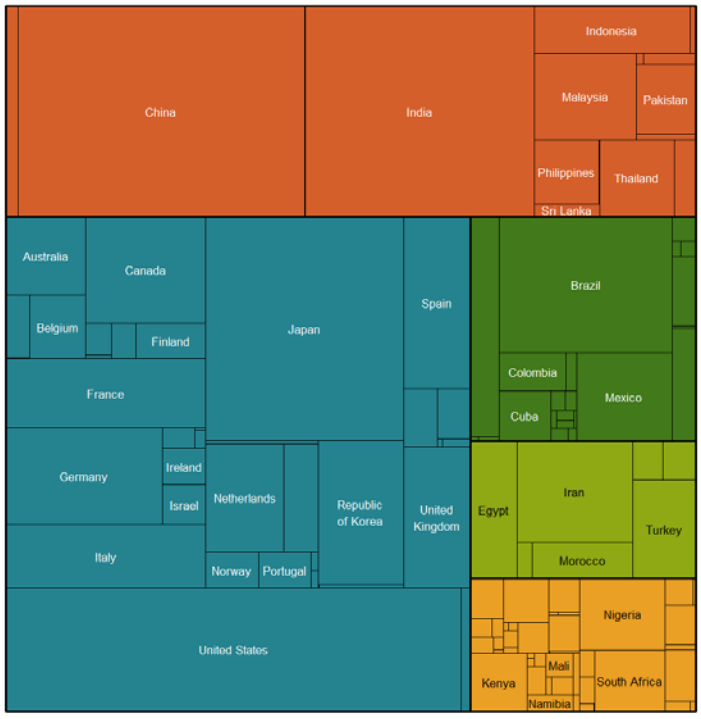
Source: InSTePP R&D Accounts, version 3.5. Population data from the United Nations.

Changing contours of global public ag R&D, 1960 and 2011

Panel a: 1960



Panel b: 2011



Source: InSTePP R&D Accounts, version 3.5.
Note: Country area indicates respective share of global public ag R&D in each of the respective years.