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AFRICA'S AGRICULTURAL R&D FUNDING ROLLERCOASTER

An Analysis of the Elements of Funding Volatility

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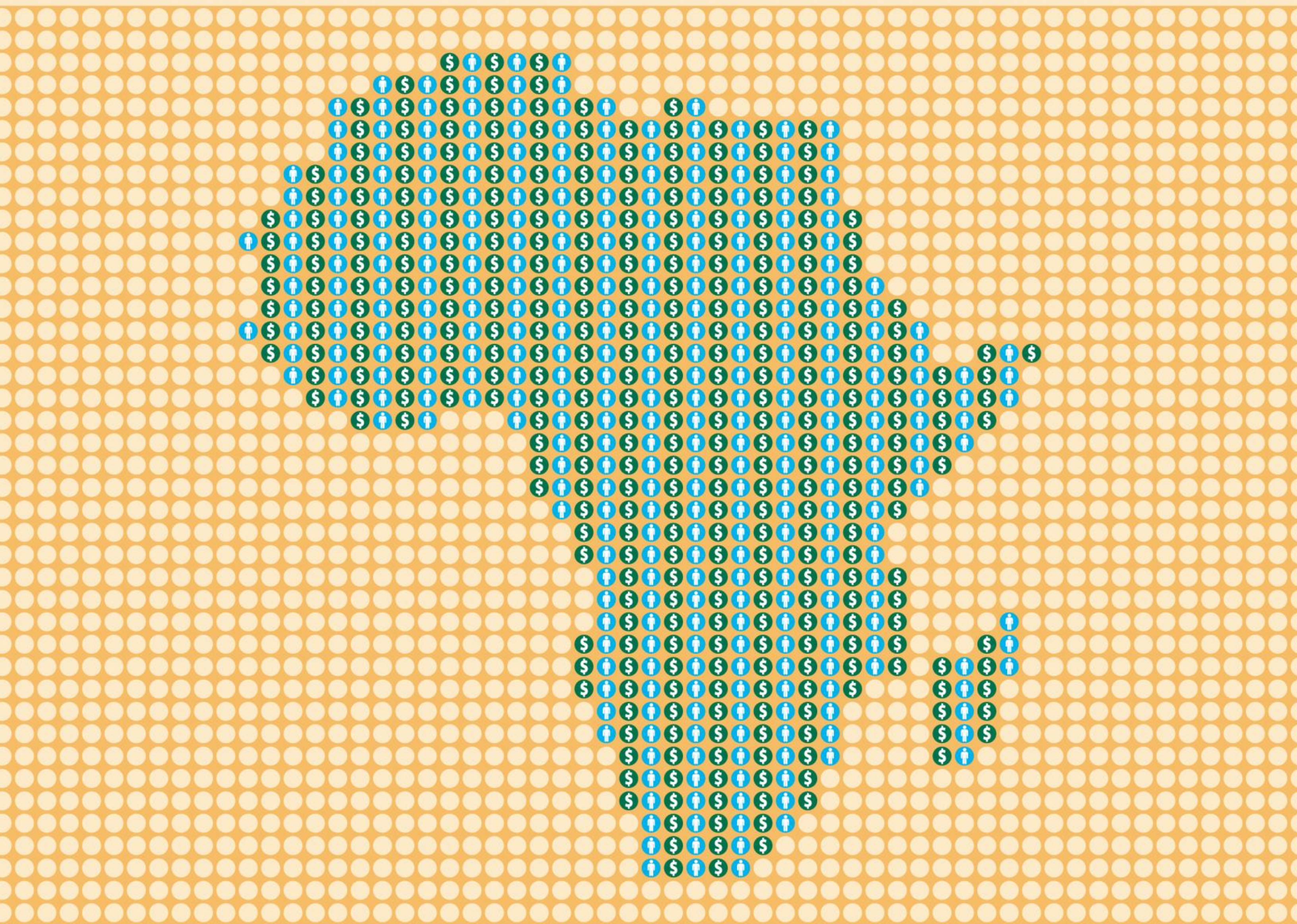
AGRICULTURAL R&D: INVESTING IN AFRICA'S FUTURE

Analyzing Trends, Challenges, and Opportunities



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Acronyms and Abbreviations

AgGDP	agricultural gross domestic product
ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
CGIAR	Consultative Group on International Agricultural Research
CORAF/WECARD	West and Central African Council for Agricultural Research and Development
CRF	Coffee Research Foundation (Kenya)
CRIG	Cocoa Research Institute of Ghana
FARA	Forum for Agricultural Research in Africa
FTE	full-time equivalent (staffing levels)
INRAN	National Agricultural Research Institute of Niger
MSIRI	Mauritius Sugar Industry Research Institute
NARS	national agricultural research systems
NEPAD	New Partnership for Africa’s Development
PNRA	National Agricultural Research Project (Niger)
PPP	purchasing power parity (exchange rates)
R&D	research and development
SRO(s)	subregional organization(s)
SSA	Sub-Saharan Africa

Abstract

The inherent lag from the inception of research to the adoption of a new technology or the introduction of a new variety calls for sustained and stable research and development (R&D) funding. The time-series data presented in this paper, however, reveal that agricultural R&D funding in many Sub-Saharan African (SSA) countries has been far from stable. Agricultural R&D agencies in SSA, particularly those in the region’s low-income countries, are very dependent on funding from donors and development banks, and this type of funding has shown considerably greater volatility over the past decade compared with government funding and other sources. Numerous examples show that agencies reverted into financial crisis upon the completion of large donor-funded projects, forcing them to cut research programs and lay off staff.

Volatility in year-to-year spending levels can be halted only with sustained, long-term backing from national governments, donors, regional and international organizations, as well as the private sector. Governments have to clearly identify their long-term national R&D priorities and design relevant, focused, and coherent R&D programs accordingly. Donor funding needs to be better aligned with national priorities, and consistency and complementarities between donor programs need to be ensured. Moreover, diversification of funding sources is needed, for example, through the sale of goods and services and increased participation in and funding of research by the private sector. This, in turn, requires that national governments provide a more enabling policy environment.

1. INTRODUCTION

Extensive empirical evidence demonstrates that investments in agricultural research and development (R&D) have greatly contributed to economic growth, agricultural development, and poverty reduction in Sub-Saharan Africa (SSA) over the past five decades. New technologies resulting from R&D investments have enhanced the quantity and quality of agricultural outputs, and have led to higher incomes, greater food security, and better nutrition. Given important challenges, such as rapid population growth, adaptation to climate change, and the volatility of prices in global markets, investing in agricultural R&D remains crucial in increasing agricultural productivity and reducing poverty in SSA (Beintema and Stads 2011).

Despite the well-documented evidence that the payoffs to agricultural research are considerable, many countries in the region continue to grossly underinvest in agricultural research. Given the substantial time lag between investing in research and reaping its rewards—which is typically decades, not just years—agricultural research requires a long-term commitment of sufficient levels of sustained funding. These long research cycles rarely coincide with short-term election cycles, shifting political agendas, and changes in government budget allocations, all of which have major impacts on agricultural research, potentially jeopardizing future research planning and outputs. In addition, agricultural R&D in many SSA countries is highly dependent on donor and development bank funding, which by nature is mostly short-term and ad hoc, and can cause major fluctuations in a country's yearly agricultural R&D investments.

This study provides an assessment of long-term trends in public agricultural R&D investments and funding sources in SSA, highlighting differences across countries, offering insight into the various funding mechanisms in use, and detailing the reasons for spending growth in some countries and falling investment levels in others. The study also introduces a measure for quantifying volatility in agricultural R&D spending and funding, assessing the degree of volatility across countries and suggesting the main drivers of funding volatility.

Box 1. Methodology

The analysis in this paper is based on comprehensive datasets derived from primary surveys conducted in region by the Agricultural Science and Technology Indicators (ASTI) initiative of the International Food Policy Research Institute (IFPRI) during 2009–10, along with subsequent country- and regional-level ASTI publications (ASTI 2010–11). ASTI datasets are collected and processed using internationally accepted definitions and statistical procedures for compiling R&D statistics developed by the Organisation for Economic Cooperation and Development and the United Nations Educational, Scientific and Cultural Organization. So as to facilitate cross-country comparisons, all financial data have been converted to 2005 purchasing power parity (PPP) prices using the World Bank's World Development Indicators. PPPs measure the relative purchasing power of currencies across countries by eliminating national differences in pricing levels for a wide range of goods and services. The sample includes 33 SSA countries, which together contribute more than 90 percent of the region's agricultural gross domestic product. For more information on ASTI methodology, visit http://www.asti.cgiar.org/methodology.

2. LONG-TERM TRENDS IN AGRICULTURAL R&D SPENDING IN SSA

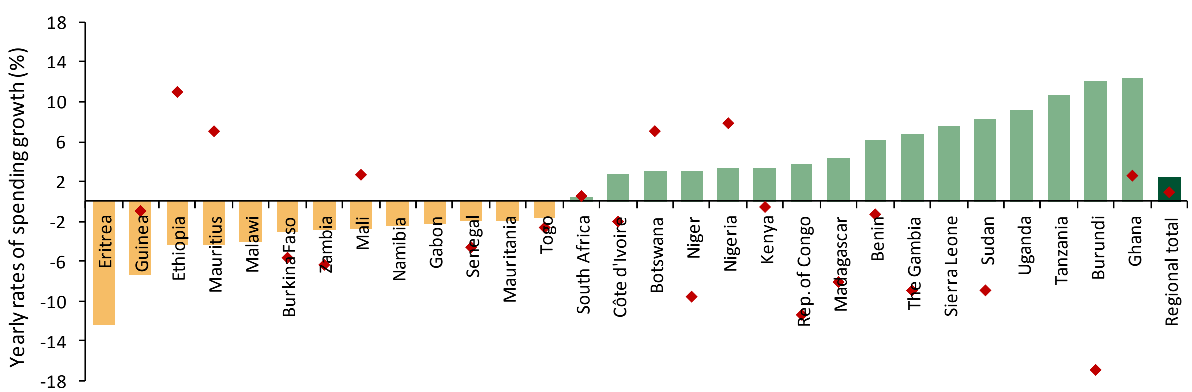
Based on data for 33 ASTI countries and estimates for 13 other (often small) countries, public agricultural R&D investments for SSA as a whole totaled $1.7 billion 2005 constant PPP dollars in 2008 or $0.8 billion in 2005 constant U.S. dollars.[1] This was almost 20 percent higher than the $1.4 billion in 2005 PPP dollars (or $0.6 billion in 2005 US dollars) recorded in 2001 and marks a considerable shift

[1] This section draws largely on Beintema and Stads (2011).

from the slow growth rate of the 1990s. A breakdown by country, however, reveals that the growth in Africa-wide spending during 2001–08 was largely driven by just a few countries. More than one-third of the growth in public agricultural R&D expenditures during this period was attributable to a $110 million increase in spending in Nigeria. Ghana, Sudan, Tanzania, and Uganda also recorded relatively high increases in total spending of between $25 million and $56 million each (all in 2005 PPP dollars).

Although increases and decreases in the absolute levels of agricultural R&D spending of the region's larger countries overshadow those of many of the smaller countries, a closer look at relative shifts in investment levels over time reveals some interesting cross-country differences and challenges. Some of the region's smallest countries have very low and declining levels of investment and human resource capacity, calling into question the effectiveness of their national agricultural R&D output. During 2001–08, 13 of 29 countries for which a full set of time-series data were available experienced negative yearly growth in public agricultural R&D spending, ranging from –1.6 to –12.4 percent per year (Figure 1), which is sizeable given that spending in SSA as a whole actually increased throughout this period. Of these 13 countries, 7 are francophone countries located in West and Central Africa. With the exception of Gabon and Mali, these countries also experienced negative growth during the 1990s, which is a major area for concern. Falling investments in agricultural R&D in these countries resulted mainly from the completion of large donor-funded projects, often financed through World Bank loans (Burkina Faso, Guinea, Senegal, and Togo). Comparing the 2001–08 growth rates with those of the 1990s clearly illustrates the volatility of agricultural spending levels for many of the region's countries. Eritrea and Ethiopia, for example, experienced strong negative growth during 2001–08 (–12.4 and –4.5 percent per year, respectively) following a decade of particularly high positive growth (32.7 and 11.0 percent per year, respectively).

Figure 1. Yearly growth grates in agricultural R&D spending, 1991–2001 and 2001–08



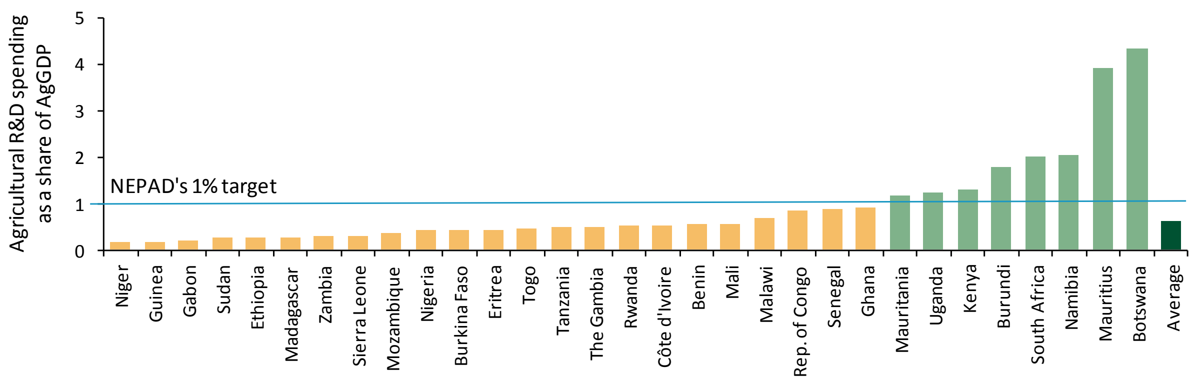
Source: Beintema and Stads (2011).

Notes: The bars depict the growth rate for 2001–08, the red dots the growth rate for 1991–2001. The figure excludes Mozambique, Rwanda, Sierra Leone, and Zimbabwe because time-series were not available; 1991–2001 growth rates are missing for Eritrea, Mauritania, Namibia, Tanzania, and Uganda due to a lack of time-series data for the full period. Compound yearly growth rates are calculated using the least-squares regression method.

Rather than looking at absolute levels of agricultural R&D investment, another way of comparing commitment to public agricultural R&D investment across countries is to measure total public agricultural R&D spending as a percentage of agricultural output (AgGDP). This relative measure indicates the intensity of investment in agricultural research. In 2008, SSA invested $0.61 for every $100 of agricultural output on average (Figure 2), which was below the national R&D investment target of at least 1 percent of total GDP put forward by the African Union's New Partnership for Africa's Development (NEPAD). Just 8 of the 31 countries for which data were available met this 1 percent target. Burundi, Kenya, Mauritania, Namibia, South Africa, and Uganda recorded 2008 ratios of between

1.2 and 2.0 percent, whereas Mauritius and Botswana recorded particularly high ratios of 3.9 and 4.3 percent, respectively. In contrast, a large number of countries recorded intensity ratios of 0.5 percent or lower. Although intensity ratios provide useful insights into relative investment levels across countries, they take into account neither the policy and institutional environment within which agricultural research occurs, nor the broader size and structure of a country's agricultural sector and economy. More detailed analysis is therefore needed to ensure a clear understanding of the implications of intensity ratios across countries.

Figure 2. Agricultural R&D intensity ratios (spending/AgGDP), 2008



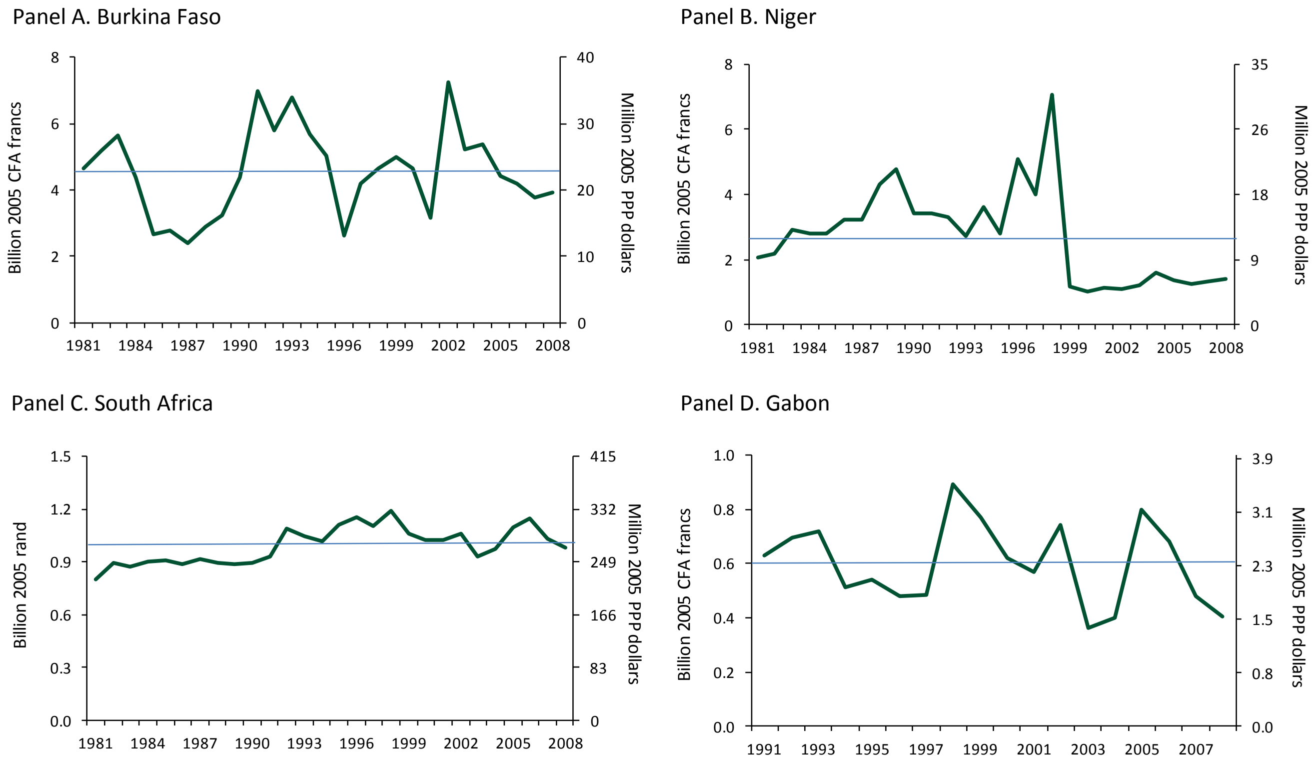
Source: Beintema and Stads (2011).

3. VOLATILITY IN YEARLY AGRICULTURAL R&D SPENDING

Time lags are unavoidable between the point of investing in agricultural R&D and that of attaining tangible benefits from it (Alston, Pardey, and Piggott 2006); in the interim, long-term stable funding is required. However, in some SSA countries like Burkina Faso and Gabon, yearly agricultural R&D investment levels have fluctuated widely over time, while in Niger spending levels plunged suddenly in 1998 and have not recovered since (Figure 3). In contrast, South African agricultural R&D spending remained comparatively stable during 1981–2008. The reasons for year-to-year spending fluctuations are manifold and differ greatly across countries.

A wide body of literature exists on the impact of macroeconomic volatility on economic growth and performance in developing countries. This literature has focused primarily on volatility across countries, thereby setting the issue within an international context. Substantial empirical evidence has demonstrated that increased macroeconomic volatility has a negative impact on economic growth, or is at least closely associated with slower growth (Hnatkovska and Loayza 2004; Agion et al. 2005; Fatás and Mihov 2006; Perry 2009). This is unsurprising given the broad consensus that high macroeconomic volatility likely slows down investment (because investment flows depend on expected rewards and risks), as well as biasing investments toward short-term returns (Servén 1997). High macroeconomic volatility has also been associated with lower investment in human capital, for similar reasons (Krebs, Krishna, and Maloney 2005).

Figure 3. Fluctuations in yearly public agricultural R&D expenditures around long-term average for selected African countries, 1981–2008



Source: Compiled by author from ASTI survey data.
Note: The horizontal lines show the long-term spending average.

In addition, a vast amount of literature has focused on the volatility of aid flows to developing countries. Aid flows are found to be more volatile than government revenues, household consumption, or GDP, and aid volatility tends to reinforce macroeconomic instability and slow down economic growth (Bulíř and Hamann 2003; Fielding and Mavrotas 2008; Desai and Kharas 2010). Desai and Kharas (2010) note that some degree of aid volatility is caused by events in recipient countries (for example, regime change, natural disasters, and civil wars), but that volatility in aid flows is primarily due to donor behavior, including bad planning and shifting priorities.

No literature was found on R&D funding volatility in developing countries; however, empirical findings from the literature on macroeconomic and aid volatility suggest that extreme volatility in agricultural R&D funding is similarly harmful to the institutional stability and long-term outputs of agricultural R&D. This is supported by substantial anecdotal evidence. Numerous examples across Africa indicate that, upon the completion of multimillion dollar projects, agricultural R&D agencies have been plunged into financial hardship and an uncertain future, forcing them to cut research programs and lay off staff. Large fluctuations in yearly investment levels are thus thought to have a detrimental impact on the release of new varieties and technologies in the long run, which in turn can have a negative impact on agricultural productivity growth and poverty reduction.

4. THE VOLATILITY COEFFICIENT

In order to measure the degree of volatility in yearly agricultural R&D spending levels across SSA countries, a commonly used method of calculating price volatility in finance and output volatility in macroeconomics was applied to ASTI's agricultural R&D spending data. The so-called volatility coefficient quantifies volatility in agricultural R&D spending by applying the standard deviation formula to average one-year logarithmic growth of agricultural R&D spending over a certain period (Durlauf, Johnson, and Temple 2008). Growth in agricultural R&D spending (g_s) can be expressed as follows:

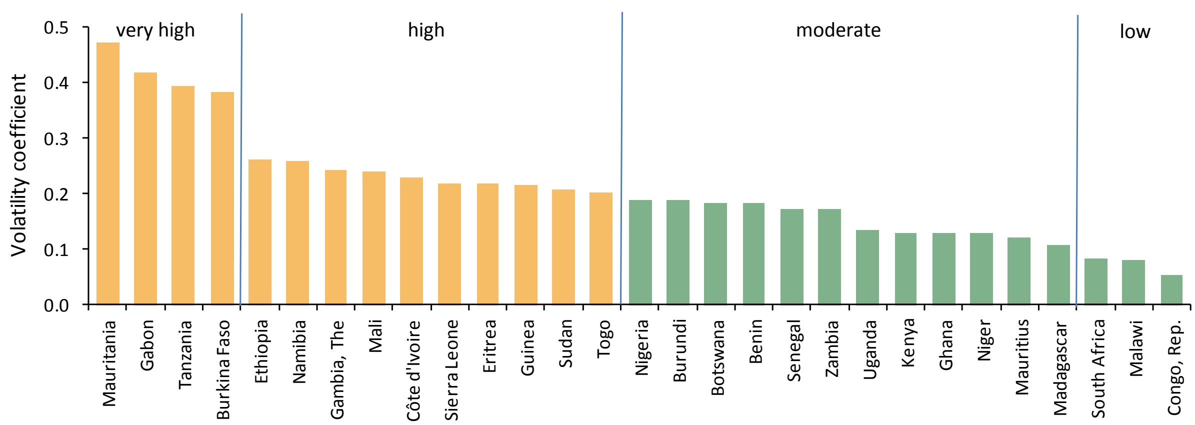
$$g_s = \ln\left(\frac{s_t}{s_{t-1}}\right) \qquad \text{s=1,…, N,}$$

where *s* is agricultural R&D spending (in constant prices), and *t* represents the year. Subsequently, the volatility coefficient (V) of agricultural R&D expenditures can be calculated by taking the standard deviation of growth in yearly agricultural R&D spending, that is,

$$\text{V} = \sqrt{\frac{1}{N}\sum_{s=1}^{N}(g_s-\mu)^2}, \text{ where } \mu = \frac{1}{N}\sum_{s=1}^{N} g_s.$$

Volatility coefficients were calculated for 29 SSA countries, based on complete time-series data on agricultural R&D expenditures for the 2001–08 period. Countries with few or no changes in yearly spending levels or those with steady (positive or negative) growth have low volatility coefficients. In contrast, countries with erratic fluctuations in spending levels from one year to the next have high volatility coefficients. A value of 0 indicates "no volatility," countries with values between 0 and 0.1 were classified as having "low volatility," countries with values between 0.1 and 0.2 were considered to have "moderate volatility," and countries with values above 0.2 fell into the "high volatility" category. The average 2001–08 volatility coefficient for the 29 SSA countries totaled 0.21 (Figure 4).[2]

Figure 4. Volatility coefficient of yearly agricultural R&D investment growth, 2001–08



Source: Compiled by author from ASTI survey data.
Notes: The figure excludes Mozambique, Rwanda, Sierra Leone, and Zimbabwe because time-series data did not date back to 2001.

Agricultural R&D spending in SSA was found to be considerably more volatile than in other developing regions. The volatility coefficient for the Asia–Pacific region for 1992–2002 was 0.12, whereas the corresponding coefficient for Latin America totaled 0.13 during 1994–98 and 0.14 during 2004–06 (calculated from Beintema and Stads 2008 and Stads and Beintema 2009). Moreover, agricultural R&D spending in SSA was also markedly more volatile than agricultural output (0.09) during 2001–08.

Understandably, a large degree of variation was recorded across SSA countries. Those with the highest degree of fluctuation in their yearly agricultural R&D spending were Mauritania (0.47), Gabon (0.42), Tanzania (0.39), and Burkina Faso (0.38). In contrast, yearly agricultural R&D spending in countries like the Republic of Congo, Malawi, and South Africa was found to be more stable, with

[2] Note that this is an unweighted average.

volatility coefficients of just 0.05, 0.08, and 0.08, respectively. It is important to note that volatility in spending at the agency level is typically higher than at the country level because aggregate fluctuations tend to hide idiosyncratic spending shocks. Similarly, the volatility coefficient for agricultural R&D investments for the combined 29 sample countries—that is, the standard deviation of yearly growth in total SSA agricultural R&D investment during 2001–08—is just 0.04, which indicates that spending in SSA as a whole is less volatile than spending in the individual countries.

In an effort to find an explanation for these large cross-country differences in volatility coefficients, the SSA countries were categorized by a number of broad characteristics: (1) income level; (2) geographic region; (3) the size of the national agricultural R&D system in terms of full-time equivalent (FTE) research staff; and (4) total agricultural R&D spending as a share of AgGDP. Income level appears to have a clear impact on volatility, given that investment levels in SSA's lower income countries were more volatile than those in middle-income countries (Table 1). Moreover, agricultural R&D spending in subregions like Southern Africa was found to be less volatile than spending in the other subregions. Support for the notion that spending levels in small national agricultural research systems (NARS) was more volatile than spending in larger systems was somewhat limited. Although spending in the large and medium-sized NARS was found to be slightly less volatile, on average, than spending in systems with fewer than 100 FTE researchers, some important exceptions contradicted this generalization; examples include Tanzania (whose NARS employed 674 FTE researchers in 2008) and Ethiopia (whose NARS employed 1,318 FTEs that year).

A clear connection was not immediately apparent between the intensity with which a country invests in agricultural R&D and its volatility coefficient. Nevertheless, seven of the eight high-intensity countries recorded volatility coefficients below 0.20, and most of the countries in this category have relatively well-funded R&D systems, some—including South Africa, Kenya, and Mauritius—producing world class research. The only country combining an intensity ratio above 1 percent with a high volatility coefficient (the highest in SSA) is Mauritania, but its high research intensity ratio actually stems from the small size of its crop sector (given its arid climate), not high investments in agricultural R&D. Excluding Mauritania as an outlier, the average volatility coefficient for countries that invest more than 1 percent of their AgGDP in agricultural R&D falls from 0.20 to 0.16, thereby adding to the evidence that high agricultural R&D intensity ratios can be correlated with lower levels of spending volatility.

Table 1. Spending volatility coefficients by country grouping, 2001–08

Country category	Average volatility coefficient	Sample size
1. Volatility by income level		
Low income countries	0.23	20
Lower middle-income countries	0.17	5
Upper middle-income countries	0.16	4
2. Volatility by subregion		
West and Central Africa	0.23	15
East Africa	0.22	7
Southern Africa	0.14	7
3. Volatility by size of agricultural research system		
> 500 FTEs	0.20	7
100 – 500 FTEs	0.19	12
< 100 FTEs	0.24	10
4. Volatility by spending intensity		
> 1.0 percent of AgGDP	0.20	8
0.5 – 1.0 percent of AgGDP	0.19	9
< 0.5 percent of AgGDP	0.23	12

Source: Compiled by author from ASTI survey data.
Notes: Average volatility coefficients are unweighted. FTE indicates full-time equivalent research staffing; AgGDP indicates agricultural gross domestic product. See Beintema and Stads (2011) for country classifications.

A closer look at a subsample of 58 agricultural R&D agencies from 25 SSA countries for which detailed time-series data were available by cost category shows that volatility in agricultural R&D spending is mainly caused by fluctuations in nonsalary expenditures, which is not surprising. Nonsalary expenditures (0.52) were more than three times more volatile than salary expenditures (0.17) during 2001–08 (Table 2). Of the nonsalary expenditures, capital investments (1.11) showed greater volatility than operating and program costs (0.52). Although these averages mask some important cross-agency differences, the results were relatively consistent across countries and institutes. Only 5 of the 58 sample agencies (or 9 percent) recorded a higher volatility coefficient for salary spending than for nonsalary spending.

Table 2. Volatility coefficient by cost category, 2001–08

Cost category	Volatility coefficient
Salary expenditures	0.17
Nonsalary expenditures	0.52
Operating and program costs	0.52
Capital investments	1.11

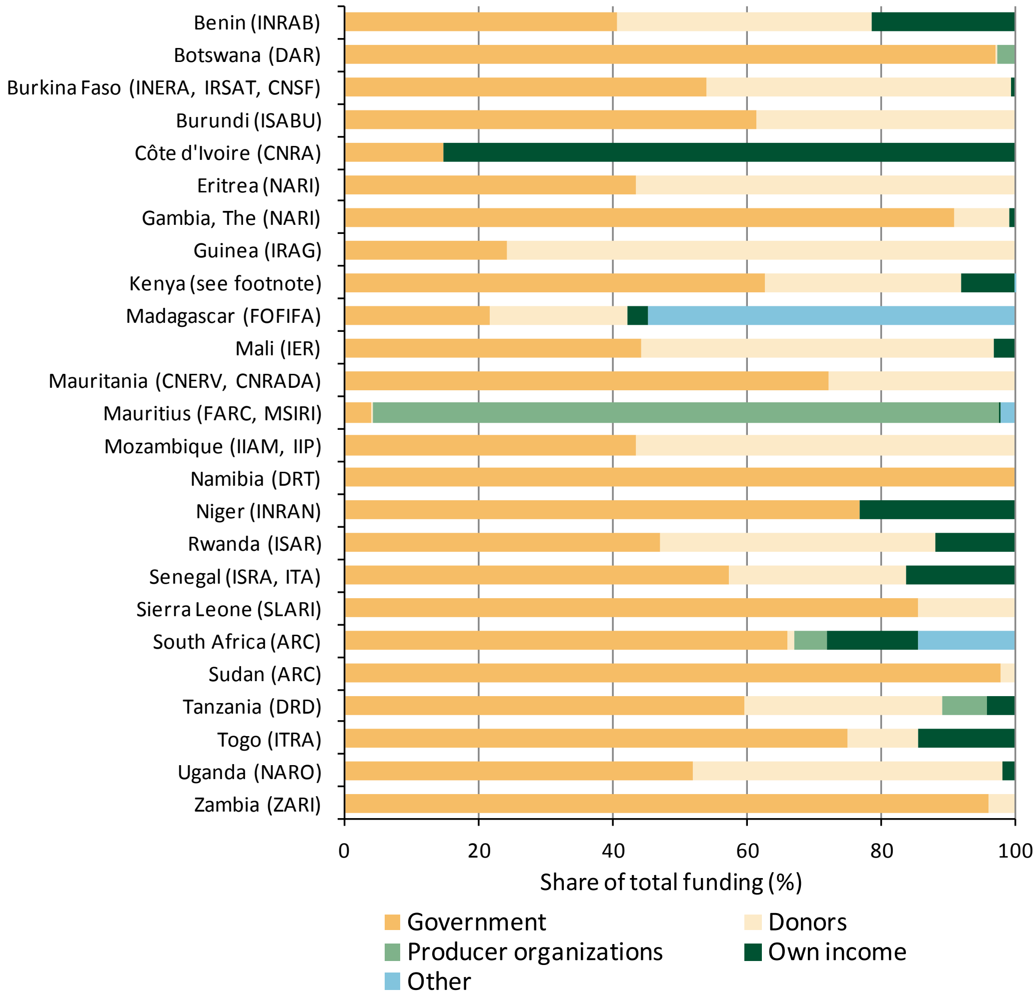
Source: Calculated by author from ASTI survey data.
Notes: The sample includes 58 large agricultural research agencies in Benin, Botswana, Burkina Faso, Burundi, Côte d'Ivoire, Eritrea, The Gambia, Ghana, Guinea, Kenya, Madagascar, Mali, Mauritania, Mauritius, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Uganda, and Zambia. Combined, these agencies accounted for 47 percent of total SSA agricultural R&D spending in 2008. Given that log transform can only be applied to nonzero values, a value of 0.01 was added to each agency's salary, operating, and capital expenditures. This had a negligible impact on individual and overall volatility coefficients, but allowed coefficients to be calculated for institutes that lacked capital spending in any one year.

5. FUNDING SOURCES OF AGRICULTURAL R&D

In order to analyze the main causes of volatility in yearly agricultural R&D investment levels, it is important to gain insight into how agricultural R&D is funded across SSA.[3] Unsurprisingly, a significant degree of cross-country and cross-agency variety exists in terms of agricultural R&D funding (Figure 5). In some countries, the national government funds the bulk of agricultural R&D activities, whereas other countries are extremely dependent on external funding from donors, development banks, and subregional organizations (SROs). R&D agencies in certain countries manage to generate large amounts of funding internally by selling goods and services, while in other countries the proceeds of such sales are transferred directly to the Treasury, discouraging agencies from pursuing these activities. Moreover, a number of countries have put innovative funding systems in place whereby the private sector finances the bulk of agricultural R&D, either through taxation or subscription dues. Unfortunately, it is not possible to present a regionwide overview of funding sources because detailed time-series data were not available for institutes in some of the larger countries in SSA, including Nigeria and Ghana.

[3] Note that this section draws largely on Beintema and Stads (2011).

Figure 5. Relative shares of funding sources of main agricultural R&D agencies, 2008



Source: Beintema and Stads (2011).
Notes: Gabon, Ghana, Malawi, Nigeria, the Republic of Congo, and Zimbabwe are excluded due to lack of complete data. SROs indicates subregional organizations; "producer organizations" include contributions through export or production levies; "own income" includes sales of goods and services and contractual research performed for public and private agencies. For full agency names and further details, see the ASTI Directory at http://www.asti.cgiar.org/pdf/ASTI-Directory-2011.pdf.

Agricultural R&D funding differs not only across agencies and countries, but also over time. The completion of a large donor-funded project, for example, can have a major impact on the continuity of R&D activities, causing sharp declines in funding levels unless the institute in question can secure funding elsewhere. It is therefore important to analyze both the relative importance of different funding sources across countries and institutes, and how the importance of each funding source has evolved over time.

National Government Funding

Overall, direct institutional funding from a central or regional government budget remains the most important source of funding for agricultural R&D in Africa, and government agencies remain the main executors of agricultural R&D across the region. In 2008, more than 90 percent of agricultural R&D in countries like Botswana, Ethiopia, Namibia, Sudan, and Zambia was funded by the national government. Government funding can be channeled to an agricultural R&D agency in a variety of ways. In some countries, salaries of research staff are paid by the Ministry of Finance, while operating costs and capital expenses for R&D are paid by the Ministry of Agriculture or another ministry overseeing agricultural research. Other countries have a Ministry of Science and Technology that allocates research funding through a science fund either on a competitive basis or through direct yearly allocations.

The overall level of government support for agricultural R&D may relate, among other factors, to the research system's and country's stage of development, the country's fiscal capacity, and the country's ability to effectively and efficiently make use of its financial resources. While increases in agricultural R&D spending in Ghana, Nigeria, Sudan, Uganda, and Tanzania were largely driven by increased government funding during 2000–08, in many SSA countries government support to agricultural research stagnated or declined during this timeframe, especially in inflation-adjusted terms. The National Agricultural Research Institute of Niger (INRAN), for example, has received a fixed government grant of 500 million CFA francs per year (in current prices) for over 20 years. In recent years, however, the cost of salaries has begun to exceed government contributions, so INRAN was forced to obtain supplementary funding in order to remain solvent.

A problem that has hampered the performance of agricultural R&D in a number of SSA countries is the discrepancy between approved allocations and actual disbursements of government funding. The Nigerian budget process, for example, has been described as complex and lacking transparency. Each research institute provides a yearly work plan with an associated budget to the federal Ministry of Agriculture and Natural Resources, which in turn submits a consolidated budget to the federal Ministry of Finance. The Ministry of Finance makes its own adjustments, after which the budget is sent to the National Assembly to be passed as an appropriations bill. The provisions of the final approved budget often differ markedly from the planned budget, and long delays and shortfalls in disbursements hinder and curtail implementation. In 2010, for example, the Nigerian government only disbursed about 60 percent of its national agricultural research institutes' approved recurrent budget and less than one-third of their approved capital budget (Ayoola and Abdullahi 2011). Other SSA countries, such as Tanzania and Uganda, also experienced discrepancies between budget allocations and actual disbursements of funds. It goes without saying that these funding discrepancies and fluctuations can have severely negative consequences for the long-term planning of research and on its outputs.

Donors and Development Banks

What distinguishes agricultural R&D in SSA from other developing regions is the high dependency on donor funding. In 2006, just 3 percent of agricultural R&D in Latin America and the Caribbean was funded by foreign donors and development banks (Stads and Beintema 2009), and the 2002/03 average in the Asia–Pacific region was similar (Beintema and Stads 2008). Although data for SSA as a whole were unavailable due to a lack of data for some of the region's largest countries, agricultural R&D agencies in SSA rely much more on donor funding than their counterparts in other developing regions. The principal agricultural R&D institutes in Eritrea, Guinea, Madagascar, Mali, Mozambique, and Uganda, for instance, derived more than half of their funding from donors in 2008. Although overall shares were lower in other SSA countries, donor funding still represents an important source of income for agricultural R&D agencies in many of the region's countries. It is important to note that donor funding is defined to include contributions from multilateral organizations (for example, the European Union, the centers of the Consultative Group on International Agricultural Research [CGIAR], and agencies of the United Nations), bilateral donors (for example, Norway and Japan, either through direct financial support or through the provision of expatriate researchers), private foundations (for example, the Rockefeller Foundation), regional and subregional organizations (for example, the Forum for Agricultural Research in Africa [FARA]), and loans and grants from development banks (for example, the World Bank or African Development Bank).

In the 1990s and early 2000s, the World Bank was a very important contributor to agricultural research activities in Africa through loan-supported projects, as well as grants. Projects variously focused on agricultural research and on agriculture more generally. Some projects aimed to reshape a country's entire national agricultural research system, whereas others focused on specific crops, agencies, or general research management and coordination (Beintema and Stads 2006). In certain cases the completion of some of these World Bank–supported projects led to a sharp decline in overall funding. Funding levels at INRAN in Niger, for instance, declined by 80 percent when the World Bank–funded National Agricultural Research Project (PNRA) ended in 1998. Similar cases, though less drastic, can be found in Guinea, Senegal, and Zambia.

Although data were only available until 2008, the share of donor and development bank funding in Africa is believed to have risen further with the launch of sizable new World Bank projects with R&D components in a large number of countries as part of the West Africa Agricultural Productivity Program and the East Africa Agricultural Productivity Program. The overall objective of these programs is to generate and disseminate improved agricultural technologies in areas that align both with the participating countries' priorities and those of the relevant subregion.

Aside from the World Bank, a large number of other donors and development banks funded agricultural R&D activities during 2000–08. Unfortunately, funding amounts by donor are difficult to quantify, largely due to lack of specificity in the data. For example, an agency in Uganda could report having received funding from a CGIAR center, which in turn received its funding from multiple donors.

Income through Sales and Services

Research agencies can increase their funding by commercializing their outputs. Many agricultural R&D agencies across SSA manage to derive a significant share of their total funding from the services they render to third parties, such as laboratory analyses or tests done on phytosanitary products, the sale of crop and animal products, renting out farming equipment, and so on. Although the growing importance of the agricultural input and processing sectors, the rise of regional free-trade blocks, and the strengthening of intellectual property legislation have enhanced incentives for the private sector to actively participate in agricultural R&D, the relative share of business enterprises conducting agricultural R&D in-house remains limited in most of the region's countries. Many business enterprises, however, outsource their research needs through contracts with public agencies. In some cases, public R&D institutes have entered into long-term alliances with private companies, conducting on-demand agricultural R&D on their behalf. In Senegal, for instance, cotton and groundnut research is carried out on behalf of SODEFITEX and SUNEOR, respectively, by the country's primary public agricultural research agency, the Senegalese Agricultural Research Institute (Stads and Sène 2011). Similar arrangements between private enterprises and the public sector exist in many other SSA countries.

Commodity Levies

Research can also be funded through levies on agricultural production or exports. The benefits of these funding mechanisms are that farmers gain increased involvement in setting the research agenda, and the more they pay in levies, the greater the benefits they gain from the research. Potential problems associated with this funding mechanism include losses in production caused by price disincentives, and the high cost of collecting the levies in some areas (Echeverría and Beintema 2009). Commodity levies play an important role in financing agricultural R&D in certain African countries. For instance, the Mauritius Sugar Industry Research Institute (MSIRI), the Cocoa Research Institute of Ghana (CRIG), and Kenya's Coffee Research Foundation (CRF) are almost entirely funded through a tax on the proceeds of sugar, cocoa, and coffee production, respectively. In Uganda, producer organizations have been reluctant to commit funds to research. Commodity taxes are currently being collected on coffee, tea, cotton, oilseeds, horticultural, livestock, and fisheries exports, but almost all of these revenues are being used for nonresearch purposes, such as marketing, extension, and administration. The only exception is the Uganda Coffee Development Authority, whose research activities are funded by revenues generated from a coffee levy.

Competitive Funding Mechanisms

Competitive funds have gained ground in Africa in recent years, but they remain limited compared with other developing regions around the world. These funds typically finance R&D carried out by government, higher education, nonprofit, and private-for-profit agencies through grants allocated to projects on the basis of their scientific merit and congruence with broadly defined agricultural R&D priorities. Competitive funds complement yearly appropriations from national budgets, while increasing the accountability of research and researchers. National and regional-level competitive funding mechanisms are believed to bring additional research resources while lowering execution costs and encouraging a more demand-driven research system. Such funds may have several contributors, including governments, multilateral development banks, bilateral donors, and private-sector organizations (Echeverría and Beintema 2009). A main concern of competitive funds is their long-term sustainability, given that many are highly dependent on external funding. In the late-1990s and 2000s, various competitive funds were established as components of World Bank–financed projects in a number of countries, including Kenya, Mali, Senegal, and Tanzania. Although most of these funds were still operating as of mid-2011, many lacked mechanisms for sustainability, so—failing other interventions— their overall funding levels will contract once the initial loan has been used. The World Bank's contribution to Senegal's National Agricultural and Agro-Processing Research Fund, for example, will reduce over time because it is intended that the Senegalese government, donors, and the private sector will progressively increase their contributions to both the fund's endowment and its operating costs. Given reduced government support to agricultural R&D in recent years and the limited bargaining power of the private sector, this obviously raises questions as to whether such competitive funding schemes are sustainable in the long run. Various other countries have attempted to establish competitive grant schemes to finance agricultural R&D without a large financial injection from a donor or development bank (including Nigeria, Uganda, and Zambia), but these schemes have generally faltered. Although the competitive grant scheme for agricultural research in Nigeria was launched some time ago, the first set of applicants has yet to be announced. Similarly, Zambia's Science and Technology Development Fund was enacted in 1997, but was not operational as of mid-2011.

In addition to national-level competitive funds, various subregional and regional competitive funds have been established in recent years. In 2004, the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) launched a competitive grant scheme using multi-donor funds. Awards are in the form of grants to government, educational, private, and civil agencies involved in agricultural R&D. The fund aims to encourage these organizations to compete for funding for activities designed to promote agricultural development in East and Central Africa. The fund also aims to promote a more demand-driven and pluralistic approach to increasing agricultural production, by encouraging the development of institutional and organizational partnerships, and by empowering end-users (ASARECA 2005). The West and Central African Council for Agricultural Research and Development (CORAF/WECARD) has implemented a similar competitive fund in order to open and diversify scientific and financial partnerships in the subregion and thereby guide research toward demand and regional priorities, and improve the quality of activities (CORAF/WECARD 2010).

Agricultural R&D Funding at Higher Education Agencies

Unfortunately, agricultural R&D funding data for higher education agencies are generally not available. Given that teaching is the core business of most agricultural faculties across the continent, they rarely have dedicated R&D budgets, and research activities undertaken tend to be ad hoc. Many African universities fund R&D activities through public grants, student tuition fees, and internally generated resources. As in the government sector, donor funding also plays an important role in funding agricultural R&D at the higher education agencies in many countries. African universities often maintain close linkages with universities in the North, and benefit from funding as part of joint research projects.

6. SHIFTS IN FUNDING ALLOCATIONS

As described above, agricultural R&D institutes in different SSA countries derive their funding from a variety of sources. Shifts in yearly allocations from one or more funding sources can therefore have a large positive or negative impact on overall agricultural R&D spending levels. As previously mentioned, most of the 20 percent growth agricultural R&D spending for SSA as a whole during 2001–08 was driven by just five countries: Ghana, Nigeria, Sudan, Tanzania, and Uganda. In all five cases, growth in government funding was responsible for the increase in agricultural R&D spending. The rapid increase in Ghanaian agricultural R&D spending, for instance, was driven almost entirely by increased salary expenditures at the Council for Scientific and Industrial Research rather than expanded research activities or greater investment in equipment or infrastructure. Higher agricultural R&D spending in Nigeria, Sudan, and Tanzania, on the other hand, stemmed largely from increased government commitment to R&D programs, equipment, and infrastructure. In Uganda, increased government funding led to higher spending on salaries, R&D infrastructure, and R&D programs.

Changes in government policy can also have highly negative effects on funding levels at agricultural R&D agencies. Moreover, governments are often forced to adjust previously approved funding levels downward in response to lower than anticipated revenues or shifts in priorities. For example, delays and reductions in the disbursement of budgeted funding by the Zambian government for public agricultural R&D are not uncommon, and reduced government funding is the main reason for the country’s dwindling agricultural R&D investment levels in recent years. Agricultural R&D agencies in Gabon face similar challenges. Given that the country’s budget estimates are based on anticipated oil revenues, fluctuations in the oil price and in the country’s production levels have had major impacts on yearly funding to agricultural R&D agencies, causing serious financial problems.

As previously discussed, donor funding is also a major cause of volatile agricultural R&D spending over time. This type of funding is typically short term and ad hoc, and in many instances the completion of large donor–funded projects has caused abrupt declines in agricultural R&D spending. Oftentimes national governments are not in a position to fill the funding gap when large donor projects come to an end. The completion of the aforementioned PNRA in Niger led to an 80 percent decline in INRAN’s spending and plunged the institute into grave financial problems. The situation has not improved since. Currently, the national government’s yearly allocation does not even cover the cost of INRAN’s salaries. The Institute must generate internal income to make ends meet, and its research program is entirely funded by donors, who also drive the research agenda. In fact, INRAN’s research is no longer organized as thematic programs, but is instead structured according to donor-funded projects.

Rising or falling world market prices for cash crops can also have a significant impact on funding levels, especially those derived through a direct tax on production or exports of a certain crop. Overall funding to MSIRI in Mauritius and CRF in Kenya declined following falling world market prices of sugarcane and coffee, respectively, in recent years, whereas Ghana’s CRIG benefited greatly both from an increase in cocoa prices and from an increase in the country’s cocoa production beginning in 2003–04.

7. VOLATILITY BY FUNDING SOURCE

Given the long period from the inception of agricultural R&D to adoption of technology, sustained and stable funding is needed to achieve high returns to agricultural R&D. Extreme volatility in funding, be it from national governments, foreign donors, or other sources, can have a severely negative impact on the continuity of R&D programs and on long-term research outputs. In efforts to curtail future volatility, it is important to identify the main drivers of funding volatility in agricultural R&D across countries over the past decade. The volatility coefficient, introduced earlier in this paper, is a useful tool for comparing the relative stability of different funding sources over time and across countries. It is important to note, however, that not all volatility is bad per se. A sudden injection of government or donor funding to rehabilitate R&D infrastructure after a civil war, for example, is of course a positive thing.

Detailed 2001–08 time-series data on agricultural R&D funding sources were available for 49 large government agencies from 22 SSA countries. A breakdown of volatility by funding source reveals that overall funding from donors and development banks is extremely volatile (0.77), and much more so than government funding (0.30), which itself is far from stable (Table 3). Internally generated resources also show a high degree of volatility (0.39) from one year to the next. Interestingly, average institute-level volatility (0.27) is lower than the volatility of the individual funding sources, indicating that in many cases shocks in one funding source are to some extent absorbed by reverse shocks in other funding sources.[4]

Table 3. Volatility coefficient by funding source, 2001–08

Funding source	Volatility coefficient
Government	0.30
Donors, development banks, and subregional organizations	0.77
Sale of goods and services	0.39
Total	**0.27**

Source: Compiled by author from ASTI survey data.
Notes: Given that log transform can only be applied to non-zero values, a value of 0.01 was added to each institute's funding sources. This had a negligible impact on the individual institutes' and overall volatility coefficients, and allowed for the calculation of volatility coefficients of institutes without donor funding or internally generated income during a certain year.

The continent-wide averages presented above mask a large degree of cross-country and cross-agency variety. Of the 49 agencies, 15 had a higher volatility coefficient in government funding than in donor funding. However, it is important to note that 10 of these 15 agencies were located in South Africa and Ghana, two countries where donors play a negligible role in funding agricultural R&D. Singling out the main national agricultural R&D agencies that derive at least a 10-percent share of their total funding from donors, development banks, and SROs presents a different picture. Of these 19 "donor-dependent" agencies, 17 recorded higher volatility in yearly donor funding levels than in government funding levels (Appendix Table A1). In many cases, donor funding was three or four times more volatile than government funding. Interestingly, all "donor-dependent" agencies were based in low-income countries.[5] Agricultural R&D in middle-income countries is much less dependent on donor funding and has shown a considerably lower degree of volatility (Figure 6).

The dots in Figure 6 (below) indicate the average share of donor funding in total agricultural R&D funding for the main agencies in each country during 2001–08. The lines intersecting the dots range from the highest share of donor funding in total agricultural R&D funding during 2001–08 to the lowest share. The shorter the line, the lower the spread in the share of donor funding over time. For example, an average of 38 percent of total funding received by the Institute of Agricultural Science of Burundi during 2001–08 was derived from donors and development banks. However, the overall share of donor

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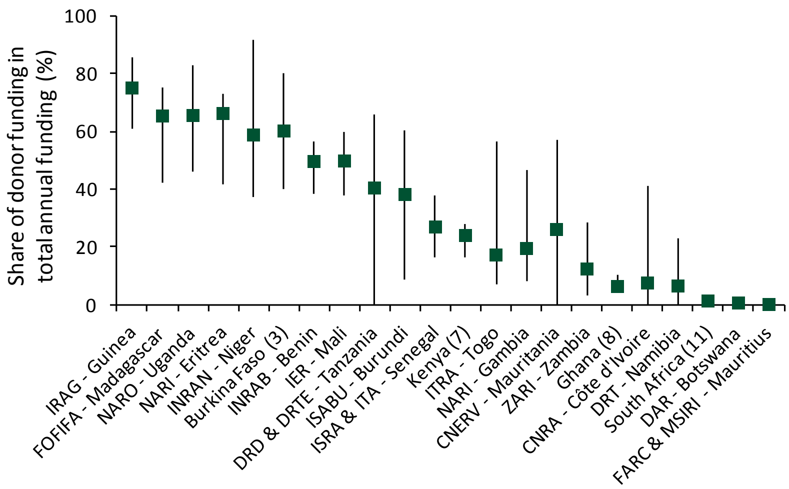
[4] Although the data allowed for the calculation of a volatility coefficient for funding derived from commodity levies and producer organizations, this coefficient was irrelevant at the SSA level as only a handful of countries generate funding for agricultural R&D this way and therefore the mean was skewed. Similarly, 11 of the 49 sample agencies received no donor funding, and 9 did not generate internal revenues.

[5] This includes two agencies in Senegal, a country that has only recently (July 2010) reached lower middle-income status.

funding ranged from 9 percent in 2003 to 60 percent in 2004, indicating large shifts in donor funding from one year to the next.

Figure 6. Average and spread of donor funding as a share of total agricultural R&D funding, 2001–08



Source: Compiled by author from ASTI survey data.
Notes: Donor funding includes loans from development banks and funding from SROs. The figures in parentheses indicate the number of agencies included in the country. Burkina Faso includes INERA, IRSAT, CNSF; Kenya includes KARI, KEFRI, KFMRI, KIRDI, KIPPRA, TRF, CRF; and South Africa includes 11 agencies under ARC. For full agency names and further details, see the ASTI Directory at http://www.asti.cgiar.org/pdf/ASTI-Directory-2011.pdf.

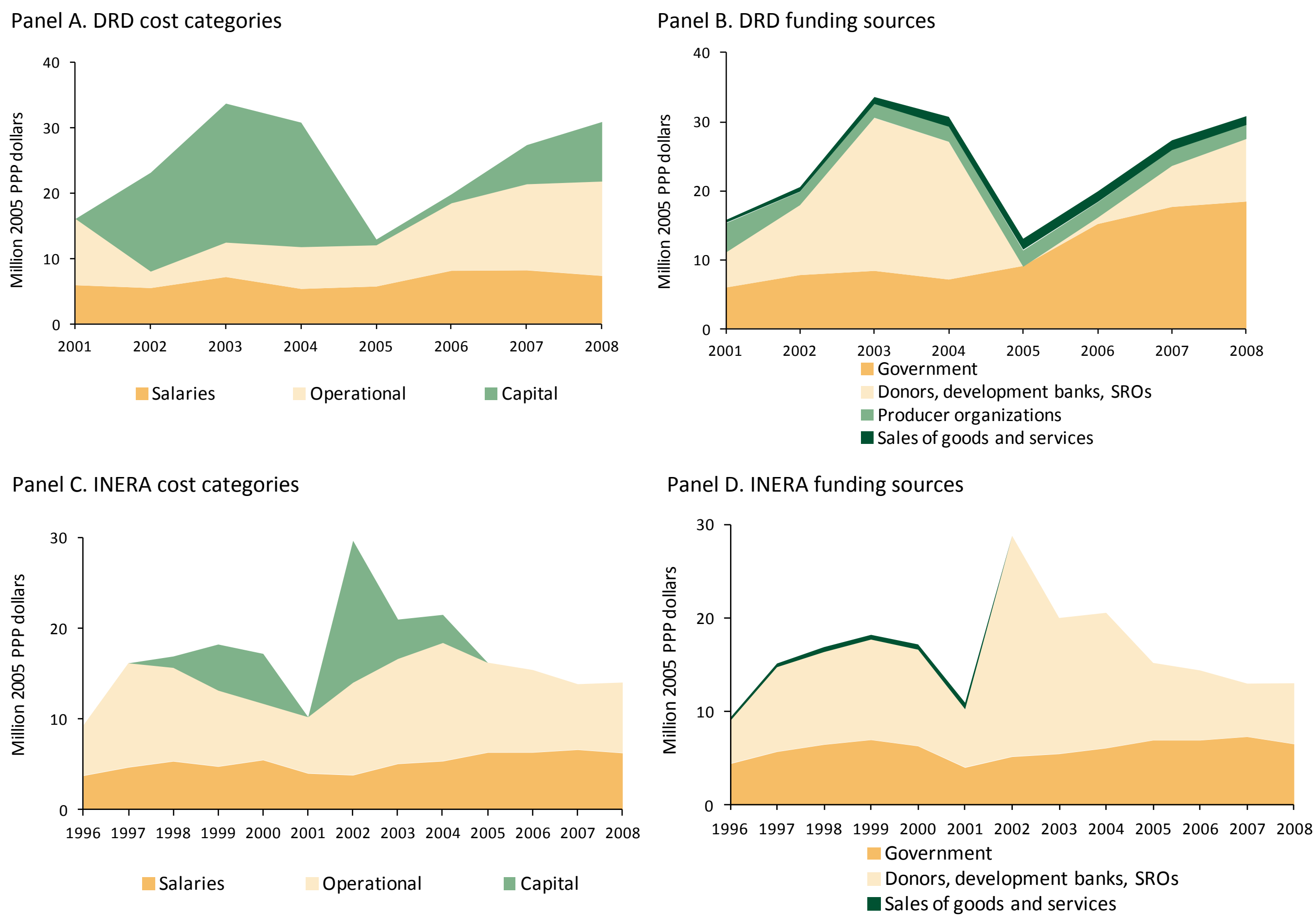
8. THE EFFECTS OF VOLATILITY IN AGRICULTURAL R&D FUNDING

Abundant empirical evidence suggests that volatility in donor funding is costly, particularly in less developed countries with weak institutions, and that measures to reduce volatility would significantly enhance the value of donor aid (Kharas 2008). The fact that donor and development bank funding for agricultural R&D shows a much higher degree of volatility than other funding sources is worrying, given that many national agricultural R&D institutes in SSA, particularly those in low-income countries, derive a significant share of their total funding from donors, development banks, and SROs. Although most national governments in SSA publicly recognize the need for rapid development of agriculture in order to reduce poverty, they have difficulty allocating sufficient resources to agricultural R&D. In many countries, the bulk of government appropriations is spent on salaries, which leaves the costs of operating research programs and investing in necessary infrastructure largely dependent on volatile funding from donors, competitive grants, or the private sector. Although competitive salaries are crucial to maintaining a critical mass of qualified researchers, it is equally important to provide these scientists with well-funded research programs and well-equipped research laboratories, which requires long-term, sustainable investment in nonsalary expenditures.

Based on the same 49-agency sample discussed above, the average volatility index for agencies that derive 10 percent or less of their total funding from donors and development banks was 0.19; for agencies deriving more than 10 percent of their funding from donors, the index averaged 0.28; and for those that derive more than 40 percent of their funding from donors, the average was 0.31. Hence, agencies that are highly dependent on funding from donors and development banks are more vulnerable to funding shocks on average than are institutes funded mostly by their governments. Uncertain inflows of funding from donors and development banks have a considerably negative impact on the long-term implementation of R&D programs, and often on much-needed rehabilitation of R&D infrastructure, as examples from Burkina Faso and Tanzania show. In Tanzania, for example, capital investments from the Department of Research and Development were high while the World Bank–

funded Tanzania Agricultural Research Project was running (1998–2004), but when this funding source ceased in 2005, the Department's capital investments fell to negligible levels (Figure 7). With the launch of the multi-donor Agricultural Sector Development Project in 2007, capital investments once again rose. At Burkina Faso's National Environment and Agricultural Research Institute—another institute with large fluctuations in yearly R&D investment levels—peaks in capital investments largely coincided with peaks in funding from two consecutive World Bank–funded projects. Following the closure of these projects, the Institute found itself in financial crisis, which seriously disrupted operations and prevented the recruitment of researchers. Many countries in SSA have or will face this same problem whereby the gains achieved through major projects are quickly eroded in the absence of viable mechanisms to sustain them.

Figure 7. A comparison of funding sources and cost categories for DRD (Tanzania) and INERA (Burkina Faso), 2001–08



Source: Compiled by author based from ASTI survey data.
Notes: Donor funding includes loans from development banks. SROs indicates subregional organizations; producer organizations include funding generated through export or production levies; own income includes the sale of goods and services, and contractual research performed for public and private agencies. DRD indicates Tanzania's Department of Research and Development; INERA indicates Burkina Faso's National Environment and Agricultural Research Institute.

9. CONCLUSION AND POLICY RECOMMENDATIONS

Despite the fact that agricultural R&D spending in SSA increased by more than 20 percent during 2001–08, overall investment levels in most countries are still well below the levels required to sustain agricultural R&D needs. In 2008, SSA invested just 0.61 percent of agricultural output on agricultural

R&D, well below NEPAD's 1-percent national R&D investment target. Agricultural R&D investment is positively associated with high returns, but these returns take time—commonly decades—to develop. Consequently, the inherent lag from the inception of research to the adoption of a new technology or the introduction of a new variety calls for sustained and stable R&D funding.

The time-series data presented in this paper, however, reveal that agricultural R&D funding in many SSA countries was far from stable during 2001–08 and that R&D spending for the region as a whole shows higher volatility compared with spending in other developing regions of the world. Agricultural R&D agencies in SSA, particularly those in the region's low-income countries, are more dependent on funding from donors and development banks than their counterparts in other developing regions, and this type of funding has shown considerably greater volatility over the past decade compared with government funding. In a large number of SSA countries, donors fund the bulk of nonsalary-related expenditures (that is, program and operating costs and capital investments) and numerous examples show that agencies reverted into financial crisis upon the completion of large donor-funded projects, forcing institutes to cut research programs and lay off staff. Questions can therefore be raised over the long-term effectiveness and efficiency of unsustainable donor and development bank funding.

Many studies have assessed the impact of funding shocks on developing economies, concluding that volatility is costly and that it negatively effects long-term macroeconomic growth. A thorough analysis of the long-term effects of funding volatility on agricultural R&D outputs and agricultural productivity was beyond the scope of the current study and would require detailed multi-decade time-series data, which were not available. Ample anecdotal evidence, however, strongly suggests that severe fluctuations in yearly agricultural R&D funding exacerbates uncertainty at the institute level and renders long-term R&D budget, staffing, and planning decisions more difficult. Consequently, the continuity of research programs is imperiled in the short run, as is the release of new varieties and technologies in the long run.

Halting excessive volatility in yearly agricultural R&D investment levels requires a long-term commitment from national governments, donors and development banks, and the private sector. Governments have to clearly identify their long-term national R&D priorities and design relevant, focused, and coherent R&D programs accordingly. Stable and sustainable levels of government funding are key, not just to secure salaries (which are fundamentally important), but also to enable necessary nonsalary expenditures. Certain governments may want to develop reserve funds or other mechanisms to smooth spending in the face of fluctuating revenues.[6] Moreover, donor and development bank funding needs to be better aligned with national priorities, and consistency and complementarities among donor programs need to be assured. Finally, mitigating the effects of any single donor's abrupt change in aid disbursement is crucial, highlighting the need for greater funding diversification, for example, through the sale of goods and services or by attracting complementary investment from additional sources, such as the private sector. This, in turn, requires that national governments provide a more enabling policy environment for R&D. These measures are necessary to put an end to the rollercoaster that currently characterizes agricultural R&D funding in Africa.

[6] Chile and Nigeria have established off-shore funds to smooth the effects of fluctuations in copper and oil prices, respectively (Desai and Kharas 2010).

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Appendix Table A1. Volatility coefficient of government and donor funding, 2001–08

Country	Agency	Volatility coefficient by funding source: Government	Volatility coefficient by funding source: Donors, development banks, and SROs	Average share of donor funding (%)
Benin	INRAB	0.18	0.32	49.5
Burkina Faso	INERA	0.11	0.64	64.1
Burkina Faso	IRSAT	0.16	0.69	34.9
Burundi	ISABU	0.26	1.07	38.1
Eritrea	NARI	0.15	0.67	66.1
Gambia, The	NARI	0.28	1.05	19.4
Guinea	IRAG	0.19	0.37	74.9
Kenya	KARI	0.13	0.36	33.4
Kenya	KIPPRA	1.47	0.54	59.4
Madagascar	FOFIFA	0.61	0.23	65.2
Mali	IER	0.59	0.72	49.7
Mauritania	CNERV	0.25	3.33	26.0
Niger	INRAN	0.22	0.30	58.6
Senegal	ISRA	0.14	0.55	26.8
Senegal	ITA	0.11	0.66	27.5
Tanzania	DRD	0.21	3.76	40.4
Togo	ITRA	0.23	0.88	17.1
Uganda	NARO	0.27	0.38	65.5
Zambia	ZARI	0.26	0.35	12.3

Source: Compiled by author from ASTI survey data.
Notes: See Table 3.

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Jointly convened by ASTI/IFPRI and the Forum for Agricultural Research in Africa (FARA), the conference, "Agricultural R&D—Investing in Africa's Future: Analyzing Trends, Challenges, and Opportunities," brought together experts and stakeholders from the region to contribute their expertise for the purpose of distilling new insights and creating synergies to expand the current knowledge base. The themes under focus were (1) why African governments under invest in agricultural R&D; (2) how human resource capacity in agricultural R&D can be developed and sustained; (3) how institutional structures can be aligned and rationalized to support agricultural R&D; and (4) how the effectiveness of agricultural R&D systems can be measured and improved.

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