Policy Brief

Productivity Growth is Key to Achieving Long Run Agricultural Sustainability

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Key Findings

Public R&D spending has been a critical component of growth in US agricultural output	US public R&D spending has been flat since 1980, leading to diminished farm output growth	Resuming earlier growth rates would more than double the growth in crop exports from 2010-2050, while mitigating land conversion and unsustainable groundwater withdrawals

Historical Role of Public Research & Development

Over the period 1951 to 2010, U.S. agricultural production grew by more than two hundred percent[1]. This remarkable feat was accomplished with relatively modest increases in farm input use. Indeed, from 1971 to 2010, the ratio of aggregate agricultural output to total farm input use has grown steadily – achieving a growth rate of 1.6% / yr[1]. Farmers today are doing more with less which is the very definition of productivity improvement. This policy brief will explore the role of publicly funded agricultural research and development (R&D) in driving these productivity gains, as well as the consequences of alternative future R&D spending paths for production, resource use and sustainability at mid-century.

Investments in productivity-enhancing agricultural research and development (R&D) is a critical policy intervention that decision makers have used to set the course for future farm productivity growth[2]. Sustained R&D spending is crucial to build and maintain research institutions, extension services and the scientific workforce needed to develop and propagate high-yielding crop varieties, modern farm management techniques and decision-making tools as well as more sophisticated farm machinery. The economic gains from R&D-driven productivity growth are well documented[3–5] and we can leverage this body of research to illustrate how past gains in U.S. agricultural output are linked to historic public R&D investments (Figure 1 – green and orange areas).

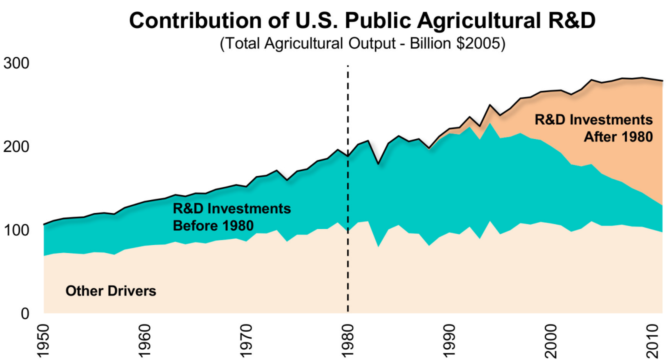


Figure 1. The role of public R&D investments in historical agricultural output growth in the US. The shrinking green area is due to technological obsolescence. 'Other Drivers' includes other sources of Total Factor Productivity (TFP) growth, as well as agricultural inputs.

Between 1950 and 2010, public R&D investments have contributed almost half of the gain in output (or around $102 billion per year, on average). A dollar invested in public agricultural R&D could ultimately produce anywhere between $10 and $69 dollars in gross economic returns[6]. But, like most investments, it takes time for R&D spending today to be translated into future productivity gains. Scientists must be trained, labs equipped and staffed, and experiments undertaken. Indeed, on average, half of the gains from public R&D investments today will only begin to accrue after two decades, and the gains within the first five years are likely to be negligible[7]. This is a fundamental distinction between public and private R&D, with the latter being targeted at near term gains, while public R&D tends to be more fundamental in nature, with a longer-term payoff. So it is not surprising that U.S. R&D investments after the 1980s have not contributed to immediate farm output gains (Figure 1 – orange area).

Consequences of the R&D Slowdown

Despite the estimated economic gains from such investments, we have seen long-run investment in the U.S. public agricultural R&D system slow down and level off in recent decades. Figure 2 shows the 10-year average annual public agricultural R&D spending from 1951-60 to 2001-10[8]. Although average annual public R&D spending has nearly tripled, from $1.5 to $4.0 billion/year from 1951-60 to 2000-10, the trend since 1980 has been relatively flat. This stagnation in public funding for U.S. agricultural scientific research is alarming, especially when contrasted with the aggressive growth in public agricultural R&D funding in the rest of the world, particularly China which already surpassed U.S. R&D spending way back in 2008[9].

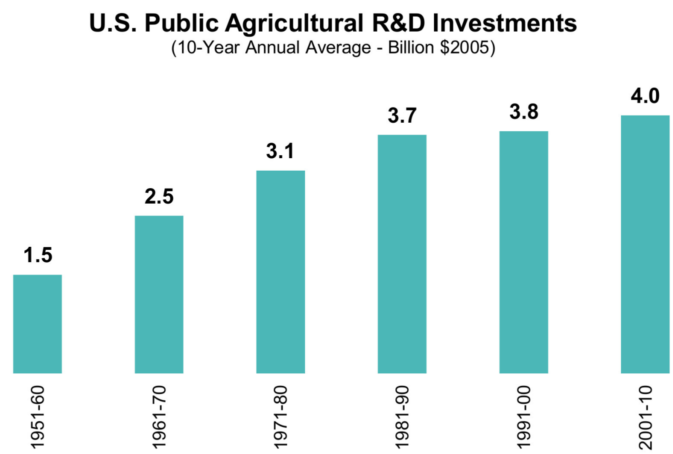
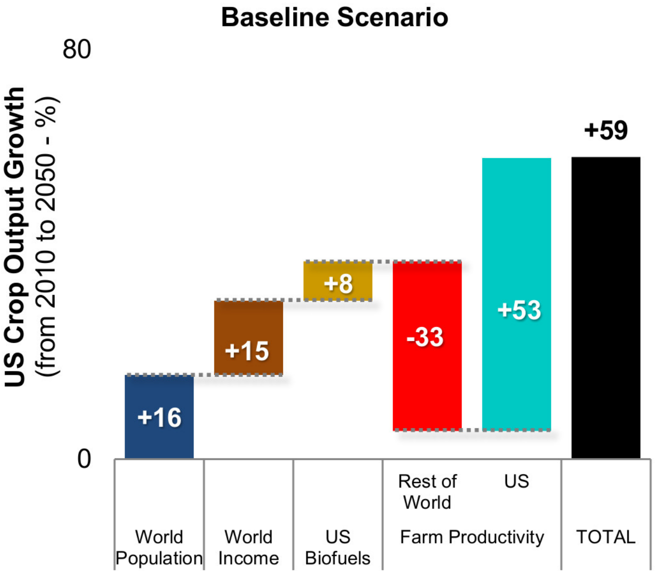


Figure 2. Historical trends in U.S. public agricultural R&D investments.

To understand the implications of agricultural productivity growth and future R&D investment and scenarios for U.S. agricultural production, exports, and resource use, we employ the SIMPLE model*. Figure 3 summarizes the results of future projections (2010-2050) and decomposes the drivers of US farm output into the contributions (left to right) from world population, world income, U.S. biofuels policy and farm productivity improvements in the rest of the world and in the US, respectively.

* SIMPLE stands for a Simplified International Model of Prices Land use and the Environment[10]. For a detailed analysis of historical changes (1961-2006) as well as future projections (2006-2050) see Hertel and Baldos (2016)[11].

It is interesting that the impact of baseline growth in US productivity (simply a continuation of recent trends) on US crop output growth (+53%) is offset by the impact of productivity growth of overseas competitors on US crop output growth (-33%). This offsetting outcome is largely a function of the slowdown public R&D investments since 1980, even as R&D investments overseas have accelerated.



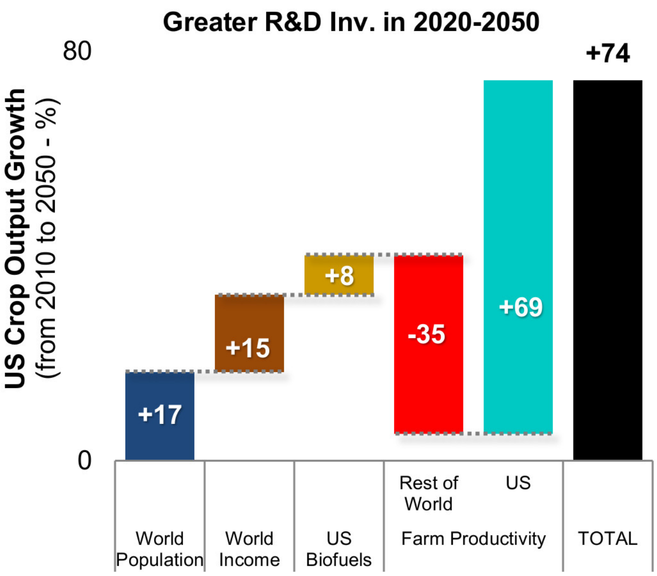


Figure 3. Key drivers of U.S. agriculture: Future projections under two alternative R&D scenarios. Demand drivers boost prices and raise output by causing more land and other inputs to be brought into production. Improvements in farm productivity allow increased demand to be met from existing resources, thereby reducing the pressure to expand land and other inputs in production. Anticipated productivity growth in the rest of the world offsets some of the demand drivers and thus moderates demand growth in US crop production and exports.

Potential Impact of Increased R&D Spending

The SIMPLE model can assist us in assessing the implications of a return to the increased R&D spending rates of the pre-1980 period. To do so, we rerun the model assuming an additional 1.8% annual growth in R&D spending starting from year 2020 and continuing through 2050. From the results in Figure 3 (bottom panel), we see that increasing R&D spending after 2020 could boost U.S. crop output at midcentury by 74% (versus 59% in the baseline). Greater productivity results in increased competitiveness in the world market, resulting in a 146% increase in U.S. crop exports (versus a cumulative 2010-2050 growth rate of 98% in the baseline). Clearly public R&D investments strongly influence the competitiveness of US agriculture.

Increased R&D spending can also play an important role in alleviating sustainability stresses. Figure 4 shows the impact of the higher rate of public R&D spending on cropland conversion and groundwater sustainability in 2050. In both cases, the accelerated R&D spending leads to improved sustainability of U.S. agriculture. In the case of the groundwater stress index, the largest improvements (reductions in the ratio of extractions to recharge) come in the Central Valley of California, the Ogallala Aquifer, the Snake River and eastern Washington State. In the case of cropland conversion, the greatest benefits occur in the marginally productive areas extending from Texas up through Missouri and into Appalachia, as well as in Northern Minnesota and Wisconsin. These are precisely the areas where the greatest proportional cropland expansion occurred during the recent boom period from 2008 to 2012[12].

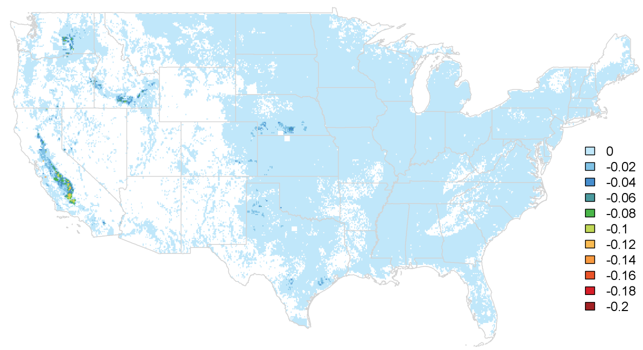


Figure 4a. Higher productivity growth leads to slower growth in groundwater withdrawal (change in ratio of withdrawal to recharge).

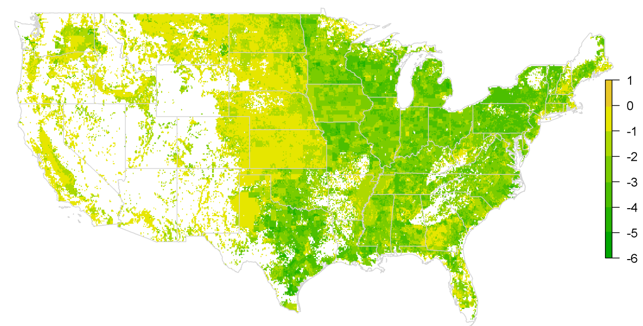


Figure 4b. Higher productivity growth leads to slower cropland expansion (% of cropland).

Limitations of the Analysis

In closing, it is important to note some key limitations of our study. Firstly, the relationship between public R&D and US agricultural productivity is changing. It is possible that the advent of new genome technologies and advances in agro-eco-informatics, as well as precision farming will reduce the lag time between R&D investments and productivity advances. In this case, we will have understated the output and export growth, as well as the sustainability improvements, attainable in 2050 from the accelerated investments. We have also ignored the synergistic relationship which exists between public and private R&D. Most of the recent advances in plant and animal breeding, for example, can be traced back to fundamental advances in basic science enabled by programs supported by USDA, NSF and NIH, among other federal agencies. By ignoring these linkages, we are once again understating the potential gains from accelerated public R&D investments in agriculture.

Summary

In summary, there is a well-established relationship between public investments in research and development and productivity growth in US agriculture. Since the 1950's, this has allowed farm output to grow strongly with minimal increases in total inputs. Looking ahead to mid-century, the current, relatively flat, spending path will result in slowing output and export growth accompanied by increased environmental stresses. By accelerating investments in public R&D, the United States can achieve a more rapid growth of output and exports over the coming decades, even as groundwater and land use stresses are moderated.

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