

Innovating for Food Security and Smallholder Livelihoods

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The world's population is expected to grow by 3 billion people over the next four decades. Feeding them—and ensuring food security for the 1 billion who are already hungry or malnourished—will require every tool available, including reforming trade-distorting policies that reduce incentives to invest in developing-country agriculture and reducing biofuel subsidies that pit food against fuel. But that's just the beginning of what developed countries should do to create a sound global environment for food security. In the face of climate change, land and water scarcity, and declining growth in crop yields, increasing investment in innovation and technological progress are also essential. With public budgets constrained and agricultural R&D in developing

countries virtually nonexistent, donors need to be more innovative in how they deliver aid for agriculture.

Australia, Canada, the United Kingdom, the United States, and the Bill and Melinda Gates Foundation took up the challenge at the June 2012 G-20 summit in Los Cabos, Mexico. They committed \$100 million for an initiative called AgResults that will use “pull mechanisms” to engage the private sector and encourage the development and dissemination of agricultural technologies aimed at improving food security and smallholder productivity.¹ AgResults will use

1. World Bank, “Innovative Fund to Boost Food Security and Farmer Livelihoods is Launched,” press release, June 18, 2012, <http://go.worldbank.org/8XZD3IX8Y0>, accessed February 25, 2013.

Summary

In the face of climate change, land and water scarcity, declining growth in crop yields, and dwindling public budgets, donors will need to be more innovative in how they deliver aid for agriculture. The world's population is expected to grow by 3 billion people in the coming four decades, and 1 billion are already food insecure. Feeding them all will require every tool available. One such tool is pull mechanisms, which can help overcome the underinvestment in agriculture in developing countries by increasing the demand and compensation for new technologies. Australia, Canada, the United Kingdom, the United States, and the Bill and Melinda Gates Foundation have committed \$100 million for AgResults, an initiative that will use pull mechanisms to engage the private sector and encourage the development and dissemination of agricultural technologies aimed at improving food security and smallholder productivity. It's a start. The first pilots under AgResults are conservative measures. Donors should be more ambitious in the future. With pull mechanisms, donors are looking for partners willing to take on some risk; they need to be willing to risk failure as well, as long as they learn from it.

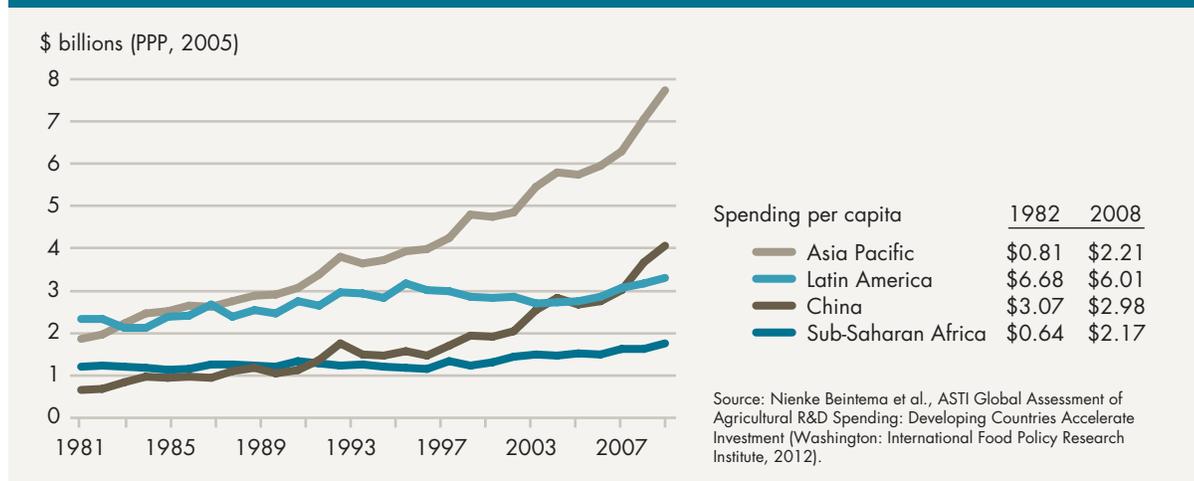
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Figure 1. Sub-Saharan Africa Lags Behind: Total Public Spending on Agricultural R&D



prizes, patent buyouts, or advance market commitments—forms of results-based aid—that pay out only upon delivery and adoption of an innovation or product that meets criteria set out in advance.

Underinvestment in Agricultural Innovation for Developing Countries

Innovation is a classic public good, and market forces alone usually fail to induce a socially optimal level of innovative activity. In response, governments can either use push mechanisms to expand the supply of innovation or opt for pull mechanisms to create demand. For some types of innovation, including basic science and early research without obvious commercial applications, governments often fund research upfront. Where potentially lucrative market applications exist, inventors can recoup research and development costs using patent and copyright laws that provide a temporary monopoly.

Agriculture presents unusual challenges for inventors trying to reap the benefits of their efforts. For crops that are self-pollinating, for example, farmers can reuse seed from year to year, making it difficult for those who develop improved varieties to enforce patents and recoup their costs. In the United States, the private sector accounted for 72 percent of all R&D spending in 2000, but only 55

percent in the agriculture sector.² Globally, private R&D for agriculture in 2008 was only 21 percent of the total.³

Developing countries face additional obstacles because their markets are often too small or too poor to induce private R&D investments, even with strong protection for intellectual property rights (IPRs) such as patents and copyrights. Though data is scarce, estimates suggest that the share of private investment in total agricultural R&D spending in developing countries was only 2 percent in 2000.⁴ It was public investment in agricultural R&D for developing countries that led to the green revolution in Asia and Latin America in the 1960s and 1970s.

The lack of funding for agricultural innovation—public or private—is especially acute in sub-Saharan Africa, where the green revolution never took hold. Although overall public R&D investments in developing countries began to grow more rapidly in the late 2000s, such investments in Africa lag behind (see figure 1). The situation is even worse for private investment. The disincentives to invest in agricultural innovation in sub-Saharan Africa are

2. Philip G. Pardey and Julian M. Alston, *U.S. Agricultural Research in a Global Food Security Setting* (Washington: Center for Strategic and International Studies, 2010), 6, 9.

3. Nienke Beintema et al., *ASTI Global Assessment of Agricultural R&D Spending: Developing Countries Accelerate Investment* (Washington: International Food Policy Research Institute, 2012), 12.

4. Nienke Beintema and GertJan Stads, "Agricultural R&D Capacity and Investments in the Asia-Pacific Region," IFPRI Research Brief No. 11 (Washington: International Food Policy Research Institute, 2008).

compounded because many staple crops, such as cassava, sorghum, and millet, are not demanded in significant quantities elsewhere. Poor soils and the lack of irrigation also prevent crop varieties developed elsewhere from being easily adapted to Africa.⁵ Thus, Africa is in special need of an innovative funding mechanism focused on invention, adaptation, and adoption.

Why Pull?

Pull mechanisms have strengths in three key areas relative to other tools for inducing agricultural innovation and adoption. First, they engage the private sector in research in developing countries where traditional IPRs are either weak or not valuable enough to generate interest. Second, they alleviate the information asymmetries that commonly arise between donors and researchers, and potentially between researchers and consumers, by making payments for technologies only when they are delivered. Finally, pull mechanisms fit well with donors' efforts to move toward incentive-based approaches to make aid more effective.

Traditional up-front grants will remain important for basic science and early R&D, but pull mechanisms can harness the energies and leverage the resources of the private sector to help develop products that are more likely to succeed in the marketplace. Pull mechanisms also addresses weaknesses of push funding in situations where funders and researchers do not have access to the same information and where it is difficult to identify the best path to an innovation, making it difficult to set benchmarks or observe the quality of the research while it is ongoing. By paying for results, pull mechanisms free donors from having to pick "winners" for research grants on the basis of imperfect information about the best scientific approach.⁶

Imperfect information about researchers also makes it difficult to ensure that researchers' incentives are aligned with those of the funders. For example, up-front funding may lead researchers, especially if they are employed in the public sector



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and do not anticipate private gains from an innovation, to undervalue features that are important to the final consumer. By putting the onus on innovators to ensure that the final product meets the needs of consumers—by linking payments to the level of demand—donors can partially address the asymmetric information between researchers and consumers and increase the prospects for broad adoption of new technologies.

Pull mechanisms are only one of a number of incentive-based programs with which donors are experimenting that pay ex post for outputs or outcomes rather than ex ante for inputs.⁷ Mechanisms in the same broad family include pay-for-performance for those implementing projects; cash-on-delivery aid for governments that meet mutually agreed-upon targets, for example in educating children; and the Millennium Challenge

5. See Kimberly Anne Elliott, "Pulling Agricultural Innovation and the Market Together," CGD Working Paper 215 (Washington: Center for Global Development, 2010), 4–5.

6. Michael Kremer and Alix Peterson Zwane, "Encouraging Private Sector Research for Tropical Agriculture," *World Development* 33(1): 92–93.

7. William Savedoff, "Incentive Proliferation? Making Sense of a New Wave of Development Programs," CGD Essay (Washington: Center for Global Development, 2011), 1.

Corporation's model that rewards countries with long-term aid compacts when they meet certain thresholds for good governance. What distinguishes pull mechanisms from these other results-based approaches is that pull mechanisms have relatively focused objectives, involving innovation and technology adoption, and they generally aim to engage the private sector.

The optimal situation for using a pull mechanism is when potential private partners are willing and able to accept some risk and when a temporary subsidy is sufficient to overcome the market failures impeding technological progress. In some cases, the main impediment to broad adoption of an existing technology is imperfect information on the part of consumers that prevents socially optimal levels of uptake. For example, the health benefits of Vitamin A–fortified maize (one of the AgResults pilots) are not readily linked to consumption of the product. Consumers may not purchase



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it if it is more expensive, or if it looks different from the less colorful variety to which they are accustomed. In such cases, a pull mechanism could still be useful in pulling innovation, but complementary public interventions, such as subsidized vouchers or public education campaigns, might be needed to support adoption until consumers learn to value the benefits.

Types of Pull Mechanisms

While all incentive-based approaches to aid might be considered pull mechanisms in some broad sense, the narrower definition here focuses on prizes, patent buyouts, and advance market commitments. Traditional prizes to spur breakthrough inventions are familiar, but there are also variants designed to encourage incremental innovation or participation by small firms. Patent buyouts and advance market commitments are flexible tools that can be designed to encourage the commercialization and dissemination of close-to-market technologies or the research and development for earlier-stage innovations.

Prizes

Traditional prizes are usually winner-takes-all and aim to encourage breakthrough innovations, such as the X Prize Foundation's competitions for a private company to reach space, or produce a 100-mile-per-gallon car.⁸ The Foundation notes that the prize amounts are often far below what it costs competitors trying to win them and that prizes work best toward problems that are attention-grabbing and can capture the imagination.⁹

Milestone prizes also create incentives for new technologies, but they provide small payments along the way rather than just at the end. They also differ from traditional prizes by not being technology-neutral. Milestone prizes are motivated by a desire to facilitate participation by smaller companies that may have problems financing research in the early stages. It rewards

8. See X Prize Foundation, "Prize Development," www.xprize.org/prize-development, accessed March 13, 2012.

9. For example, the prize that Charles Lindbergh won for being the first to fly nonstop from New York to Paris was worth \$25,000, but the teams competing for it collectively spent \$400,000. See X Prize Foundation, "Incentivized Competition Heritage," www.xprize.org/x-prizes/incentivized-competition-heritage, accessed February 27, 2013.



Image: Gates Foundation. Some rights reserved.

multiple successful competitors with relatively small prize amounts as they hit early-stage targets. One or a few receive a larger prize if they successfully developing a technology with the specified attributes. BIO Ventures for Global Health (BVGH), for example, is testing this model in a competition to develop a fever diagnostic because it wants smaller biotech companies to participate.¹⁰

Like traditional prizes, **proportional prizes** are technology-neutral, but they are designed to reward incremental progress and to explicitly link prize payments to adoption. They are well suited for agriculture, where improvements in productivity are often incremental and where it can be difficult to predict which technologies will be successful. In one such proposal for African agriculture, prizes would be rewarded in proportion to their measured (and verified) social benefit, including

a measure of adoption.¹¹ By revealing what works in a given environment, the proportional prize could attract private investment (or donor funds) to scale up and disseminate the winning practices or products.

Patent buyouts and advance market commitments

A **patent buyout** can be used either to promote or disseminate innovation. In some cases, donors might decide that buying up an existing patent is the most cost-effective way to make a useful technology more widely available to poorer consumers. Alternatively, a patent buyout might be designed to resemble a prize for new innovation if donors commit in advance to pay an innovator for developing a technology that addresses a specified problem. In contrast to a traditional prize, where it is usually left to the market to develop and market the product, a patent buyout is

10. See BIO Ventures for Global Health, "Global Health Innovation Quotient Prize (IQ Prize)," www.bvgh.org/What-We-Do/Incentives/IQ-Prize.aspx, and, for a brief analysis of the proposal, Results for Development Institute, "BVGH's Fever Diagnostic Prize: Kudos and Comments," <http://healthresearchpolicy.org/blog/2011/sep/9/BVGH-fever-diagnostic-prize>, blog posted September 9, 2011 (both accessed April 10, 2012).

11. The arguments for the proportional prize in general, and applicability to Africa, are discussed in William A. Masters and Benoit Delbecq, "Accelerating Innovation with Prize Rewards: History and Typology of Technology Prizes and a New Contest Design for Innovation in African Agriculture," IFPRI Discussion Paper 835 (Washington: International Food Policy Research Institute, 2008).

Table 1: Choosing Among Pull Mechanisms

<i>Partners' access to finance for R&D and other up-front costs</i>	<i>Donor's stance on best technological path</i>	
	<i>Less neutral</i>	<i>More neutral</i>
<i>More access</i>	Advance market commitment Patent buyout Proportional prize divided among multiple winners based on adoption (complement to other prizes if dissemination suboptimal)	Winner-takes-all prize (usually for breakthrough innovations) Proportional prize divided among multiple winners based on relative social benefit (rewards incremental and unpredictable innovations)
<i>Less access</i>	Milestone prize	Grant

designed to promote broad dissemination by putting the knowledge into the public domain. Still, delivery and adoption will be a problem if there are too few potential producers, large economies of scale, or other market failures that impede commercialization at an affordable price.

The **advance market commitment** (AMC) aims to encourage both innovation and broad adoption by paying producers a subsidy for each unit of a new technology delivered to consumers. The subsidy is intended to cover up-front costs for R&D and development of productive capacity for developing countries when market prices alone would not be enough. The AMC was originally designed to encourage the development of vaccines for developing countries with donors committing to pay a subsidized price per dose for each dose purchased by developing countries, up to a designated ceiling. In return, manufacturers signed contracts agreeing to continue supplying the drug for a minimum number of years at an affordable price (near marginal costs).¹²

12. See Advance Market Commitment Working Group (Ruth Levine, Michael Kremer, and Alice Albright, chairs), *Making Markets for Vaccines: Ideas to Action* (Washington: Center for Global Development, 2005) for information on AMCs for vaccines in general. For information about the pneumococcal vaccine, see GAVI Alliance, "Pneumococcal AMC," www.gavialliance.org/funding/pneumococcal-amc/, accessed February 27, 2013.

Different types of mechanisms can also be combined into hybrid designs. An example that combined a traditional prize for introducing a technology with a proportional prize to encourage adoption was the Haiti Mobile Money initiative, funded by the US Agency for International Development and the Bill and Melinda Gates Foundation. The goal was to encourage faster dissemination of mobile banking services, especially in rural areas, and to facilitate the transfer of remittances to survivors of the earthquake. The Haiti Mobile Money project offered lump-sum payments to the first two companies to launch mobile money services and then an additional prize to be paid out proportionally based on the number of new subscribers using cell phones for e-banking.¹³

Choosing Among Pull Mechanisms

The appropriate pull mechanism in a given situation will depend on a number of factors, but there are two general criteria, shown in table 1. The first is the amount of information the donor has about potential technological solutions to a problem and

13. See USAID, "Gates Foundation and USAID Announce Innovative Fund to Incentivize Mobile Money Services in Haiti," press release, June 8, 2010, <http://transition.usaid.gov/press/releases/2010/pr100608.html>, accessed May 23, 2012.

the degree to which the donor is able to specify desirable attributes of the technology. The second is access to finance and the ability of potential competitors to take on risk.

To summarize the key differences, winner-take-all prizes are useful when funders are neutral regarding the preferred technological path to achieve a goal. They are most often used to help pull out a breakthrough technology. Proportional prizes can also be used when donors are uncertain about the most appropriate technology for a given problem, but they are more appropriate where progress is likely to be incremental or when adoption of an existing technology is the main goal. Milestone prizes require more specificity regarding attributes of the desired technology and will be more useful when seeking to engage smaller firms or when access to finance is a problem in the R&D phase. Advance market commitments are useful when donors have an idea of the type of technology they want, but do not have the information to specify the best path for developing it, do not want to pick a winner *ex ante*, and do not want to pay unless the technology is adopted.

Only the AMC links innovation and uptake by design. With the prize options and the patent buyout, the link between innovation and adoption is not necessarily part of the design and donors will need to decide if complementary policies are needed to make this link. If there are many potential producers and the potential market seems well developed enough to support commercialization and delivery of the technology, then a patent buyout may be preferable to a prize because it incorporates affordable adoption as a goal. In some cases, however, imperfect competition or other market failures might still prevent the desired level of dissemination. One option would be to combine a traditional prize for innovation with a proportional prize for adoption, as may be proposed for at least one of the AgResults pilots.¹⁴

Before adopting any of these approaches, however, donors need to analyze the problem they are trying to solve. Numerous recent studies

underscore the wide range of social, behavioral, or broader market failures that impede sustainable adoption of agricultural technologies in developing countries. Farmers will not invest in productivity-improving technologies if they cannot make a profit because there are no roads to get their crops to market or if they do not have access to saving or borrowing mechanisms. Consumers will not pay extra for micronutrient-fortified crops if the benefits are intangible. In those cases, donors may need to consider complementary policies, such as cash-on-delivery aid to improve market connections for farmers or vouchers to subsidize consumption of fortified varieties.

Implementation of AgResults

At the June 2010 G-20 summit meeting, Australia, Canada, the United Kingdom, and the United States, along with the Bill and Melinda Gates Foundation, announced that they were committing \$100 million to the AgResults initiative. They also announced the goals of the first three pilots testing the use of pull mechanisms under the initiative:

- improved on-farm storage technologies for smallholders in Kenya
- Vitamin A–fortified maize in Zambia
- a method to control aflatoxin in maize in Nigeria¹⁵

There is not a great deal of innovation being pulled in these initial pilots. Two of them, for nutrient-fortified maize and aflatoxin control, target the broader dissemination and uptake of specific technologies that already exist. Moreover, since the benefits to consumers from using the technologies are not immediately obvious, sustaining adoption in the absence of ongoing public subsidies could be a challenge. The storage-technology pilot is more technology-neutral, but it is designed to do no more than provide incentives for adaptation or tweaks to expand the uses of existing products. Proposed pilots that did not make the cut, which

14. Something similar is suggested for the storage technology pilot; see Australian Agency for International Development, "AgResults: Innovation in Research and Delivery," draft concept note on behalf of the AgResults Steering Committee, June 18, 2012, available at http://siteresources.worldbank.org/CFPEXT/Resources/AgResults_concept_note.pdf.

15. The details of the proposals are still not publicly available but brief descriptions are in Australian Agency for International Development, "AgResults" (n. 14). For additional information, see the AgResults webpage (World Bank, "AgResults," <http://bit.ly/Zuy3OB>, accessed March 13, 2013).



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would have been higher risk and taken longer to come to fruition, included those to develop improved fertilizers, livestock vaccines, or rice varieties. But the benefits also might have been larger. Development of a more effective and energy-efficient fertilizer is on the short list for the next round of pilots, and that could be a big step up in ambition.

What is perhaps most notable about the initiative is that the donors are committed to incorporating well-designed monitoring and evaluation from the outset. If nothing else, donors hope to gain knowledge about what works under what conditions—and that is essential to innovation in aid delivery.

innovation to develop more stress-resistant crop varieties, efficient irrigation technologies, and much more. Donors should also be more ambitious in encouraging investment by the private sector, including by engaging multinational companies with deep pockets and extensive experience developing improved seeds and other inputs. A true test of the AgResults approach would give more latitude to markets to determine the best technological solution to a designated problem. With pull mechanisms, donors are looking for partners willing to take on some risk, and they need to be willing to risk failure as well, as long as they learn from it.

Recommendations

Donors are being conservative in this first round of pilots under AgResults, perhaps understandably so, but they should be more ambitious in the future. Encouraging the adoption of existing technologies in the short run is helpful. But adapting to climate change, for example, also requires new

This brief draws on the analysis in Kimberly Ann Elliott, “Pulling Agricultural Innovation and the Market Together,” CGD Working Paper 215 (Washington: Center for Global Development, 2010) and “Ag Aid and Tech Breakthroughs: Pull Funding for Smallholder Productivity,” CGD Policy Paper 005 (Washington: Center for Global Development, 2012).

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