

World Spending on Agricultural Research and Development

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fibres through memberships in various committees, as an author of articles and papers for industry publications, and as a consultant. Dr. Townsend has a deep appreciation of the importance of fundamental analysis in understanding structural change in commodity markets.

Introduction

USDA reported in May 2022 that public spending on agricultural research and development (R&D) was the largest in China, followed by the European Union, the United States, India, and Brazil (Fuglie and Nelson, 2022). The report emphasized that public expenditures on agricultural R&D in the United States were about a third lower in real terms in 2019 than they had been at their peak in 2002 when spending, in 2019 dollars, was \$7.64 billion.

In contrast to the decline in public expenditures in the United States since 2002, public expenditures on agricultural R&D (deflated by national GDP indexes), rose by a factor of approximately five in China in the two decades since 2000. Expenditures rose by about one-third in the EU, approximately double in India, and expenditures rose by about half in Brazil.

The USDA report carries an alarmist tone, suggesting that the reduction in public spending on agricultural R&D in the United States will lead to a reduction in competitiveness in agricultural production and lower social welfare in the long term. The purpose of this article is to provide a wider perspective on the recent evolution of public investments in agricultural R&D across major producing countries, highlighting their relative size to the value of local agricultural production, and the role of private R&D.

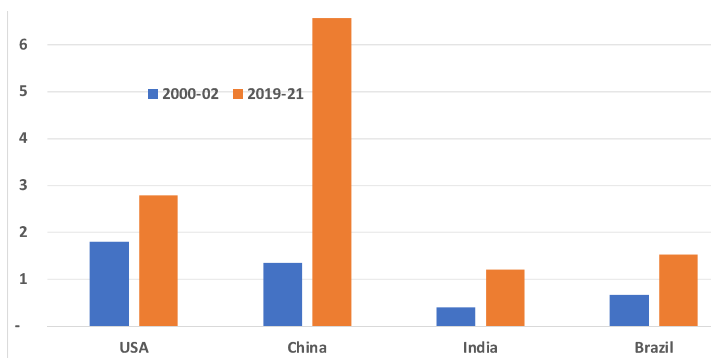
Public R&D vs. value of Ag production

Data from the OECD demonstrate the relative size of public sector expenditures on agricultural research and development (OECD, 2022). Annual average spending on Agricultural knowledge and innovation systems (OECD speak for R&D) rose in the USA, India and Brazil in nominal dollars between 2000-02 and 2019-21 by about \$1 billion in each country. According to the OECD, investments in Agricultural knowledge and innovation systems include budgetary expenditure financing (1) R&D activities related to agriculture, and associated data dissemination, irrespective of the institution (private or public, ministry, university, research center or producer groups) where they take place, the nature of research (scientific, institutional, etc.), or its purpose; as well as (2) agricultural vocational schools and agricultural programs in high-level education, training and advice to farmers that is generic (e.g. accounting rules, pesticide application), not specific to individual situations, and data collection and information dissemination networks related to agricultural production and marketing.

Spending in the United States rose from \$1.8 billion per year to \$2.8 billion, from \$400 million to \$1.2 billion in India, and from \$700 million to \$1.5 billion in Brazil. In contrast, public sector expenditures on agricultural R&D in China leapt by a factor of approximately 5, growing from around \$1.3 billion per year to \$6.6 billion. Annual average public sector expenditures on

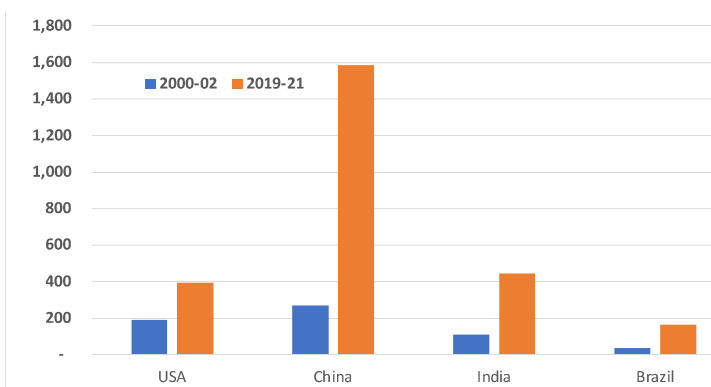
agricultural R&D in China were larger than in the USA, India and Brazil together by 2019-21.

Figure-1. Spending on agricultural knowledge and innovation systems, US\$ Billion. Source: OECD (2022), Agricultural Policy Monitoring and Evaluation 2022, OECD Publishing, Paris, <https://doi.org/10.1787/7f4542bf-en>.



China also now has the largest agricultural system in the world by value of production. As of 2019-21, the value of production at the farm gate was about \$1.6 trillion in China, compared with \$400 billion in the USA and India and about \$200 billion in Brazil. The structure of the farm economy in China is different from the structures in the other countries because China does not have an abundance of arable land. Except for in the far-West region known as Xinjiang, where cotton is produced, farmers in China operate relatively small farms producing high-valued products such as meat and vegetables. In contrast, the USA and Brazil have larger arable areas and much smaller populations and can afford to produce huge swaths of row-crops. India, with a population as large as China's but with more arable land can also afford to produce lower-valued products.

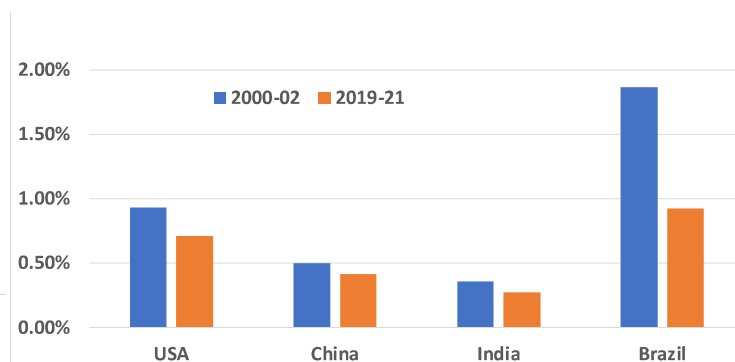
Figure-2. Value of agricultural production at the farm gate, US\$ Billion. Source: OECD (2022), Agricultural Policy Monitoring and Evaluation 2022, OECD Publishing, Paris, <https://doi.org/10.1787/7f4542bf-en>.



Therefore, as a share of the value of agricultural production at the farm gate, public sector expenditures on agricultural R&D were the largest in Brazil in 2019-21 at 0.9%, compared with 0.7% in the USA, 0.4% in China, and 0.3% in India. Public sector expenditures on agricultural R&D declined as a percentage

of the value of agricultural production in all countries between 2000-02 and 2019-21, mainly because the value of production rose.

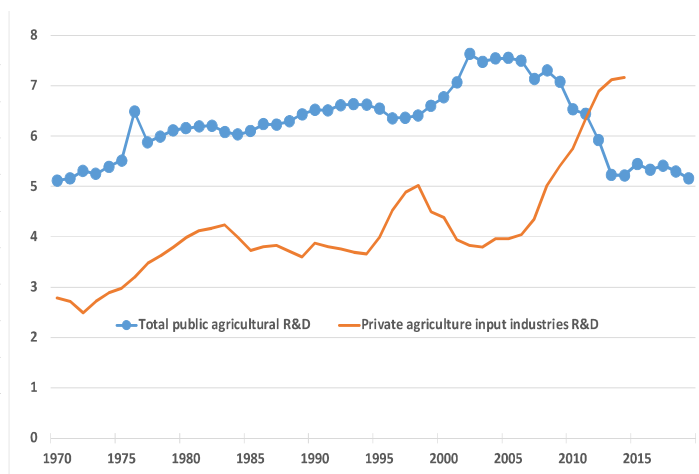
Figure-3. Spending on agricultural knowledge and innovation system as % of value of production. Source: OECD (2022), Agricultural Policy Monitoring and Evaluation 2022, OECD Publishing, Paris, <https://doi.org/10.1787/7f4542bf-en>.



The role of private R&D

The USDA report acknowledges that lower public spending on agricultural R&D in the United States may be offset by private sector spending. The public sector funded about half of the agricultural R&D directly used by agriculture in the United States between 1970 and 2008. However, by 2013 the share funded publicly had fallen to between 40% and 45% because real (inflation-adjusted) public agricultural R&D fell by about 20%, while real private R&D spending by input firms increased by around 50%. Furthermore, if private sector expenditures on R&D for food manufacturing are excluded from the comparison (as shown in the following graph), the average share of private agriculture input industries R&D increased from 38% between 1970 and 2010 to 55% between 2011 and 2014.

Figure-4. Real agricultural R&D funding, 1970-2019. US\$ Billion inflation-adjusted 2019. Source: USDA, Economic Research Service.



When private sector spending is considered, the United States is probably still the world leader in funding for agricultural R&D.

The USDA report does not disaggregate R&D expenditures by commodity, and budget information specific to cotton R&D is difficult to estimate. Expenditures on ginning research, for example, would be specific to cotton, but expenditures on pesticide or soil health research would be applicable to all crops. Nevertheless, there is no reason to think that public expenditures on R&D applicable to cotton has followed a path different than that for all expenditures on agricultural R&D.

Beginning in the 1800's, the U.S. government funded most agricultural research in the United States because firms in the private sector did not have the means to do so and because there are significant externalities generated by agricultural research resulting in significant public benefit. Over time, specialized firms in the farm machinery, agricultural chemical, crop seed, and other agricultural input industries grew large enough to make considerable investments in R&D. Between 1970 and 2013, private sector expenditures on agricultural R&D in the United States rose by a factor of three to about \$6 billion, while public spending on agricultural R&D in the United States grew very little.

As a result, by 2013, private sector expenditures on agricultural R&D (not counting food manufacturing R&D spending) accounted for nearly 60% of total agricultural R&D expenditures. Data on private sector expenditures on agricultural R&D in the United States are not available for recent years, but the upward trend apparent between 2008 and 2013 has probably continued. By 2020, it is likely that private sector agricultural R&D spending was between two and three times that of the public sector in the United States, meaning that total agricultural R&D spending in the United States was between \$15 billion and \$20 billion.

In contrast, private sector expenditures on agricultural research and development in China are, almost by definition, zero, and private sector expenditures on agricultural R&D in the EU, India and Brazil are, at best, modest. Accordingly, total expenditures on R&D related to agriculture are still the largest in the world in the United States, albeit by a shrinking margin as public expenditures in China, the EU, India and Brazil rise.

There is a distinction between public and private agricultural R&D expenditures, but such expenditures tend to be complementary, rather than competitive. Therefore, the fall in public sector agricultural R&D spending and rise in private spending in the United States does not necessarily presage a decline in the rate of growth of agricultural productivity.

Improvements in genetics, chemicals, fertilizers, agricultural machinery, and farm management techniques have transformed United States agriculture since WWII. As agricultural productivity has increased, public sector research has tended to focus on environmental impacts, animal welfare, farm worker welfare, issues with farm structure (meaning the size of farms and how they are organized and managed), and other issues of broad public interest. Meanwhile, privately funded R&D has tended to focus on the development of marketable inputs and services eligible for patent protection.

Recent research suggests that over the last seven decades it has taken about twenty years for advances in basic agricultural science to be reflected in the adoption of useable technologies (Matt Clancy, 2021). Given that agricultural R&D expenditures by the private sector in the United States began to exceed public expenditures only about a decade ago, it may be another decade before the implications of reduced public sector spending become apparent.

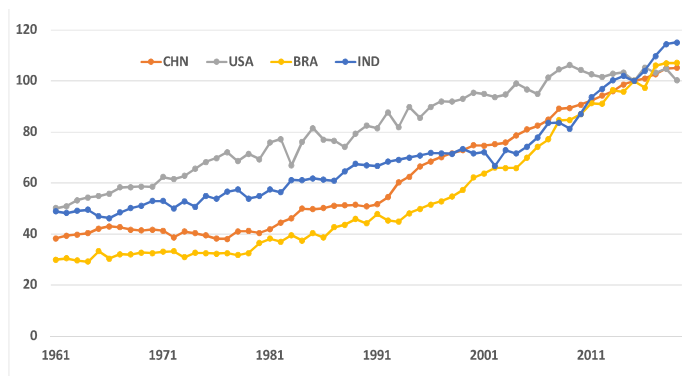
Total Factor Productivity

Total factor productivity, usually measured as the ratio of aggregate output to aggregate inputs, is a measure of productive efficiency. It measures how much output can be produced from a certain amount of inputs.

Data from USDA on total factor productivity (TFP) suggest that the decline in public sector spending on agricultural R&D in the United States may be affecting growth in productivity. An index of agricultural TFP, 2015 = 100, peaked in the United States at 106 in 2009. As of 2019, the index of TFP in the USA was 100, meaning that efficiency in the use of inputs in the United States actually declined by about 6% during the decade ending in 2019.

In contrast, indexes of TFP in China, India and Brazil increased between 2009 and 2019, meaning that the agricultural industries of those countries became more efficient in the use of inputs.

Figure-5. Total factor productivity indexes, 1961-2019 (for each country, 2015=100).



country, 2015=100). Source: Fuglie, Keith O. (2015). "Accounting for Growth in Global Agriculture," *Bio-based and Applied Economics* 4(3): 221-54, and the website for the ERS-USDA data product, "International Agricultural Productivity."

Indexes of TFP cannot be compared from one country to another. Therefore, we cannot say that as of 2019, India was the most efficient agricultural producer among the countries shown. However, we can say that productivity grew faster in India than in China, the USA or Brazil during the past decade, rising from an index value of 81 in 2009 to 115 in 2019. The index of TFP, 2015 = 100, in Brazil grew from 85 in 2009 to 107 in 2019, and the index in China rose from 89 to 105 over the same years.

It is curious that productivity growth among the countries

shown was the greatest in India between 2009 and 2019. Spending on Agricultural Knowledge and Innovation Systems during 2000-02 and 2019-21 was lower in India than in China, the USA or Brazil, both in absolute dollars and as a percentage of the value of agricultural production. The index of TFP in India probably rose faster than in Brazil, China or the USA during the last decade because India was starting from a smaller base. Nevertheless, the growth in TFP in India between 2009 and 2019 is still a significant achievement.

The decline in the index of TFP in the United States between 2009 and 2019 might be a result of reduced public sector expenditures on agricultural R&D after 2002; this is what is implied in the USDA/ERS report. With public sector spending on agricultural R&D declining, enhancements to productivity in the agricultural sector of the U.S. economy are increasingly coming from private sector investments, and these may not be sufficient to maintain growth in agricultural input use efficiency in the United States.

However, the reduction in productivity could also be a reflection of the fact that a rising proportion of public sector spending on agricultural R&D in the United States is oriented toward welfare and environmental issues, rather than traditional productivity-enhancing topics like soil science and breeding. Therefore, the decline in agricultural input use efficiency in the United States after 2009 could reflect not just a decline in public sector R&D spending but also a shift in spending to topics that, while important, have little impact on traditional measures of productivity.

The reduction in the index of TFP in the USA could also be derived from factors having nothing to do with agricultural R&D spending. Reduced productivity in the USA could reflect reduced investments in agricultural infrastructure in response to better opportunities for the use of capital in other segments of the USA economy. It is possible that the agricultural sector of the USA economy attracted less investment during the past decade than more glamorous segments, such as cell phones, electric cars or space tourism, and productivity in the USA agricultural economy was destined to decline no matter how much was spent on R&D.

Regardless of what caused the decline in TFP in the United States after 2009, it is self-evident that more spending on agricultural R&D would result in more input use efficiency, other things equal. Therefore, while the reduction in public sector spending on agricultural R&D in the United States since 2002 may not in and of itself be a cause of a decline in agricultural

productivity, it nevertheless is a subject that warrants more study.

Conclusions

Public sector spending on agricultural research and development has been declining in the United States since the early 2000's. However, private sector spending on agricultural R&D has been climbing, and total agricultural R&D spending (public plus private) is probably still larger in the United States than in other countries.

Public sector spending on agricultural R&D during 2019-2021 in China was roughly double the level of public sector spending in the United States and was four to six times more than spending in India or Brazil. As measured by indexes of Total Factor Productivity, agricultural productivity declined in the United States during the decade between 2009 and 2019 but rose in India, Brazil and China. Accordingly, the advantage enjoyed by the United States in agricultural productivity is less now than a decade ago.

It is not clear what caused the decline in Total Factor Productivity in the United States between 2009 and 2019. In all probability, the decline was caused by a multitude of factors, of which the reduction in public expenditures on agricultural R&D and the shift in public sector spending away from topics having a bearing on input use efficiency toward welfare and environmental issues, may be among those factors.

References

- Fuglie, K and Nelson, K.P. 2022. Agricultural and Food Research and Development Expenditures in the United States ([/data-products/agricultural-and-food-research-and-developmentexpenditures-in-the-united-states/](#)), USDA, Economic Research Service, May 2022.
- OECD. 2022. Agricultural Policy Monitoring and Evaluation 2022, OECD Publishing, Paris, <https://doi.org/10.1787/7f4542bf-en>.
- Clancy, M. 2021. "How long does it take to go from science to technology?" by Matt Clancy, August 13, 2021 in New Things Under the Sun. <https://mattsclancy.substack.com/p/how-long-does-it-take-to-go-from#details>
- Fuglie, Keith O. 2015. "Accounting for Growth in Global Agriculture," *Bio-based and Applied Economics* 4(3): 221-54, and the website for the ERS-USDA data product, "International Agricultural Productivity."