Agriculture in Africa

Telling Myths from Facts

Luc Christiaensen and Lionel Demery, Editors

WORLD BANK GROUP

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Foreword

We all agree that policies must be evidence-based and that establishing the facts lies at the heart of sound policy making. But what if our facts are flawed?

Take agriculture for instance, a sector vital for Sub-Saharan Africa's future. Much of what we know about agriculture in Africa may no longer be true, given Africa's rapid economic transformation, fast urbanization, demographic and climatic changes, and more important, a scarcity of quality data. In a rapidly changing world, the facts that drive our research and policy focus quickly become outdated.

Conventional wisdom holds that farmers in Africa use few modern inputs, such as improved seeds or fertilizers; that women provide the bulk of labor input in African agriculture; and that one-third of the food produced in Africa gets spoiled or lost after harvest. It's time for some myth-busting.

A consortium of international organizations and universities, led by the World Bank Africa Region in collaboration with the African Development Bank, put these widespread assumptions to the test using recent data from the Living Standards Measurement Study—Integrated Surveys on Agriculture. These surveys were conducted in six countries. The findings should, thus, not be seen as representative of the continent as a whole. Nonetheless, given that they represent more than 40 percent of Sub-Saharan Africa's population, and many of its agroecological zones, they provide a good starting point to revisit common wisdom on African agriculture.

This report presents the insights obtained, organized around the confirmation (fact) or rebuttal (myth) of 16 frequently held perceptions. We learn, for example, that women do not contribute 60 to 80 percent of the work in Africa's crop production, as we have heard so often, but rather less than half (40 percent in the six countries studied). And that farmers lose only 2–6 percent of their maize production after harvest, which stands in stark contrast to the much-touted 30 percent postharvest loss widely quoted. This is not to say that addressing postharvest loss and increasing female labor productivity in agriculture are no longer important. Rather, the findings challenge us to revisit and refine our arguments as to why doing so is still important and how to get there.

In short, sound policy design requires establishing solid facts, as well as a clear understanding of the causal links between them. The contributors to this book

take an important step in this direction, and I can only encourage others to follow suit. I close by calling on policy makers, development practitioners, and research institutes for continued public investment in the type of data collection under-pinning this research. The reason is simple: better data lead to better policies and better lives.

Makhtar Diop
Vice President, Africa Region
World Bank Group

Acknowledgments

We close by attributing this volume to one of its earliest supporters and core contributors, Hans Binswanger-Mkhize. He passed away just before its publication. Hans's passion and relentless efforts to advance agriculture and African development are simply unparalleled. This was no less the case in this project. We are tremendously proud to have had this giant in the profession inspiring all of us from the start and to be able to feature here one of his last contributions. Thank you, Hans!

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Abbreviations

AEP	agroecological potential
AEZ	agroecological zone
APHLIS	Africa Post-Harvest Loss Information System
APPs	average physical products (of nitrogen in maize production)
ARCH	autoregressive conditional heteroskedasticity (model)
AVCR	average value cost ratio
B-R	Boserup-Ruthenberg (framework)
CCI	Household Crop Commercialization Index
CI	confidence interval
FAO	Food and Agriculture Organization of the United Nations
GDP	gross domestic product
GPS	Global Positioning System
HAZ	height-for-age Z-score
ICT	information and communications technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
LSMS	Living Standards Measurement Study (World Bank)
LSMS-ISA	LSMS–Integrated Surveys on Agriculture (World Bank)
MVCR	marginal value cost ratio
MPPs	marginal physical products (of nitrogen in maize production)
NFEs	nonfarm enterprises
OLS	ordinary least squares
PHL	postharvest losses
RIGA	Rural Income-Generating Activities
RNFE	rural nonfarm employment
SAFEX	Johannesburg futures market
SSA	Sub-Saharan Africa

TC	transportation costs
UG	urban gravity
UNECA	United Nations Economic Commission for Africa
WAZ	weight-for-age Z-score
WHZ	weight-for-height Z-score

Myths Become Realities— Or Do They?

Luc Christiaensen and Lionel Demery

Motivation and Opportunity

Africa is changing. It is a continent on the move. Yet public awareness has not always kept pace. Major events such as war, famine, and drought might be well covered by the media. But little is generally known about the day-to-day lives of ordinary Africans, especially African farmers, let alone how they are changing. Information is often partial and piecemeal (Carletto, Jolliffe, and Banerjee 2015). And, given the remarkable changes taking place on the continent, even this knowledge base can quickly become out-of-date and misleading. Thus, much of what is commonly believed about African agriculture could be based on flimsy evidence, more akin to myth than fact.

But the data situation is also changing. Information has significantly improved about the social aspects of the lives of Africa's farmers in the 21st century—their health, education, and fertility (Beegle et al. 2016). The World Bank's Living Standards Measurement Study (LSMS) has for some time provided important information on income, economic activities, and well-being. More recently, these surveys have strengthened their coverage of household agricultural activities— the LSMS–Integrated Surveys on Agriculture (LSMS-ISA). These surveys have been conducted in eight African countries—Burkina Faso, Ethiopia, Malawi, Mali, Niger, Nigeria, Tanzania, and Uganda—which together make up more than 40 percent of the population of Sub-Saharan Africa (SSA). Information is gathered at the household and plot levels, covering every aspect of farming life, including the plots farmers cultivate, crops they grow, harvest that is achieved, and inputs they use. Data are also gathered on the time farmers spend on each (farm and off-farm) activity, the amount they earn working off the farm, and how they spend their income. This broad perspective on farming households is the strength of the data. Further details are provided in annex 1A.

The LSMS-ISA data thus extend an open invitation for a careful review of the perception of African agriculture and its farmers' livelihoods. This opportunity is fully exploited by the contributing authors of this monograph. Together they

scrutinize much of the current common wisdom about African agriculture.[1] The main themes emerging from this work, and the key messages they contain, are summarized in this chapter. The references to the longer papers underlying the chapters are listed in annex 1B.

Emerging Messages

Although they are not meant to be exhaustive in their coverage of farmers' livelihoods, the subjects in the study are breathtaking in scope, ranging from the markets facing African farmers, to the decisions they make about planting trees and strategies to preserve the rewards of their efforts postharvest. Together, the studies provide a very real sense of what African agriculture and its farmers' livelihoods are currently all about. The chapters also speak to many of the core prevailing stylized facts that have been driving research agendas and policy debates about Africa's rural development over the past couple of decades. They are, however, deliberately descriptive in nature, largely shying away from causal statements, which would require panel data analysis.

To help synthesize and assimilate this work, and taking the smallholder farm household as the organizing framework, the studies are grouped under the following topics:

- Market Engagement: farmers' engagement in factor and product markets
- The Smallholder Setting: the constraints and opportunities of smallholder farming
- Backward Technology: modern farming methods in the African setting
- A Risky Business: coping with shocks from the weather or market instability.

The chapters discuss 16 broad conventional views about African agriculture, and assess whether the views are well founded empirically. Are these myths or realities in Africa's current farming context? Table 1.1 summarizes the findings. But farming is complex, and farmers' behavior is unlikely to be as cooperative as it would seem from the table. Reality varies across farming systems, regions and countries, and over time. The studies reflect this complexity and explore the nuances that any answer to the question "myth versus fact?" must recognize.

Market Engagement

Views about African agriculture often concern how it fits into the economy at large. To what extent are farmers engaged in markets—factor markets (labor, credit, and land) and product markets (buying or selling surplus output)? How well served are they by these markets? A first set of issues concerns how well factor markets function in Africa, and how that affects farm enterprises. The findings are somewhat mixed. Factor markets overall are found to fail African farmers, but not all the news is bad. Exchanges do happen, and especially land markets are already starting to play a beneficial role. But not so much credit markets, and the sale of surplus remains still limited.

Table 1.1 Conventional Wisdom about African Agriculture

Chapter	The wisdom	The finding
I. Market Engagement		
2	Factor markets are largely incomplete in Africa.	True
3	Land markets play a minor role in African development.	Increasingly false
4	Modern inputs are not financed through formal credit.	True
5	Agricultural commercialization enhances nutrition.	False
II. The Smallholder Setting		
6	Labor is much less productive in agriculture.	False
7	Women provide the bulk of labor on African farms.	False
8	Incomes among African farmers are underdiversified.	Largely false
9	Household nonfarm enterprises only exist for survival.	Largely true
III. Backward Technology		
10	African farmers use very low levels of modern inputs.	Not generally true
11	Population growth and market access determine intensification.	Not generally true
12	Given its profitability, fertilizer use is too low.	Not true in Nigeria
13	Trees on farms are not important for African livelihoods.	False
IV. A Risky Business		
14	Droughts are the main hazard for African livelihoods.	Largely false
15	Price volatility in Africa arises from international markets.	False in Burkina Faso
16	Food markets are no longer seasonal.	Largely false
17	Postharvest losses are seriously large.	Plausibly false

Factor markets in general do not function well. The conventional wisdom sees African agriculture trading in incomplete and imperfectly functioning factor markets. Dillon and Barrett (chapter 2) conclude that this is largely true. At the heart of their test is the observation that the number of working-age people in the household should not affect the amount of labor used on the farm if *all* factor markets function well. If the size of the household affects the amount of labor used on the farm, some factor markets (possibly labor markets, but not necessarily, or credit or land markets) are absent or functioning poorly. The authors find a significant link between labor input and household size, suggesting some market failures. These market failures are not limited to certain locations or gender, but are general and structural. Overall, most farmers engage in labor and land markets (so these markets are not absent in an absolute sense); but the markets nonetheless often fail farmers. In other words, market existence appears less of a problem than market function. There are profound messages for policy makers here. They should focus more on reducing barriers to market participation and improving the efficiency of markets than on wholesale creation of factor markets. But to do so requires further analysis, to identify which factor markets are failing and why. For analysts, this message serves as a reminder that findings based on complete factor market assumptions are bound to be off the mark.

But land markets already do perform a useful role. The empirical test employed by Dillon and Barrett examines just one (albeit important) relationship—between

labor use and household size. But this relationship does not identify which markets are poorly functioning, only that some must be. In chapter 3, Deininger, Savastano, and Xia explore in greater depth and more directly the extent to which farmers are engaged in land markets, and the nature of that engagement. Contrary to the conventional view, they find that farming households actively engage in land markets, especially land rental markets. The authors find that such access has beneficial effects for the equalization of land endowments and farm productivity. Engagement in land markets permits land-poor but labor-rich households to raise their resource base by renting land. It enables other farmers to diversify their activity by renting out their land and taking up nonfarm employment (without the risk of losing their land assets). These are profound gains in a process of structural change. But there remain important opportunities to improve the functioning of land markets. The authors suggest that institutional reforms (especially within the legal framework) are needed, and are effective in strengthening the role that land markets can play in enhancing farmers' welfare.

Farmers rarely use credit when purchasing farm inputs. The role of credit in rural transformation is well understood. But do African farmers make use of credit when purchasing modern farm inputs, such as inorganic fertilizer or improved seeds? In chapter 4, Adjognon, Liverpool-Tasie, and Reardon estimate that only 6 percent of farmers use any form of credit to buy modern inputs, at least in the four countries they cover (Malawi, Nigeria, Tanzania, and Uganda). Larger farms are more likely to use credit, but even the use of informal credit is found to be rare. Modern inputs are purchased mainly through savings from income, crop sales, and nonfarm activities. By far the most common purpose of credit for a farming family in Africa is to finance the start-up costs of nonfarm enterprises, or to finance consumption.

Farmers' engagement in product markets does not necessarily enhance nutritional outcomes. African farmers are very much involved in product markets—the vast majority sell some of their produce. However, Carletto, Corral, and Guelfi show that, at 20–40 percent, African farmers' marketed shares remain rather limited (chapter 5). Conventional wisdom further suggests that the more farmers commercialize their operations through increased product market orientation, the better off they can become. Greater market orientation of agriculture is expected to raise incomes, improve consumption and sanitary conditions, and enhance nutritional outcomes in rural households. In short, it should enhance well-being. But many other factors could intervene. For example, commercialization may affect the gender earnings balance within the household, which, given different spending patterns, may even worsen nutritional outcomes. Despite the somewhat positive view in general of the effect of agricultural commercialization on nutrition, the evidence is mixed and somewhat dated. In the three countries studied, there appear to be no systematic links between commercialization and nutrition. These results are obtained using better data and more sophisticated statistical techniques, and are consistent with the few recent studies on the topic. Agricultural commercialization alone does not suffice to improve food security and nutritional outcomes.

The Smallholder Setting

Agriculture in Africa is organized mainly around the family farm, with relatively small parcels of land. The household is the institution within which farming decisions are made. This situation has implications for the operation and performance of the farm. And it is a source of much of the conventional wisdom about African agriculture.

Labor in agriculture is not much less productive. One common view is that labor productivity is much lower in agriculture than elsewhere in the economy. Indeed, national accounts data suggest that in Africa labor outside agriculture is six times more productive than agricultural labor. But McCullough shows (in chapter 6) that this is not true when productivity is measured at the micro level. Taking a household perspective and using micro data, McCullough accounts for production for own consumption, and links output more closely to labor input. She also defines the labor input not so much as a stock of labor (which the macro data are obliged to do), but more accurately as a flow of labor services, that is, the number of hours worked per worker. Using these preferred measures of labor output and input, productivity gaps become minimal. The differences in output per worker per year reflect gaps in employment levels rather than gaps in the returns to each hour of work.

This finding implies that agriculture is not intrinsically less productive. Workers outside agriculture supply on average far more hours of labor per year than do agricultural workers. Seasonality in agricultural demand for labor may be one reason. Irrigation investments, enabling multiple cropping seasons in a year, and diversification into products with labor demand at different times or more constant labor demand throughout the year (for example, poultry or dairy) can reduce the seasonality effect. But McCullough is agnostic about why the number of hours in agriculture is less. Digging further into the difference in labor productivity across sectors, especially the reasons behind it, is an important area for further research. The topic of sectoral labor productivity measures is starting to attract attention (see, for example, Arthi et al. 2016; Gollin, Lagakos, and Waugh 2014; Hicks et al. 2017; Vollrath 2013).

Women do not provide most of the labor on the family farm. The conventional wisdom has been that women contribute as much as 80 percent of the labor used on the African farm. But the source of this estimate is unknown. With the availability of reliable and more recent micro data, Palacios-Lopez, Christiaensen, and Kilic (chapter 7) put the record straight. They find that women in Africa contribute 40 percent of the total labor input in crop production (at least in the six countries they cover). This finding means that a disproportionate focus on women in strategies to raise African agricultural output might be misplaced, although it may be justified for other reasons (such as female empowerment). But this case should be made separately, by comparing it with the costs and benefits of other interventions.

African households are not unduly tied to agriculture. The common view is that families in rural Africa rely more on agriculture compared with other parts of the developing world. But Davis, Di Giuseppe, and Zezza find otherwise

(in chapter 8). It is true that rural African households derive about two-thirds of their income from on-farm agriculture, compared with one-third (on average) in other developing countries. But if the analysis takes into account differences in the level of development in Africa compared with elsewhere (as reflected in gross domestic product per capita), Africa is not really on a different structural trajectory from the other developing regions. But there are some important differences. Most off-farm income in Africa is derived from informal self-employment. Rural households are more involved in nonfarm household enterprises (often closely related to agriculture—see chapter 6) than in wage employment (agricultural and nonagricultural), which is more important in other developing regions. Of course, there are differences across and within African countries. Chapter 8 provides details about Africa's income diversification patterns and reviews these variations.

Households in rural Africa diversify into nonfarm activities mainly for survival. Chapter 8 shows that structural change in rural Africa is on a similar trajectory as in other developing regions. The chapter also highlights peculiar features of the African case—especially that nonagricultural incomes come mainly from nonfarm household enterprises in Africa, rather than wage income outside agriculture. Why is this? Might this be because nonfarm activities in rural Africa serve a different purpose, the survival of the household? Nagler and Naudé pose this question in chapter 9. They find that nonfarm activities in the African household are indeed mostly oriented around survival. The evidence lies in the nature of the activities: most are small, unproductive, informal household enterprises, only operating for a portion of the year. But obviously not all are just there for survival. The authors show that when the conditions are right, households can seize the opportunities for enhancing family income. When households are better educated and have access to credit, they engage in agribusiness and trade throughout the year—not just in survival mode. The policy challenge is to create the demand and a business climate to foster such activities. This is not an easy task, and it is aggravated further by emerging concerns about premature de-industrialization (Rodrik 2016).

Backward Technology

The prevailing view of African agriculture is that technology is backward and changing only slowly. Africa is decades behind Asia from this perspective. Farmers are slow to respond to modern methods of farming, such as using new seed varieties, applying modern inputs and mechanization, improving land, and irrigating crops. The studies included here confront this conventional wisdom with the data.

African farmers do in fact use modern inputs. According to common wisdom, farmers in Africa are reluctant to use modern farming methods. They hardly use modern inputs such as nonorganic fertilizer and other agrochemicals. But Sheahan and Barrett (chapter 10) put the record straight with more recent household survey data. They find that the use of fertilizer and agrochemicals is greater than is often thought, but varies by country. It appears favorable in Malawi, Ethiopia, and Nigeria, and not so good in Niger, Tanzania, and Uganda.

Maize (corn) is on the move—maize farmers are using higher levels of fertilizer and improved seed varieties. But it is not all good news. The authors also find that farmers fail to use these inputs in the most productive combinations at the plot level. Perhaps the biggest message of chapter 10 is that the country setting is the main factor behind farmers' input use—the policy and market environments really do matter. From this perspective, the higher rates observed in Malawi, Ethiopia, and Nigeria do not surprise.

But agriculture is not intensifying as much as expected, given population pressure and better market access. Sheahan and Barrett are fairly positive about the use of modern inputs in Africa. In this sense, they find the glass half full, especially for maize. But Binswanger-Mkhize and Savastano (chapter 11) are less sanguine about the processes influencing modern input use among African farmers. Although they use the same data, they find the glass half empty. The Boserup-Ruthenberg framework (Boserup 1965; Ruthenberg 1980) suggests that a virtuous cycle can emerge, involving increased fertilizer use, mechanization, and land development in response to population pressure and increased market access. But the authors find only partial support for the existence of such a cycle in Africa. They establish that fallow areas have virtually disappeared, and observe some response of modern input use (fertilizer, agrochemicals, and improved seeds), but not other measures of intensification, such as irrigation or increased number of crop cycles per year. The authors conclude that the use of fertilizer and other agrochemical inputs is insufficient to maintain soil fertility when fallow practices cease. The weak response of land improvement and irrigation is also not consistent with the virtuous cycle of the Boserup-Ruthenberg framework. The authors call for further research when panel data become available.

Returns to fertilizer use are not always favorable—at least not in Nigeria. Is the glass half full or half empty? One reason why conventional wisdom considers it half empty—that fertilizer use really is too low—is because its profitability would suggest greater use. According to this commonly held view, fertilizers are profitable but farmers are not convinced. The analysis in chapter 12—by Liverpool-Tasie, Omonona, Sanou, and Ogunleye—focuses on fertilizer profitability in maize production in Nigeria. The authors conclude that fertilizer use is not particularly profitable for maize. The reasons are the poor yield response to the application of fertilizers, but also the high (last mile) transport costs involved in procuring fertilizers. Thus, the application of fertilizers for maize by Nigerian farmers is consistent with its profitability—application rates are for the most part not "too low." This finding sheds important new light on Africa's agricultural technology debate, in that input use may not always be profitable, because of poor soil, poor-quality fertilizer, high transport costs, limited market access, and so forth. The implicit profitability assumption of modern input use deserves further scrutiny with good plot-level data.

On-farm trees are important to African farmers. Chapter 13 changes gear, and takes our attention away from fertilizers and other modern inputs. Rather, it focuses on something very traditional and part of the rural landscape over centuries—trees. Miller, Muñoz-Mora, and Christiaensen raise this issue because

conventional wisdom has viewed trees as unimportant for African farms; they think otherwise. They find that trees are widespread on farmland and serve useful economic functions. Trees provide cash crops, timber for firewood, and fruits for consumption. Overall, trees are grown on about one-third of the farms, providing 17 percent of total gross income among tree-growing households. This income is in addition to the indirect contributions of trees (such as soil and water conservation and biodiversity), which the authors do not measure directly. So the reality is quite different from the myth.

A Risky Business

If there is one commonly held view about Africa—and African agriculture in particular—it is that the economic environment is very volatile and uncertain. Fluctuating markets and massive weather shocks combine to make for an uncertain agricultural livelihood, and a risky life for farmers. The following paragraphs summarize the chapters that deal with the empirical reality of these risks and their associated coping mechanisms.

The risks affecting African farmers go well beyond droughts. A commonly held view is that drought is the dominant risk faced by households in Africa, and because droughts can affect all households at once in an area, the risk is difficult to manage (as all neighbors and relatives are affected in the same way). Another common view is that asset sales and informal transfers are the main coping strategies available to households in the absence of well-developed financial markets and effective public safety nets. Nikoloski, Christiaensen, and Hill (in chapter 14) show that price risk is just as prevalent as climate risk, and that price risk affects more people at once than droughts do. Health shocks are also widely reported by rich and poor households alike. The use of savings was the most commonly reported coping mechanism. That many households simply have no means to cope with climate and price shocks underscores how important this issue is for policy intervention.

Maize price volatility does not arise from international markets. Food price volatility has been a long-standing concern in food policy making, with world market price fluctuations often seen as an important cause. The 2008 world food price crisis gave additional impetus to this concern and viewpoint. Ndiaye, Maître d'Hôtel, and Le Cotty (in chapter 15) explore this issue in the context of Burkina Faso, and conclude that maize prices in the country are not closely linked to world prices. Seasonality (predictable, regular price swings) only explains about a fifth of the observed volatility. The authors' big message is that price volatility in Burkina Faso comes mainly from the physical constraints facing farmers. Remoteness from markets has a massive effect on price volatility. Therefore, infrastructure and enhanced regional integration are the featured policy responses.

African food markets continue to display substantial seasonality. Although seasonality in African livelihoods is well known, what exactly is known is less clear. Systematic analysis of seasonality in markets and consumption has been absent, and the topic has largely disappeared from the rural development policy debate. Since the 2008 world food price crisis, the focus has also been more on

food price volatility. Christiaensen, Gilbert, and Kaminski challenge this in chapter 16, starting with a focus on seasonality in food prices. Unlike most of the studies reported here, their main data source is not rural household surveys, but rather price data obtained in rural markets across the seven countries covered. With ingenuity, the authors demonstrate that seasonality is still a fact of life in Africa. Seasonality proves to be a feature of prices for most commodities (especially maize and perishable foods such as tomatoes). And it is two and a half to three times greater in the countries covered than that experienced in international markets (at least for maize and rice). But seasonality does not explain much of the *overall* price volatility over the year. Using the LSMS-ISA data from Tanzania, the authors further show that seasonality in food prices can translate into seasonality in caloric intake, which is especially detrimental when it occurs during the first 1,000 days of life. The chapter concludes that the neglect of seasonality in the policy debate has been premature.

Food losses may not be as large as is often portrayed. The commonly held view that farmers experience significant postharvest losses is based mainly on flimsy and outdated information. Kaminski and Christiaensen, in chapter 17, ask the farmers instead, and find that self-reported postharvest losses are only a fraction of what is commonly reported. Only about a fifth of maize farmers report experiencing a loss of their maize after the harvest. Those who do have losses lose on average 20–25 percent of their harvest—at least in the three countries studied (Malawi, Tanzania, and Uganda). For Tanzania, the authors delve deeper by exploring the factors behind the reported losses. That makes for interesting reading in chapter 17 and adds an important cautionary note to the ongoing conversations about the gains from better postharvest handling techniques. Irrespective of whether the authors are right or wrong, if farmers do not believe postharvest loss to be important, they are less likely to adopt storage silos or other improved postharvest handling techniques.

Annex 1A: LSMS-ISA Data

The Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA) initiative supports national statistical offices in the collection of at least four rounds of nationally representative household panel survey data in eight African countries during 2008–20.[2] The studies in this monograph mainly draw on the first rounds collected during 2009–12 in six of the countries (Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda), which together cover more than 40 percent of the population in SSA and most of its agroecological zones. Although this does not make them representative of SSA as such, together they provide a broad picture of the emerging new reality, and allow for elucidating differences across settings. In these countries, a total of 31,848 households were interviewed, with sample sizes per country varying between 2,716 (Uganda) and 12,271 (Malawi) households. Of the surveyed households, on average 76 percent were rural. Burkina Faso and Mali joined the initiative more recently. Their survey findings are not included here.

The LSMS-ISA initiative presents several notable innovations for the World Bank's LSMS surveys. First, most important, the initiative strengthens the coverage of household agricultural activities—the ISA part of LSMS-ISA. The surveys are based on household samples and designed from the perspective of the household, not the farm. As a result, it is difficult to draw statistically sound inferences about the practices of medium- and large-scale farms, because there are not many of these in the sample (Jayne et al. 2016). Second, in addition to the integrated approach to data collection, data gathering took place at highly disaggregated levels, at the plot level, but also at the individual level, such as for time allocation and plot management. This type of data gathering enabled a more refined, gendered perspective on agriculture and rural livelihoods. Third, the surveys made wide use of information and communications technology (ICT) tools (tablets and Global Positioning System devices) for data collection and plot measurement, improving the quality of data. Finally, individuals (not just households) are tracked across survey waves, opening a host of new research areas, such as the study of migration.

These four innovative features of the data—integration, individualization, ICT use, and intertemporal tracking—not only helped obtain more refined insights into African agriculture and its rural livelihoods, but also helped researchers scrutinize several conventional views that have so far lacked an adequate information base to do so, such as the gender patterns in agricultural labor allocation or the application of joint input packages in practice, that is, at the plot level. The nationally representative scope of the data and the great degree of standardization across countries in questionnaire design and survey implementation further facilitated cross-country comparison as well as comparisons across settings within countries.

Annex 1B: Companion Papers

The chapters in this volume draw upon companion papers that are published elsewhere. We hope that they have awakened your interest, and encourage you to read these fuller versions.

Chapter 2
Dillon, Brian, and Christopher B. Barrett. 2017. "Agricultural Factor Markets in Sub-Saharan Africa: An Updated View with Formal Tests for Market Failure." *Food Policy* 67: 64–67.

Chapter 3
Deininger, Klaus, Sara Savastano, and Fang Xia. 2017. "Smallholders' Land Access in Sub-Saharan Africa: A New Landscape." *Food Policy* 67: 78–92.

Chapter 4
Adjognon, Serge G., Lenis Saweda O. Liverpool-Tasie, and Thomas A. Reardon. 2017. "Agricultural Input Credit in Sub-Saharan Africa: Telling Myth from Facts." *Food Policy* 67: 93–105.

Chapter 5

Carletto, Calogero, Paul Corral, and Anita Guelfi. 2017. "Agricultural Commercialization and Nutrition Revisited: Empirical Evidence from Three African Countries." *Food Policy* 67: 106–18.

Chapter 6

McCullough, Ellen. 2017. "Labour Productivity and Employment Gaps in Sub-Saharan Africa." *Food Policy* 67: 133–52.

Chapter 7

Palacios-Lopez, Amparo, Luc Christiaensen, and Talip Kilic. 2017. "How Much of the Labour in African Agriculture Is Provided by Women?" *Food Policy* 67: 52–63.

Chapter 8

Davis, Benjamin, Stefania Di Giuseppe, and Alberto Zezza. 2017. "Are African Households (Not) Leaving Agriculture? Patterns of Households' Income Sources in Rural Sub-Saharan Africa." *Food Policy* 67: 153–74.

Chapter 9

Nagler, Paula, and Wim Naudé. 2017. "Non-Farm Entrepreneurship in Rural Sub-Saharan Africa: New Empirical Evidence." *Food Policy* 67: 175–91.

Chapter 10

Sheahan, Megan, and Christopher B. Barrett. 2017. "Ten Striking Facts about Agricultural Input Use in Sub-Saharan Africa." *Food Policy* 67: 12–25.

Chapter 11

Binswanger-Mkhize, Hans P., and Sara Savastano. 2017. "Agricultural Intensification: The Status in Six African Countries." *Food Policy* 67: 26–40.

Chapter 12

Liverpool-Tasie, Lenis Saweda O., Bolarin T. Omonona, Awa Sanou, and Wale O. Ogunleye. 2017. "Is Increasing Inorganic Fertilizer Use for Maize Production in SSA a Profitable Proposition? Evidence from Nigeria." *Food Policy* 67: 41–51.

Chapter 13

Miller, Daniel C., Juan-Carlos Muñoz-Mora, and Luc Christiaensen. Forthcoming. "Prevalence, Economic Contribution and Determinants of Trees on Farms across Sub-Saharan Africa." *Forest Policy and Economics*. http://doi.org/10.1016/j.forpol.2016.12.005.

Chapter 14

Nikoloski, Zlatko, Luc Christiaensen, and Ruth Hill. 2015. "Household Shocks and Coping Mechanism: Evidence from Sub-Saharan Africa." Mimeographed. World Bank, Washington, DC.

Chapter 15

Ndiaye, Moctar, Elodie Maître d'Hôtel, and Tristan Le Cotty. 2015. "Maize Price Volatility: Does Market Remoteness Matter?" Policy Research Working Paper 7202, World Bank, Washington, DC. doi: 10.1596/1813-9450-7202.

Chapter 16

Gilbert, Christopher L., Luc Christiaensen, and Jonathan Kaminski. 2017. "Food Price Seasonality in Africa: Measurement and Extent." *Food Policy* 67: 119–32.

Kaminski, Jonathan, Luc Christiaensen, and Christopher L. Gilbert. 2016. "Seasonality in Local Food Markets and Consumption: Evidence from Tanzania." *Oxford Economic Papers* 68 (3): 736–57.

Chapter 17

Kaminski, Jonathan, and Luc Christiaensen. 2014. "Post-Harvest Loss in Sub-Saharan Africa—What Do Farmers Say?" *Global Food Security* 3: 149–58.

Notes

1. This was organized under the umbrella of an ambitious research program initiated by the Chief Economist's Office of the World Bank Africa Region, in partnership with the African Development Bank, the Alliance for a Green Revolution in Africa, Cornell University, the Food and Agriculture Organization, the London School of Economics, the Maastricht School of Management, the University of Pretoria, the University of Rome Tor Vergata, the University of Trento, and Yale University.

2. For a detailed description and access to the data and their documentation, see http://www.worldbank.org/lsms.

Additional Reading

This chapter draws on:

Christiaensen, Luc, and Lionel Demery. 2017. "Agriculture in Africa—Telling Myths from Facts—A Synthesis." *Food Policy* 67: 1–11. https://doi.org/10.1016/j.foodpol.2017.02.002

Other key references:

Arthi, Vellore, Kathleen Beegle, Joachim De Weerdt, and Amparo Palacios-Lopez. 2016. "Not Your Average Job: Measuring Farm Labor in Tanzania." Policy Research Working Paper 7773, World Bank, Washington, DC.

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Jayne, T. S., J. Chamberlin, L. Traub, N. Sitko, M. Muyanga, F. K. Yeboah, W. Anseeuw, A. Chapoto, A. Wineman, C. Nkonde, and R. Kachule. 2016. "Africa's Changing Farm Size Distribution Patterns: The Rise of Medium-Scale Farms." *Agricultural Economics* 47: 197–214.

Rodrik, D. 2016. "Premature Deindustrialization." *Journal of Economic Growth* 21: 1–33.

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An Updated View of African Factor Markets

Brian Dillon and Christopher B. Barrett

Overview

Common wisdom: *Land, labor, and capital markets remain largely incomplete and imperfect in Africa.*

The findings:

- *Factor markets generally are not missing. Many farmers in Africa trade in labor and land markets.*
- *But factor markets regularly fail these farmers, which impedes productivity growth and poverty reduction.*
- *The pattern of market failures is general and structural, not related to the gender of the household head or geographic characteristics, such as the distance to roads or large population centers.*
- *In some countries, the degree of market failure varies between agroecological zones, suggesting that market performance across the region is related at least in part to agroclimatic factors outside households' control.*

Policy message: *The overall message is a strong endorsement of the maintained hypothesis that underpins much current discourse on African agricultural and rural development: there is a pressing need to address widespread input market failures that impede productivity growth and poverty reduction. There is also a call for further research into identifying the nature of market failures in rural Africa.*

The Issue: Is Factor Market Failure Widespread?

Agricultural factor markets of Sub-Saharan Africa (SSA) are widely believed to be failing or incomplete. There are good reasons to suspect that rural markets are not functioning well in this region, as agricultural productivity and rates of modern input use lag far behind the rest of the world. However, to make

appropriate policy choices in an atmosphere of potentially dysfunctional or imperfect markets, it is important to distinguish between three cases. The first is a situation in which a market is truly *missing*, in the sense that exchange is legally prohibited, rendered infeasible by some nonmarket force, or impossible to undertake without the creation of a new regulatory or market-making institution. The second is a case in which a market is in operation but is *failing* in the sense that exchange takes place at noncompetitive prices, that is, prices that do not equate marginal benefit and marginal cost. The third situation is one in which a market is present and functioning at competitive prices, but welfare outcomes for some households are so low that the development community uses the mantle of "market failure" to motivate interventions aimed at improving well-being.

Consider the following illustration. High transaction costs, weak enforcement of contracts, and significant output risk—features common to rural economies in SSA—could induce market failure by causing mismatches in supply and demand or supporting noncompetitive pricing. But these features also increase suppliers' costs, which shifts supply curves inward, raises equilibrium prices, and reduces trading volumes. In the latter case, low levels of input use are the equilibrium outcomes of competitive markets, even though such levels may be suboptimal from a social perspective. This distinction is essential for policy design, because the instruments for fixing missing markets are not the same as those for introducing competition to noncompetitive markets or increasing the welfare of certain agents in a well-functioning market.

Given that policy makers and donors make substantial investments based on the assumption of market failure, careful empirical study of the hypothesis that *factor market failures are widespread in rural Africa* is clearly desirable. The goal of this study is to test this hypothesis comprehensively in Ethiopia, Malawi, Niger, Tanzania, and Uganda, to distinguish between the three cases described above.

The Analysis: Testing the Separation Hypothesis

The study makes two main contributions. First, it provides a comprehensive overview of farmers' participation in factor markets. The focus is on land and labor markets, as it is commonly conjectured that few farmers participate in these markets in rural Africa, instead relying on household labor and owned or informally allocated land. The study shows that a large share of farmers transacts in agricultural labor and/or land markets (figure 2.1). Even excluding harvest labor hiring, a large minority of cultivating households participates in labor or land markets, or both. These markets plainly exist and are used extensively, so it would be clearly incorrect to portray land and labor markets as "missing" across much of SSA. (Chapters 3 and 6 investigate African land and labor markets, respectively, in greater depth.)

Second, the study assesses how well factor markets function. The analysis uses a well-established, reduced-form approach to test for failures in the markets serving agrarian households (Benjamin 1992; Udry 1999). The test is grounded in the standard model of the agricultural household (Singh, Squire, and Strauss 1986),

Figure 2.1 Many Rural Households Trade in Land and Labor Markets
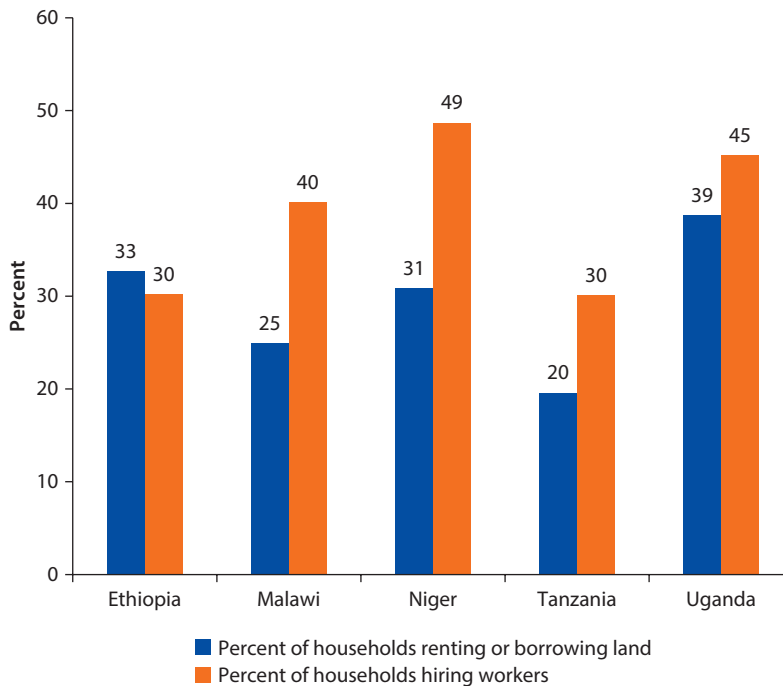
Source: Calculations from the Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS–ISA) data.

which makes explicit the prediction that when markets are complete and competitive, households can make decisions about production and consumption separately. This is widely known as the "separation hypothesis." If the separation hypothesis holds, households behave as if they allocate resources to maximize farm profits first, and then make consumption choices conditional on the budget set that results. Separation is consistent with complete and competitive markets; rejection of the separation hypothesis is consistent with market failure.

At the heart of the empirical test is the observation that with separation, the number of working-age people in the household does not affect the amount of labor used on the farm. The intuition is straightforward: if a farmer can borrow, lend, buy, and sell inputs freely and at market prices, then it should not matter whether the household consists of one person or 10. The hypothesis is tested by estimating regressions of total farm labor demand (given by $\log L_h$) on prices, labor and land endowments, and household characteristics using the following general specification:

$$\log L_h = \alpha + \beta \log \overline{L}_h + \delta \log \overline{A}_h + \gamma Z_h + \phi \, Prices + \mu_h$$

where α, β, δ, γ, and ϕ represent coefficients; subscript h indicates households; and μ is an error term with mean zero. $\overline{L}$, $\overline{A}$, and Z represent (respectively) the number of working-age adults in the household, land endowments, and

household demographic characteristics. The *Prices* variables include nonlabor input prices, market wage rates, price of land, and price of output. The test focuses on the estimate of β. The separation hypothesis is represented by the null hypothesis H_o: $\beta = 0$. Rejection of the null in favor of the alternative hypothesis, H_A: $\beta \neq 0$, implies the absence of complete and competitive markets. If the null hypothesis is rejected (that is, the coefficient on household size is statistically distinguishable from zero), it can be concluded that some factor markets (potentially including markets for labor, credit, insurance, or land) are failing. A detailed exploration of precisely which markets are failing requires additional estimation, which is left to future analysis.

The data are from the World Bank Living Standards Measurement Study and Integrated Surveys on Agriculture (LSMS-ISA) project, sponsored by the Bill & Melinda Gates Foundation. LSMS-ISA is implemented by the national statistics offices of participating countries, with technical expertise and oversight provided by the Development Research Group of the World Bank. Five countries are studied here: Ethiopia, Malawi, Niger, Tanzania, and Uganda. The nationally representative data sets cover a comprehensive set of demographic, health, economic, and agriculture topics. Although there is variation in survey content between countries, efforts were made to ensure as much cross-national comparability as possible in questionnaire design and coverage. Because the hypotheses of interest here relate to market function within a cultivation period, the analysis uses data relevant for the major cropping season in some of the most recent waves of each of the data sets. These are the 2011 cropping season in Ethiopia, 2008/09 rainy season in Malawi, 2010 rainy season in Niger, 2010 long rainy season in Tanzania, and first cropping season of 2010 in Uganda.

The analysis is based on some simplifying assumptions. It treats land inputs as fixed within the cropping season and household labor endowment as exogenous. The labor endowment of a household is defined as the number of adults ages 15–60 years. Demographic controls are included in all the regressions, but the labor endowment is not further disaggregated by demographics (although box 2.1 assesses whether the gender of the household head plays a role).

Box 2.1 Is Market Failure Selective?

The study describes the structural failure of multiple factor markets in rural Africa. But are these problems ubiquitous in these countries, or are they concentrated among identifiable subpopulations? To explore this question, the study examines some of the household- and location-level correlates of factor market failure. The approach remains strictly reduced form. To test whether a particular characteristic is associated with variation in the degree of market failure, the variable for that characteristic is included in the estimating equation independently and interacted with the log of the household size variable. In this way, the analysis can assess whether the estimated relationship between household labor endowment and labor demand varies in magnitude or statistical significance with each characteristics of interest. Such a result

box continues next page

Box 2.1   Is Market Failure Selective? *(continued)*

Table B2.1.1   Market Failure Affects Men and Women

	Ethiopia	Malawi	Niger	Tanzania	Uganda
	Dependent variable: Log labor demand				
Log of household size	0.579***	0.680***	0.816***	0.588***	0.331***
	(0.085)	(0.073)	(0.074)	(0.061)	(0.049)
Head is female	−0.138	−0.018	0.450**	−0.149	0.031
	(0.179)	(0.145)	(0.199)	(0.130)	(0.084)
Head is female x log of household labor endowment	−0.077	−0.063	−0.470***	0.081	−0.047
	(0.155)	(0.139)	(0.179)	(0.113)	(0.061)

Note: ** and *** denote significance at the 5 and 1 percent level, respectively.

would suggest that factor market failures affect subpopulations in different ways, and are not generalized within rural Africa. The analysis considers three sources of heterogeneity in access to complete markets: gender of the household head, distance from key points such as paved roads and large population centers, and agroecological zone (AEZ).

Table B2.1.1 shows the results of regressions with controls for the gender of the household head. There is little evidence of heterogeneity in factor market performance by gender of the head. In all the study countries other than Niger, the coefficients on the level and interaction variables are statistically insignificant and of relatively small magnitude. Overall, it does not appear that gender of the household head helps in explaining variation in the completeness of the markets facing rural households.

Similar regressions were estimated including *distance* variables (distance from paved road, closest town, regional capital, and a large market), and these also proved uninformative. Although market failure might be considered more likely in remoter areas, there is little evidence of this in these data. There is also no change in the main result when the sample is split by above/below median wealth; education variables are interacted with household size; or additional controls for soil type are included in the regression.

Evidence of differences across AEZs is more mixed. For Malawi and Uganda, there are no significant differences between AEZs. For Ethiopia, the only statistically significant difference (from the baseline category of cool, subhumid tropics) is in warm, semi-arid areas, where smaller households exhibit lower demand for agricultural labor. However, the interaction term with log of household size is not significantly different from zero in any of the AEZs, and the magnitude and statistical significance of the coefficient estimate on log of household size are essentially unchanged. In Niger, there is likewise a level difference in conditional labor demand between AEZs, with greater demand in arid areas than semi-arid areas, but the interaction with log of household size is again not significant, and there is no discernible effect on the log of household size coefficient of interest. In Tanzania, there is suggestive evidence that factor market failures are greater in areas outside the warm, subhumid tropics that are home to the bulk of Tanzanian cultivation. This finding is surprising, as it suggests that rural market failures are most acute where agricultural production is least concentrated.

The analysis also ignores the role of supervisory household labor as a complement to hired labor, and does not impose an adjustment factor for possible productivity differences between hired workers and household workers. Extensions to cover these concerns are left for future work. All the regressions are weighted by inverse sampling probabilities, and standard errors are clustered at the level of the zone (Ethiopia), TA (Malawi), grappe (Niger), or district (Uganda and Tanzania).

The Results: Market Failure Is Pervasive in Rural Africa

For all five study countries, the analysis strongly rejects the hypothesis of complete and competitive factor markets. In all countries, the β coefficient is statistically different from zero. The estimated elasticity of farm labor demand with respect to the household labor endowment ranges from 0.32 in Uganda to 0.75 in Niger. The magnitude of this elasticity can be taken as a rough indicator of the depth of market failure. Demand-side participation in labor markets appears weaker in Niger than in the other study countries. Although many households in Niger hire agricultural laborers (figure 2.1), the total amount of labor applied to farms in Niger is linked more closely to the (larger) size of Nigerien households than it is in the other study countries. Nevertheless, the consistent message is that across all the study countries, agricultural households are not served by complete and competitive markets for factors of production.

The results indicate that the pattern of market failures is general and structural. The core results do not vary meaningfully with the gender of the household head, geographic characteristics such as the distance to roads or large population centers, education level of the household head, wealth, or controls for soil type (see box 2.1). In some countries, the degree of market failure varies between agroecological zones, suggesting that market performance across the region may be related in part to agroclimatic factors outside households' control.

However, the overall message is an endorsement of the maintained hypothesis that underpins much of the current discourse on African agricultural and rural development: there is a pressing need to address widespread, systemic market failures that impede productivity growth and poverty reduction.

The Implications

The overall conclusion rejects the notion of widespread *missing* markets, but supports the assumption among the development community that factor markets are not complete and competitive. These market failures are not concentrated among households readily identified by location or gender, but are general and structural.

Although the reduced-form "separation hypothesis" test implemented here relies on an analysis of labor demand, the analysis does not allow identification of precisely which factor markets fail. The results do not necessarily imply that labor markets fail, because violations of the separation hypothesis

can occur even with perfectly functioning labor markets (Barrett 1996). That a large share of agricultural households transacts in rural labor and land markets suggests that the issue is less one of outright market absence than structural barriers. The barriers might be related to financial intermediation, uncertain and expensive contract enforcement, or weak physical infrastructure resulting in high transactions costs, all of which can impede efficient factor market functioning.

Programming and policy making should account for the fact that factor markets within major SSA countries are not fully integrated. Hence, interventions that treat the rural farm economy as a unified, well-functioning whole are unlikely to achieve the desired objective. As the development community and African governments increasingly intervene to try to rectify perceived market failures, the onus is on researchers to locate more precisely the sources and causes of factor market failures that impede productivity and income growth in rural Africa. Effective targeting of interventions likely depends on additional work beyond the tests in this study. However, the findings given here suggest that policy makers might focus more on reducing barriers to market participation and improving the efficiency of markets than on wholesale creation of factor markets, as such markets plainly exist in the study countries.

Additional Reading

This chapter draws on:

Dillon, Brian, and Christopher B. Barrett. 2017. "Agricultural Factor Markets in Sub-Saharan Africa: An Updated View with Formal Tests for Market Failure." *Food Policy* 67: 64–67. https://doi.org/10.1016/j.foodpol.2016.09.015.

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Smallholder Land Access: A New Landscape in Africa?

Klaus Deininger, Sara Savastano, and Fang Xia

Overview

Common wisdom*: Land is abundant in Africa, and since technology is relatively traditional, there is limited scope for productivity-enhancing land transactions. Land rental markets and their institutional underpinnings therefore play only a minor role in the development process.*

Findings:

- *Land rental markets are important for most of the countries studied.*
- *Large differences in land endowments and productivity create potential for land markets to equalize endowments and contribute to higher levels of productivity.*
- *Land rental markets improve equity by promoting land access to those with limited land endowments.*
- *Labor-rich and young households are more likely to participate in land markets in most countries. (Niger is an exception.)*
- *Female heads of households are much less likely to lease in land. This finding points toward significant barriers to land market participation by women.*
- *Rental market performance seems lower where there are greater risks of expropriation.*

Policy messages:

- *Legal framework: To support sustainable land management, investment in land improvements, and efficiency-enhancing transfers, property rights that effectively protect against the threat of land loss are essential. Low-cost models to secure these*

rights in ways that can evolve over time are available and implemented in many countries.

- *Institutional development: easy access to unambiguous and comprehensive information on land rights is key for transparency, land market functioning, and planning. In urban areas, access to this information will also affect the ability to raise local revenue and, if markets function well, the ability to use land as collateral for credit*
- *Women's rights: Land and associated resources make up the lion's share of most households' wealth. Women's use rights, control rights, and transfer rights to land will thus affect not only land use but also women's ability to start independent nonfarm enterprises.*

The Issue: Do Land Markets Support Structural Change in Africa?

Economic development and structural transformation involve specialization and the transfer of labor out of agriculture. This implies an important role for efficiency-enhancing land transfers, as households rent out their land holdings to cultivators or sell their land to finance nonfarm enterprises. Institutions facilitating such transactions at low cost can increase the productivity of land use, help diversify the economy, and foster economic development.

According to the conventional view, land markets are largely absent in subsistence economies, where land is relatively equally distributed, the skill intensity of agricultural cultivation is low, and the availability of nonfarm opportunities is limited. These characteristics are often the presumed state of rural Africa. But as the economy starts to diversify, the scope for land transfers beyond immediate kin assumes considerable importance. Chapter 2 of this volume suggests that factor markets in general function imperfectly in Africa. Therefore, it is important to assess whether the functioning of land markets equalizes land access and raises productivity.

The institutional environment plays a pivotal role. The operation of land markets is likely to depend on the institutions involved in land transactions, and these processes can affect women differently from men. Social conventions governing land access, and land conflicts that disproportionately affect women may reduce the security of their property rights. This could contribute to lower productivity on female-managed plots. These are the issues addressed in this chapter.

The Analysis: From the Bird's Eye View to the Details

The study uses data from the World Bank Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS–ISA) surveys in Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda. These are large, multipurpose household surveys with detailed information on agricultural production. They are

representative of the entire country or rural areas within a country. These data have three principal advantages:

- They use the Global Positioning System (GPS) consistently to measure plot size, which reduces the measurement error inherent in farmers' estimates.
- They permit analysts to retrieve information on the gender of the plot manager and in many cases also the owner. This allows a much better appreciation of gender-disaggregated asset ownership and control, and the potential implications for efficiency of resource use.
- All the surveys provide GPS coordinates of at least the homestead, to link the household to infrastructure access and other geographic data, including agroecological potential. These factors may have an important impact on production, input and output prices, and the ease with which nonfarm opportunities can be accessed.

The study presents a two-pronged analysis. First, the *descriptive analysis* presents a bird's eye view of information on whether and how the household is participating in land markets and the characteristics of that household. Second, the study analyzes the *determinants* of land market participation by taking a multivariate econometric approach (see box 3.1 for the specification).

Box 3.1 Econometric Exploration

The descriptive statistics are extremely informative. But the study explores the determinants of land market participation even further. It estimates a probit equation of the form

$$R_{ij} = \alpha + \beta X_{ij} + \gamma Z_j + \varepsilon_{ij}$$

where *i* and *j* index households and enumeration areas, respectively; R_{ij} is an indicator variable for households renting in land; X_{ij} is a vector of household characteristics; Z_j is a vector of location-specific variables; and β and γ are vectors of the parameters of interest. The estimation provides insights into the determinants of land market household behavior. The analysis focuses on the determinants of *renting in* land. This is because information on leasing out land is too thin in the available data sets.

   The results for specifications with geovariables (population density, distance to road, and nonagricultural income shares) complement the conclusions from the descriptive statistics. The main conclusion is that although land rental can play an important role in equalizing land endowments and land/labor ratios, allowing more efficient producers to access land and contributing to the movement of labor out of agriculture, the extent to which it does so varies widely across countries in ways that are partly linked to institutional factors. The analysis suggests that although land rental markets fail to equalize factor ratios, they contribute to structural transformation by helping to transfer land to land-poor and relatively labor-rich households.

The Results: Land Markets Support Structural Change in Africa

A Bird's Eye View

Descriptive statistics from the surveys suggest that there are five main characteristics of land markets in Africa. First, *the amount of land used for crop cultivation remains small*, with land distribution skewed to the right in virtually all countries. For all countries except Niger, the operated area per adult (household members ages 14 to 60 years) is less than one hectare (figure 3.1). With 3.02 plots per household, fragmentation is highest in Ethiopia and lowest in Malawi (1.74 plots).

Second, *returns to farm labor vary*. Apart from Ethiopia and Nigeria, it is possible to estimate the returns per day to adult farm labor (figure 3.1). The estimates suggest some variation in the returns, from US$1.19 in Uganda to US$2.21 in Malawi.

Third, *gender patterns in land access are diverse*. Male managers are in charge of some 80 percent of cultivated area in Ethiopia and Nigeria, 70 percent in Malawi, and 53 percent in Niger. But male managers command much less land in Tanzania and Uganda (27 and 9 percent, respectively). Women are solely in charge of 24 percent of operated land in Tanzania and 38 percent in Uganda (other land is jointly managed with the men).

Fourth, *land market activity varies across countries*, partly in response to land scarcity. Land sales are much less frequent than land rentals. Renting in land is highest in Ethiopia and Uganda (21 and 19 percent of households, respectively). It is lowest in Tanzania and Niger (6 and 7 percent, respectively). Malawi and Nigeria are in the middle (each with around 10 percent of households). By comparison, the share of households that report renting out land is much lower, being highest in Ethiopia (5 percent), followed by Niger (1.6 percent), Tanzania (1.1 percent), and Uganda, Malawi, and Nigeria (less than 1 percent).

Figure 3.1 Variations in Farm Characteristics
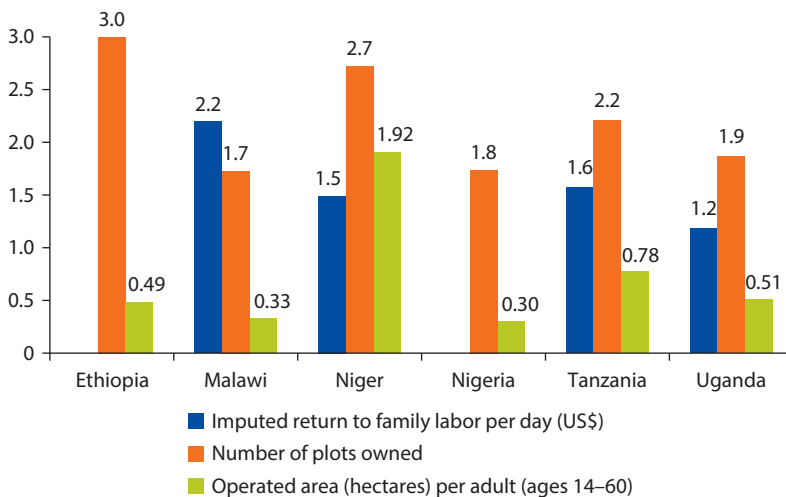
Source: Computations based on LSMS–ISA surveys.

Fifth, *there are large differences between households participating in land markets and nonparticipating households:*

- Land markets allow households that are landless or relatively land-poor but well-endowed with family labor or other fixed assets to access productive resources.
- Land markets facilitate younger operators' access to land. Relatively younger household heads are more likely to use land rental markets and expand their agricultural production.
- Female heads of households are much less likely to lease land, especially in Ethiopia, Malawi, and Niger.
- Land rental markets are more active in areas with higher levels of economic activity (reflected by infrastructure access, light intensity,[1] or urban gravity[2]). Nonfarm diversification appears to drive some of the observed land rental activity. In Malawi, Nigeria, and Uganda, land markets are more active in areas with greater nonagricultural employment. This finding may suggest that land markets contribute to structural transformation by allowing interested individuals to take up nonagricultural employment without losing the safety net function implied by land ownership, and make effective use of their land.

Delving Deeper into the Determinants

Estimates of the probit model (box 3.1) suggest four main findings about land markets. First, land markets help equalize land endowments and land/labor ratios. Evidence of endowment equalization through land markets—with lower land endowments increasing the propensity for land market participation—is found everywhere. The estimated effects are largest in Malawi, Uganda, and Nigeria, where overall land pressure is high, and rather modest in Tanzania, Niger, and Ethiopia. Labor-rich and young households are more likely to participate in land markets everywhere except possibly in Niger.

Second, land markets operate differently for women. The regressions point toward females being less likely to rent in land in many countries, even accounting for differences in other factor endowments. The effects are most pronounced in Ethiopia, followed by Nigeria, Niger, and Malawi.

Third, land markets operate differently in response to population pressure. Although higher population density is associated with higher levels of rental activity in Malawi and Niger, the relationship is insignificant in Uganda and Tanzania and negative in Ethiopia and Nigeria.

Fourth, land markets affect households differently depending on the institutional environment. In four of the countries covered (Ethiopia, Nigeria, Uganda, and Tanzania), rental activity does not increase or is lower in more densely populated areas, possibly because of higher expropriation risk in these contexts. This finding suggests that there is less potential for land transactions to enhance efficiency in these four countries. Reducing expropriation risks would therefore be a priority.

The Implications

This analysis suggests that land markets are more active and have greater potential to contribute to structural transformation in Africa than is commonly assumed. These findings point toward a need to replace traditional views of African agriculture with a more differentiated and empirically grounded view.

Although factor markets do not function perfectly, land rental markets perform an important function in the process of structural transformation, making it possible for those with better nonfarm opportunities to take advantage of them. At the same time, land rental markets allow land-poor but labor-rich and more productive households to increase the amount of land they cultivate.

Land market performance seems to be lower where there are implicit or explicit restrictions on land rental. Perceived threats of uncompensated expropriation reduce subjective tenure security. Even when there are legal regulations to this end, often they are not implemented, or they are implemented in a way that affects groups (such as women) differently.

Policy Agenda

The role of land markets in the process of structural change and development in Africa is significant, calling for serious policy attention. Three policy issues emerge from this study:

- *Legal framework*. To support sustainable land management, investment in land improvements, and efficiency-enhancing transfers, property rights that effectively protect against the threat of land loss are essential. Low-cost models to secure these property rights in ways that can evolve over time are available and implemented in many countries.
- *Institutional development*. Easy access to unambiguous and comprehensive information on land rights is key for transparency, land market functioning, and planning. In urban areas, access to information will also affect the ability to raise local revenue and, if markets function well, the ability to use land as collateral for credit.
- *Women's rights*. Land and associated resources make up the lion's share of most households' wealth. Women's use rights, control rights, and transfer rights to land will thus affect not only land use but also women's ability to start independent nonfarm enterprises.

Research Agenda

The study shows that microdata can help provide a better understanding of the forces shaping structural change in Africa's rural areas. Consistently implementing improvements in questionnaire design to obtain data on nonagricultural land, land acquisition history, individuals' rights, land-attached investment, tenure and ownership status, prices, and output and input at the plot level can help in better harnessing this potential for analysis. Households' awareness of and trust in key institutions could make the data even more useful.

Improving the capacity of African land institutions implies considerable scope for complementing household surveys with administrative data. Improved capacity would exploit complementarities and cross-check results—for example, to explore the extent of informal transactions and potential reasons for them, cross-check information on sales prices, follow up in more detail on rare events such as disputes, and explore positive or negative spillover effects from large land transfers (for agro or other industries). Exploring these opportunities, together with links to remotely sensed imagery, is likely to further expand the usefulness of household data in seeking to understand the processes of structural transformation in Africa and beyond.

Notes

1. The sum of nighttime lights from the satellite of the DMSP-F16 across all pixels of the city in 2009 is used to proxy light intensity. Ephemeral events, such as lightning strikes and fires, have been discarded. The light emitted by each city is assumed to be highly correlated with its overall gross domestic product.

2. As a proxy for urban demand, a measure of urban gravity based on the gravity model is developed that captures the interaction between a particular location and all urban centers in the country with a population over 500,000 in 2010.

Additional Reading

This chapter draws on:

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Financing Agricultural Inputs in Africa: Own Cash or Credit?

Guigonan Serge Adjognon, Lenis Saweda O. Liverpool-Tasie, and Thomas Reardon

Overview

Common wisdom*: Access to formal credit is limited; farm inputs are financed largely through informal credit.*

Findings:

- *The use of credit (formal, informal, tied, and untied) for financing modern inputs is extremely low.*
- *Low use of credit applies in all countries and for all crops and farm sizes. The use of credit for financing inputs is similar for food crops and cash crops.*
- *Farmers primarily finance modern input purchases with cash from nonfarm activities and crop sales.*
- *Tied output-factor market arrangements with input traders and output traders play a minor role in financing external inputs, but appear to be relatively widely used for labor credit.*
- *"Traditional cash crop" farmers selling to processors rarely receive credit from processors, except in a few enclaves, such as larger tobacco farmers in Tanzania.*
- *Access to loans (mostly informal) has a favorable effect on fertilizer use.*
- *Nonfarm self-employment is associated with greater use of fertilizers.*

Policy message: *Rural development policies and programs that spur broad development of the rural nonfarm sector would benefit farm input purchases and thus productivity and food security. These policies and programs would be important complements to credit policies and programs.*

The Issue: How Are Farmers in Africa Financing Modern Input Use?

Recent evidence indicates that many farmers in Sub-Saharan Africa purchase external inputs such as fertilizer, seeds, and pesticides and herbicides (see chapter 10, and Sheahan and Barrett 2014). However, there is limited information on how the increasing use of modern inputs is being financed. This study therefore investigates empirically how African smallholders finance the purchase of modern external inputs.

The study derives testable hypotheses from the literature, which, over the years, has fed conventional wisdom about how African farmers finance agricultural activities. Points of conventional wisdom include the following:

- Farmers use little to no formal bank credit to finance input purchases.
- Farmers rely heavily on informal credit from two sources. The first is input and output traders, who give farmers advances and, in the case of output traders, "tie" their output sale to the provision of credit at the start of the season. Second, farmers are believed to obtain credit from friends, family, and village moneylenders to finance input purchases.
- Farmers in cash crop contract farming schemes obtain input credit from processors.

The Analysis: Combining Description with Multivariate Analysis

The study tests these three sets of common wisdom. The analysis fills a gap in the literature, because there is no current and systematic inventory of how farmers pay for inputs. To fill this gap, the study undertakes a cross-country empirical examination of input finance among smallholders, using recently available, nationally representative Living Standards Measurement Study farm household survey data sets. These data comprise more than 10,000 households in four countries: Malawi, Nigeria, Tanzania, and Uganda. The study focuses on purchases of "external inputs," that is, nonlabor variable inputs (fertilizer, pesticides, and seeds) and of labor. Relying mostly on descriptive statistics on formal and informal tied and untied credit sources, the study explores the influence of crop types (cash crops versus food crops) and farm size. It also uses econometric regression methods to examine the correlates of input purchases.

The Results: Use of Credit for Input Purchases Is Not Commonplace

There Is Much Variation across Countries in Modern External Input Purchases
The survey data show that there is a marked contrast across countries. Nigeria and Malawi have a high share of farmers (71 and 70 percent, respectively) buying external inputs such as fertilizer, improved seeds, and pesticides. In Uganda and Tanzania, the share is lower—16 and 18 percent, respectively.

The results for Malawi and Nigeria are at odds with the traditional notion that few farmers in Sub-Saharan Africa use external inputs, but are consistent with recent literature (Sheahan and Barrett 2014). The results in Malawi and Nigeria might be driven by their fertilizer subsidy programs. That is likely to be true in Malawi, where about 60 percent of households receive subsidized fertilizer (Chirwa and Dorward 2013). But the Nigeria data show that only 5 percent of households that purchase fertilizer bought it from government sources (the channel through which subsidies were delivered at the time of the survey).

The Use of Credit for Input Purchases Is Rare

Although there is significant variation across countries in input purchases, there are only modest differences in the use of credit for these purchases. On average, about 6 percent of households that buy these inputs use any form of credit (figure 4.1). This finding suggests that an average of 94 percent of African households use their own cash (from noncredit resources, such as cash sales of crops, and employment earnings) to buy external inputs. This finding goes against the general presumption that farmers would use informal credit (from moneylenders, friends, and family) or trader credit. The survey data reveal not just a case of limited formal credit but also a near absence of the use of any credit, formal or informal, tied with input or output traders, in kind or in cash.

Figure 4.1 Very Few Farmers Who Buy External Inputs Use Credit
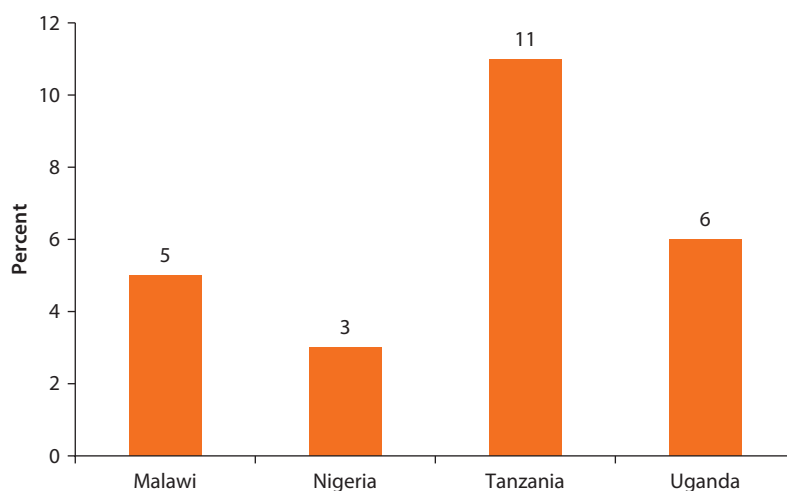
Source: Computations based on Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS–ISA) data.

Credit Is More Commonly Used for Fertilizers Than for Other External Inputs

Credit is most commonly used for purchases of fertilizer in Tanzania and Uganda, where about 14 percent of fertilizer purchases are financed in this way. In Malawi and Nigeria, where the majority of farmers buy external inputs, credit is not the major source of finance, even for fertilizer purchases. In sum, the importance of input credit tends to be mainly for fertilizer purchases, and not for pesticides and seeds. Two to three times more households tend to obtain some kind of credit for fertilizer purchases, compared with seeds or pesticides and herbicides.

Input Credit Is Related to Farm Size in Malawi, Tanzania, and Uganda

Most credit-based external input purchases in Malawi, Tanzania, and Uganda are concentrated in farms that are larger than one hectare (figure 4.2). Nigeria is an exception, with more of the input credit taken by the "under one hectare" group. These results do not differ much over input type.

The Use of Input Credit Is Rare, Even for Traditional Cash Crop Production

Conventional wisdom suggests that farmers growing traditional cash crops (such as cocoa, cotton, tea, and tobacco) would commonly access external inputs on credit, in particular from processors, while food crop producers would not. But the results of the study indicate that although there is a lot of variation across countries, the average share of credit-financed input purchases over all traditional cash crops is 13 percent, compared with 6 percent for food crops. The cash crop share is mostly driven by tobacco producers, who represent only about 1 percent of the total sample. These producers receive input credit for tobacco production through contract farming arrangements.

Figure 4.2 Credit-Financed Inputs Are More Common in Larger Farms
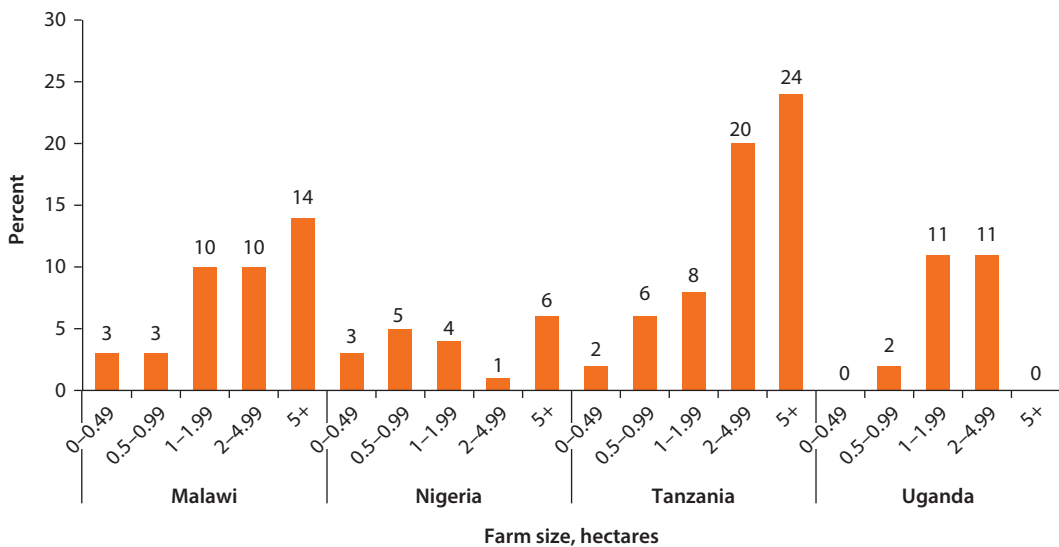
Source: Computations based on LSMS–ISA data.

Excluding tobacco plots puts the overall credit share of traditional cash crop producers close to that of food crop producers.

The results vary across countries. In Nigeria and Uganda, there is little difference in the use of credit between cash and food crop farmers. In Malawi and Tanzania, the difference is more striking (in the latter case because of tobacco farming).

"Tied Credit" Is Rare for External Inputs but More Common for Labor Inputs

Tied output and input credit arrangements occur when credit for inputs or cash for inputs (received at planting) is repaid at harvest time. The study finds that less than 2 percent of farmers across all countries use tied credit arrangements for external inputs. However, labor output-tying is much more common, with as many as 42 percent of the farmers in Malawi, 26 percent in Nigeria, and 68 percent in Tanzania engaged in this (see figure 4.3).

Loans Are Rarely Used for Farming

Loans (defined here as credit unconnected directly to transactions of outputs or inputs) can come from formal (banks), semiformal (microfinance), or informal (friends, relatives, cooperatives, and so forth) sources. Although data on the actual use of loans were not available for Nigeria, as much as 38 percent of the sample households took loans. In the Malawi sample, 23 percent of the households took a loan, but only 5 percent of those households did so for farming. In Tanzania, 11 percent of households took loans, of which 2 percent were for farming purposes. This is a 5-to-1 ratio of overall loans to farm-destined loans in both countries. It is quite striking that loans are predominantly used to finance nonfarm business start-up costs and consumption.

Figure 4.3 Tied Credit Is Important for External Labor but Not for Inputs
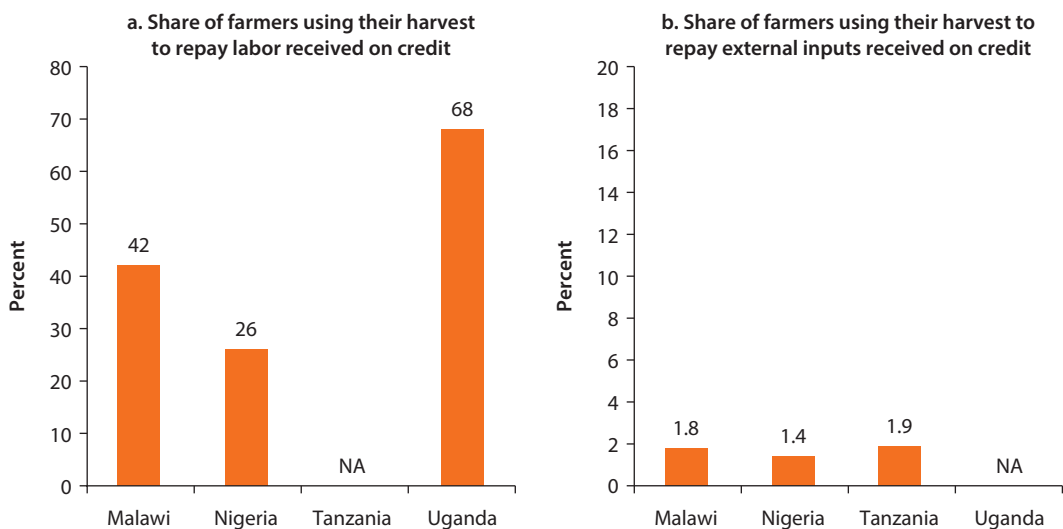
Source: Computations based on LSMS–ISA data.

Understanding Farmers' Decisions

Regression Analysis

The study expands the descriptive analysis with a multivariate regression analysis of the fertilizer purchase *decision* and the *intensity* of purchases by Nigerian farmers. Using panel data and probit and Tobit estimation methods (box 4.1), the analysis emphasizes the role of nonfarm employment (wage and self-employment) and agricultural productivity risks (captured by rainfall variability), as well as regional differences (North versus South) in decisions on fertilizer purchases and intensity.

Box 4.1 Econometric Modeling of Input Purchases

Fertilizer demand can be expressed as a function of output and input prices, risk proxies, complementary and substitute farm capital, and relevant shifter variables, such as crop type. The study considers the decision to purchase fertilizer and then the intensity of use. In each case,

$$Y_{it} = f\left(X_{it}, u_{it}\right)$$

where Y_{it} refers to the binary-input-use variable or the quantity of fertilizer purchased (in kilograms), X_{it} refers to a vector of controls that explain fertilizer demand, and $u_{it} = \varepsilon_{ijit} + c_i$ is a composite error term comprising time-invariant unobservable heterogeneity (c_i) and time-varying unobserved characteristics (ε_{it}) of the input demand function. The study models farmers' fertilizer purchase decisions using the standard-unobserved-effects, binary-dependent-variable model. The intensity of fertilizer use is modeled using the unobserved-effects Tobit model to account for the corner solution nature of the dependent variable. In both models, c_i represents the unobserved-effect parameter called correlated random effects (CRE):

$$c_i = \psi + \overline{X_i}\xi + a_i,$$

$$a_i \mid X_i \sim Normal\left(0, \sigma_a^2\right)$$

where $\overline{X_i}$ represents time averages of the explanatory variables. The CRE model is preferred over alternative methods, such as the fixed effects and random effects models, in the case of nonlinear models. However, for comparison, the study estimates the linear model with household fixed effects, given its suggested conceptual robustness over nonlinear models, such as the probit and Tobit.

Consistent with the CRE model, the determinants of the fertilizer purchase decision and level of use are estimated using pooled probit and Tobit regressions, respectively. Each regression equation includes a set of explanatory variables, as well as the time averages of these variables. A Wald test of joint significance of the time average variables is performed to test whether a traditional random effects model would be appropriate. A dummy variable for the time period is included to account for time-specific factors that affect fertilizer demand. Since it is not possible to completely rule out endogeneity

box continues next page

Box 4.1 Econometric Modeling of Input Purchases *(continued)*

due to time-varying unobservables, the results are interpreted as correlates rather than causal effects.

The following explanatory variables were used for the use and intensity regressions:

Proxies for input finance: rural nonfarm income, crop sales, and whether a household member had previously obtained credit.

Socioeconomic variables: gender, age, and education of the household head, and the household dependency ratio to capture the household's composition and productive structure.

Household assets: size of total landholdings (in hectares) and a principal-components assets index reflecting household ownership of agricultural assets (tractors, pumps, plows, and so forth).

Environmental factors: dummies for the main zones in Nigeria (Northeast, Northwest, Southeast, Southwest, and Southcentral), reflecting infrastructural and growing conditions, and dummies for urban and rural. The regressions also controlled for the shares of grains, legumes, tubers, horticulture crops, oil crops, and so forth in total land cultivated by the household, which reflect biophysical differences.

Regression Results

The results reveal substantial differences between northern and southern Nigeria. Most relevant determinants of fertilizer purchases show higher significance in the North compared with the South. This possibly reflects that farmers in the North use more fertilizers and therefore are more responsive to various determinants than farmers in the South are. The following are the key messages emerging from this analysis:

Access to loans affects fertilizer purchase positively. The effect is significant only in the northern part of Nigeria. A closer look indicates that loans from friends and relatives (rather than loans from formal and semiformal institutions) seem to drive most of this result, illustrating that loans, especially loans from formal and semiformal institutions, are limited for agricultural investment.

Nonfarm self-employment also has a positive effect. Participation in nonfarm self-employment raises the likelihood of purchasing fertilizers by about 7 percent—an effect that is present in North and South Nigeria.

Rainfall is important. As expected, the coefficient of variation of rainfall has a strongly negative effect on fertilizer purchasing, but is significant only in the North. This result is important, as investments in modern input use, although generally profitable, are costly and can yield very low (or even negative) returns in case of negative weather shocks.

Education is important. Education of the household head has a positive and significant effect in both the North and the South.

Farm size matters in the North. The farm size effect is significant and positive only in the North; the effect is negative but not significant in the South.

The Implications

This study finds that few farmers in these African countries use any form of credit, formal or informal, to finance external input purchases. What is still significant is the link between the labor and output markets through informal arrangements. Although farmers take loans to finance the start-up of nonfarm enterprises rather than the purchase of external inputs, they use cash from these nonfarm enterprises and crop sales to purchase external inputs.

The main policy implication of the research is that retained earnings from employment income pay for almost all farm inputs in the countries studied. Subsidies are minor, and credit, informal or formal, is also minor. The earnings that pay for farm inputs come mainly from rural nonfarm employment (RNFE), some from crop sales, and a little bit from migration. Currently, RNFE is mainly from local services linked to agri-food supply chain off-farm activities, like commerce and processing and logistics. This finding suggests a virtuous circle of helping the farm and food supply chains to co-develop, to generate cash to buy inputs to ratchet up productivity via farm investments over time. Farm credit is lacking, but a current concern is that agricultural sales and RNFE are relatively concentrated among a subset of households. That concentration translates into concentration in farm investments, and hence productivity gains. All that can be done to help agricultural commercialization and RNFE development to be broad-based and inclusive is important. The results of the study point to the extreme centrality of factors to reduce entry barriers to RNFE and agricultural sales (for example, roads and other infrastructure, as well as research and training) and allow more farm zones and farmer strata to find it easier to participate.

The study indicates that further analysis of the factors that explain the limited use of noncash income sources to finance external input purchase is called for. In addition to credit availability, issues such as the associated interest rates and expected returns to investing in modern external inputs should be explored.

Additional Reading

This chapter draws on:

Adjognon, Serge G., Lenis Saweda O. Liverpool-Tasie, and Thomas A. Reardon. 2017. "Agricultural Input Credit in Sub-Saharan Africa: Telling Myth from Facts." *Food Policy* 67: 93–105. https://doi.org/10.1016/j.foodpol.2016.09.014.

Other key references:

Chirwa, E., and A. Dorward. 2013. *Agricultural Input Subsidies: The Recent Malawi Experience.* Oxford: Oxford University Press.

Conning, J., and C. Udry. 2007. "Rural Financial Markets in Developing Countries." *Handbook of Agricultural Economics* 3: 2857–2908.

Haggblade, S., P. B. R. Hazell, and T. Reardon. 2010. "The Rural Nonfarm Economy: Prospects for Growth and Poverty Reduction." *World Development* 38 (10): 1429–41.

Poulton, C., J. Kydd, and A. Dorward. 2006. "Overcoming Market Constraints on Pro-Poor Agricultural Growth in Sub-Saharan Africa." *Development Policy Review* 24 (3): 243–77.

Sheahan, M., and C. B. Barrett. 2014. "Understanding the Agricultural Input Landscape in Sub-Saharan Africa: Recent Plot, Household, and Community-Level Evidence." *Food Policy* 67: 12–25.

Revisiting the Gains from Agricultural Commercialization

Calogero Carletto, Paul Corral, and Anita Guelfi

Overview

Conventional wisdom: *Agricultural commercialization is likely to enhance economic development and nutritional outcomes at the household level.*

Findings:

- *Market involvement is commonplace among farm households; it accounts for 90 percent of production in Malawi.*
- *Contrary to common perceptions, the bulk of market participation is driven by the sale of food crops.*
- *In most cases, market participation only involves the sale of small quantities of own food production.*
- *Although female farmers appear to participate less in market activities, when they do participate, they tend to sell larger shares of the production under their control relative to their male counterparts.*
- *Simply comparing levels of commercialization of agriculture and household nutrition outcomes reveals few links between the two.*
- *Measuring nutrition in per capita food expenditure and per capita caloric consumption, the study finds little association with commercialization.*
- *No clear trends emerge when the degree of agricultural commercialization is correlated with children's anthropometrics as measured through Z-scores.*

Policy conclusion: *In line with previous research, the study finds little evidence of a relationship between increased commercialization and improved nutritional status in the three African countries covered.*

The Issue: Does the Commercialization of Agriculture Harm Nutrition?

According to conventional wisdom, the transition from subsistence (or semisubsistence) to commercial agriculture represents a key ingredient for the economic development of low-income countries. By exploiting comparative advantage, the process of agricultural commercialization is expected to enhance efficiency and the gains from trade. This in turn is expected to lead to economic growth and welfare improvement at the national, household, and individual levels. The progressive move toward a market-oriented system of production in agriculture is thereby expected to initiate a virtuous cycle that, by raising income levels, improves consumption, food security, and nutritional outcomes in rural households. Nonetheless, this process requires that households choose to commercialize their production and use the returns from crop sales in ways that foster improved nutrition. Thus, although the commercialization of crops may potentially increase incomes, and thereby improve nutrition, farming households often avoid commercializing their crops. This finding is often attributed to the fact that households are not indifferent between production for the market and production for the homestead.

The empirical literature on the nutritional outcomes of agricultural commercialization can be grouped into three main strands:

1. *Earlier studies* tended to lack a proper conceptual framework, adopting instead a black box approach that neglected the processes that generate outcomes. The main approach was a comparison of nutritional outcomes between cash crop adopters and nonadopters. The evidence was often anecdotal and based on country case studies, which made it impossible to compare results across and within countries. In most of the studies, the definition and measurement of commercialization was subjective and mainly based on the adoption or nonadoption of a given list of cash crops. Von Braun and Kennedy (1994) and Von Braun, Kennedy, and Bouis (1989) provide useful summaries of this literature.

2. *The work of the International Food Policy Research Institute (IFPRI)* between 1986 and 1994 was more systematic. IFPRI first developed a conceptual framework to represent the complex set of links between the process of agricultural commercialization and the nutritional and health status of households. This framework sought to explain the variety of mechanisms through which the transition to a more market-oriented production system can affect household consumption and nutrition. IFPRI's empirical work during this period focused on Guatemala, Kenya, Rwanda, the Philippines, and The Gambia. Two key results emerged:

   • Most country studies found a positive (although relatively low) impact of agricultural commercialization on the nutritional status of rural households. This positive relationship mainly operated through income and calorie links. Cash crop adoption generally increased real incomes, thereby

stimulating a virtuous cycle through which higher incomes led to increased food consumption that benefited, on average, the household in general and children in particular.

• Agricultural commercialization of smallholder production systems is not in itself positive or negative. The complex set of links characterizing the commercialization process and its impact on household welfare and nutrition suggests that several scenarios can emerge, depending on the factors in each context. Policies aimed at enhancing beneficial outcomes while minimizing adverse ones play a key role.

3. *Recent studies* conducted since the IFPRI work have made few significant empirical contributions. One such study, by Wood et al. (2013), emphasizes that all previous evidence (including the IFPRI studies) considered periods of high stability in food prices; in contrast, recent studies seek to understand the nutritional consequences of a shock in food prices. However, the few additional studies do not provide any new, clear-cut conclusions about the positive or negative effects of agricultural commercialization on nutrition.

The Analysis: Back to the Data and More Recent Evidence

This study covers two survey panel waves in three countries included in the Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS–ISA) program, namely Malawi, Tanzania, and Uganda. The surveys were fielded throughout the year. Given the focus, the study sample only includes agricultural households, defined as households that reported involvement in agricultural activities through ownership and/or cultivation of land in the most recently completed agricultural season. After excluding nonpanel and nonfarming households, the final sample that was used for the panel analysis consisted of 2,222 households in Malawi, 1,744 in Tanzania, and 1,587 in Uganda.

Defining and Measuring Commercialization
The study adopted a simple but insightful measure of commercialization, the Household Crop Commercialization Index (CCI), defined as:

$$CCI_i = \frac{Gross\ value\ of\ crop\ sales_{hhi,\ year\ j}}{Gross\ value\ of\ all\ crop\ production_{hhi,\ year\ j}} * 100$$

According to this measure, the process of agricultural commercialization can be represented on a continuum, ranging from pure subsistence ($CCI_i = 0$) to a completely commercialized production system ($CCI_i = 100$). The main advantage of the CCI is that it goes beyond the traditional dichotomies of sellers versus nonsellers or producers of cash crops versus producers of staple crops. The CCI provides an additional layer to the discussion and is relatively easy to apply.

Measuring Nutrition

The study adopts the following indicators of nutrition:

- Child anthropometric measures (measured as percentages of children stunted, wasted, and underweight, and through the computation of Z-scores)
- Food expenditure per capita
- Total expenditure per capita.

The data reveal high levels of malnutrition in all three countries, with an incidence of stunting among preschool children of about 42 percent in Tanzania, 36 percent in Uganda, and 31 percent in Malawi. Similarly, the share of wasted children in Tanzania amounts to 6.2 percent, compared with 3.2 percent in Uganda and 3.6 percent in Malawi. Tanzania exhibits average per capita caloric consumption of 2,044 kilocalories, compared with 2,536 kilocalories in Malawi and 2,243 kilocalories in Uganda.

Exploring the Links

As a first approximation, the study allocates households into CCI quintiles (quintile 1 having the lowest CCIs, and quintile 5 the highest). A comparison is then made across the quintiles for each of the anthropometric Z-scores (anthropometric measure expressed as standard deviations above or below a reference median):

- Height for age, a measure of stunting indicating past inadequate nutrition and/or chronic and frequent illness
- Weight for age, a measure of underweight reflecting current deprivation
- Weight for height, a composite measure of short- and long-term conditions, or wasting.

Comparison of the nutrition outcomes across the quintiles revealed little evidence of any clear link between the level of commercialization and nutritional outcomes (table 5.1). To account for the small sample of children for the anthropometric measures, the study pools the data across countries and runs a local polynomial nonparametric regression (without any control variables). The results suggest that there is some correlation between CCI and nutritional outcomes, particularly for stunting, with a more accentuated upward slope (figure 5.1).

The empirical strategy taken involved ordinary least squares (OLS) multivariate analysis with panel fixed effects using several specifications, varying the CCI and nutritional measures. For two of the dependent variables (per capita food expenditure and per capita total expenditure), sample size considerations do not apply and OLS estimates were obtained for each country separately. For children's anthropometric measures (where individual country samples were limited), the pooled data were exploited. All the regressions involved the following explanatory variables: gender, age and education of the household head, land holdings,

Table 5.1 Little Evidence of a Link between Nutritional Outcomes and Commercialization

Country and quintile		HAZ	WAZ	WHZ	Stunted	Wasted	Underweight	Food expenditure ($)	Kilo-calories
						Nutrional measure			
Malawi CCI quintile	No Sales	−1.31	−0.52	0.29	25.6	3.9	5.7	0.42	2418
	1	−1.22	−0.48	0.28	25.2	3.0	4.7	0.47	2352
	2	−1.53	−1.57	0.41	32.8	2.7	7.5	0.53	2546
	3	−1.32	−0.41	0.46	30.3	3.6	5.5	0.54	2670
	4	−1.40	−0.54	0.35	30.5	4.7	6.8	0.55	2538
	5	−1.52	−0.51	0.47	36.5	3.8	7.7	0.57	2640
	Country mean	−1.39	−0.57	0.39	30.7	3.6	6.4	0.52	2536
Tanzania CCI quintile	No Sales	−1.72	−0.95	0.02	42.6	5.7	14.4	0.63	1972
	1	−1.81	−1.10	−0.15	43.4	7.7	24.1	0.66	2215
	2	−1.85	−0.97	0.10	47.2	7.1	16.9	0.59	2051
	3	−1.67	−1.02	−0.13	45.1	6.2	15.5	0.61	2004
	4	−1.62	−0.88	0.03	40.1	5.5	12.1	0.62	2074
	5	−1.58	−0.92	−0.06	32.4	5.5	14.0	0.64	2044
	Country mean	−1.71	−0.96	−0.02	41.9	6.2	15.6	0.63	2044
Uganda CCI quintile	No Sales	−1.43	−0.83	−0.04	32.1	2.4	14.5	0.35	1954
	1	−1.35	−0.58	0.26	36.8	1.7	9.4	0.40	2229
	2	−1.85	−1.01	0.07	45.6	6.1	16.1	0.41	2299
	3	−1.59	−0.78	0.18	37.0	5.1	12.3	0.44	2546
	4	−1.57	−0.70	0.27	31.8	1.6	10.7	0.40	2362
	5	−1.44	−0.58	0.31	34.4	2.4	7.9	0.44	2132
	Country mean	−1.53	−0.75	0.16	36.0	3.2	11.9	0.40	2243

Source: Computations based on LSMS–ISA data.
Note: Food expenditure and kilocalorie data are per capita, and at the household level. CCI = Household Crop Commercialization Index; HAZ = height-for-age Z-score; WAZ = weight-for-age Z-score; WHZ = weight-for-height Z-score.

Figure 5.1 Some Correlation between Commercialization and Nutrition

a. Height-for-age Z-score, HAZ vs. CCI, pooled data

b. Weight-for-height Z-score, WHZ vs. CCI, pooled data

- - - 95% confidence interval
—— lpoly smooth: height-for-age Z-score

- - - 95% confidence interval
—— lpoly smooth: weight-for-height Z-score
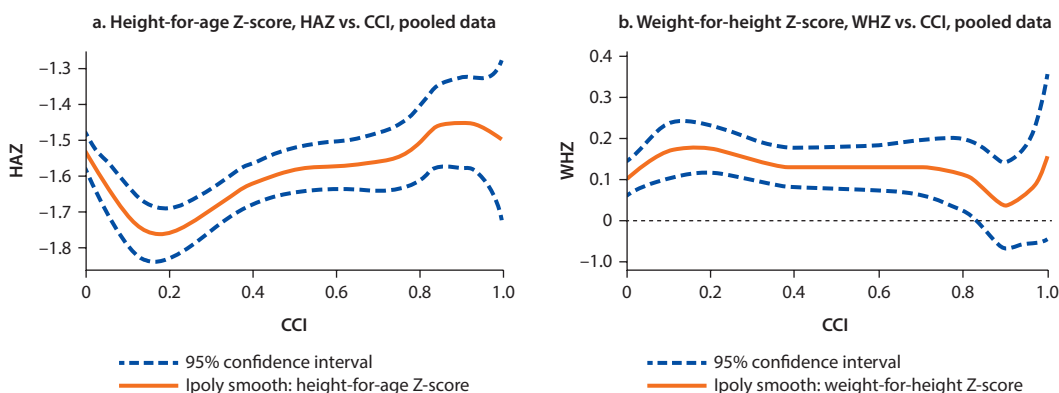
Source: Computations based on LSMS–ISA data and local polynomial nonparametric regressions.
Note: Local polynomial for pooled data. CCI = Crop Commercialization Index; HAZ = height-for-age Z-score; poly = Smoothed local polynomial; WHZ = weight-for-height Z-score.

land holdings squared, wealth index, distance to market, distance to population center, value of the household harvest, and regional dummies. In addition, the household's per capita expenditure, child's age in months, and gender were added to the child anthropometric analysis. Alternative measures of CCI were used as regressors, in part to test for the sensitivity of the results to the measure of commercialization. The measures were disaggregated by gender and crop. The study counsels caution in interpreting the results, given the potential endogeneity of the CCI variable.

The Results: Little Evidence of a Link between Nutrition and Commercialization

The results are mixed, depending on the regression specification and the country.

Dependent variable: Z-score level. These regressions use the pooled data covering all three countries. The fixed-effects results consistently fail to show any relationship between the CCI and anthropometric outcomes, however defined. The level of per capita expenditure is also not significant in these regressions.

Dependent variable: percentage stunted, wasted, and underweight. The probability of a child being stunted, wasted, or underweight is also modeled with pooled data. The coefficients only show a significant and negative effect of greater commercialization by women on short-term nutritional indicators, which is possibly a reflection of the potentially deleterious effect of lower levels of child care on child nutritional status. Per capita expenditure in this instance seems to play a role, with an increase in expenditure negatively related to the child's likelihood of being stunted and underweight.

Dependent variable: household per capita food expenditure. The study finds little evidence of a relationship between CCI and food expenditures, except for Uganda, where the coefficient is negative and marginally significant. All the other coefficients provide little support for the existence of a relationship between commercialization, in its different specifications, and food expenditures in any of the countries analyzed.

Dependent variable: household total per capita expenditure. There is little evidence of any effect of commercialization on total expenditures. This lack of impact may be because although commercialization is widespread across farmers, sales often involve small amounts, which fail to have a significant impact on total household per capita expenditures.

The Implications

Despite the inconclusiveness of the available empirical evidence to date, agricultural commercialization among poor smallholders continues to be heralded as an effective solution to foster growth in rural areas, reduce poverty, and improve household food and nutrition security. Based on new, comparable data from across Sub-Saharan Africa, the study contributes to the ongoing debate by investigating

the relationship between increased agricultural commercialization and several nutritional indicators in three African countries, differentiated by gender and types of crops.

Against the conventional wisdom, the data reveal a very high level of market involvement by even the poorest and smallest landholders, with rates of market participation as high as 90 percent in Malawi. Similarly, against the common perception, a considerable portion of this market presence is driven by the sale of staple and other food crops, and not necessarily by traditional cash crops. This finding is in part because the great majority of smallholders are still specializing in the production of food crops (between 80 and 90 percent in the three countries analyzed), with only a relatively small share cultivating food and traditional cash crops, and virtually none specializing in cash crops. However, in most cases, particularly in Malawi, market participation only involves the sale of small quantities of own food production, resulting in a rather low food CCI (at 10 percent for the entire sample, and only 14 percent among the largest farmers).

Another important finding of the cross-country descriptive analysis is that although female farmers appear to participate less in market activities, when they do, they tend to sell larger shares of the production under their control compared with their male counterparts.

Finally, the study finds little evidence of a relationship between increased commercialization and improved nutritional status. The only exception is a weak, negative relationship between the portion of commercialization accruing to females and short-term nutritional indicators, which could be the result of the negative effect of greater female market participation on time allocated to child care and homemaking. Although the use of panel data partly resolved some of the endogeneity issues of the proposed specification, and the availability of comparable cross-country data helped in making some of the conclusions more robust, some caution is warranted in interpreting the findings.

Additional Reading

This chapter draws on:

Carletto, Calogero, Paul Corral, and Anita Guelfi. 2017. "Agricultural Commercialization and Nutrition Revisited: Empirical Evidence from Three African Countries." *Food Policy* 67: 106–18. https://doi.org/10.1016/j.foodpol.2016.09.020.

Other key references:

Von Braun, J., and E. Kennedy, eds. 1994. *Agriculture Commercialization, Economic Development, and Nutrition*. Baltimore: Johns Hopkins University Press.

Von Braun, J., E. Kennedy, and H. Bouis. 1989. *Comparative Analyses of the Effects of Increased Commercialization of Subsistence Agriculture on Production, Consumption, and Nutrition*. Washington, DC: International Food Policy Research Institute.

Wood, B., C. Nelson, T. Kilic, and S. Murray. 2013. "Up in the Smoke? Agriculture Commercialization, Rising Food Prices and Stunting in Malawi." Policy Research Working Paper 6650, World Bank, Washington, DC.

Agricultural Labor Is Not So Unproductive in Africa

Ellen B. McCullough

Overview

Common wisdom: *In poor economies, agriculture is typically the sector that employs the most people and uses labor least productively.*

Findings:

- *Microeconomic analogs of productivity gaps between agriculture and nonagriculture (measured as the ratio between annual output per agricultural worker and annual output per nonagricultural worker) in four East African countries suggest that nonagriculture is only 3.4 times as productive as agriculture, rather than six times, as national accounts data for these countries would suggest.*
- *However, nonagriculture is only 1.4 times as productive as agriculture when productivity is measured as output per hour worked rather than annual output per worker.*
- *Workers in agriculture tend to supply fewer hours of labor per year: 700 hours per agricultural worker, compared with 1,850 hours per nonagricultural worker. Therefore, the cross-sector productivity gaps observed in output per worker per year reflect gaps in employment levels rather than gaps in returns per hour worked.*
- *The nonfarm activities in which rural households are engaged (whether in industry or services) have very close links to agriculture. Because of this, agriculture continues to play a key role in Sub-Saharan African economies.*

Policy messages: *These results suggest that the forces pulling labor into the industry and service sectors may be weaker than is commonly believed. The results also cast doubt on the notion that agriculture is intrinsically less productive than other sectors. Because time inputs in agriculture are generally low, possibly due to biophysical constraints, participation outside agriculture is associated with higher annual output per worker, because it presents the opportunity to supply more hours of labor per year.*

Better understanding of the reasons for low agricultural labor demand would help in identifying opportunities to increase employment in agriculture and annual output per agricultural worker.

The Issue: Is Labor So Unproductive in African Agriculture?

This study addresses structural change in Africa, which involves the reallocation of labor from low-productivity sectors to more productive sectors. This is a dynamic process powered by several key features—productivity levels within sectors, productivity gaps between them, and the movement of labor between sectors. The larger the productivity gap between agriculture and other sectors, the greater the opportunity to achieve productivity growth as labor shifts out of agriculture. According to the conventional view and national accounts data, in poor economies, agriculture typically is the sector that employs the most people and uses labor least productively. Over time, cross-sector productivity gaps tend to shrink, as labor shifts out of agriculture and returns to labor across sectors are equalized through factor markets.

What Is the Problem?

The premise of higher returns to labor outside agriculture is central to structural change and is supported by trends in national accounts statistics across countries and over time. Are these productivity differentials as high as the national accounts data suggest? If labor productivity levels are so much higher outside agriculture, why does so much African labor remain in rural areas? And why does rural income diversification remain somewhat limited? Explanations for these situations would include the following:

- *Farmers may face barriers to participating in nonagriculture opportunities.* Although returns may be higher outside farming, workers may not be able to diversify out of farming. Opportunities pulling rural workers into nonfarm employment are limited by the growth and productivity of the nonfarm economy (Reardon, Berdegué, and Stamoulis 2006). Accessing these opportunities can be difficult for individuals with limited human capital, experience, or financial capital. Nonfarm work requires different skill sets from farm work, so farmers must find ways to retool if they are to switch away from farming (Rodrik 2014).
- *Labor productivity levels may not be higher outside agriculture.* Although national accounts data indicate that labor outside agriculture is six times more productive than labor inside the sector, there are concerns about how reliable these estimates are. Gollin, Lagakos, and Waugh (2014) find several biases that lead to an *overestimation* of these gaps. Even so, after correcting for these biases, they still conclude that labor productivity outside agriculture in Africa is 3.3 times more productive.
- *Workers may not benefit from higher returns outside agriculture.* If the differential returns to nonagricultural activities accrue to owners of capital

rather than labor, the cross-sector gaps that households face at the micro level would be smaller than those suggested by national accounts. In capital-intensive industries like mining, wage rates are likely to be much lower than average labor productivity, as per national accounts data (McMillan and Harttgen 2014).

The study focuses on the second and third of these explanations by using micro-level household data to measure and analyze sectoral productivity gaps in four countries.

The Analysis: Comparing Micro with Macro Data

Taking the Worker's Perspective

Understanding micro-level, cross-sector productivity differences, and how they relate to labor allocation decisions, is crucial for comprehending the dynamic forces that power structural change and economic progress in the developing world. Such an understanding would have huge policy payoffs. The study departs from much of the previous literature on structural change by taking the perspective of workers.

The analysis draws on newly available household survey data—the Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA) data sets from the World Bank—to measure three key structural change parameters: sector participation, time use, and labor productivity. This micro perspective gets closer to the labor supply decisions made by households and the labor demanded by farm and firm owners.

Calculating Meaningful Aggregates from the Micro Data

The study analyzes LSMS-ISA data from four countries: Ethiopia (2013/14), Malawi (2010/11), Tanzania (2010/11), and Uganda (2010/11). It estimates the microeconomic analogs of key structural change metrics. Specifically, the analysis computes the following:

- *Labor supply.* At the individual and household levels, annualized labor supply aggregates are constructed for three sectors (agriculture, industry, and services) and three types of activities—household operated farm enterprises (farms), household operated nonfarm enterprises (NFEs), and wage labor market participation. All activities are assigned to their respective sectors of the economy (agriculture, industry, or services) using Industry Standard Industrial Classification codes.
- *Returns to labor.* Given the LSMS survey design, average returns to labor are estimated differently for each type of activity:
  - The returns to operating a farm enterprise are based on annual net farm revenue derived from the Rural Income Generating Activities aggregates.
  - For NFEs, an annualized net firm revenue variable is constructed using reported profits or household estimates of gross NFE revenue and costs.

- Returns to labor market participation are given by gross total wages received by wage workers, including in-kind payments (for example, meals received) and gratuities.
- *Labor productivity*. Two types of average labor productivity measures are constructed using the labor supply and return variables:
  - *Per worker*, based on output per worker per year.
  - *Per hour*, based on output per hour of labor supplied to each activity per year.
  - *Per firm*, for farms and NFEs, based on net revenue per firm labor inputs (including hired workers).

The Results: There Are Employment Gaps Rather Than Productivity Gaps

The study pursues two major objectives. First, it seeks to establish whether the national accounts estimates of sectoral gaps in labor productivity are borne out by the micro data. Second, it explores the ways in which rural individuals participate in different sectors of the economy as self-employed and wage laborers.

Micro Data Tell a Different Story

To obtain measures of labor productivity gaps, labor shares are first estimated by sector. Two empirical insights emerge from this analysis. First, *workers in different sectors supply different amounts of labor per year.* Generally, those working in nonagriculture sectors supply far more hours than those working in agriculture. The study finds that workers supply twice as many hours to nonagriculture in Ethiopia, Malawi, and Tanzania, and up to 1.6 times as many hours in Uganda. By calculating labor productivity based on sector participation rather than hours worked, agricultural labor productivity will be underestimated relative to nonagricultural labor productivity. Researchers should avoid the assumption that labor inputs are equal across sectors.

Second, *secondary work should not be ignored*. The data show that nonagricultural workers more commonly also participate in some agricultural work than vice versa (agricultural workers also participating in some work outside agriculture). If secondary activities are ignored, estimates of labor supplied to agriculture will be biased downward, and estimates of agricultural productivity will be overestimated.

Vanishing Productivity Gaps

The study finds that productivity gaps measured using micro data are smaller than those derived from the national accounts (figure 6.1). Figure 6.1, panel a, shows the gap based on per-person-per-year productivity measures, comparing the LSMS-ISA estimates with the national accounts estimates. For the latter, two estimates are presented: the raw national accounts productivity gaps, and the adjusted gaps constructed by Gollin, Lagakos, and Waugh (2014). The gaps from the micro data are much smaller, especially in

Figure 6.1 Micro Productivity Gaps All but Disappear When Taking Hours of Work into Account

a. Per-person-per-year productivity gap

Legend: ■ Agriculture ■ Industry ■ Services □ Nonagriculture (macro, raw) ⊟ Nonagriculture (macro, adjusted)

b. Output-per-hour productivity gap

Legend: ■ Agriculture ■ Industry ■ Services
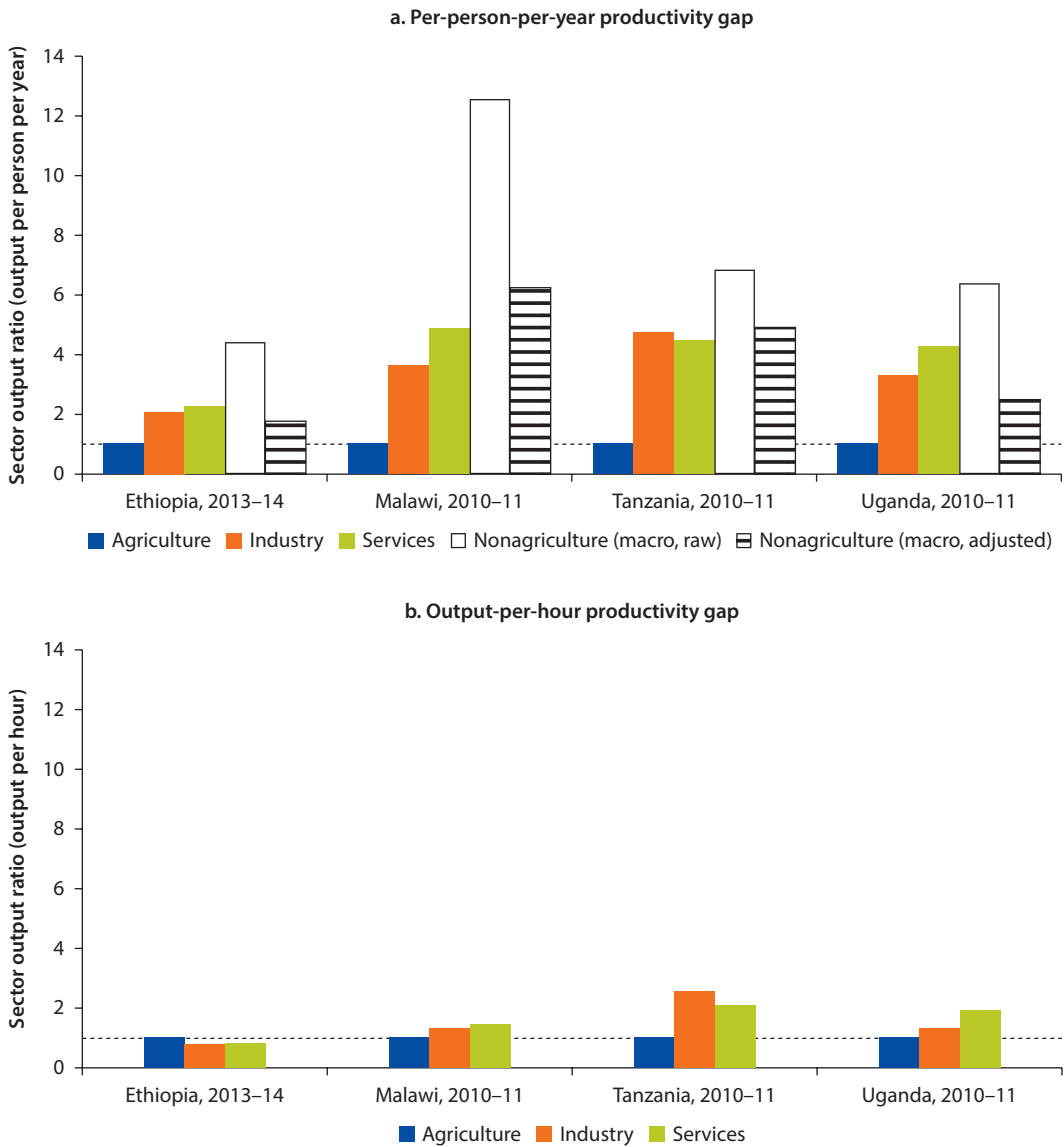
Source: Estimates based on LSMS–ISA data.

Ethiopia and Malawi, and less so in Uganda and Tanzania. The gaps all but disappear when they are based on hours worked in each sector rather than the number of workers (figure 6.1, panel b). Workers outside agriculture supply, on average, far more hours of labor per year than do agricultural workers. The study checked whether similar results applied if different measures of returns to labor were used (box 6.1).

Box 6.1 How Robust Is the Micro Evidence?

Estimates of labor productivity could be affected by mismeasurement of returns to labor (the numerator) or of the labor supply (the denominator). The study explores the robustness of productivity gap estimates to alternative measures of labor returns and labor supply.

Alternative numerator. Measurement of farm and firm net income is challenging, as is measurement of wage labor earnings. Do the results change if alternative measures of returns to sector participation are used to calculate labor productivity? The study takes *household consumption per worker* as an alternative measure of the net returns to participating in a sector. The Living Standards Measurement Study–Integrated Surveys on Agriculture surveys are designed to measure household consumption, so this variable plays to the strengths of the data. Figure B6.1.1, panel a, compares annual consumption per working household member in households participating primarily in agriculture with those engaged primarily in other sectors. Figure B6.1.1, panel b, shows a cross-sector comparison of consumption *per hour of labor supplied* by the household. These gaps are fairly similar across countries and are smaller than productivity gaps, although they follow similar rankings. As with productivity gaps, consumption gaps disappear almost entirely when they are expressed per hour of labor supplied by each household.

Alternative denominator. The study investigates the extent to which the results are sensitive to how the labor supply variable is calculated. First, the study assesses whether the timing of the interview affects the findings. Although seasonality appears to influence the productivity measure marginally (there were some months with especially high or low productivity measures), there does not seem to be a major pattern of overrepresentation or

Figure B6.1.1 Gaps in Household Consumption per Worker per Year Disappear after Accounting for Cross-Sector Differences in Hours Worked
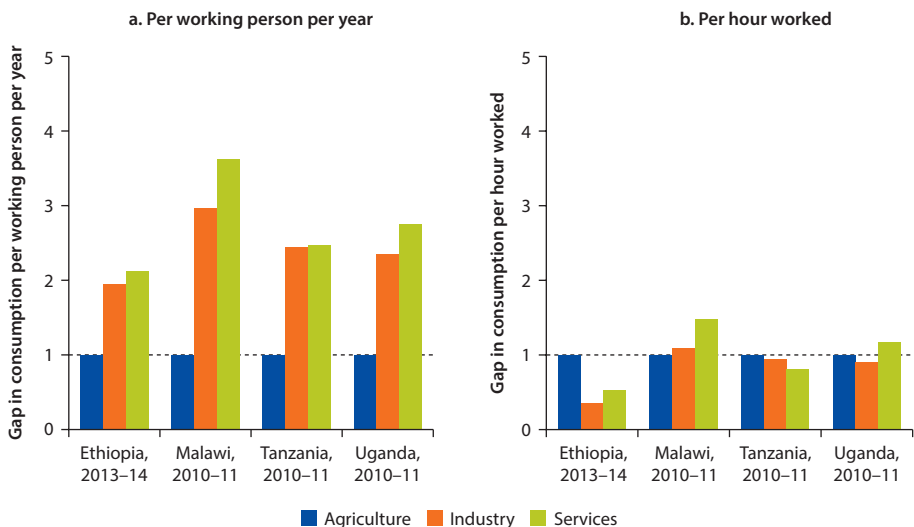
Source: Estimates based on LSMS–ISA data.

box continues next page

Box 6.1 How Robust Is the Micro Evidence? *(continued)*

underrepresentation of these months. The study concludes that seasonal bias due to survey timing does not bias the key labor supply or productivity variables. Second, the study examines whether the recall period used to obtain labor supply information affected the results. The findings suggest that, given the survey design, labor supply for smallholders is likely to be overestimated rather than underestimated. If this is the case, then underemployment in agriculture would likely explain an even larger proportion of the productivity gaps.

Key finding: Intersectoral differences in annual earnings per worker arise from differences in employment volume (hours per worker of labor supplied) rather than different productivity per hour of labor.

Nonfarm Activities Are Closely Linked to Agriculture

The study takes a closer look at the specific nonfarm activities that engage rural households in the four countries.

Activities in Industry

- Manufacturing accounts for between 13 and 38 percent of NFEs (the smallest share being in Tanzania and the largest in Malawi). The focus is on elementary manufacturing, such as brewing alcoholic beverages, producing charcoal, milling grains, butchering, baking, weaving, and other activities that transform raw primary materials.
- Wage employment in manufacturing is similar to the NFE activities, with a focus on agro processing for food, timber, and textiles, as well as manufacturing bricks and other construction materials.

Activities in Services

- Commerce is the dominant service sector focus of NFEs, constituting between 26 and 66 percent of rural and urban firms. NFEs are likely to engage in the wholesale and retail trading of fruits and vegetables, other food products, charcoal, and other household goods.
- In wage employment, activities are wide ranging, including teaching, health, social, and religious workers; public administrators; technicians; domestic service providers; as well as restaurant, hotel, and tourism employees.

Key finding: A large portion of NFEs and wage jobs involve buying and selling agricultural products, processing raw agricultural materials, or providing services in support of farm production. Activities in both sectors are oriented toward local demand. Growth in industry and services is therefore very closely linked with growth in agriculture.

The Implications

The study underscores agriculture's strategic role in Sub-Saharan Africa. Agriculture continues to be the predominant income-earning activity for most households, and most nonfarm agricultural work is closely linked to agriculture. These strong links highlight additional benefits from achieving agricultural productivity growth, since agricultural growth in Africa has been linked especially with increased demand for nontradable goods and services (Delgado et al. 1998; Christiaensen, Demery, and Kuhl 2011).

Productivity gaps are about half as large when measured from the household perspective rather than the national accounts perspective. And gaps are half as large again when measured in hours worked rather than annual output per worker. The micro evidence is consistent with the idea that there is some scope for achieving productivity gains by shifting labor from agriculture to industry or services. Understanding what limits the labor supply of workers in agriculture compared with other sectors is an important next step.

The time sensitivity (or, more generally, seasonality) of agricultural tasks could reduce demand for agricultural labor during parts of the year. Indeed, the time sensitivity of agricultural tasks could explain the coexistence of seasonal labor bottlenecks and widespread underemployment in the agriculture sector. In the presence of time-sensitive labor tasks, water control and agricultural land management practices might have a role to play in smoothing agricultural labor demand throughout the year.

Finding ways to increase annual returns to agricultural workers is an important challenge, especially as the rural labor force continues to expand due to population growth. Increases in these returns could arise through increased employment levels of agricultural workers, or increased productivity per hour worked.

Helping workers retool for employment outside agriculture might allow rural workers to employ themselves more fully. Nonagricultural wage employees appear to have higher levels of education than agricultural wage employees and self-employed workers, suggesting that human capital plays a role in securing employment outside agriculture.

Additional Reading

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CHAPTER 7

Women's Work on African Farms

Amparo Palacios-Lopez, Luc Christiaensen, and Talip Kilic

Overview

Common wisdom: *Women provide the bulk of labor input in African agriculture, with their share regularly quoted at 60 to 80 percent.*

Findings:

- *Careful analysis of representative, individual labor input data from Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda puts the average female share of labor in crop production across these countries at 40 percent.*
- *The share varies across countries, from 24 percent in Niger to 56 percent in Uganda, but remains consistently well below what the common wisdom suggests.*
- *There are no systematic differences across crops and activities, but female labor shares tend to be higher in households where women own a larger share of the land and when they are better educated.*
- *Accounting for the gender and knowledge profile of the survey respondents does not overturn this lower-than-expected female labor share in Africa's crop production.*
- *Underlying processes associated with female work include demographic, cultural, and economic factors, but these relationships vary by country, and there are no systematic differences in female labor participation across staple and cash crops or across agricultural tasks.*

Policy messages: *First, the findings question prevailing assertions that increasing female agricultural productivity could yield substantial gains in aggregate crop output. As a result, the findings do not support the universally disproportionate focus on female farmers to boost crop production. However, investment in female labor productivity in agriculture can still be a high-return activity for reaching other objectives, such as female empowerment or improved nutritional outcomes of children. Establishing these relationships would require further research. Second, the findings underscore the importance of nationally representative household surveys to inform policy making, not least to get the stylized facts right. The World Bank Living Standards Measurement Study–Integrated Surveys on Agriculture initiative provides a great step in this direction. Yet, for such*

initiatives to become more widely adopted, the political economy of data production and usage will need to be better understood.

The Issue: Who Does the Farming?

Do Women Perform the Bulk of the Work in African Agriculture?

Women are commonly considered to perform the bulk of work in African agriculture. Combined with evidence of significant gender gaps in agricultural productivity, this belief has motivated increased attention to raising agricultural productivity among African women. Doing so is seen not only as important for empowering Africa's women and improving the development outcomes of the next generation, but also as an important vehicle to increase Africa's food supply, a key objective on the agenda of African and international policy makers.

Yet, the premise—that women perform the bulk of the work in African agriculture—is untenable. On the one hand, there is the widely shared notion that women in Sub-Saharan Africa (SSA) are responsible for the bulk of the agricultural labor supplied. The following quotations are illustrative:

- "Women produce 60 to 80 percent of the food in developing countries and 50 percent of the world's food supply" (Momsen 1991).
- "In SSA, agriculture accounts for approximately 21 percent of the continent's GDP and women contribute 60–80 [percent] of the labor used to produce food both for household consumption and for sale" (FAO 1995).

On the other hand, systematic data on the labor input in agriculture is difficult to come by, let alone systematic data on labor input by gender. Therefore, it is not surprising that the widely quoted female labor share of 60–80 percent can only be traced back to an undocumented quotation in a 1972 United Nations report: "Few persons would argue against the estimate that women are responsible for 60–80 [percent] of the agricultural labor supplied on the continent of Africa" (UNECA, Human Resources Development Division 1972, 359).

What Are the Men Doing?

The oddity of the belief that one-half of the population would conduct the lion's share of the most important economic activity in rural Africa (in addition to food processing, water and fuelwood fetching, and other domestic tasks) has been noted before (Doss et al. 2011). More recent assessments have suggested that women's contribution is slightly less than half, based on the total number of women who are economically active in agriculture divided by the total population that is economically active in agriculture (Doss et al. 2011). This finding assumes that men and women who report agriculture as their main activity spend an equal amount of time in agriculture. Other estimates, based on time-use surveys, range from 30 percent time contribution by women to agricultural activities in

The Gambia, to between 60 and 80 percent in different parts of Cameroon. Yet, these findings are drawn from case studies that are not nationally representative and therefore cannot be generalized.

As a result, the statistical basis for the 60–80 percent share estimate has remained largely uncontested, although it continues to be quoted widely, especially in policy circles. This study takes advantage of the World Bank Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA) initiative to put the estimate on more solid empirical footing. The focus is on time allocation to crop production by gender. Although this focus excludes time allocated to livestock and food processing and marketing, crop production makes up the bulk of agricultural gross domestic product in most African countries. Thus, crop production marks an adequate starting point to revisit the issue.

The Analysis: New Gender-Disaggregated Data Provide Insights

Great Data for Analyzing Labor Input Shares
The LSMS-ISA-supported surveys provide an excellent basis for the study of the female labor share in African crop agriculture. Although it is not representative of the whole continent, the initiative encompasses six countries— Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda—which together cover a wide array of agroecological zones, crops, and farming systems. Altogether, the six countries make up 40 percent of SSA's population. The surveys are nationally representative and collect data on each household member's labor input per plot per agricultural activity. The amount of hired labor input (by gender) is also recorded.

The national female labor share can then be calculated as the total labor input in crop production provided by women across all households (rural and urban) divided by the total labor input provided by men and women. The estimates are weighted with sampling weights in accordance with the complex survey design, involving stratification and clustering in each country.

But Are There Biases in These Data?
One potential weakness of the data is that the responses may differ according to the characteristics of the respondent. Information about labor input per plot is typically provided by the most knowledgeable household member. But male respondents may overestimate or underestimate contributions by female household members, and vice versa. Similarly, less knowledgeable respondents may be inclined to overreport or underreport the contribution of men or women systematically. The little evidence available in the literature does not exclude the potential existence of such effects, but does not provide any evidence of the bias systematically going either way. As well as reporting the relative shares of labor input in crop production in these countries, the study assesses whether the estimated shares change with the gender and knowledge

Box 7.1 Testing the Sensitivity of the Findings to Survey Design

The study assesses whether the estimated female labor share in crop production is influenced by the survey design—by the gender or knowledge profile of the respondent. To do this, the analysis estimates the following ordinary least squares regression for Malawi, Niger, and Nigeria: $L_{fi} = \alpha + R_f + R_k + \beta X_i + \gamma D_i + \varepsilon_i$, where L_f is the female labor share in crop production in household i; R_f is a dummy variable that equals 1 if the respondent is female for the majority of the household plots; R_k is a dummy variable that equals 1 if the respondent has worked at least 50 percent of the total number of hours worked on all household plots (a measure of how knowledgeable the respondent is about what is happening on the plots); X is a vector of household-level demographic, cultural, and socioeconomic attributes that may affect the outcome of interest; D is a vector of location fixed effects; and ε is the stochastic error term, randomly distributed across households. This setup permits investigation of the effects of differences in questionnaire and survey design, as well as the more fundamental processes that influence female labor input shares.

Controlling for various demographic, cultural, and socioeconomic household characteristics, the reported female labor share in Malawi is predicted to be 4 percentage points higher when the respondent is knowledgeable and 7 percentage points higher when the respondent is female. In Nigeria, the opposite is observed. More knowledgeable respondents tend to report a lower female share of labor, as do female respondents (although the latter effect is not statistically significant). Overall, the conflicting findings highlight that, while there is a lingering effect of the characteristics of the respondent on the reported labor shares, after controlling for various factors, the direction of these effects can go either way.

One way to gauge the possible effect is to establish a range by predicting the estimated female labor shares for the extreme cases when all respondents are knowledgeable and female, as well as the case when all respondents are not knowledgeable and male. Doing so situates the female agricultural labor share between 50 and 60 percent in Malawi, and between 24 and 38 percent in Nigeria, compared with estimated shares of 56 and 32 percent, respectively. Put differently, the point estimates may be 5 to 8 percentage points higher or lower when considering these extreme cases. Clearly, more work is needed to more accurately establish the role of the characteristics of the respondent in estimating the female labor share. This would require randomly assigning respondents with different features across households.

profiles of the respondents (box 7.1). The model used to make this assessment also serves to provide insights into the processes behind household decisions on female work.

The Results: From Myths to Facts

Women Contribute Substantially Less Labor to Agriculture Than Expected, but at Varying Degrees

On average, across the six countries, the female share of labor input into crop production is 40 percent (figure 7.1). But there is substantial variation

Figure 7.1 Female Labor Contribution to Crop Production Is Well Below the Commonly Cited Figure of 60 to 80 Percent
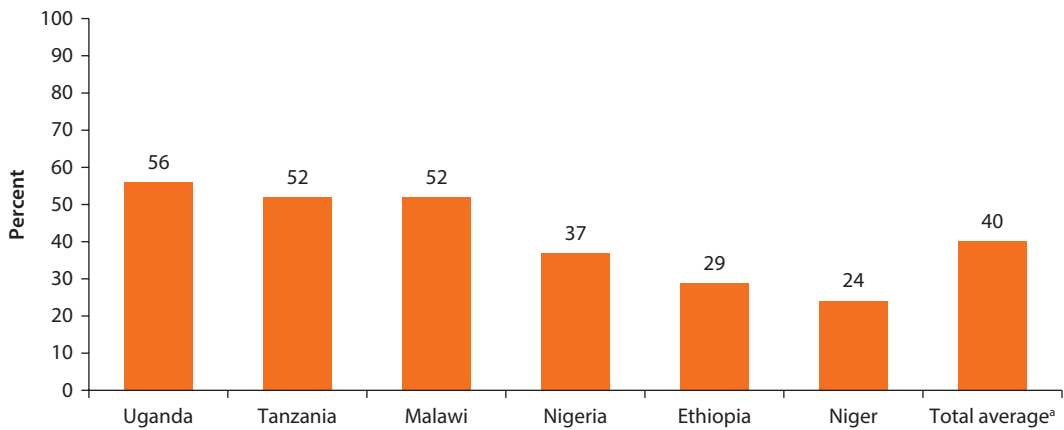
Source: Computations based on LSMS–ISA data.
a. Population-weighted average.

across countries. At 56 percent, the estimated female share of agricultural labor is highest in Uganda, followed by Tanzania (52 percent) and Malawi (52 percent). These are also the countries where the female share in the total population is slightly greater than half (52, 53, and 51 percent, respectively). In the other countries, the female labor share in agriculture is substantially lower. For example, the female share is well below half in Ethiopia and Niger, estimated at 29 and 24 percent, respectively.

The findings for Nigeria are especially illuminating. On average, about 37 percent of labor in crop production is contributed by women. Yet, the female share reduces to less than a third (32 percent) for northern Nigeria. In southern Nigeria, the share is similar to the shares found in eastern and southern Africa (51 percent). These findings tally well with expectations. The ability of the data to distinguish these differences in Nigeria provides confidence in the approach. It also underscores the heterogeneity in women's time allocation in agriculture, even within countries.

How the Data Are Collected Does Not Change the Core Findings
Using multivariate analysis (box 7.1), the study assesses the potential bias introduced by the way in which the data were obtained, at least in two countries. Two important conclusions emerge:

- First, the analysis confirms that the reported labor shares can be influenced by the characteristics of the respondent, but also that the direction of the bias can go either way (box 7.1 provides details). More research is needed on this.
- The key point advanced by the study still stands: the average female agricultural labor share across these countries is well below the shares commonly quoted in policy circles.

Labor Shares Do Not Systematically Differ by Crop, Task, or Most Household Characteristics

It is common to assume that women focus more on food crops, and men on cash crops. Nonetheless, there is no systematic difference across crops in terms of labor contribution by gender. There is also no clear difference in female labor shares across various agricultural tasks—land preparation, planting/weeding, and harvesting. The exceptions are Ethiopia and Niger, where women were relatively less involved in land preparation. Animal traction is also much more common in these countries, while Africa's agricultural mechanization remains limited in general.

Fundamental Processes Underlying Female Labor Contribution to Crop Production

The multivariate analysis described in box 7.1 casts light on the underlying processes behind women's work inputs. The analysis suggests the following:

- More educated women tend to provide a larger share of a household's labor.
- If women own the land, their labor share is greater.
- Female labor shares in crop production are not affected by livestock ownership.

The Implications

The implications of these findings for policy are twofold. First, the policy priority for females in agriculture is not so clear-cut: the lower-than-expected female labor shares (well below 50 percent in some countries) do not support *universally disproportionate* attention to female farmers to boost crop production. That said, could concerted policy attention to women to boost agricultural output in Africa still be justified based on the gender gap in agricultural productivity? Caution is counseled here as well. The estimated gender gaps in agricultural productivity are not based on differences in returns to male and female labor time spent on crop production within the household. The gaps are calculated based on differences in land productivity between male- and female-managed plots. With female-managed plots, on average, less than 25 percent of the plot population, full elimination of the gender gap in land productivity (estimated at 25 percent at most) would increase aggregate crop output by no more than 6.25 percent (and often less).

Second, there is a need for robust data to inform policy. The findings underscore the continuing importance of household surveys to query the common wisdom and put the policy debate on solid empirical footing. In addition to time modules to record time allocation across activities, more systematic and nationally representative information on the locus of control over the returns to these activities is needed, as well as methodological research on survey design effects on the information thus acquired. The new survey rounds supported under the LSMS-ISA initiative are making useful steps in this direction, creating promising opportunities for future research on gender and agriculture in SSA.

Additional Reading

This chapter draws on:

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Households in Rural Africa Still Rely on Agriculture

Benjamin Davis, Stefania Di Giuseppe, and Alberto Zezza

Overview

Common wisdom: *Despite overall economic growth and its potential for household income growth, the role of nonagricultural income sources remains limited in rural Africa, with more rural households specializing in own-account agriculture compared with other regions.*

Findings:

- *About 90 percent of rural households in the nine African countries studied are engaged in agriculture. This compares with an average of 85 percent in 13 non-African countries.*
- *Rural African households derive two-thirds of their income from on-farm agriculture. Although this share is higher than the average in the other developing countries (33 percent), it is consistent with the gross domestic product of countries in Africa.*
- *Engagement in agricultural wage labor is limited in the region, typically contributing less than 5 percent of rural income. In the other countries, the corresponding rates are about twice as large.*
- *Income from nonfarm wage employment is 8 percent of total income on average in the African countries, compared with 21 percent elsewhere.*
- *For their level of development, rural households in Africa appear no less engaged in nonagriculture, with greater focus on nonfarm household enterprises than on nonagricultural wage employment.*
- *Higher-income households participate more in nonfarm activities, receive a greater share of income from them, and are more likely to specialize in nonagricultural wage activities.*
- *Proximity to cities and agricultural potential interact to influence decisions to specialize in nonagricultural activities, with patterns that differ across countries, and according to whether distance from large cities or small towns is considered.*

- *In some countries (such as Tanzania and Uganda), the combination of favorable conditions for agriculture and lower distance from secondary urban centers tends to create the conditions for more households to specialize in off-farm activities.*
- *If distance to larger cities is considered, the role of urban proximity in encouraging off-farm specialization is generally stronger, and at times higher in areas that are also more favorable for agriculture.*

Policy messages: *Agriculture remains the mainstay of Africa's rural livelihoods, particularly when agroecological conditions are favorable. Therefore, the following are the main policy conclusions:*

- *Inclusive growth requires improvements in agricultural productivity.*
- *Given differences across regions and countries and over time, one size of policy package does not fit all. An understanding of the interactions between spatial issues (agricultural potential and pull forces from small and large urban centers) and households' endowments and incentives is key to more effective policy design.*

The Issue: Is Africa Any Different?

The body of literature developed over the past 20 years suggests that rural household income diversification is the norm rather than the exception, with some diversification off the farm common at all levels of economic welfare (Barrett, Reardon, and Webb 2001; IFAD 2011; World Bank 2008). Do these patterns also hold in Africa, a latecomer to the process of structural transformation? Conventional wisdom has it that rural households in Sub-Saharan Africa are primarily employed in agriculture, with little agricultural wage labor and even less nonagricultural wage labor due to limited industrialization. This study explores the patterns of income generation among rural households in Sub-Saharan Africa, and looks at how the strategies of households in the region compare with those in other regions, taking into account different levels of development. The study also seeks to establish how geography drives these strategies, focusing on the role of agricultural potential and proximity to urban areas.

The Analysis: Measuring Diversification

The Data

The analysis uses comparable income aggregates from 41 national household surveys in 22 developing countries spanning 1991–2012, as compiled in the Food and Agriculture Organization's (FAO's) Rural Income Generating Activities (RIGA) database. The RIGA database is constructed from a pool of several dozen surveys under the World Bank Living Standards Measurement Study (LSMS) and other multipurpose household surveys made available by the World Bank through a joint project with FAO. The most recent additions are six surveys from the Living Standards Measurement Study–Integrated Surveys on Agriculture

(LSMS-ISA) initiative. Each survey is representative of urban and rural areas, but only the rural sample was used for this study. Although it is not representative of all developing countries or all of Sub-Saharan Africa, the sample covers a significant range of countries, regions, and levels of development; it has proven useful in providing insight into the income-generating activities of rural households in the developing world.

The nine African countries included in the study—Ethiopia, Ghana, Kenya, Madagascar, Malawi, Niger, Nigeria, Tanzania, and Uganda—represent 51 percent of Sub-Saharan Africa's population in 2012. Comparable protocols were followed to construct the occupational classifications and income aggregates (described in detail on the RIGA website). The georeferencing of the households in the LSMS-ISA surveys is exploited to analyze the role of geography in income diversification and specialization for a subset of countries.

Describing Diversification

Income is allocated to seven basic categories: crop production, livestock production, agricultural wage employment, nonagricultural wage employment, nonagricultural self-employment, transfers, and other. These categories are aggregated into several higher-level groupings, depending on the type of analysis. The first grouping distinguishes between "agricultural" (crop, livestock, and agricultural wage income) and "nonagricultural" (nonagricultural wage, nonagricultural self-employment, transfer, and other income) activities. In the second grouping, crop and livestock incomes are referred to as "on-farm" activities; nonagricultural wage and self-employment income as "nonfarm" activities; and agricultural wage employment, transfers, and other income are left as separate categories. Finally, "off-farm" activities are defined as including all nonagricultural activities plus agricultural wage labor.

Rural households employ a wide range of income-generating activities—although perhaps rural households in African countries are more dependent on agriculture than rural households in other countries are. The question remains whether households specialize in activities—with diversity in activities across households in the rural space—or whether households diversify income-generating activities. Income shares can be analyzed as the mean of income shares or as the share of mean income. In the first instance, income shares are calculated for each household, and then the mean of the household shares is calculated for each income category. In the second case, income shares are calculated as the share of a given source of income over a given group of households. Since the household is the basic unit of analysis, the study uses the mean of shares throughout. It examines the degrees of *specialization* and *diversification* by defining a household as "specialized" if it receives more than 75 percent of its income from a single source, and "diversified" if no single source is greater than that amount.

Understanding Diversification

To analyze the spatial patterns of income generation, a set of georeferenced variables from external sources is linked to the household-level data via their Global Positioning System attributes. This can only be done for the six LSMS-ISA

data sets (for Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda). The study features two important factors underpinning diversification:

Agricultural potential. The study uses an aridity index as a proxy for agricultural potential, which is defined as the ratio between mean annual precipitation and mean annual potential evapotranspiration (thus, a higher value of the index identifies wetter areas).

Market access. To proxy market access, the study takes the Euclidean ("as the crow flies") distance to cities of 20,000, 100,000, and 500,000 inhabitants. This distance is independent of travel infrastructure, but provides a reliable measure of the spatial dispersion of households relative to urban populations.

The Results: Agriculture Still Dominates in Rural Africa

Findings of the Study

The study examines *participation* in various types of activities (given by the proportion of households participating in such activities) and the *share* of income obtained by activity. The study shows the following basic facts:

- First and foremost, nearly all the rural households in the sample countries are engaged in own-account agriculture. This is true in Africa (92 percent, on average) and in other regions (85 percent), even at higher levels of gross domestic product (GDP). It is difficult to overemphasize this result and its robustness across countries.

- Rural households also participate in nonfarm activities (nonagricultural wage labor and self-employment). The shares vary widely, ranging from 24 percent (Ethiopia and Nigeria in 2004) to over 90 percent (Bolivia in 2005). The simple mean nonfarm participation share for African countries is 44 percent, which is 10 percentage points less than for non-African countries. Among African countries, the highest share is in Niger (at 65 percent).

- The African countries show a marked tendency toward on-farm sources of income (agricultural income minus agricultural wages). They have higher shares of on-farm income (63 percent) and lower shares of nonfarm wage income (8 percent), compared with countries in other regions (33 and 21 percent, respectively). All the African countries in the sample earn at least 55 percent of their income from agricultural sources, reaching 80 percent in several countries (Ethiopia, Madagascar, Malawi, and Nigeria in 2004). Figure 8.1 provides details.

- Despite the fact that nonagricultural activities are ubiquitous in the African countries (70 percent participation), they still account on average for only about one-third of total earnings. Overall, the share of nonagricultural income among rural households increases with the level of GDP per capita (figure 8.2).

Figure 8.1 Agriculture Dominates Everywhere in Rural Africa

Legend:
- Transfers and other
- Nonfarm self-employment
- Nonfarm wage employment
- Agricultural wage employment
- On-farm total
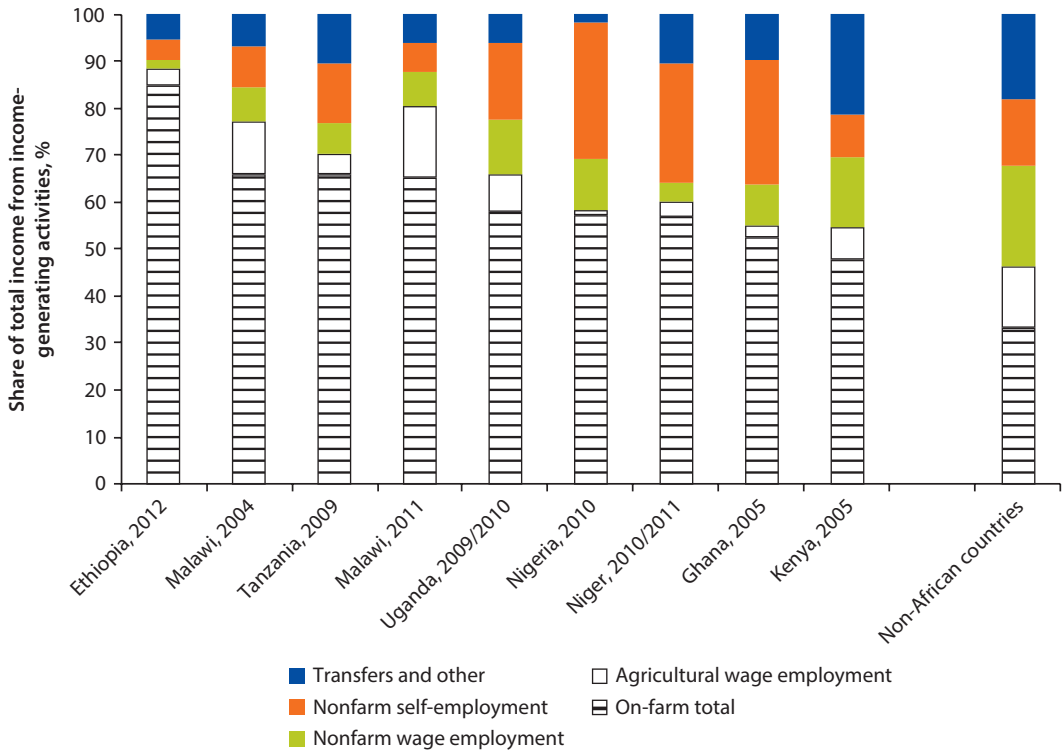
Source: Computations based on LSMS–ISA data.

Figure 8.2 Sector Shares Vary by GDP Level

a. Share of nonagricultural income

b. Share of on-farm income

- Africa
- Non-Africa
- Overall trend
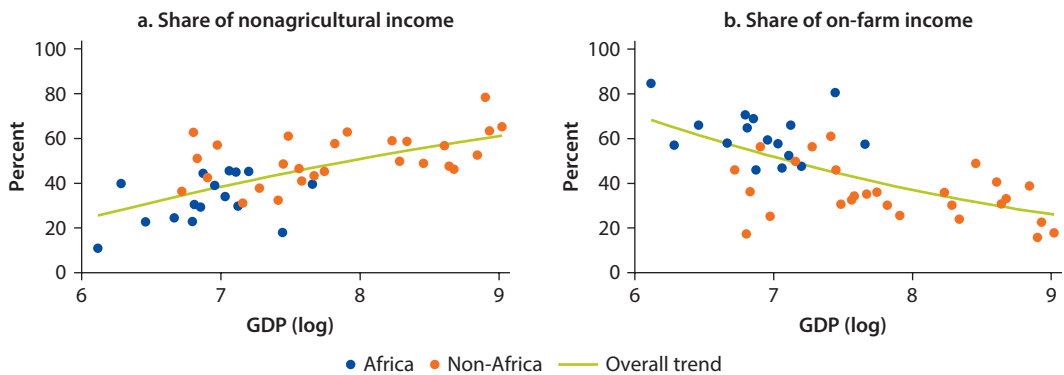
Source: Computations based on LSMS–ISA and Rural Income Generating Activities (RIGA) data.

Among the African countries, the largest share of income from nonfarm sources is recorded in Nigeria (40 percent), and the lowest in Ethiopia (6 percent).

• An important difference between the African and non-African countries in the sample is the composition of nonagricultural income. Although the shares of nonfarm self-employment income are comparable across countries in the two groups (14–15 percent), the average share of nonfarm wage employment is generally much smaller in Africa, with a maximum level of 15 percent in Kenya in 2005, compared with an average of 21 percent in the non-African countries.

• Among rural African households, specialization in on-farm activities continues to be the norm—practiced by 52 percent of households on average. This ranges from one-third of households in Kenya to five-sixths in Ethiopia. This result is quite different from the non-African countries, where only about one-fifth of households on average specialize in farming. Most countries outside Africa—generally with higher levels of GDP—have a larger share of households with *diversified* portfolios (45 percent compared with 29 percent in Africa).

Diversification, Specialization, and Household Economic Welfare

The study examines the complex relationship between the economic well-being of a household and its diversification/specialization circumstances. The study compares the cumulative distributions of household consumption per capita for the different diversification/specialization groups. If the distribution of one diversification category "dominates" another, that group can be considered better off than the other. This analysis is undertaken for Malawi, Niger, Tanzania, and Uganda. Figure 8.3 reports the results for Malawi and Uganda.

Figure 8.3 Nonagricultural Wage Workers and the Self-Employed Tend to Be Better Off; Agricultural Wage Workers Tend to Be Worse Off
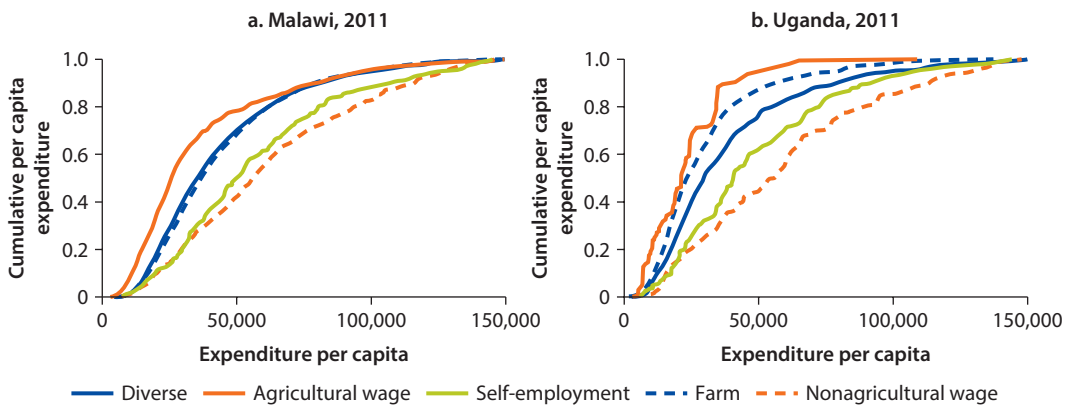
Source: Computations based on LSMS–ISA data for Malawi and Uganda.

Across all countries, specialization in nonfarm activities (that is, nonagricultural wage income and self-employment) stochastically dominates other household income-generating strategies in per capita expenditure. Nonfarm activities are followed by on-farm specialization and diversified strategies, and then finally agricultural wage labor, which is clearly associated with the lowest levels of welfare. Overall, these observations confirm the common finding in the literature that increased reliance on nonfarm income, particularly in wage employment, is strongly associated with higher levels of overall household welfare and lower likelihood of living in poverty.

Does Geography Matter?

The study investigates whether the location of a household has any bearing on its decision to diversify or specialize (box 8.1). The results are broadly consistent with the predictions of the theory. There is no sign of African households adopting income generation strategies that differ from those observed elsewhere in their relationship to basic exogenous determinants, such as agricultural potential and distance from urban centers.

Box 8.1 Does Location Affect Diversification?

Much of the literature on rural income diversification in developing countries has sought to explain how asset endowments and barriers to entry tend to push or pull households into different activities. Location (or geography) may also be an important factor in determining income diversification decisions, but the literature is much more silent on this. Georeferenced information based on household location is available for the subset of Living Standards Measurement Study–Integrated Surveys on Agriculture countries in the data set (Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda). The study uses two dimensions of location derived from external data, linked to households via georeferencing:

Aridity index. Serving as a proxy for agricultural potential, the index is defined as the ratio of mean annual precipitation to mean annual potential evapotranspiration (a higher index indicates a wetter area).

Distance to cities. A proxy for market access, this variable gives the Euclidean ("crow-fly") distance to cities of 20,000, 100,000, and 500,000 or more inhabitants.

The study analyzes the links between these location proxies and the household diversification strategy. Five specialization categories are identified: farm activities, agricultural wage, nonagricultural wage, nonagricultural self-employment, and other income/transfers.

Results. Nonfarm specialization is less likely the further the household is located from a town or city (especially a large one). But the interactions are more complex once the analysis takes other (often interacting) factors into account. The study focuses on two important nonfarm specialization strategies: nonagricultural wage specializers and nonagricultural self-employment specializers. For most countries and "sectors" of specialization, the role of distance changes markedly with agricultural potential and city size.

box continues next page

Box 8.1 Does Location Affect Diversification? *(continued)*

The findings speak to different dynamics when the role of small towns is considered and when large cities come into play. For small towns, high-potential, distant areas see less specialization in off-farm activities; the reverse is true for closer-to-town, low-potential areas. When distance increases and agricultural conditions are more difficult, the picture is mixed, with households more likely to engage more fully in nonfarm activities in Niger, but less likely to do so in Uganda and Tanzania. When distance to large cities is considered, its impact is generally more marked than in the case of small towns. In high- and low-potential areas, the impact of distance generally prevails, and nonfarm specialization is less likely. In both cases, however, there are instances (Tanzania and Ethiopia) that counter this broad pattern for at least some of the income specialization categories considered.

The Implications

Although specialization in on-farm, income-generating strategies is the norm among rural households in the sampled African countries, the evidence seems to point to African patterns of household-level income diversification having the potential to converge toward patterns similar to those observed in other developing regions. Once the analysis controls for the level of GDP, the shares of income and participation in nonagricultural activities are not far from those found elsewhere. Nevertheless, agriculture-based sources of income remain critically important for rural livelihoods in all countries, in the overall share of agriculture in rural incomes and the large share of households that still specialize in agricultural and on-farm sources of income. What are the policy messages emerging from this analysis?

Agricultural productivity improvements are needed for inclusive growth. Even if long-run development entails exiting from agriculture, the orthodox conclusion that this transition needs to happen via investment in the sector, and not its neglect, is still valid today. It is unlikely that inclusive growth and poverty reduction can happen in rural Africa, where half the households specialize in agriculture, without productivity growth in the sector.

Territorial development African style? The spatial analysis shows how the constraints on off-farm specialization are likely to differ between high- and low-potential and high- and low-integration areas. The analysis also shows that small and large urban centers are likely to exert different influences on the transformation of the rural economy. These findings add complexity to the formulation of policies to promote rural nonfarm growth. However, the findings also testify to a series of trends that are not uncommon in other countries, and suggest that the African specificity in higher incidence of farming activities may be due more to a GDP-level effect than to a different response by households to the incentives and opportunities coming from agricultural and nonagricultural growth opportunities. The findings lead to the question why the "territorial development" discourse, which is part and parcel of the policy dialogue in Latin America and Europe, does not appear to get much traction in Africa. Greater attention to spatial

factors appears to have the potential to offer a richer policy menu than the traditional small/large farms, or agriculture/non-agriculture dichotomies.

Additional Reading

This chapter draws on:

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Nonfarm Enterprises in Rural Africa

Paula Nagler and Wim Naudé

Overview

Common wisdom: *Nonfarm enterprises in rural Sub-Saharan Africa are most often operated for economic necessity and survival. Consequently, they tend to have low productivity, do not create many jobs, and do not drive structural transformation in Africa.*

Findings:

- *Among rural households in the six countries covered by the study, 42 percent operate a nonfarm enterprise. These enterprises contribute between 8 percent (Malawi) and 36 percent (Niger) of total household income.*
- *Most households operate businesses in easier-to-enter activities.*
- *Most are informal, often operating only seasonally and creating few jobs.*
- *Their productivity is low, and most nonfarm enterprises perform poorly. But a few perform well. Nonfarm enterprises are less productive when operated by women, located in rural areas, or operated in response to a shock (drought, flood, or illness).*
- *Being unable to cope with shocks, reacting to seasonality in agriculture, or trying to provide jobs for household members can force households into operating an enterprise. The extent and frequency of these factors vary across countries.*
- *In many instances, especially for households living closer to denser markets (such as a capital or secondary city), business opportunities pull rural households into operating enterprises. Access to human and physical capital may matter in these cases, as the better educated and those who can acquire credit are more likely to become entrepreneurial.*
- *Rural enterprises most often cease operations due to a lack of profitability, a lack of finance, and/or idiosyncratic shocks such as illness or the death of a family member.*

Policy message: *Nonfarm enterprises will benefit from policies that improve the business environment, assist rural households to manage and cope with risk, and*

strengthen the capabilities of individuals to be entrepreneurial. Policy making will benefit from improvements in data collection on rural enterprises.

The Issue: Survival or Opportunity?

Nonfarm enterprises (NFEs) are ubiquitous in rural Sub-Saharan Africa. Fox et al. (2013) estimate that 15 percent of Africa's labor force works in the nonfarm sector. Such enterprises tend to be small, informal businesses that provide a wide range of goods and services in or nearby the household residence, or in a village market. Many are linked to agriculture and can be located on a farm. The conventional wisdom is that these enterprises are generally operated for purposes of economic survival (Ellis 2000). Hence, their productivity is low. They do not create many jobs, nor do they drive structural transformation in Africa—at least, this is the conventional view.

The conventional wisdom has two corollaries, namely, that rural nonfarm enterprises have low productivity and low survival rates. However, the conventional wisdom is largely based on limited survey data. Comparable cross-country and panel data analyses that cover a representative geographical area of Sub-Saharan Africa have so far been lacking. The recent rounds of the World Bank Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA) provide a rich set of data on the rural nonfarm sector in Africa, including entrepreneurial household activities. This study uses this data set to review the conventional wisdom about NFEs and assess whether the current knowledge is a myth or a fact (Nagler and Naudé 2017).

The Analysis: Combining Description with Analysis

The study presents an array of descriptive material documenting the prevalence and characteristics of NFEs in rural Africa. This is combined with an in-depth analysis using multivariate econometric techniques (Nagler and Naudé 2017).

Over 40 percent of the rural households surveyed in the LSMS-ISA operate such an enterprise (table 9.1). Overall, the sample comprises 11,064 individual enterprises in 8,115 rural households, resulting in an average of 1.36 enterprises per entrepreneurial household. The shares vary widely across countries, from a relatively low share of 17 percent entrepreneurial households in rural Malawi, to almost 62 percent in rural Niger.

Having established the prevalence of NFEs, the study seeks to answer three important questions:

- First, what factors determine the establishment of an NFE? The study estimates a probit model in which the probability of a household operating an NFE depends on the characteristics of the household head and the household, and the household's geographical location. (Box 9.1 provides more detail on the multivariate techniques.)

Table 9.1 NFEs Are Common in the Study Countries, Especially Niger and Nigeria

Country	Households surveyed	Households with NFEs	Weighted share (%)	NFEs	Mean NFEs per household
Ethiopia	3,466	919	22.87	1,112	1.21
Malawi	10,038	1,755	16.88	1,872	1.07
Niger	2,430	1,427	61.73	2,188	1.53
Nigeria	3,380	1,707	52.62	2,688	1.57
Tanzania	2,629	1,061	38.65	1,363	1.26
Uganda	2,105	953	42.24	1,471	1.54
Total	24,551	8,115	41.63	11,064	1.36

Source: Compilation based on LSMS-ISA data.
Note: NFEs = nonfarm enterprises.

Box 9.1 The Issues Raised Call for Different Econometric Approaches

Understanding a Household's Decision to Operate a Nonfarm Enterprise
To identify the determinants of a rural household's decision to operate a nonfarm enterprise (NFE), the study uses a discrete-choice estimator, a probit model (for an antecedent, see Abdulai and Delgado 1999). Formally, the study estimates

$$\Pr(Y_i | v_i, w_i, x_i, z_i) = \Phi(v_i' \alpha + w_i' \beta + x_i' \gamma + z_i' \delta) \tag{B9.1.1}$$

where the dependent variable Y_i is a binary variable equal to 1 if the household operates an NFE, and 0 if not. The term v_i' is a vector of individual characteristics, including a constant, and comprises the variables gender, age, marital status, and education (proxied by the ability to read and write) of the household head. The term w_i' is a vector of household characteristics, including the number of adult household members, annual net household income, number of rooms in the dwelling, and a binary variable for whether a household member has taken out credit over the past 12 months, indicating the possibility of accessing financial support. The variable land size (in acres) per adult household member is also added, where land can be owned or rented. The term x_i' records whether the household has experienced a food shortage or shock over the past 12 months. Finally, z_i' is a set of location variables, including a household's distance to the next population center and annual precipitation. The model is estimated for each country.

Determinants of Productivity
To estimate the determinants of labor productivity in rural enterprises, the study utilizes a Heckman selection model. The variables are selected from the Living Standards Measurement Study–Integrated Surveys on Agriculture database. Formally, the study estimates

$$z_i^* = w_i \gamma + u_i \tag{B9.1.2}$$

representing the selection stage of the model, where z_i^* determines whether an enterprise is operated. Thus, $z_i = 1$ if $z_i^* > 0$ and $z_i = 0$ if $z_i^* \leq 0$. w_i is a vector containing the possible

box continues next page

Box 9.1 The Issues Raised Call for Different Econometric Approaches (continued)

determinants of enterprise operation. Once z_i is known, the outcome stage with the dependent variable "log of labor productivity" can be modeled as

$$y_i^* = x_i\beta + \varepsilon_i \tag{B9.1.3}$$

with $y_i = y_i^*$ if $z_i = 1$, and y_i not observed if $z_i = 0$. x_i is a vector containing the possible determinants of labor productivity.

In the selection stage, the analysis takes the individual characteristics of the household head, and includes the variables gender, age, and education. As household characteristics, it uses access to credit, experience of shocks, and land size (in acres) per adult household member, as well as the location characteristics distance to the next population center, rural, and agroecological zone. As the selection variable, it uses the number of adult household members, since larger households have surplus labor available to allocate to entrepreneurial activities.

In the outcome stage, the analysis takes the individual characteristics of the enterprise owner (instead of the household head), and otherwise includes the same variables as in the selection stage. Information about the enterprise, such as months in operation, is also included.

For the probit and the Heckman selection models, the analysis uses a cross-section sample, which includes data from the six countries (with variations, depending on the regression), and takes the most recent rounds available as of the fall of 2013.

- Second, how productive are these enterprises? If NFEs are mainly operated for survival, there is an expectation that their productivity will be low. The study uses a Heckmann selection model, with explanatory variables again including individual, household, and location characteristics (box 9.1).
- Third, do rural NFEs typically operate for shorter periods (another manifestation of a survival orientation)? The study examines the continuity of NFEs in more detail—the extent to which they operate throughout the year compared with more seasonal activities.

The Results: The Conventional View Is Confirmed

Four features of rural entrepreneurship support the conventional view:

- *Rural enterprises contribute relatively little to total income.* NFEs contribute between 8 percent in rural Malawi and 36 percent in rural Niger to household income. Household income generated by self-employment is less in rural than in urban areas across all the countries covered by the LSMS-ISA. This finding suggests that there are fewer rural opportunities and more constraints on entering the business sector compared with an urban setting.

- *NFEs are unproductive.* The study shows that productivity levels are low in NFEs, especially when they are motivated by survival. Productivity is typically lower in rural NFEs than in their urban counterparts.
- *Enterprises are small.* Most of the NFEs are small household enterprises. Over 80 percent do not employ nonhousehold workers. Less than 3 percent employ five or more nonhousehold workers. Most of the enterprises operate from the household's residence or the immediate surroundings. This profile is consistent with a survivalist type of entrepreneurship.
- *Enterprises operate for only a portion of the year.* Many enterprises operate only seasonally (between 36 percent in rural Nigeria and 58 percent in rural Ethiopia), and rural enterprises show this intermittent pattern more frequently than urban enterprises do.

The necessity to cope with and manage risks can push households into operating an enterprise. This situation is due to the lack of social protection and insurance schemes, risky environment, shocks, surplus household labor, and seasonality. The "necessity" motivation is reflected in the nature of the enterprises as small, informal, and low-productivity household enterprises, operating for only a portion of the year.

However, Some Households Are Responding to Opportunities

Despite the empirical confirmation that rural enterprises are operated "in survival mode," the study also finds evidence that households respond to opportunities when markets beckon. The evidence suggests that the focus on the household and the individual level is appropriate for rural entrepreneurship. The character of these enterprises as household enterprises implies that decisions are made collectively at the household level. Household heads with higher education and who are older, the household's wealth, and access to credit are associated with a higher likelihood to exploit opportunities for enterprise operation.

The Motivation Influences the Type of Business Activity

The study further finds that the determinants of enterprise operation influence the type of businesses households operate. Credit and education are closely associated with agribusiness and trade, as well as bars and restaurants. Businesses whose physical and human capital requirements make them "easier to enter," such as sales, are more likely to be operated by households that have experienced a shock. Distance to a population center is less important for professional services or bars and restaurants, since these businesses cater to clients in the immediate surroundings. Although gender is not found to be a significant constraint for operating an enterprise, women are less likely to operate certain types of businesses, a finding that is consistent with expectations from nonunitary household decision-making models. Women are less likely to engage in transport businesses, professional services, and nonagricultural businesses. The latter are among the most frequently operated types of business in the sample (table 9.2).

Table 9.2 Trade and Sales Is the Most Prevalent Nonfarm Activity

Activity	Ethiopia (%)	Malawi (%)	Niger (%)
Trade and sales	31.5	35.6	35.4
Agribusiness	26.3	20.1	26.6
Nonagricultural business	25.7	18.1	7.4
Professional services	1.1	0.5	4.3
Bar or restaurant	0.5	2.4	1.1
Transport	1.2	2.6	1.4
Other	13.7	20.7	23.8
Total	100	100	100

Source: Compilation based on LSMS-ISA data.
Note: Weighted shares; rural areas only.

This finding suggests that female entrepreneurs may face important barriers to entry in certain types of business activity.

Enterprises Motivated by Necessity Are Less Productive Than Those Responding to Opportunity

The results suggest a link between a household's motivation to operate an NFE and its subsequent productivity. Enterprises that are operated by necessity—for example, due to shocks—are more likely to be less productive than enterprises that are operated because the household is utilizing an opportunity. Households with the latter motivation not only attain better capacity utilization by operating all year long but may also seek credit or have better-educated enterprise owners. Perhaps because of the greater risk and more prevalent market failures in rural areas, the study finds that rural enterprises are on average less productive than their urban counterparts (figure 9.1). Moreover, enterprises located in regions with a history of violent conflict (for example, northern Uganda) report lower productivity levels.

Urban-rural productivity differences reveal little about the factors underpinning productivity outcomes in African NFEs. The study therefore explores productivity outcomes in greater empirical depth. It finds that female-owned enterprises are less productive than male-owned enterprises. However, the productivity of female-owned enterprises may be underestimated because of women's time-use constraints. In Malawi, where information on the time use of workers is available, the study indeed finds that productivity differences almost disappear between male and female enterprise owners. The effect of education on labor productivity is positive and significant. Surprisingly, access to credit is not significant (or only marginally so). The effect of rural location is negative in Malawi and Nigeria. Firm size is associated with lower productivity in these two countries. Shocks (reflecting risk) have a negative impact in most cases. Although distance from a population center lowers the probability of households entering

Figure 9.1 Rural Enterprises Are Less Productive

a. Ethiopia

b. Malawi

c. Nigeria

d. Uganda
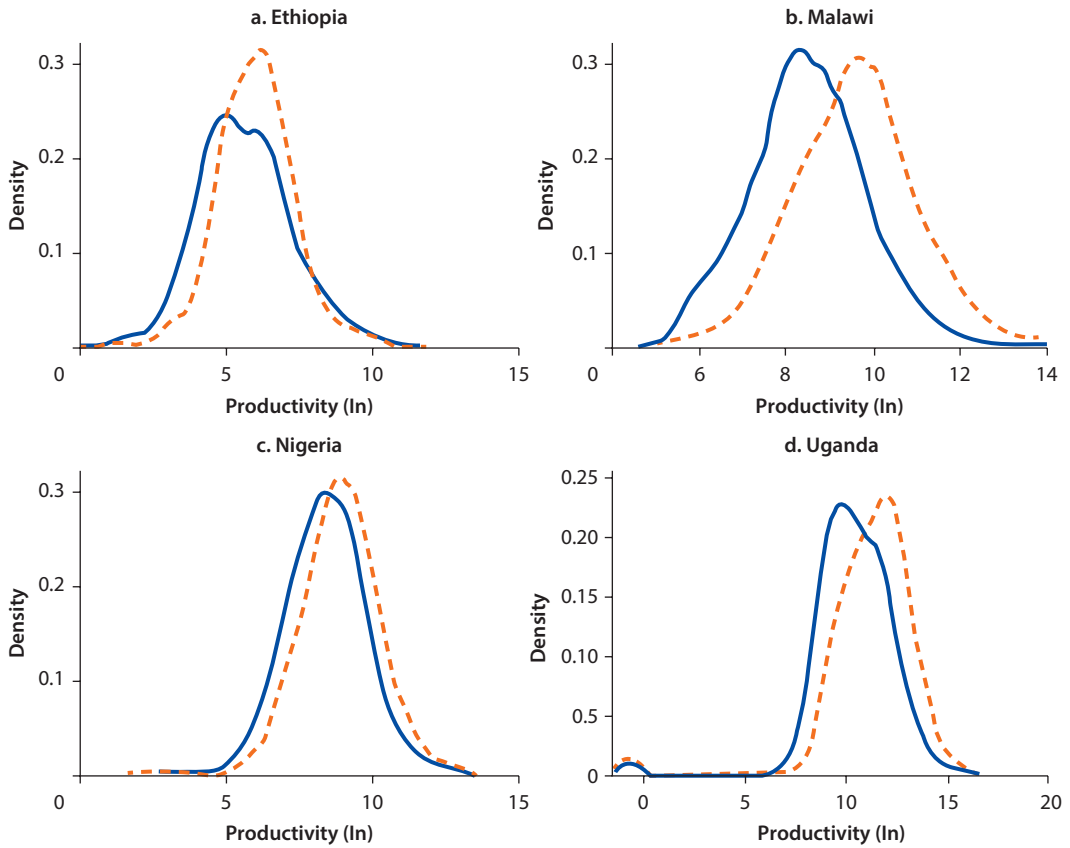
Source: Compilation based on LSMS-ISA data.
Note: The continuous lines represent the productivity of enterprises located in rural areas; the dashed lines the productivity of urban enterprises.

entrepreneurship, it is associated with higher labor productivity in Malawi, but lower productivity in Nigeria and Uganda.

Increases in Agricultural Productivity Do Not Necessarily Lead to Increases in Nonfarm Enterprise Productivity in the Same Region

Using georeferenced household data from rural Ethiopia and Nigeria, Owoo and Naudé (2017) find that high (low) productivity NFEs were surrounded by other high (low) productivity enterprises. This finding confirms the existence and benefits of local agglomeration. Furthermore, the study finds a negative relationship between rural NFE performance and agricultural activity in Ethiopia and Nigeria, implying that increases in farm productivity are not necessarily associated with increases in NFE productivity in the same region. Thus, it may be that in areas with high agricultural productivity, higher wages reduce the competitiveness of NFEs. This result runs counter to the "most prominent view amongst development practitioners" (Deichmann, Shilpi, and Vakis 2008, 1), and calls for more

research—for instance, to establish whether the result is due to the type of business activity, wages in agriculture, or some other, unexplained characteristic of rural NFEs in Africa.

Nonfarm Enterprises Have Intermittent Patterns of Operation

The survey data tell us that many NFEs do not operate throughout the year. In most countries (the exception is Nigeria), about a fifth of rural enterprises operate for less than six months. This evidence of seasonal operation suggests that many NFEs are motivated by survival, for instance, for risk diversification purposes in a high-risk agricultural setting.

Understanding the Dynamics: The Factors behind Entries and Exits

The Uganda survey asked respondents about the reasons why NFEs stopped operation. Two reasons stand out in their responses: a lack of profitability and a lack of finance (table 9.3).

Rural enterprises often exit the market; they are more likely to cease operations due to idiosyncratic shocks in Uganda, reflecting the risky environment in which they operate. Although rural enterprises have low survival rates, the ease of entry means they can readily be restarted. The LSMS-ISA data for Uganda show that a small share of enterprise owners who exited the market considered restarting their business activities: 73 percent did not plan a restart, 25 percent considered it a possibility, and the remaining 2 percent were certain about reviving operations (survey year 2011/12).

Table 9.3 Enterprises in Uganda Mostly Cease Operating Because of Economic Factors and a Lack of Finance

	Enterprises, 2010–11 (%)		Enterprises, 2011–12 (%)	
Reason	Urban	Rural	Urban	Rural
Insecurity or theft	2.95	4.10	3.28	0.19
Lack of supply (inputs or raw materials)	9.00	7.52	4.74	7.43
Lack of demand	5.14	6.04	5.84	1.50
Economic factors (profitability)	**27.59**	**32.93**	**19.09**	**15.72**
Technical issues	0.46	0.62	0.89	0.76
Labor related (death or illness)	5.57	9.00	5.68	7.07
Government regulation	—	—	—	0.89
Competition	1.79	1.67	—	3.30
Lack of electricity	—	0.15	—	—
Lack of space or premises	0.55	0.29	0.43	1.47
Lack of transport	2.97	0.81	—	1.11
Lack of finance	**29.33**	**23.59**	**34.63**	**31.37**
Other	14.65	13.30	25.41	29.16
Total	100	100	100	100
Number of observations	97	314	84	273

Source: Compilation based on LSMS-ISA data for Uganda.
Note: Survey weights included. — = not available.

The Implications

The NFE sector is characterized by a great deal of heterogeneity across African countries. Its contribution to household income is proportionately lower in rural than in urban areas. The great heterogeneity in the NFE sector reflects different motivations for enterprise operation, as well as different country contexts and economic geographies. Overall, the findings paint a picture of rural enterprises as "small businesses on a big continent."

The common perception that Africa's rural household enterprises operate mainly in survival mode is generally valid, although some businesses are also operated due to perceived opportunities and are more productive. There is much scope for policy and further research to contribute to the development of rural entrepreneurship in Africa.

However, there is no simple solution to the weak dynamics of the nonfarm sector. On the one hand, the challenges are deep-seated and characterized by market and government failures. On the other hand, there is considerable heterogeneity among the various countries, which makes a one-size-fits-all prescription neither possible nor desirable. Still, five broad sets of policy takeaways that have the potential to add value in all countries, irrespective of the social and economic framework, are suggested by the study.

Improving the business climate in rural Africa. First, the study recommends a set of policies that could improve business conditions, including policies that have the potential to increase labor productivity, such as access to credit to expand business activities, and the development of local infrastructure. Such policies are already part of most entrepreneurship development programs in Sub-Saharan Africa. Perhaps it is time to be more critical of these programs and gain a better understanding of why they seem to have been ineffective so far.

Improving the conditions for taking and managing risks. Second, the study recommends policies that encourage risk taking if individuals find a promising opportunity to start a business. Such measures could play a useful role in expanding the nonfarm sector, and would consequently lead to a more productive sector. Furthermore, attention should be given to providing more concentrated support for enterprises with high growth potential, due to the large heterogeneity in enterprise performance. Hence, it is crucial to identify and support highly talented entrepreneurs who have the potential to take on riskier, but also more productive, types of businesses, and who will locate their activities where positive spillovers can best be generated.

Improving individual competencies. Third, policies that expand education, as well as individual competencies and skills, are highlighted. Based on the finding that young people are less likely to enter the entrepreneurship sector, or, once they become entrepreneurs, operate less productive enterprises, additional support for young enterprise owners is recommended. Given that Africa is the continent with the most youthful population, and has millions of young job seekers entering rural labor markets annually, support in this area is of utmost importance.

Improving risk-mitigating policies. Fourth, what may be missing or inadequate in enterprise policies is measures that can cushion shocks and protect households from negative external events, such as (micro)insurance or social protection schemes. Such policies can help households to avoid operating unsustainable types of businesses, such as selling seeds or livestock, or prevent well-functioning enterprises from closing operations.

Improving data collection. Fifth and finally, the study makes recommendations for improving data collection on rural entrepreneurship. The LSMS-ISA data collection has some weaknesses. For example, a comprehensive analysis of enterprise survival and failure is constrained by a lack of information on failed enterprises, and it is not possible in most countries to match enterprises over time and survey rounds.

Additional Reading

This chapter draws on:

Nagler, P., and W. Naudé. 2017. "Non-Farm Enterprises in Rural Sub-Saharan Africa: New Empirical Evidence." *Food Policy* 67: 175–91. https://doi.org/10.1016/j.foodpol .2016.09.019

Other key references:

Abdulai, A., and C. Delgado. 1999. "Determinants of Nonfarm Earnings of Farm-Based Husbands and Wives in Northern Ghana." *American Journal of Agricultural Economics* 81 (1): 117–30.

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The Use of Modern Inputs Viewed from the Field

Megan Sheahan and Christopher B. Barrett

Overview

Common wisdom: *African farmers' use of modern inputs is dismally low.*

Findings:

- *Chemical input use is not as low as is often assumed.*
- *Irrigation and tractor use are negligible.*
- *Input use varies strikingly within countries.*
- *Modern inputs are often not combined to reap agronomic gains.*
- *Input intensification is happening, for maize in particular.*
- *Larger farms and plots receive inputs less intensively.*
- *Input application does not adjust to farmer-perceived soil quality.*
- *Few households use credit to purchase modern inputs.*
- *There are gender differences in input use.*
- *National-level factors explain the bulk of the variation in binary modern inputs use.*

    In sum, modern input use is not as low as is commonly believed, but there is room for considerable improvement in the level and method of input use.

Policy messages: *The central message is that governments should build on and learn from achievements in promoting modern agricultural input use. The findings open a range of important new policy research questions that are amenable to further exploration.*

The Issue: Do Farmers Use Modern Inputs?

Conventional wisdom holds that farmers in Sub-Saharan Africa (SSA) use few modern inputs. Yet, most growth-inducing and poverty-reducing agricultural growth in the region is expected to come largely from expanded use of inputs. These inputs embody improved technologies, particularly improved seed,

fertilizers, other agrochemicals, machinery, and irrigation. After several years of high food prices, concerted policy efforts to intensify the use of fertilizer and hybrid seed, and increased public and private investment in agriculture, does modern input use continue to be negligible in Africa? Amid the many changes in policy priorities and the overarching environment within which smallholder farmers make input decisions, it is time to check the accuracy of the prevailing beliefs about African agricultural inputs.

The Analysis: Measuring and Understanding Input Use

This study revisits Africa's agricultural input landscape, exploiting unique and recently collected survey data: the nationally representative, agriculturally intensive, and cross-country comparable Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA). LSMS-ISA covers six countries in the region (Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda). The study used LSMS-ISA data from more than 22,000 farming households and 62,000 plots not only to produce national-level statistics derived from household responses but also to study within-country and within-household variation in input use.

The Results: 10 Key Messages

This section summarizes 10 important or surprising findings that may help to guide policy choices, serve as an empirical check on conventional wisdom about modern input use in SSA, and motivate a new wave of research to further understanding of agricultural practices in contemporary SSA.

1. *The use of chemicals is not as low as is often assumed.*
Inorganic fertilizer. Using data from FAOSTAT, Minot and Benson (2009) found that households in SSA apply an average of 13 kilograms (kg) of inorganic fertilizer nutrients per hectare (ha) of cultivated land. This statistic has endured and prompted considerable pressure on African governments to stimulate fertilizer use and reinstate input subsidies. From the LSMS-ISA data, it is clear that although many smallholders still use rudimentary technologies on the farm, inorganic fertilizer use has picked up to significant levels in some countries. Over three-quarters of all cultivating households in Malawi, half in Ethiopia, and around two-fifths in Nigeria use inorganic fertilizer (figure 10.1). Indeed, Uganda is the only country in the sample where the percentage of farming households using inorganic fertilizer is still in the single digits. The observed average application rates are well above the widely quoted 13 kg/ha statistic, including 25 kg/ha in Ethiopia, 56 kg/ha in Malawi, and 64 kg/ha in Nigeria. These three countries happen to have some form of national fertilizer subsidy program, although the descriptive analysis is unable to suggest a causal relationship.

    Agrochemicals. The use of other agrochemicals has also increased. Zhang, Jiang, and Ou (2011) find that only 3 percent of global pesticide consumption takes

Figure 10.1 Use of Modern Inputs Varies across Countries

Percentage of cultivating households using inorganic fertilizers and agrochemicals
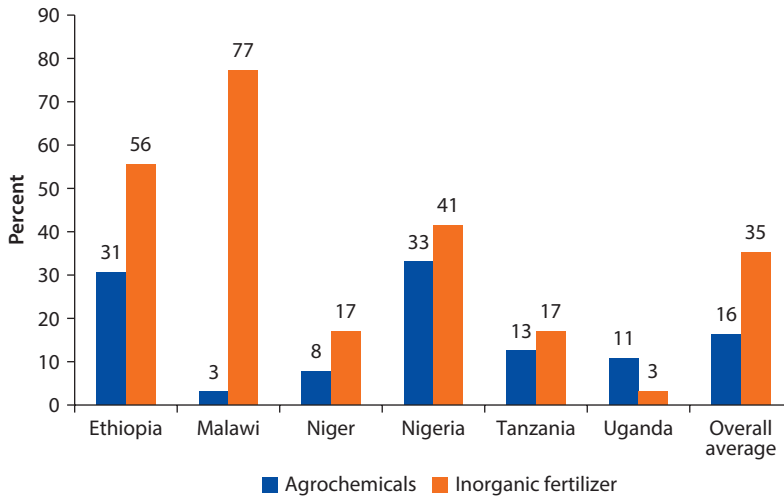
Sources: Calculations using LSMS-ISA data for Ethiopia 2011/12, Malawi 2010/11, Niger 2011/12, Nigeria 2010/11, Tanzania 2010/11, and Uganda 2010/11; Sheahan and Barrett 2017.

place in Africa, with 2 percent in South Africa, leaving only 1 percent for the remainder of the continent. But most such analyses rely on official government estimates using outdated data. These oft-cited figures might dramatically understate pesticide and other agrochemical use in SSA. The LSMS-ISA data reveal that over 30 percent of households in Ethiopia and Nigeria use pesticides and herbicides, with a simple average of about 16 percent of households across the six countries (figure 10.1).

2. *Irrigation and tractor use is negligible.*

Irrigation. The lack of irrigation is often a starting point in the discussion of low input use in Africa. In a recent analysis of irrigation across the region, Svendsen, Ewing, and Msangi (2009) use AQUASTAT data from the Food and Agriculture Organization (FAO) to show that Sub-Saharan Africans withdraw about one-quarter as much water as the per capita global average. Similarly, Rosegrant, Ringler, and De Jong (2009) claim that less than 3.5 percent of all agricultural land in SSA is irrigated. Across the six LSMS-ISA countries, about 5 percent of households use some form of water control on their plots, covering only about 1–3 percent of the land under cultivation. Although they are slightly higher than the macro statistics, the micro estimates still show a very low incidence of irrigation across these countries.

Tractors. Using FAOSTAT/AGS data, Mrema (2011) finds that there were 2 tractors per 1,000 ha of arable land in 1980, but only 1.3 in 2003. Ashburner and Kienzle (2011) also show a decrease in mechanization over time in SSA, claiming that primary preparation carried out by hand tools is currently

80 percent, with draft animal technology only at 15 percent, and the remaining 5 percent using tractors. The LSMS-ISA data confirm these claims by showing that tractor ownership at the household level remains quite low, with around 1 percent of households across all countries claiming to own a tractor. Tractor and oxen utilization in Ethiopia, Niger, and Nigeria is not as insignificant, implying that community-level rental or sharing schemes help to facilitate mechanization.

3. *Input use varies strikingly within countries.*
One of the welcome features of nationally and regionally representative household survey data is the ability to break down these statistics at lower levels of geography. Doing so reveals a great deal of heterogeneity across subnational regions, agroecological zones, and underlying soil types, as well as according to the characteristics of individual households and plots. Analysis of the marginal costs and benefits of using modern inputs—which is not feasible in this descriptive, cross-sectional work—may help to explain the considerable variation observed among and within regions intranationally. Map 10.1 shows how binary inorganic fertilizer and agrochemical use varies within the LSMS-ISA countries.

Map 10.1 Striking Variation in Input Use within Countries

a. Agrochemicals
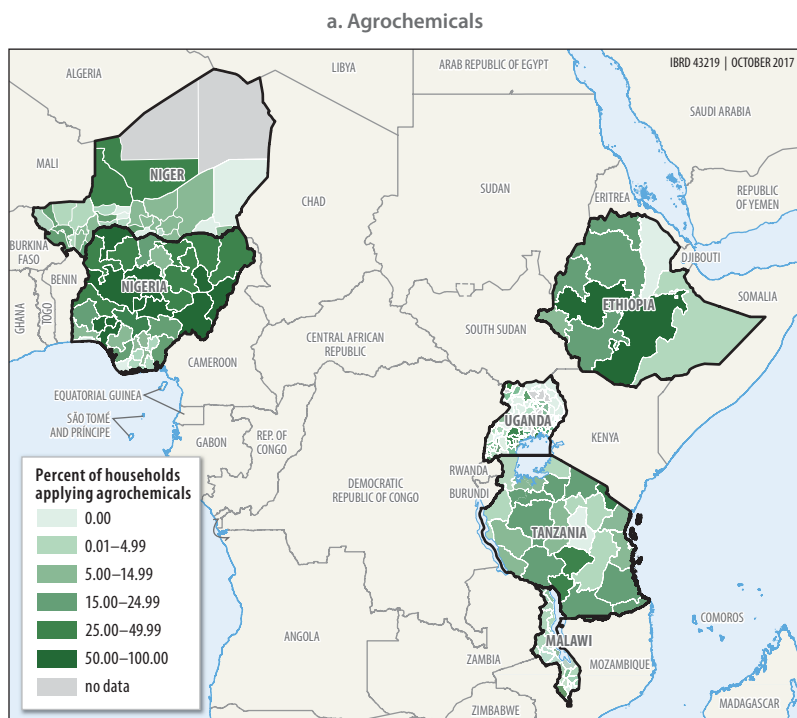
map continues next page

Map 10.1 Striking Variation in Input Use within Countries *(continued)*

b. Inorganic fertilizer
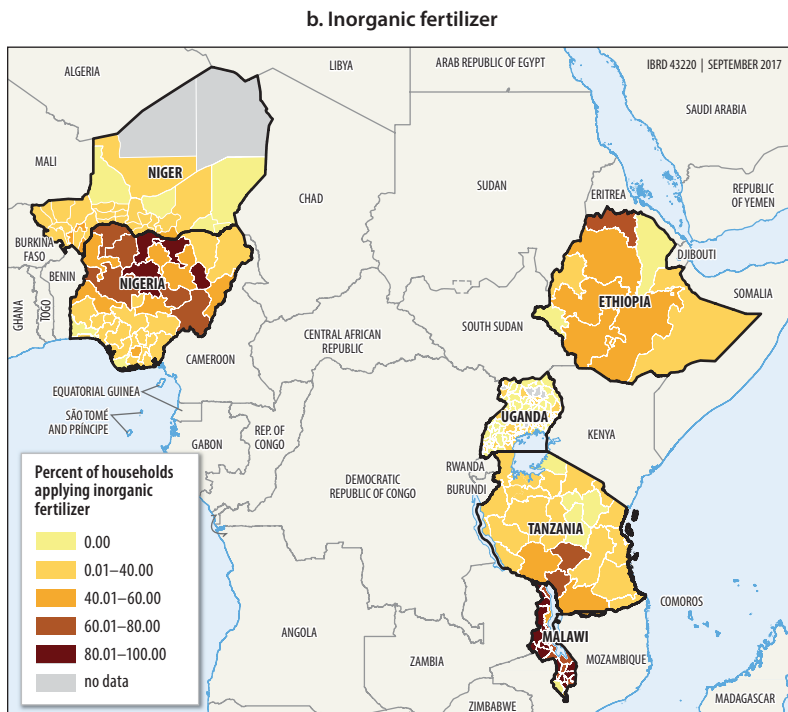
Sources: Calculations using LSMS-ISA data: Ethiopia 2011/12, Malawi 2010/11, Niger 2011/12, Nigeria 2010/11, Tanzania 2010/11, and Uganda 2010/11; Sheahan and Barrett 2017.

4. *Modern inputs often are not combined to reap the gains from joint use.*

It is commonly thought that modern inputs are rarely adopted in isolation, since the complementarity between particular sets makes adopting them together advantageous for farmers. For example, some modern seed varieties are bred to respond better when paired with inorganic fertilizer. The use of inorganic fertilizer may increase the presence of more weeds on the plot, necessitating the combined use of herbicides. Irrigation systems help to secure the necessary soil moisture for efficient inorganic fertilizer use and improved seed varietal growth.

The LSMS-ISA data show that even when households pair modern agricultural inputs together *on the farm*, there is surprisingly very little correlation in the use of modern inputs *at the plot level* where known agronomic and biophysical complementarities arise. The example of Ethiopia is illustrated in figure 10.2. This finding implies that households are spreading inputs across the farm rather than concentrating them on single plots. This behavior has gone largely unstudied to date and raises important questions about prospective untapped productivity gains from the coordinated use of modern inputs, with implications for extension programs and policies aimed at promoting efficient input uptake and use.

Figure 10.2 Inputs Are Not Used in the Right Combinations
Venn diagrams of three-way input use in Ethiopia

| **a. Household level** | **b. Plot level** |

— Use inorganic fertilizer
— Use irrigation
— Use improved seed variety
□ All cultivating households

— Use inorganic fertilizer
— Use irrigation
— Use improved seed variety
□ All cultivating plots
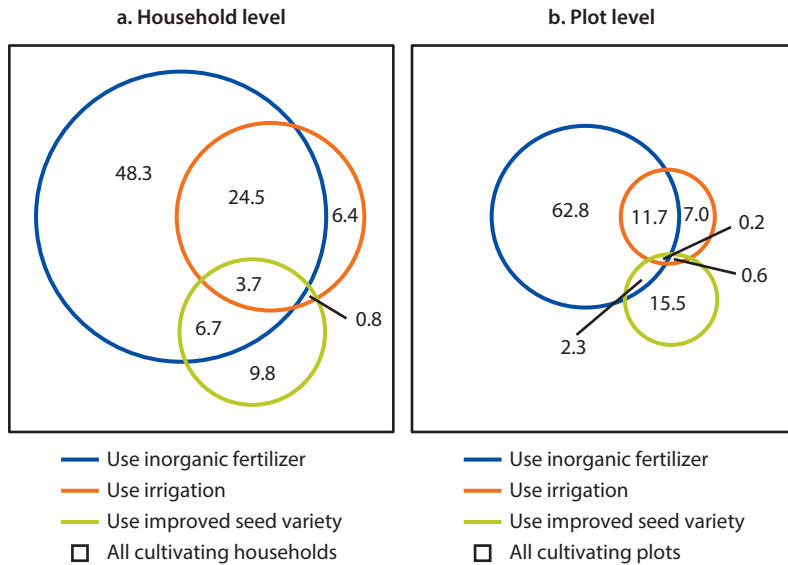
Source: Calculations using LSMS-ISA data for Ethiopia 2011/12.
Note: The areas of the circles proportionally represent population size relative to the full sample of cultivating households. The percentages in these figures are not weighted and are conditional on using any one of the three included inputs (that is, excluding the population that does not use any of the three inputs).

5. *Input intensification is happening for maize.*
A major strongpoint of the LSMS-ISA data is the assembly of detailed plot-level information, including on all crops and their relative share of plot area. When isolating the "most important" crop on the plot by area, the study finds that modern input use is generally higher on plots where maize is dominant. Average fertilizer application rates are higher on plots where maize is grown than on plots where it is not. Among maize-cultivating households, 25–40 percent purchased new maize seed in the last main agricultural season, while nearly one-quarter of the maize-cultivating households in Ethiopia and over half in Malawi use improved varieties.

These findings suggest that there is more widespread participation of African agricultural households in modern input distribution systems than has been widely recognized. The weight of the evidence suggests that maize may be "on the move" in Africa. This finding is especially important given the significance of maize as a food security crop for many households in the region. Niger is largely not included in this discussion, given the very small contribution of maize to its household production and consumption.

6. *Larger farms and plots receive inputs less intensively.*
The inverse relationship between farm size and productivity has been well studied. What has been less well documented is the relationship between input use intensity and farm size. The LSMS-ISA data show that this inverse relationship

is robust even when controlling for farm-level effects and possible self-reporting measurement error (corrected using Global Positioning System measurement of plots). That this relationship is in most cases more exaggerated at the plot level means that interhousehold variation in the shadow price of inputs and outputs based on household endowments, distance to market, and so forth cannot explain the relationship. Thus, the relationship raises novel puzzles about farmers' behavior that have yet to draw much research attention.

7. *Farmers do not adjust input application to perceived soil quality.*
It would be expected that farm management practices would follow from the knowledge farmers have about their farming environs. An important characteristic of the operating environment that should affect input use decisions is *soil quality.* It is well known, for example, that the responsiveness of crops to fertilizer application depends on the quality and fertility of the soil. Even within a given farm, the evidence suggests that productivity can vary enormously between plots, as would fertilizer use. Household perceptions of soil quality may influence fertilizer application rates and be influenced in turn by previously observed crop yields.

The study tested these claims in three countries—Malawi, Tanzania, and Uganda—where the LSMS-ISA surveys report farmer perceptions of soil quality by plot. The plots that the respondents considered "average" or "poor" in quality are statistically significantly more likely to receive inorganic fertilizer applications than are plots categorized as "good" quality, all else equal. However, these variables explain only a tiny amount of within-household fertilizer allocation decisions, and this relationship does not hold over self-reported erosion status. If "poor" and eroded plots have suffered serious nutrient mining, then this surprising finding may signal a knowledge gap among farmers, and it raises important questions about the accuracy and drivers of farmer perceptions of soil quality.

8. *Few households use credit to purchase modern inputs.*
Because of the poorly developed financial markets and the high risks associated with providing credit to smallholder farmers, credit is widely thought to be used only minimally throughout Africa, and to act as a major constraint on input use. In all the countries except Ethiopia, the LSMS-ISA data show that less than 1 percent of cultivating households used credit—either formal or informal—to purchase improved seed varieties, inorganic fertilizer, or agrochemicals. This finding corroborates evidence about the weakness of agricultural input credit markets in the region (see chapter 4 for more on this). Much scope remains for deepening rural financial markets, despite recent advances in money transfer systems based on mobile phone platforms, the proliferation of microfinance institutions, and similar interventions.

9. *The gender of the farmer matters.*
The headship of the household is a characteristic that is often believed to limit modern input use. Male-headed households in the LSMS-ISA sample

are indeed statistically significantly more likely to use modern inputs across almost all the countries and input types. This result is found in simple descriptive statistics and multivariate regression analysis, holding other important covariates constant. Similarly, plots owned or managed by women (who control less than a quarter of all cultivated plots) are less likely to receive modern agricultural inputs and receive lesser amounts when applied. Gender differences in modern agricultural input use, both among and within households, merit more attention, as they may lead to needless productivity losses and food insecurity.

10. *Mostly national-level factors explain modern input use.*
A huge body of literature promotes one set of variables as the most important reason for the "adoption" of a particular input, be it biophysical, infrastructure, market, socioeconomic, or otherwise. Having so many observations across multiple countries with similar covariates allows the rare opportunity to test which of these variables or classes of variables is most strongly associated with variation in input utilization (box 10.1). This analysis shows that most of the variation in the decisions to use inorganic fertilizer and agrochemicals comes from the *country level*, even after controlling for a range of important household-level and agroecological variables. This is an especially striking finding that signals the importance of the policy and market environment beyond the observed variables and what we can control for statistically.

Box 10.1 Identifying the Main Correlates

Based on standard ordinary-least-squares regression, the Living Standards Measurement Study–Integrated Surveys on Agriculture data are used to estimate separate binary linear probability models for inorganic fertilizer and agrochemical use at the household level, pooling observations across all six countries. Shapley values are calculated, which decompose the explained variance (measured by R^2) of the regressions into contributions over groups of regressors. In other words, the study calculates the mean marginal contribution of each variable or group of variables to the overall regression model R^2. The variables represent the following:

- *Biophysical*: rainfall, elevation, soil nutrient availability, greenness index, and agroecological zones.
- *Sociodemographic*: consumption quintiles, gender of the household head, household size, and household dependency ratio.
- *Farming operation*: total hectares under cultivation, number of crops cultivated by household, maize production, and cash crop production.
- *Market and infrastructure*: distance to nearest market, distance to nearest road, price of fertilizer, and price of the main grain.
- *Country-level dummy variables*: overarching policy and institutional environment variability.

box continues next page

Box 10.1 Identifying the Main Correlates *(continued)*

For inorganic fertilizer, the overwhelming amount of variation—indeed, nearly half (45 percent)—is accounted for by the country dummy variables. Even controlling for a wide range of important observable household-level variables, some combination of other policy, institutional, or macroeconomic variables explains most of the micro-scale variation in inorganic fertilizer use in this unprecedentedly large sample. Since the dependent variable is the binary input use decision, differences in survey design, which may lead to differences in the measurement of continuous input volumes, cannot plausibly account for the importance of the country-level variables. This is an important finding, as clearly the policy and operating environments facilitated by governments matter.

Biophysical variables account for 24 percent of the explained variation in fertilizer use, followed by farm operation characteristics (16 percent), market and accessibility variables (nearly 10 percent), and socioeconomic variables (less than 4 percent). That geography and biophysical characteristics (accounting for a combined 70 percent of variation) matter so much to the fertilizer use decisions mirrors, to a large extent, the findings of McCord and Sachs (2013) on the importance of the same factors in explaining variations in macroeconomic development conditions across countries. The percentages are virtually the same for the agrochemical model. Together, these findings suggest the need for broad-based policy reforms at the country level, which are likely to have tangible impacts on spurring input use and staple grain productivity.

The Implications

Policy Agenda

Two central messages that emerge from the findings of the study have profound implications for current policy. First, in the aggregate, modern input use is not as dismally low as is commonly assumed. Nonetheless, for some countries—Uganda, for example—input use is quite low across the board. Governments should build on and learn from the gains where input use has increased over time (findings 1 and 5). Second, the importance of the national-level policy and socioeconomic environment is hugely important for input use (finding 10). Implementing policy that encourages efficient modern input use and techniques is crucial. This finding also underscores the importance of regional processes, such as the Comprehensive Africa Agriculture Development Programme initiated by the New Partnership for Africa's Development.

The following specific micro messages emerged from the study for the design of extension services:

- There are lessons for encouraging farmers to apply modern inputs in more effective and productive combinations that raise their returns (finding 4).
- Extension services might also focus on improving farmers' perceptions about soil quality and input use outcomes (finding 7).
- Finally, rural credit markets need to be deepened to serve farmers better, especially with respect to modern input use (finding 8).

Research Agenda

The following areas for further research are suggested by this study:

- Input use, farm and plot size, and farmer behavior (see finding 6)
- Gender correlates with input use (finding 9).

Additional Reading

This chapter draws on:

Sheahan, Megan, and Christopher B. Barrett. 2017. "Ten Striking Facts about Agricultural Input Use in Sub-Saharan Africa." *Food Policy* 67: 12–25. https://doi.org/10.1016/j .foodpol.2016.09.010.

Other key references:

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McCord, G. C., and J. D. Sachs. 2013. "Development, Structure, and Transformation: Some Evidence on Comparative Economic Growth." NBER Working Paper 19512, National Bureau of Economic Research, Cambridge, MA.

Minot, N., and T. Benson. 2009. "Fertilizer Subsidies in Africa: Are Vouchers the Answer?" IFPRI Issue Brief 60, International Food Policy Research Institute, Washington, DC.

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Mrema, G. 2011. "Public Sector Strategy Development." In *Investment in Agricultural Mechanization in Africa: Conclusions and Recommendations of a Round Table Meeting of Experts*, edited by J. Ashburner and J. Kienzle, 23–36. Rome: Food and Agriculture Organization of the United Nations.

Rosegrant, M. W., C. Ringler, and I. De Jong. 2009. "Irrigation: Tapping Potential." In *Africa's Infrastructure: A Time for Transformation*, edited by V. Foster and C. Briceño-Garmendia, 287–98. Paris and Washington: Agence Française de Développement and World Bank.

Svendsen, M., M. Ewing, and S. Msangi. 2009. "Measuring Irrigation Performance in Africa." IFPRI Discussion Paper 00894, International Food Policy Research Institute, Washington, DC.

Zhang, W., F. Jiang, and J. Ou. 2011. "Global Pesticide Consumption and Pollution: with China as a Focus." *Proceedings of the International Academy of Ecology and Environmental Sciences* 1 (2): 125–44.

African Agriculture Is Intensifying—But Not by Much

Hans P. Binswanger-Mkhize and Sara Savastano

Overview

Common wisdom: *Population pressure and improved market access are intensifying African agriculture.*

Findings:

- *Fallow practices for soil fertility regeneration have virtually disappeared.*
- *The use of chemical and organic fertilizer varies enormously across countries.*
- *In Ethiopia, Malawi, and Nigeria, nearly half or more of the farmers use chemical fertilizer. However, in Nigeria very little organic manure is used, putting soil fertility at risk. In Tanzania and Uganda, the share of farmers using chemical or organic fertilizer is so low that soil fertility on the land of most farmers cannot be sustained.*
- *Population pressure and market access have so far triggered an inadequate response of the farming systems with respect to irrigation and improved technology.*
- *The study adopted two innovative variables (agroecological potential and urban gravity) to gain further insights into intensification processes. The responses to these variables were mixed, and suggested the need for further research.*

Conclusion: *In response to rising population densities and market opportunities arising from urbanization and better market access, cropping intensities have increased everywhere, but the expected increase in the use of inputs, technology, and investments has been less than what could have been predicted under the Boserup-Ruthenberg model of intensification.*

Policy messages: *The process of intensification over many of these African countries has been far less beneficial to farmers than what could have been expected. This may be due in part to the poor policies and low public agricultural development expenditures that prevailed during the 1970s and 1980s, which started to improve only in the 1990s. But these improvements do not appear to have led to a better pattern of*

intensification. Long-running panel data and additional intensification variables are needed to assess whether Africa will experience a virtuous cycle of growth and agricultural intensification. This holds an important area for further policy research.

The Issue: We Expected a Virtuous Cycle

A central issue in agricultural development is how agricultural production responds to higher population density and the development of markets. What will happen to the cropping intensities, adoption of technologies, and use of inputs and capital to enable yields to grow? Will soil fertility be maintained or increased to a sustainable level? Will these changes be sufficient to allow per capita agricultural incomes to rise sufficiently to maintain or improve per capita agricultural incomes? A rich body of literature on agricultural intensification addresses these issues. The Boserup-Ruthenberg (B-R) framework has long been used to understand the process of agricultural intensification across the developing world (see Boserup 1965; Ruthenberg 1980). Under this theory, population growth and market access first lead to a reduction in fallow periods—periods of rest for the land when soil fertility is restored. Farmers are likely to respond in a virtuous cycle for crop production, involving an increase in cropping intensity (the number or crops that are produced in a plot per year); increased use of organic manure and fertilizers; and investments in mechanization, land development, and irrigation. As observed in Asian countries, such changes have the potential to offset the negative impact of population growth on farm sizes, to maintain or increase per capita food production, and even increase farmers' incomes. But it is also possible that the changes in farming practices and technology occur too slowly, and that the intensification process leads to a decline in farm income—a process referred to as agricultural involution (Geetz 1963). The agricultural development literature has produced an extensive body of evidence that summarizes or tests the B-R hypothesis in Africa and often confirms it.

In the past two decades, rapid population growth has put African farming systems under stress. At the same time, there has been a sharp increase in urbanization and economic growth that is providing new market opportunities for farmers. It is therefore a good time to investigate whether this has resulted in rapid intensification of farming systems, permitting rapid agricultural growth and increased incomes of the farming population.

The Analysis: Has There Been a Virtuous Cycle?

To address this question, the study describes the status of intensification of *crop production* in six African countries using the first round of data from the Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA). The six are Ethiopia, Malawi, Niger, Nigeria, Tanzania, and Uganda. The study does the following:

• Develops an internationally comparable measure of agroecological potential (AEP) based on estimated attainable crop yields across all agricultural areas of

the globe (box 11.1 provides details on how these estimates were obtained). AEPs are given in map 11.1, by enumeration area. Country averages are given in box 11.1. By defining AEP *per capita*, the study proposes an alternative measure of population pressure—one that reflects the potential of the area being assessed.

- Uses a measure of urban gravity (UG) to reflect the access of a particular location to urban demand, defining urban areas as those with a population of more than 500,000 (map 11.2 provides UGs by enumeration; box 11.1 provides country averages).
- Estimates the relationship between AEP and UG on population density, infrastructure, and market access, these being the main explanatory variables for agricultural intensification in the B-R framework.

But there are limits to using just cross-section data. Ideally, panel data are needed (data for the same households *over time*) to test properly whether the B-R framework currently applies to Africa. But only cross-section data are

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Box 11.1 Calculating the Two Key Variables

The study considers several aspects of farming outcomes as important when analyzing the Boserup-Ruthenberg framework:

- Population density of the enumeration area
- Distance to the nearest road and nearest markets
- Average owned or cropped area per household
- Cropping intensity, defined as gross cropped area per net cropped area
- Proportion or area of land area under fallow
- Proportion of net crop area irrigated
- Proportion of households using different technologies: high-yielding varieties, organic manure, fertilizer, or pesticides.

These aspects were obtained from the Living Standards Measurement Study–Integrated Surveys on Agriculture data. But two key variables were obtained outside the household surveys:

Agroecological potential (AEP) is estimated using currently available global agroecological zone data from the International Institute for Systems Analysis and the Food and Agriculture Organization (Tóth et al. 2012). The study estimates yield potential for 15 crops (wheat, rice, maize, barley, millet, sorghum, white potatoes, cassava, soybean, coffee, cotton, groundnut, banana, sweet potatoes, and beans). These potentials are based on current climatic conditions, intermediate input use, and rainfed conditions. The 15 crops are aggregated into one index using average world prices over the past three years. Figure B11.1.1 gives the country averages; map 11.1 shows how the measure varies within each country. Because only recent crop prices and cropping patterns are used in the measure, it may not

box continues next page

Box 11.1   Calculating the Two Key Variables *(continued)*

Figure B11.1.1   Higher Agroecological Potential per Person in Tanzania and Niger; Greater Market Access in Nigeria and Malawi
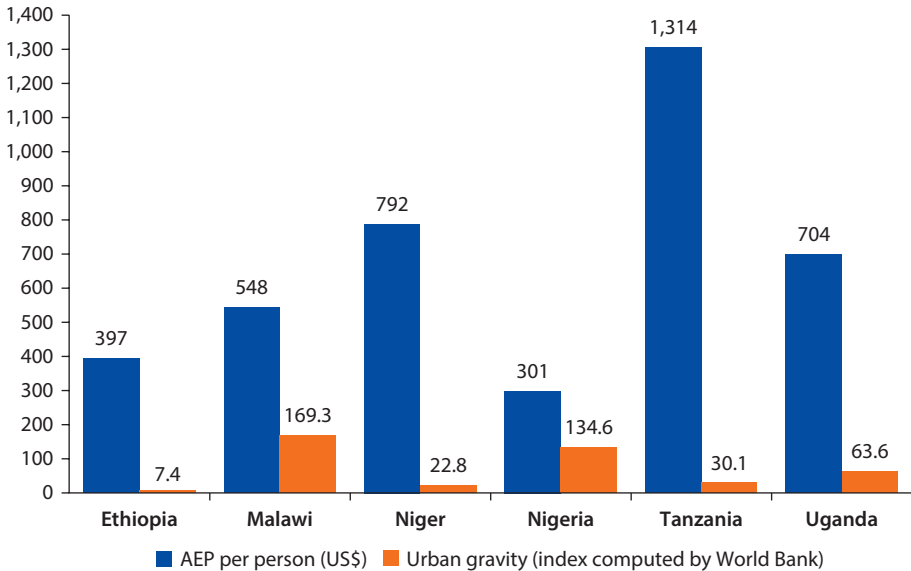
Source: Calculations based on LSMS-ISA data.
Note: AEP = agroecological potential.

reflect past AEPs. Therefore, the analysis assumes that today's AEP is highly correlated with the AEP of the past.

The study measures population pressure in two ways. The traditional measure of population pressure (persons per square kilometer) does not account for the vast differences in AEP. An alternative measure is therefore used, defined as the AEP per square kilometer divided by the population density. This gives the AEP per person in each enumeration area. Unlike with population density, the lower this number is, the higher is the population pressure. The study finds that this measure ranks countries quite differently from rural population density rankings. Rural population density is therefore considered to be a weak measure of population pressure on natural resources.

Urban gravity is the intensity of light emitted as a proxy for economic activity in a particular urban area. Light intensity measures (unlike more orthodox measures of activity, such as gross domestic product) are available for specific areas in a country. The data come from the Defense Meteorological Satellite Program of the National Geophysical Data Center. Figure B11.1.1 shows how averages for urban gravity vary across countries, and map 11.2 shows how urban gravity varies within each country. As with AEP, the study assumes that current urban gravity is closely related to what it was in the past.

Map 11.1 AEP per Person for the Enumeration Areas in the Six Countries

agppd
- ■ 0–182
- ■ 182–343
- ■ 344–440
- ■ 441–594
- ■ 595–774
- ■ 775–1,034
- ■ 1,035–1,885
- ■ 1,886–445,633

Uganda

Malawi

Ethiopia

Tanzania

Nigeria

Niger
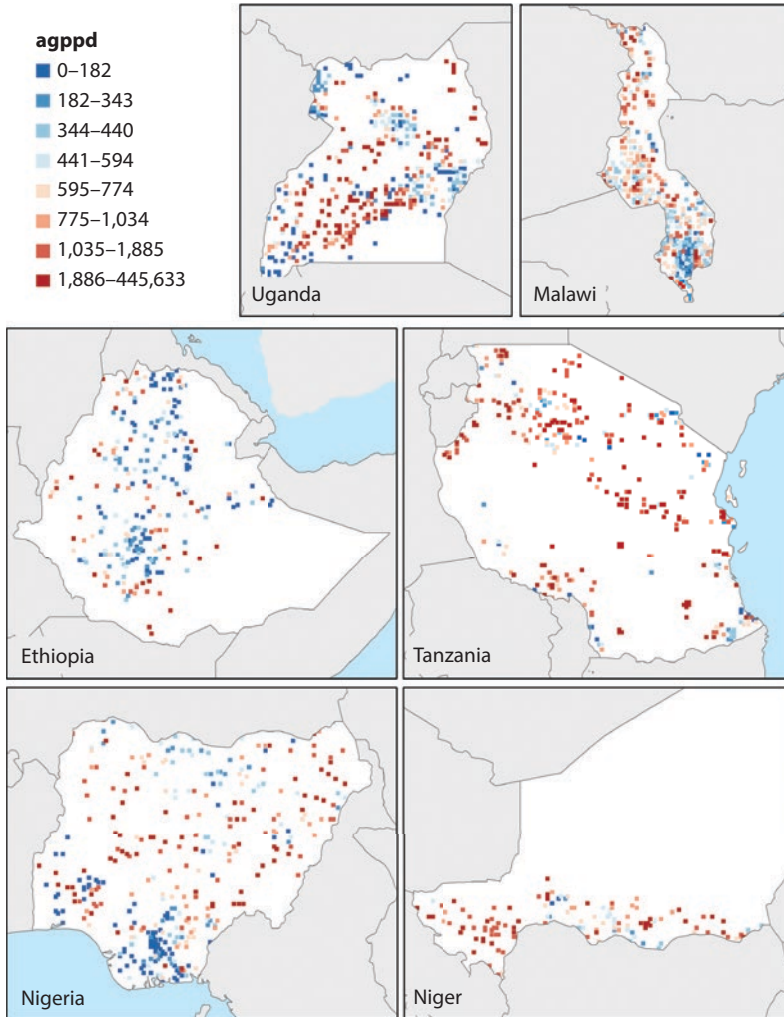
Source: Computations based on LSMS-ISA data.
Note: AEP = agroecological potential (US$); agppd = agroecological potential per person (US$).

available from the LSMS-ISA surveys. When the intensification measures are regressed against the AEP and UG variables, the coefficients reflect the direct effects of the intensification measures on the farming characteristics of interest, and the indirect effects via their influence on population density and infrastructure.

Map 11.2 Urban Gravities for the Six Countries
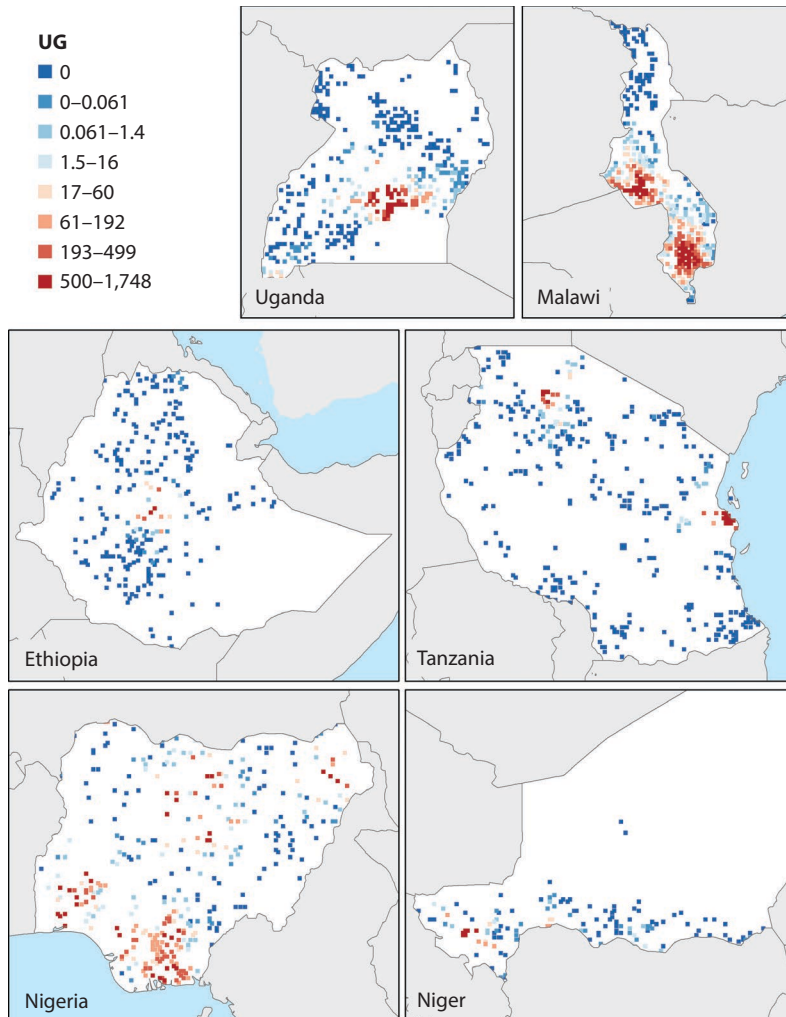
The Results: Little Sign of a Virtuous Cycle

The analysis shows that the patterns of intensification observed across countries are not entirely consistent with the B-R framework.

Cropping intensities have increased and fallow land has disappeared. Given the rise in population pressure in all the countries, improvements in infrastructure, and growing urban demand, Africa's land use intensity has reached the stage where land is cropped every year (permanent cropping) in all the countries. Fallow areas have virtually disappeared. Since fallowing is used to restore soil fertility, organic and chemical fertilizers are needed to do this job. This is as predicted by B-R.

Cropping intensity is defined as gross cropped area divided by net cropped area (figure 11.1). At 1.89, crop intensity is highest in Uganda, because of its bimodal rainy season, which, unlike in the other countries, allows for two crops per year. Cropping intensity is especially low in Malawi (1.01) and Tanzania (1.07). In the other countries, cropping intensities also remain below 1.2. Although cropping intensity is greater than 1 in all the countries, indicating that the stage of permanent cropping has been reached everywhere, it could have been higher in light of the observed population density and increased market access. This is especially the case for Malawi,

Figure 11.1 The Practice of Fallowing Has More or Less Disappeared
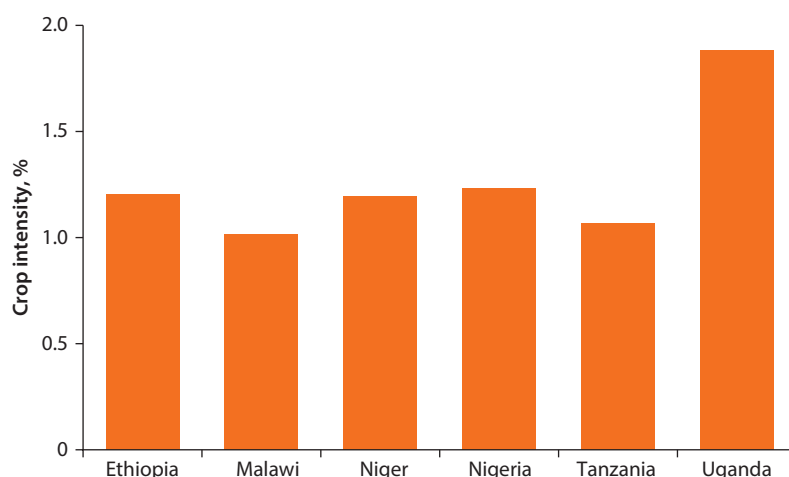
Source: Computations based on LSMS-ISA data.
Note: Cropping intensity is the gross cropped area per year divided by the cropped area and reflects the number of times the area is used for crop cultivation per year.

Table 11.1 Irrigation and New Technologies Are Lagging in Many Countries

	Ethiopia	Malawi	Niger	Nigeria	Tanzania	Uganda	All
Average irrigated area (hectares)	0.016	0.003	0.036	0.033	0.045	0.02	0.029
Share of households (percent) using							
Improved seeds	18	61	3	—	18	18	9
Inorganic fertilizer	41	76	18	41	16	3	38
Organic fertilizers	53	16	48	3	17	12	25
Agrochemicals	23	3	7	34	12	11	27

Sources: Estimates based on LSMS-ISA data; Binswanger-Mkhize and Savastano 2017.
Note: — = not available; totals across countries are population weighted.

where agroecological population pressure is already high and, contrary to the B-R model, intensity of land use is low.

Use of improved technology is uneven. To be consistent with the B-R model, countries should have a proportionate use of new technologies combined with their AEP and population pressure. The countries exhibit very uneven input use, despite having cropping intensities at or above unity (figure 11.1). Except for Malawi, the proportion of households using improved seeds is less than 18 percent (table 11.1). More than 41 percent of the households in Ethiopia, Malawi, and Nigeria use chemical fertilizers. In Ethiopia, 53 percent of the households also use organic manure, which is an important input to maintain soil fertility. However, in Nigeria, only 3 percent of the households use organic manure, which means that even households that use chemical fertilizer may not be able to maintain soil fertility. In Tanzania, the use of these two inputs is very low; it is even worse in Uganda. With cropping intensities of more than unity, the use of organic and chemical fertilizer is surely insufficient to maintain soil fertility.

Investments in irrigation are limited, falling far short of what the high agroecological population pressures would imply. This finding partly also explains the lower cropping intensities. Across the six countries, the average area irrigated per farm is only 0.03 hectares, and the share of irrigated area in total area is only 4.4 percent. Surprisingly, the mean area under irrigation is higher in Tanzania (0.045 hectares) compared with Malawi (0.03 hectares), where land pressure is highest. This is not consistent with the B-R hypothesis. The warm arid zones have the largest mean irrigated area per farm, at 0.11 hectares, but, because of the large farm sizes, this amounts to just 2.4 percent of the land area. The warm semi-arid areas come next in the use of irrigation, followed by cool semi-arid and warm subhumid areas.

The multivariate results are mixed. The study finds significant responses of population density and infrastructure, farming system characteristics, farm technology, and profits per hectare to the measures of AEP and UG, and the signs are all according to expectations. However, there is a sharp divide between the nature of the impacts of AEP and UG across the variables:

- AEP increases population density and road investment, but does not reduce distance to markets. UG does not affect population density, but reduces the distance to roads and markets.
- AEP has no impact on key characteristics of the farming system, such as area farmed, crop intensity, and fallow areas. UG reduces all area measures and increases cropping intensity.
- Although neither AEP nor UG has an impact on irrigation investment, AEP affects the use of all four inputs, while UG only increases the use of improved seeds. The interpretation of these finding is that higher input use has significantly higher payoffs in areas of high AEP.

The Implications

The results of the study are far from reassuring for the ability of intensification to enhance agricultural incomes. In several countries, the intensification that has occurred in the recent past is likely to threaten long-term soil fertility. Instead, agriculture may persist in a low-yield equilibrium, consistent with the very slow growth of yields observed in Africa. Since average farm sizes have also declined in most of the countries, the findings are consistent with agricultural involution in some countries, a process where intensification is not fast enough to lead to per capita increases in income.

The implication of these results, and other observations of African agriculture, is that the process of intensification over many of the countries appears to have been far less beneficial to farmers than would be implied by the B-R framework. This finding may be due in part to the poor policies and limited public agricultural development expenditures that prevailed during the 1970s and 1980s. In addition, international agricultural prices remained at historic lows up to 2006. Institutions, public investment, and private investment take time to respond, leaving hope for an accelerating response in the future.

From a research point of view, the study's cross-section analysis goes only so far, and certainly does not involve a rigorous test of the B-R hypothesis. For that, long-running panel data and additional intensification variables would be required.

Additional Reading

This chapter draws on:

Binswanger-Mkhize, Hans P., and Sara Savastano. 2017. "Agricultural Intensification: The Status in Six African Countries." *Food Policy* 67: 26–40. https://doi.org/10.1016/j.foodpol.2016.09.021.

Other key references:

Boserup, Ester. 1965. *The Conditions of Agricultural Growth*. Chicago: Aldine.

Geertz, Clifford. 1963. *Agricultural Involution*. Berkeley: University of California Press.

McIntire, J., D. Bourzat, and P. Pingali. 1992. *Crop-Livestock Interaction in Sub-Saharan Africa*. World Bank Regional and Sectoral Studies. Washington, DC: World Bank.

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Maize Farming and Fertilizers: Not a Profitable Mix in Nigeria

Lenis Saweda O. Liverpool-Tasie, Bolarin T. Omonona, Awa Sanou, and Wale Ogunleye

Overview

Common wisdom: *Despite being profitable, fertilizer use among African farmers is too low.*

Findings:

- *Fertilizer use is common in Nigeria, although varying widely across farming systems.*
- *Where most of the maize is produced, fertilizer application is not profitable for many farmers.*
- *The two major factors behind low profitability are*
  - *Low yield response to nitrogen*
  - *High acquisition costs.*
- *Fertilizer use and application rates are higher than the optimal levels for some farmers—that is, the levels indicated by estimated profitability.*

Policy messages:

- *Increased attention needs to be paid to interventions that raise the yield response to fertilizer application.*
- *In addition to complementary input use and improved management practices, increasing yields also requires improving soil health and ensuring fertilizer quality.*
- *Maize profitability will be well served by investment in infrastructure and strategies to reduce the distance farmers have to go to secure fertilizer.*

The Issue: How Profitable Is Fertilizer Use?

The notion that inorganic fertilizer use in Africa is too low is based on the assumption that it is profitable to use higher rates than is currently the case. Because of this, the literature generally looks to other constraints to fertilizer adoption—financial market imperfections, inadequate knowledge, or lack of access to markets. But these constraints all link again to profitability issues. This study therefore analyzes the profitability of fertilizer use as a likely explanatory factor for observed fertilizer use rates, focusing on maize production in Nigeria.

Overall, there is little rigorous empirical evidence on fertilizer profitability in Africa. Although various studies have explored the yield response of fertilizer in crop production, few studies have explored the profitability of fertilizer use. Most studies of profitability are outdated or based largely on unrepresentative case study evidence. The study takes advantage of recent nationally representative data in Nigeria to put this discussion on a more secure empirical footing. It addresses two gaps in the literature. First, it addresses a key issue as yet untested in the literature, which appears to believe that fertilizer use is low in Sub-Saharan Africa, although it is profitable. Second, the study identifies more consistently the yield response to fertilizer application, by accounting for unobserved time-invariant household characteristics that are likely to affect fertilizer application and the resulting yields.

The Nigerian Context

Fertilizer Is Commonly Used in Nigeria, Especially in the Northern States

There is limited empirical evidence on the nature and rationale for the patterns of observed inorganic fertilizer use rates across Nigeria's diverse farming systems. Fertilizer use will naturally vary depending on agroecological and market conditions, government policies, cropping systems, and yield responsiveness. Its use in the northern states is typically higher than in the southern states (map 12.1). This is partly attributed to lower soil fertility, larger area cultivated, and the growth of high-value crops, such as vegetables and particular cereals, in the region. Northern states have also traditionally provided greater fertilizer subsidies since the colonial era.

Why Maize?

Maize is one of the three most important cereals grown in Nigeria, alongside sorghum and millet. Maize is a versatile crop, grown across a wide range of agroecological zones. Every part of the maize plant has economic value. As a priority under the flagship agricultural programs of the Nigerian government since 2012, maize farmers have received support through access to subsidized fertilizer and improved seeds. The study focuses on the main cereal-producing area, selecting plots where maize is grown. These account for over 60 percent of the plots in the study sample. Although the results are not nationally representative, they can be

Map 12.1 Inorganic Fertilizer Use on Plots in Nigeria, 2012

a. Proportion of plots on which inorganic fertilizer is applied
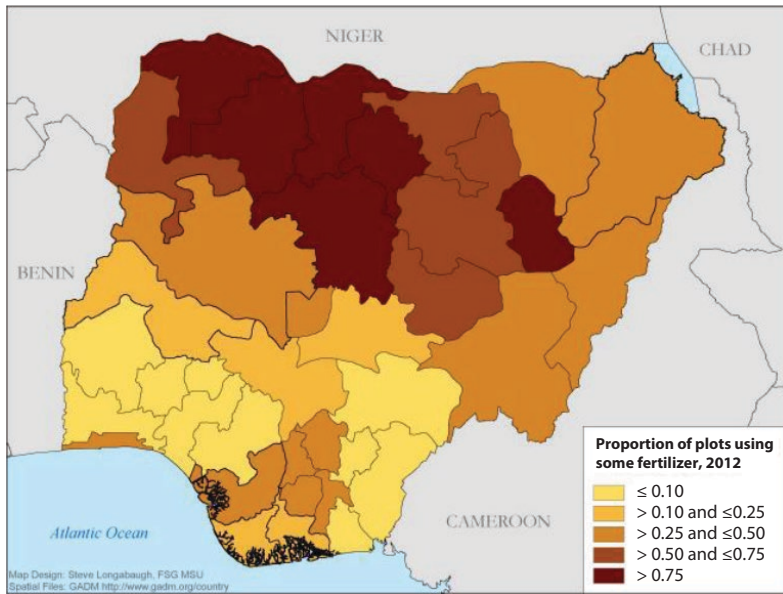
b. Median quantity of inorganic fertilizer applied per hectare
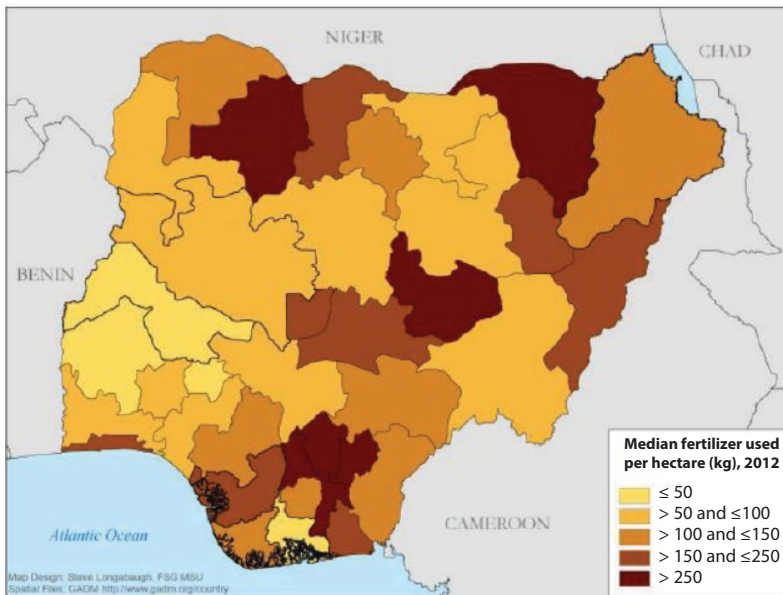
Sources: Data generated from the 2012 LSMS-ISA; map generated by Steve Longabaugh (2014). Used with permission; further permission required for reuse.

considered representative of the main farming system for maize production in the country. Maize is produced mainly by smallholders in Nigeria. The average maize plot is between 1 and 1.5 hectares, managed by a middle-aged male with limited use of irrigation and mechanization. Although only about 20 percent of the maize plots use purchased seed, almost 50 percent of the farmers use some chemicals (herbicides and pesticides) in maize production. For those who apply fertilizer, the average fertilizer use is between 150 and 170 kilograms (kg) per hectare.

The Analysis: Estimating Maize Yields and Profitability in Nigeria

The Data

The Nigeria Living Standards Measurement Study–Integrated Survey on Agriculture (LSMS-ISA) provides a rare opportunity to estimate the yields and profitability of fertilizer use in the country. LSMS-ISA is a nationally representative panel data set with detailed agricultural information at the plot level. This makes it possible to address specifically the profitability of fertilizer use in a production function framework. The LSMS-ISA data set includes georeferenced plot locations and Global Positioning System–based plot areas. It also includes plot-level information on input use, cultivation, and production. The information was collected over two visits per household per year in 2010/11 and again in 2012/13. The first visit each year collected information on planting activities; the second visit collected information on postharvest outcomes. The study selects all plots on which maize was grown in the main agricultural season in each survey year. It therefore draws on information on the size of plots, amount of fertilizer and other inputs used, and yields for about 1,200 maize plots over the two survey periods.

From Production to Profitability

The profitability of fertilizer use requires an understanding of the following:

- *Fertilizer agronomics*, that is, the yield response to applying fertilizer under different circumstances (such as soil quality or water availability).
- *Fertilizer economics*, which involves the output/input price ratio as well as the quantities and costs of inputs, such as seed, chemicals, labor, and transportation. Understanding fertilizer economics requires detailed information on agricultural practices and input costs.

The study deals first with the agronomics, measuring the relationship between maize output and the relevant factors of production (including inorganic fertilizer). The production function estimates (box 12.1) are used to calculate the *marginal and average physical products* of nitrogen in maize production (MPPs and APPs, respectively). The MPP of applied nitrogen (which describes how much extra maize output can be produced by using one additional unit of

Box 12.1 Challenges of Estimating the Maize Production Function

To estimate the profitability of the use of inorganic fertilizer in maize production, the study first estimates the impact of fertilizer use on maize yields, other things constant. The emphasis is on the application of nitrogen. The basic model is specified as:

$$Yield_{ijt} = f(X_{kijt}, Z_{hijt}, u_{ijt})$$

where $Yield_{ijt}$ refers to the yield per hectare (in kilograms) of maize on plot i for household j at time t, which is a function of several vectors of endogenous and exogenous factors. The term X_{kijt}, refers to a vector of plot- and time-specific determinants of maize yields, including the use of various k inputs (including applied nitrogen); Z_{hijt} is a vector of h controls that affect crop production, such as soil quality, access to information and markets, as well as the level and distribution of rainfall. The term Z_{hijt} also includes household characteristics, including the age and gender of the plot manager and household wealth. Finally, $u_{ijt} = \varepsilon_{ijt} + c_i$ is a composite error term comprising time-invariant (c_i) and time-varying unobserved characteristics (ε_{ijt}) of the production system.

A key problem in estimating the effect of fertilizer on yields is that the decisions to use nitrogen and the quantity of nitrogen applied on a maize plot are endogenous—they are components of household decision making. It is likely that fertilizer application is correlated with farmer- and plot-specific characteristics (such as unobserved variation in soil characteristics or farmer ability) that are also likely to influence yields. This endogeneity restricts any causal interpretation of the coefficient on fertilizer use in a yield response model. The correlation between the unobserved individual effect in the error term (C_i) and the rate of application of fertilizer would cause a bias in ordinary-least-squares (OLS) estimators. Therefore, estimation of the effects of fertilizer on yields is largely based on a fixed-effects model. This method attenuates potential biases by using variation in fertilizer use within a household over time to identify the causal effect of fertilizer on yields.

Although the fixed-effects model addresses bias caused by *time-invariant* factors (such as farmer ability), it does not deal with any bias caused by *time-varying* unobservable factors that may be correlated with yields and the household's fertilizer use. A unique feature of this study is the availability of plot-level characteristics, which are included in the production function estimates. This addresses some of the usually absent but important time-varying unobserved characteristics of concern when using a fixed-effects model, by accounting for factors such as the plot wetness potential index and the slope and elevation of the plot.

The estimates of this production function highlight the importance of addressing the effects of unobserved household-specific characteristics when estimating nitrogen yield response functions. The difference between the pooled OLS and fixed-effects results indicates the presence of some invariant, unobserved factors that are likely correlated with nitrogen application as well maize yields. The consistency of these results was confirmed with other models, including the correlated random-effects model.

Using the production function estimates, the study calculates the marginal physical product of the use of nitrogen in maize production as the derivative of the yield with respect to the

box continues next page

Box 12.1 Challenges of Estimating the Maize Production Function *(continued)*

nitrogen variable for each plot. The average physical product is defined as the change in output due to the use of applied nitrogen compared with not applying any nitrogen. The marginal product of applied nitrogen (which describes how much extra maize output can be produced by using one additional unit of nitrogen, all else held constant) is obtained by taking the first derivative of the production function with respect to applied nitrogen.

applied nitrogen, all else held constant) is obtained by taking the first derivative of the production function with respect to applied nitrogen. The APP is the gain in maize yield per unit of applied nitrogen relative to not using any nitrogen. MPPs and APPs are calculated at the plot level and then used to calculate partial profitability measures. These measures are defined as the marginal value cost ratio (MVCR) and average value cost ratio (AVCR) for plot i and household j at time t as follows:

$$\textit{Marginal value cost ratio}: (MVCR_{nijt}) = \frac{(P_{mtv} * MPP_{nijt})}{p_{nijt}}$$

$$\textit{Average value cost ratio}: (AVCR_{nijt}) = \frac{(P_{mtv} * APP_{nijt})}{p_{nijt}}$$

where p_{nijt} is the acquisition price of nitrogen (market price plus transportation cost) and p_{mtv} is the price of maize in the farmers' community. The output price is the median community selling price of maize per kilogram. The nitrogen price is a simple average of the market price of the nitrogen components of urea and nitrogen, phosphorus, and potassium converted to a 1 kilogram equivalent.

When $AVCR_{nijt}$ is greater than or equal to 1, the net benefit from using fertilizer is positive for a risk-neutral household and it is profitable to use fertilizer. When $MVCR_{nijt}$ is greater than 1, it implies that a risk-neutral household could increase its income by increasing its nitrogen application rate, as the current rate is not profit maximizing. The study assumes risk neutrality, but recognizes that measured profitability under this assumption would overestimate profitability for risk-averse farmers.

The Results: Fertilizer Is Not Profitable for Many Maize Farmers

Among risk-neutral farmers in the main maize-growing zone, the net benefit of the use of fertilizer is positive in about a half the plots covered in 2012 (that is, plots for which AVRC > 1). About 50 percent of the maize plots could increase their income by expanding nitrogen application (MVCR > 1). But this points to limited profitability in the remaining half of the plots.

Why Is Maize Not Profitable for Many Farmers?

Yield Response to Applied Fertilizer Is Quite Low

The MPP of maize for applied nitrogen in the main farming system in Nigeria was just 7.7 kg (in 2012). This is much lower than the potential yields of up to 50 kg of maize per kg of nitrogen when research management protocols are followed (Snapp et al. 2014). It is also lower than recent estimates from East Africa of about 17 kg of maize per kg of nitrogen (Sheahan, Black, and Jayne 2013). The study explores possible interventions that would increase this response—such as irrigation, use of improved seeds, and enhanced crop management practices.

Transport Costs Clearly Harm Maize Profitability

Given transport costs, the study finds that expanding fertilizer use would be profitable on 53 percent of the plots in 2012, assuming risk neutrality. But if fertilizers were available in the village (avoiding transportation costs borne by the farmer), fertilizer use would be profitable on most of the plots (86 percent of them—figure 12.1). These are large effects. They indicate that although the low profitability of nitrogen application is partly driven by its low MPP, reducing the cost of fertilizer acquisition can significantly enhance its profitability.

Fertilizer Subsidies Could Also Raise Profitability

Fertilizer subsidies have been a dominant component of agricultural input programs throughout most of Nigeria's recent history. Under the current scheme in Nigeria, participating farmers receive two bags of subsidized fertilizer (typically subsidized at 50 percent of market price). If the majority of maize farmers

Figure 12.1 There Is Scope to Raise Fertilizer Profitability by Reducing Transportation Costs

Percent of maize plots where expanding fertilizer use was profitable for risk-neutral farmers in 2012
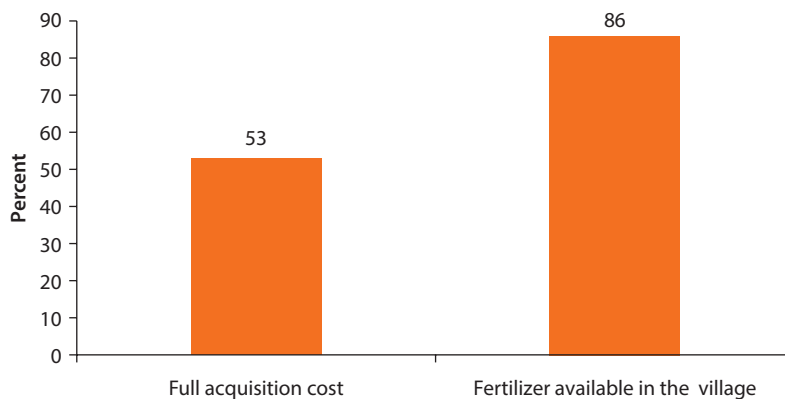
Source: Data generated from the 2012 LSMS-ISA in Nigeria.

received subsidized fertilizer, this could significantly reduce the cost of fertilizer use. But recent empirical evidence suggests that typically larger and more affluent farmers benefit from such programs. Furthermore, given that less than 20 percent of applied fertilizer in Nigeria is likely to be subsidized (Takeshima and Liverpool-Tasie 2015), the relative costs and benefits of such a strategy should be carefully considered.

Nitrogen Use Is Not Too Low, Given Its Expected Profitability

The study compares the profitability of plot-level nitrogen application with the observed application. Are observed use patterns in line with those indicated from expected profitability, as estimated from the survey data? For the cereal–root crop farming system, the study demonstrates that fertilizer use is only profitable in expectation for about half the plots. Yet, the surveys report about 65 percent of the maize plots use some fertilizer. This finding indicates that fertilizer use is not purely driven by observed market prices and yields. For example, given food security concerns (especially when faced with poor quality soils and poor infrastructure), the shadow price of maize might be much higher than the observed market prices. But are fertilizer application levels too low, given predicted profitability? Taking individual plots, application rates are higher than desirable for between about 15 and 25 percent of current fertilizer users (with an average gap of between 10 and 15 kg across all plots). Thus, many farmers are using too much fertilizer—at least from the perspective of farm profits.

In sum, the study does not support the conventional wisdom. Fertilizer application is not too low compared with what can be considered profitable; rather, the reverse is true. Some Nigerian farmers are applying fertilizer more than what is indicated to be profitable by the study.

The Implications

This study confirms that fertilizer use can be profitable for maize producers in Nigeria. However, at current input acquisition costs and output prices, and given the current yield response to applied nitrogen, such profitability remains a reality for only a subset of maize farmers. The study also shows that current application rates exceed optimal (based on profitability) levels of fertilizer use for some farmers.

Policy Agenda

Since the 1970s, Nigerian governments have tried to stimulate fertilizer demand, grow the commercial fertilizer sector, and lower fertilizer prices. The strategies that have been used to stimulate fertilizer use include subsidies and programs to increase farmers' access to credit. These programs were reported to have not significantly raised fertilizer demand. This study indicates that attention needs to be paid to the profitability of fertilizer use as a key factor driving fertilizer demand. Significant reforms are under way in the Nigerian agricultural sector,

particularly on fertilizer. Such reforms (including improvements in infrastructure and increased access to fertilizer and seed for smallholder farmers) might change the results of the study. But these findings could provide a basis for the evaluation of such programs in the future.

The study has three important messages for policy. First, among farmers engaged in the cereal–root crop farming system, nitrogen fertilizers are not profitable for many maize producers under current conditions.

Second, policies to reduce fertilizer acquisition costs, such as transportation policies, could be effective in enhancing fertilizer profitability and use. Such policies would not only raise expected profitability, they would also reduce the risks associated with maize production. The findings of the study call for programs that encourage setting up retail depots within communities or in smaller towns closer to farmers. Although the market price may increase, it is likely that transporting fertilizer in bulk closer to many farmers (say, in a state in Nigeria) would cost less than the cost that many farmers would have to bear to travel individually 40–70 kilometers to a fertilizer distributor.

Third, improving the yield response to nitrogen in Nigeria is key for the profitability of fertilizer use. In addition to the likely gains from complementary input use and improved management practices, more attention likely needs to be paid to understanding and addressing soil health and issues of fertilizer quality. Understanding the soil's organic matter and chemical properties is very important, and likely necessary for any increased use of fertilizer in Nigeria to translate into a meaningful increase in farmer productivity. This will also likely increase the effectiveness of subsidy programs geared to increase farmers' access to inorganic fertilizer. Better understanding of issues related to fertilizer quality could also potentially help explain cases of beyond-optimal use or limited adoption.

Research Agenda

Further research on strategies to increase the efficiency of fertilizer application for maize and other cereals in Nigeria (and Sub-Saharan Africa, more generally) is needed. Such research is crucial for farmers to use fertilizer profitably and increase smallholder demand for the product. Identification and evaluation of schemes to strengthen farmers' links to input dealers are also worthy of further attention. In addition to observed market prices, other factors explain fertilizer use. Therefore, more effort is needed to understand the rationale for the current nitrogen application rates across smallholder farmers.

Additional Reading

This chapter draws on:

Liverpool-Tasie, Lenis Saweda O., Bolarin T. Omonona, Awa Sanou, and Wale O. Ogunleye. 2017. "Is Increasing Inorganic Fertilizer Use for Maize Production in SSA a Profitable Proposition? Evidence from Nigeria." *Food Policy* 67: 41–51. https://doi .org/10.1016/j.foodpol.2016.09.011.

Other key references:

Liverpool-Tasie, L. S., and H. Takeshima. 2013. "Moving Forward with Fertilizer in Nigeria: Fertilizer Promotion Strategies within a Complex Fertilizer Subsector." *Agricultural Economics* 44 (6).

Sheahan, M., R. Black, and T. S. Jayne. 2013. "Are Kenyan Farmers Under-Utilizing Fertilizer? Implications for Input Intensification Strategies and Research." *Food Policy* 41: 39–52.

Snapp, S., T. S. Jayne, W. Mhango, T. Benson, and J. Ricker-Gilbert. 2014. "Maize Yield Response to Nitrogen in Malawi's Smallholder Production Systems." Working Paper 9, Malawi Strategy Support Program, International Food Policy Research Institute, Washington, DC. http://fsg.afre.msu.edu/gisaia/masspwp9_Snapp_et_al_2014.pdf.

Takeshima, H., and L. S. O. Liverpool-Tasie. 2015. "Fertilizer Subsidies, Political Influence and Local Food Prices in Sub-Saharan Africa: Evidence from Nigeria." *Food Policy* 54: 11–24.

Do Trees on Farms Matter in African Agriculture?

Daniel C. Miller, Juan Carlos Muñoz-Mora, and Luc Christiaensen

Overview

Common wisdom: *Trees on farms are not important in Sub-Saharan African agriculture.*

Findings:

- *With about a third of smallholder farmers reporting cultivating trees on their farms, trees are not uncommon in the five Sub-Saharan African countries studied. Fruit trees and tree cash crops (such as coffee, cacao, and cashew nuts) are the most frequent tree categories grown.*
- *The prevalence of on-farm trees for timber is also sizable in Tanzania (18 percent of smallholders), but minimal or poorly recorded elsewhere.*
- *In addition to sales, fruit trees are also commonly used for self-consumption in Ethiopia and Uganda, implying that they may play an important role in food security and nutrition.*
- *Their contribution to income is not negligible—17 percent of total gross income among tree crop growers, and 6 percent on average across all rural households.*
- *Tree-growing households are better off on average in most of the study countries.*
- *Trees are more likely on larger farms, in warmer areas, and closer to forests. Their prevalence also appears to be shaped by national policies and institutional factors.*

Policy message: *This study highlights the prevalence and importance of trees in African agriculture. Trees on farms provide a significant source of income for many households across the continent. In many contexts, trees provide a measure of food security and play a key role in soil and water management. However, trees on farms are often overlooked in African agricultural and forestry policy. This research suggests they should be given much more attention in agriculture, food security, and*

poverty-related policy debates in Sub-Saharan Africa, particularly in the context of climate change.

The Issue: Can Trees on African Farms Be Safely Ignored?

Trees on farms, particularly those that do not yield cash crops, are often overlooked in research and policy on African agriculture. Trees are usually considered the domain of forestry. However, forestry as a field is largely focused on trees in forests rather than outside them. The focus in agriculture is usually on annual crops. For their part, small farmers appear to have few incentives to engage in agroforestry (the incorporation of woody perennials into farming systems). High input prices, a long time lag between planting and harvesting, weak access to information and credit, and informal, often insecure property rights present significant barriers to such practices in many African contexts (Godoy 1992).

   Nonetheless, whether as a source of timber or nontimber products—or for ecological services such as shade, nitrogen fixing, prevention of soil erosion, and water management—trees do play an important role on farms across the continent (Place and Garrity 2015). Indeed, roughly a third of the agricultural land in Sub-Saharan Africa is estimated to have had at least 10 percent tree cover during 2008–10 (Zomer et al. 2014). Trees and agricultural activities therefore often coexist not only in larger landscape contexts but also in single landowner holdings. Such arrangements likely have important implications for household welfare. The welfare implications are especially important given that trees have been found to reduce the exposure and sensitivity to external shocks, such as those related to climate change, market volatility, and liquidity constraints, among others (Place and Garrity 2015).

   Despite their prevalence and likely importance, however, knowledge of the prevalence and economic contribution of trees on farms at the national scale remains limited. This lack of evidence, along with the institutional separation of forestry and agriculture, means that policy recognition and support for agroforestry also remain lacking.

The Analysis: Trees in African Agricultural Landscapes

The data for this chapter pertain to five of the six countries originally covered under the Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA) initiative. The countries are Ethiopia, Malawi, Nigeria, Tanzania, and Uganda. The first challenge is to define what plants to consider as trees. Based on an initial classification using biological definitions, the study carried out focus group interviews with experts to refine and validate the definition (box 13.1). This resulted in a crop classification that combined the biological description of each crop/tree and its economic role on the farm. The five categories are fruit trees; cash crop trees; timber and fuelwood trees; plants, herbs, grasses, and roots; and those not identified. The study focused on the first three.

Box 13.1 What Is a Tree?

Identifying trees on farms is not a straightforward conceptual or analytical task. There appears to be no standard approach to classify crops as trees. For each species, the study therefore started by using the comprehensive description provided by the Encyclopedia of Life, a collaborative project that gathers scientific information on all species of life on Earth (Parr et al. 2014), to categorize plants as trees or not. To qualify as a tree, the plant should be a woody perennial with an elongated stem or trunk that supports branches and leaves. Turning to the data, the Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA) data focused on trees with a productive function on farms. To pinpoint the existence and nature of these trees, the study used data from two modules used in all six LSMS-ISA countries. First, for uncultivated plots, it identified those that were covered by *forest*. Second, for cultivated plots, it extracted information on all crop planting and production by each household and identified those crops that can be considered a tree.

Although the effort to capture tree-related information is as comprehensive as possible, the stock of trees on farms identified in the study likely represents a lower bound, for several reasons. First, home gardens may have been underreported as plots, and trees with no immediate productive function may have been left out. Second, respondents may not recall all the trees on their lands or may be hesitant to report them where, for example, colonial legacies of state control of tree resources persist (Ribot 1999). Last, the study was also unable to classify a few species for which only the local name was available. However, such omissions would especially affect the number of trees reported, and not so much their incidence or the share of land allocated to trees (for each plot, the surveys recorded whether trees were present). Consequently, the study focuses on the prevalence of trees on farms and the share of land allocated to trees, as opposed to the number of trees per se.

The Results: Trees Are Significant on Farms in Sub-Saharan Africa

Many African Farms Are Growing Trees

Across the study countries, about one-third of African farms report growing trees, often in the proximity of existing forests. Nonetheless, the stock of trees on farms varies substantially by country and category of tree (table 13.1). On the one hand, there are the cases of Nigeria and Malawi, where the prevalence of trees on farms is relatively low. In these countries, only 16 and 23 percent (respectively) of landholders report having trees on their farmland. On the other hand, in Tanzania, Ethiopia, and Uganda, trees on farms are considerably more prevalent (54, 38, and 30 percent of landholders, respectively).

The prevalence of trees also varies across countries by tree type. In Tanzania, for example, fruit trees are especially widespread, with 45 percent

Table 13.1 A Non-neglible Share of Farmers Have Trees on Their Farms

Country	Share of smallholders with trees on farms (%)	Share of smallholders with fruit trees (%)	Share of smallholders with tree cash crops (%)	Share of smallholders with trees for timber or fuelwood (%)
Ethiopia	37.9	17.1	32.2	3.5
Malawi	23.4	23.3	—	0.2
Nigeria	16.1	5.5	14.2	—
Tanzania	54.2	45.2	22.6	18.2
Uganda	30.4	5.6	27.2	2.5
Overall average	33.1	20.0	20.0	5.1

Source: Calculations from LSMS-ISA data sets.
Note: All descriptive statistics corrected by sampling weight; — = not available.

of the landholders having at least one plot with fruit trees. Trees for timber and fuelwood were reported among 18 percent of smallholders in Tanzania, but very little elsewhere. In contrast, in Ethiopia, less than 4 percent of small-holders report having trees for timber and fuelwood (likely an underestimate, given that eucalyptus trees were not properly captured in the questionnaires). But Ethiopia has the highest proportion of farms with tree cash crops (32 percent), especially coffee. Uganda follows a similar pattern to that of Ethiopia, with tree cash crops being the most common type of tree found on farms (27 percent). In Malawi, fruit trees are the most common trees (found on 23 percent of plots).

The Contribution of Trees on Farms to Rural Livelihoods Is Not Negligible

Trees can perform multiple functions (for example, production, intercropping, and gardens, among others), which turn them into a valuable asset within the productive structure of farms (Dewees 1995; Place and Garrity 2015). Figure 13.1 shows the main uses for the products harvested from trees on farms. Most of the products (fruits and tree cash crops) are sold, although in Ethiopia and Uganda, a sizable share of the fruit is also directly consumed on the farm. In Ethiopia, the same holds for tree cash crops. Trees also contribute importantly to gross annual household income (17 percent on average among tree-growing households, and 6 percent of gross annual household income among all rural households). Among tree growers, 14 percent of annual gross income comes from cash crops, but a nonnegligible 5 percent also comes from fruit trees. The latter only stands to increase, as Africa's emerging urban middle class continues to expand.

Trees on farms can also have very important nonproductive uses, such as soil conservation, nitrogen fixing, water regulation, and carbon sequestration (Booth and Wickens 1988; Nair 2007; Place and Garrity 2015). The presence of trees can therefore have indirect (beneficial) effects on farm output—be it crops or livestock. It is very difficult to account for such impacts (Wunder, Angelsen, and

Figure 13.1 A Larger Share of the Tree Products Tends to Be Sold

a. Ethiopia

b. Malawi

c. Nigeria

d. Uganda

■ Sold   ■ Self-consumption   ■ Other uses
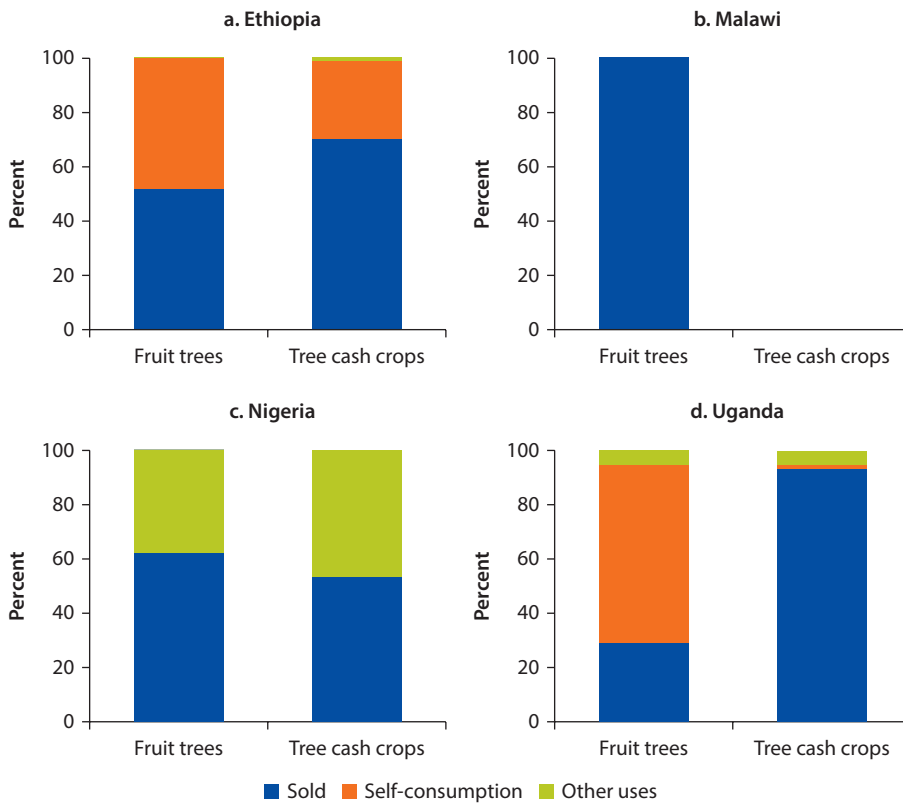
Source: Computations based on LSMS-ISA data.
Note: The graphs show whether different categories of trees on farms were sold, used for self-consumption, or put to other uses. Information on the main uses for Tanzania is not gathered for trees. All statistics were corrected by sampling weights.

Belcher 2014), and information on them was not directly collected by the LSMS-ISA surveys. As an indirect measure, welfare levels among tree-growing households were compared with those among non-tree-growing households. The former were on average substantially better off than the latter in most of the study countries. For instance, real consumption per capita among tree cash crop growers was on average 84 percent higher in Ethiopia, 19 percent in Nigeria, and 3 percent in Tanzania, although no difference was discerned in Uganda. Fruit tree growers were also better off in three of the five countries (Ethiopia, Nigeria, and Uganda). Therefore, looking only at direct income contributions is bound to underestimate the contribution of trees on farms to household welfare.

Drivers of On-Farm Tree Growing

Using multivariate analysis, the correlates of on-farm tree growing are further explored. The analysis shows that the adoption of and land allocation to trees on farms are highly influenced by national policies and institutions. Together, they account for more than 40 percent of the explained variation in the models.

Proximity to forests is also an important predictor of on-farm tree presence. Beyond these broader policy and agroecological factors, household characteristics also play a role. Households with more land, for example, tend to allocate more of their land to trees (cash crop and fruit trees). This is consistent with the land-intensive nature of tree growing. Female-headed households tend to be less engaged in tree growing, with the effect being largest for tree cash crops. This is possibly linked to higher land tenure insecurity for female farmers and is consistent with the higher nutritional value of fruit trees. These findings provide first entry points for policy makers to investigate in designing interventions to foster on-farm tree growing.

The Implications

The main message from the study is that trees on farms in Sub-Saharan Africa are typically more widespread and important than was previously thought. They provide a significant source of income for many households across the continent. With data limitations preventing a proper accounting of the indirect effects of trees on farms to livelihoods—such as erosion control, climate regulation, and soil enrichment—they are likely even more important than the numbers presented here suggest.

The implication is that governments and others should raise the profile of trees as an important crop in debates concerning agriculture, food security, and poverty reduction policy in Sub-Saharan Africa. The occurrence of trees does not stop at the border of the forest. Trees on farms should be an integral part of landscape planning, given their relative resilience in the face of more intense and frequent climate stressors. Critically, realizing the full benefits that trees on farms can bring requires a supportive policy environment.

Overall, the analysis and database provide a baseline for future benchmarking, as well as the building blocks for improving the information base on Africa's privately owned tree coverage.

Additional Reading

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CHAPTER 14

Coping with Shocks: The Realities of African Life

Zlatko Nikoloski, Luc Christiaensen, and Ruth Hill

Overview

Common wisdom: *Drought is the dominant shock that households face in Sub-Saharan Africa, and effective coping strategies remain wanting.*

Findings:

The shocks:
- *More than 60 percent of households report sudden losses in income and assets.*
- *Weather shocks are very common, but price risk is just as prevalent. Death and illness were also frequently reported.*
- *Health and weather shocks are often repeatedly experienced by the same household. Price risk is by far the most commonly reported covariate shock, much more so than weather shocks.*
- *Risk is higher in rural areas, particularly risks to income. Rural households are more susceptible to income shocks because agriculture is a risky business.*
- *Female-headed households are less susceptible to agricultural price risk, but more susceptible to food price risk.*

The coping mechanisms:
- *Many households have no means to cope with shocks.*
- *Savings are the most widely used coping mechanism, but have a more limited role for poor and rural households, which as a result rely more on their assets.*
- *Increasing work (sometimes involving migration) is a common coping strategy in rural areas.*
- *Government assistance is limited. Social assistance is most often informal and is the most prevalent coping mechanism among households headed by women.*

Policy messages:

- *Reducing the risk associated with agricultural livelihoods is an important part of reducing volatility for households in Africa. This can be done by increasing access to irrigation and drought-tolerant crops and by improving the integration of domestic crop markets.*
- *Strengthening financial markets to provide financial products as buffers in periods of distress should be part of the development strategy, especially for rural areas.*
- *Improving and strengthening national social protection systems as well as formalizing social transfers would also help the most vulnerable in smoothing the impact of risk.*

The Issue: Is Drought the Only or Main Risk?

Everyday life in Sub-Saharan Africa carries considerable risk, which often is linked to extreme weather, such as drought. *World Development Report 2014: Risk and Opportunity* documented that more people have died in Sub-Saharan Africa from drought than any other natural hazard (World Bank 2014). But households also face price shocks—increases in food prices or input prices, or falls in output prices. Illness or death in the household is also frequently reported by rich and poor households alike. And Africa is changing. Climatic conditions are changing, and so too are markets, asset holdings, and livelihoods.

In dealing with shocks, households commonly rely on informal transfers, reductions in household expenditures, and even asset sales. These mechanisms can be ineffective, especially in dealing with shocks that affect many in the community (asset prices may collapse, and neighbors may no longer be able to help out), and costly. Asset sales, for example, can lead to lower human capital accumulation and curtail the household's ability to generate adequate income for a long time after the shock. Other coping mechanisms include drawing on savings, increasing family labor supply, and accessing formal safety nets. This chapter addresses the question: is drought indeed still the dominant risk faced by households, and how do households cope with shocks today?

The Analysis: What Do People Say?

The Data
The study draws on the World Bank's Living Standards Measurement Study–Integrated Surveys on Agriculture, which have been fielded in six Sub-Saharan African countries: Uganda, Ethiopia, Nigeria, Niger, Malawi, and Tanzania. These are standard household surveys that include modules on the shocks experienced, negative consequences of the shocks (loss of assets, income, food production, and food stocks), as well as the coping mechanisms that households adopt in the wake of an income shock. Most of the surveys are available for one year (one wave or round) only. For some countries (Uganda and Nigeria), the study was able to utilize pooled data across years.

Although the surveys are meant to be comparable across countries, there are some notable differences in how data on shocks are collected, and these need to be

recognized in the analysis. First, *the differences in recall period* have a bearing on the number of shocks reported by the surveyed households. In four of the surveyed countries, where the recall period is 12 months (Uganda, Niger, Malawi, and Ethiopia), the number of shocks experienced by the affected households ranges from two to eight. In Tanzania and Nigeria, where the recall period is five years, the number of shocks goes up to 14 and 15 (respectively).

Second, *the way the shock question is asked* has a bearing on how the affected households respond. In Ethiopia, Malawi, Niger, and Tanzania (where the survey asked households whether they have been negatively affected by a shock), there is a greater similarity in the prevalence of crop diseases, output price falls, input price rises, livestock diseases, and illnesses, compared with Nigeria and Uganda, where the survey only asked whether the household experienced a shock episode. Clearly, survey design makes a difference. Unlike the data on shocks, there is much greater uniformity in reported coping mechanisms across countries.

The Approach
The study grouped shocks and coping mechanisms into a few broadly comparable categories.

The Shocks Households Face
- Weather risks: drought, floods, landslides, heavy rains, and severe water shortage
- Crop disease and damage
- Price shocks: falls in output prices and increases in input and food prices
- Livestock disease
- Business and employment shocks
- Theft
- Death or illness: of an income earner or another member of the household
- Conflict and other shocks

The Ways Households Cope with Shocks
- Dissaving and borrowing
- Working more (including migration of selected household members)
- Receiving assistance from friends and family
- Receiving assistance from the government and nongovernmental organizations (NGOs)
- Selling productive assets
- Reducing overall consumption
- Utilizing other coping mechanisms
- Doing nothing

In analyzing these events, the study describes them and uses regression analysis to identify the factors associated with them, other factors held constant (box 14.1). All the data that are used are self-reported; therefore, the data carry the biases associated with such self-reporting. In the case of self-reports of

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Box 14.1 Gaining Insights from Regression Analysis

The study uses multivariate regression to investigate several issues.

Identifying Factors Associated with the Occurrence of a Shock and the Related Coping Strategy

The study takes two approaches to identify systematic patterns in the incidence of shocks. First, it simply examines the frequency of reported shocks, opting to focus on *relative frequencies*, in which the occurrence of one type of shock is expressed in relation to another. This helps control for differences in recall period. Second, the study explores the conditional correlation between shocks and household types, using regression techniques (after Heltberg, Oviedo, and Talukdar 2013). It uses ordinary least squares to explore the relationship between a dummy that captures the occurrence of a particular shock experienced by the households and a battery of household and household-head characteristics (the consumption quintile of the household, the rural/urban divide of households, households that are headed by women, and households whose head is employed in agriculture). Regressions are run on the entire sample of survey respondents in each country and, where applicable, on pooled data across years (Uganda and Nigeria). The same two approaches are used to assess the frequency and conditional correlation of coping strategies.

Identifying Whether Shocks Recur

The literature on the impact of shocks on welfare suggests that crises are more crippling when they follow in quick succession. To test whether shocks are likely to be repeated for the same household, the study uses regression techniques with dummy variables to represent the occurrence of a shock. The analysis regresses the shock dummies on their lagged terms (for Uganda and Nigeria, where panel data are available).

Identifying How Widespread Shocks Are in a Given Community

The literature also suggests that shocks can be more challenging to manage the more covariate they are. When a shock hits all households in a community, it is often not possible to rely on family and friends to help, as all have been equally hit. The analysis regresses the occurrence of a shock on a set of dummy variables capturing the survey clusters. The R^2 of the regression provides a measure of how covariate the shock is, that is, how widely it is experienced by the households in each cluster.

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ill-health, the literature has shown that these biases can be quite large, with poor households significantly underreporting ill health when longer recall periods are used (Das, Hammer, and Sánchez-Paramo 2012).

The Results: Shocks Are Many and Come in Many Ways

The Risks Households Face

Sudden losses in income and assets were reported by the majority of the households surveyed. Over 60 percent of the households in all the countries reported a drop

Figure 14.1 Most Households Report Sudden Losses in Income and Assets
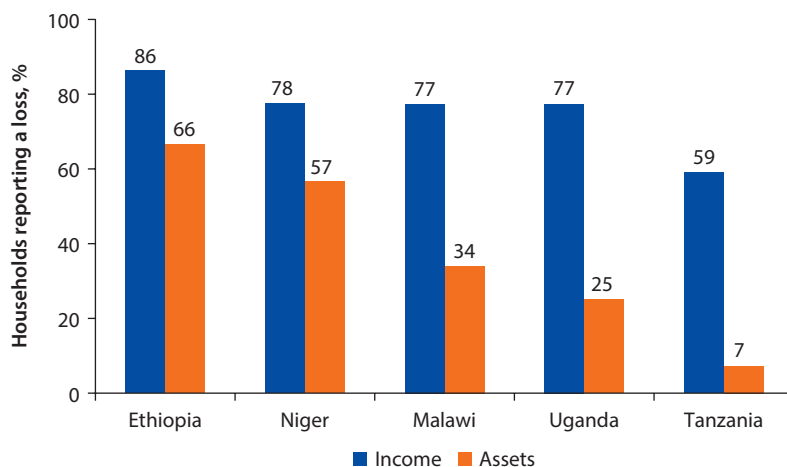
in income as the result of a shock (figure 14.1). Reported asset losses were less common (although important in Ethiopia and Niger).

Weather shocks are very common, but price risk is just as damaging. For example, increases in food prices are more prevalent than weather shocks in Ethiopia (1.2 times), Niger (1.3 times), and Tanzania (1.02 times). In Nigeria, sudden falls in the prices of the crops were also much more frequent than weather shocks (1.6 times), although sudden increases in the price of food were much less prevalent (also in Malawi).

Death and illness were also frequently reported. In most countries, serious illnesses affected just under 30 percent of the households affected by weather shocks (although as high as 67 percent in Ethiopia). Death affected one-tenth to one-third of the number of families affected by weather shocks. Death was particularly frequently reported in Tanzania and, to some extent, Nigeria, both of which use a five-year recall period in the questionnaire. The data do not capture the magnitude of the impact of the shock, but other work highlights the catastrophic impact of severe ill-health. In a study of rural Kenya and Madagascar, Barrett et al. (2006) find, for example, that every poor household that was interviewed could ultimately trace its poverty to ill health or an unexpected loss of assets.

Other shocks occur, but less often. The relative frequency of business and employment shocks is very low across countries, except in Nigeria. Thefts and other loss-of-asset shocks tend to follow the same pattern, and seem to be particularly prevalent in the Nigerian sample. Finally, conflict shocks are the least prevalent (relative to weather shocks). However, the countries in the sample are not conflict-affected states.

Multiple shocks are reported more often than single shocks. Every shock module in each of the countries in the sample contains questions on the number of shocks experienced by the surveyed households. In most countries, the households are more likely to report experiencing multiple shocks rather than a single shock.

This in part reflects the multifaceted nature of shocks. For example, a weather shock can cause producer prices to rise, resulting in a food price shock, and a weather shock can cause ill health as a result of lack of clean water or reduced food consumption.

Health and weather shocks are often repeatedly experienced by the same household. In Uganda, households affected by disease (human, livestock, or crop) in one year are much more likely to experience poor health in the following year, suggesting this is a shock that lasts for more than one year. Weather shocks are also more likely in a subsequent year for those already affected by a weather shock, suggesting that households that experience drought may do so not because the weather is particularly bad one year, but because they live in marginal agroclimatic zones and are likely to experience water shortages in many years. It is evident that very different policy responses are required. Similar findings emerge for Nigeria.

Price shocks hit all households in a community at once, much more so than weather shocks do. The study regresses the occurrence of a shock on a set of dummy variables capturing the survey clusters. The R^2 of the regression (a measure of how widely the shock is experienced) is highest for input price rises, output price falls, and food price rises, showing that these are the shocks that are most covariate. The R^2 is also fairly large for weather shocks and crop disease (the latter is particularly high in the cases of Uganda and Tanzania). Conflict seems to be mostly covariate in nature in Ethiopia (compared with the other countries). Illness, theft, death, and business or employment shocks are mostly idiosyncratic in nature, with very little of the variation explained by cluster dummies, as expected.

Shocks are more frequently reported in rural areas. Figure 14.2 compares the shocks reported by urban and rural households. The bars represent the share of

Figure 14.2 Shocks Are More Frequent in Rural Areas
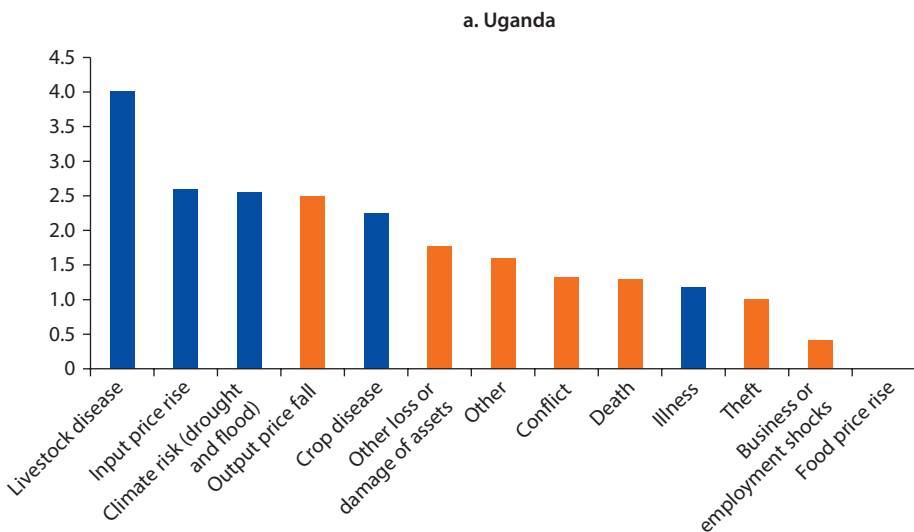
a. Uganda

figure continues next page

Figure 14.2 Shocks Are More Frequent in Rural Areas *(continued)*

b. Ethiopia

c. Niger

figure continues next page

Figure 14.2 Shocks Are More Frequent in Rural Areas *(continued)*
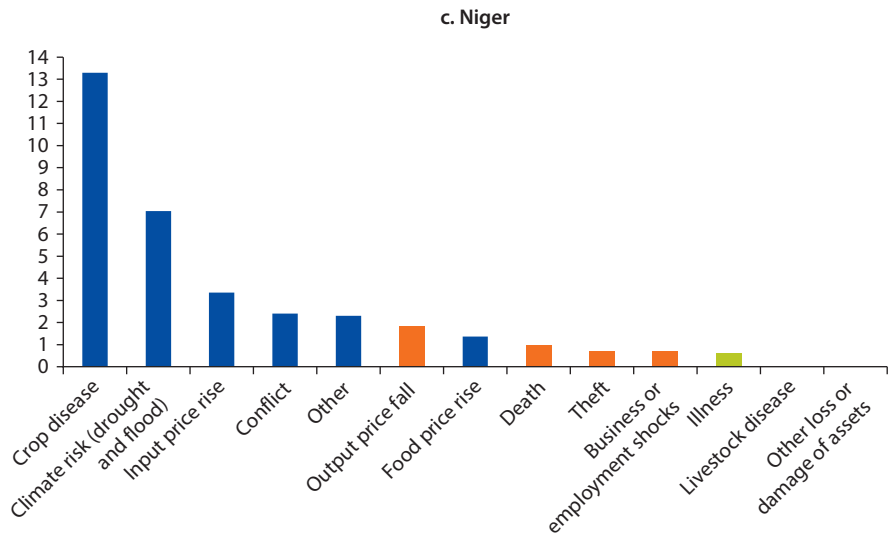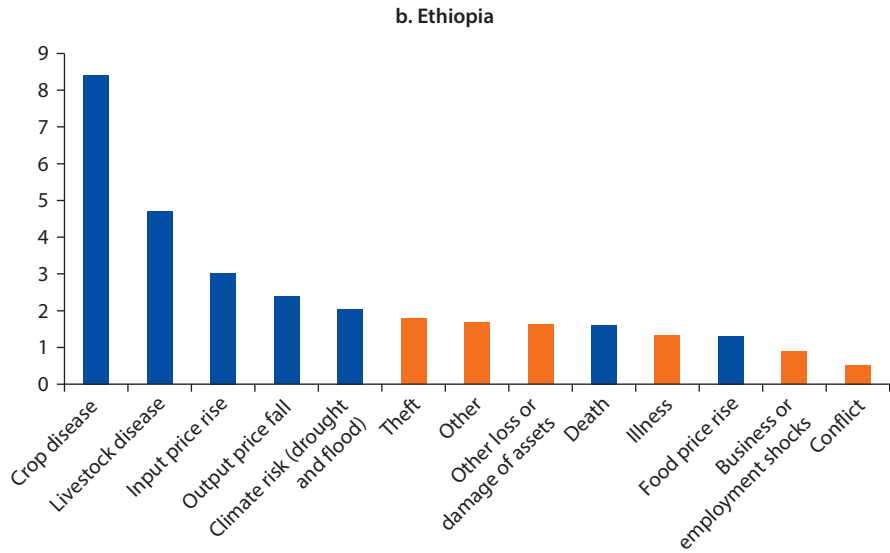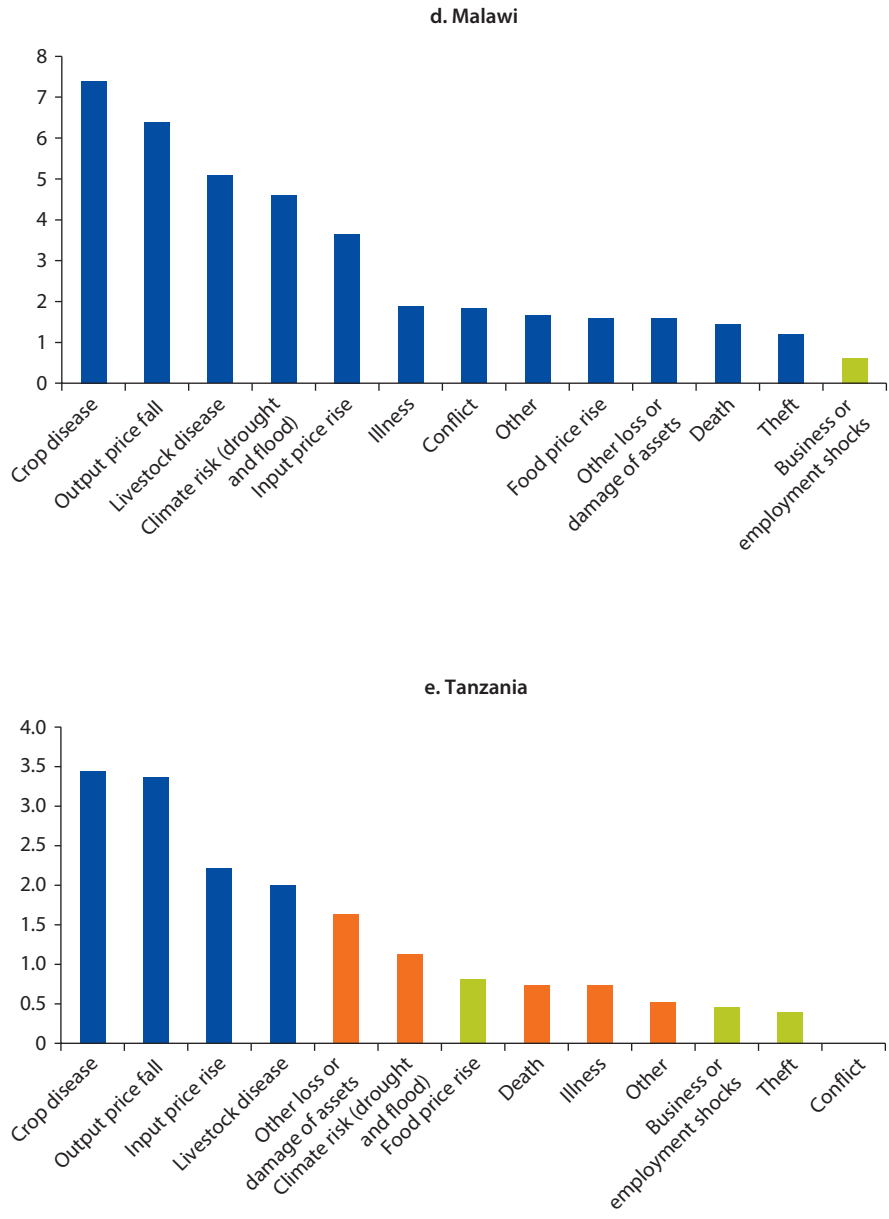
d. Malawi

e. Tanzania

figure continues next page

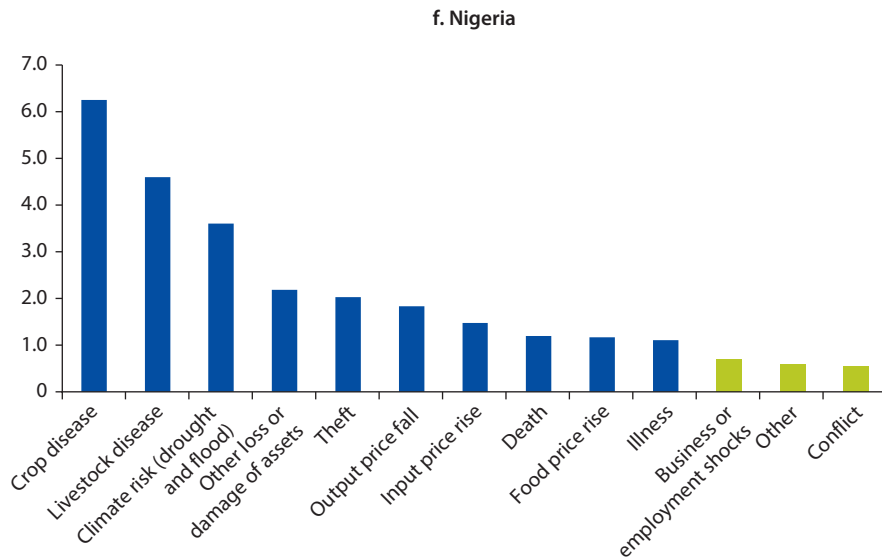**Figure 14.2   Shocks Are More Frequent in Rural Areas** *(continued)*

f. Nigeria

Source: Computations based on LSMS-ISA data.
Note: The graphs depict the ratio of the percentage of rural households that have experienced shocks to the percentage of urban households that have experienced shocks. Blue bars denote that the ratio is significantly higher than 1; green bars denote that the ratio is significantly lower than 1; orange bars denote no significant difference between rural and urban areas.

rural households experiencing the shock relative to urban households. Blue bars indicate that rural households report the shock significantly more often than urban households do. Green bars indicate that rural households report the shock significantly less often than urban households do. For almost all the countries and shock categories, the prevalence of shocks is higher among rural households, even when controlling for other factors through multiple regression. This analysis does not capture the impact of these shocks, so it does not provide information on whether shocks experienced by rural households have a larger or smaller effect on welfare than shocks experienced by urban households.

Rural households are more susceptible to income shocks, because agriculture is a risky business. Reliance on agricultural income in rural areas results in high levels of risk to rural incomes. This vulnerability comes not only from weather risk but also from price risk. Reducing the volatility of crop income is essential. This can, for example, be achieved through increased irrigation, the use of drought-resistant varieties, and addressing price risk through better-functioning markets. But for many households, it may be the case that increasing income stability will entail a move out of agriculture.

Business- and employment-related shocks are more prevalent among urban households. Across all the countries in the sample, the prevalence of business and employment shocks is higher among urban than rural households.

Theft is as often a feature of the rural landscape as the urban landscape. Theft is often thought to be an urban problem, associated with the weaker social ties that are present in urban communities. However, this is not the case. In three countries,

theft is more frequent in rural areas; in the other three, it is more frequent in urban areas. But, in all cases, the differences are small and disappear when other variables are included in the regression analysis.[1]

Wealth reduces and changes the nature of income risk. Although shocks are in general less prevalent among rich households, death and illness affect all households equally. Rich households suffer more from theft and employment and business shocks. This is also true when controlling (in regression analysis) for other characteristics of the household.

Death is more prevalent among households headed by women. This finding highlights the fact that female-headship is often synonymous with widowhood and the loss of a male head. Death is 1.5 to 2 times more prevalent among female-headed households compared with male-headed households across all the countries. Regression analysis shows this to be a significant difference for all countries.

Female-headed households report fewer output price falls but more food price increases as shocks. This finding may indicate that female-headed households farm less commercially than male-headed households do, and thus female-headed households experience fewer input and output price shocks.

How Households Cope with the Shocks They Experience

Many households do not cope with shocks. Half of all the households in Malawi report doing nothing in the face of a shock, as do a quarter of the households in Niger and Nigeria. In Ethiopia, it is just 14 percent. It is not clear whether households do nothing because their welfare was unaffected by the event or they were unable to cope.

Savings are the most widely used coping mechanism, but have a more limited role for poor and rural households. For those households that are able to undertake strategies to cope with a shock, relying on own savings and access to credit or borrowing are the most commonly reported coping strategies undertaken. Almost a quarter of the households resorted to using this type of coping mechanism (the percentage is low only in Nigeria). The vast majority of these households rely on savings, not credit or borrowing. Households in the top 60 percent can use financial markets to manage risk, and risk has less of an impact on income and assets for these households. Financial markets are less effective for rural households regardless of poverty status, resulting in many rural households using assets to manage risk.

Increasing work (sometimes with migration) is a common coping strategy for poor households in rural areas. In Niger, for instance, poor households were three times more likely to migrate for work as a coping strategy, compared with non-poor households. In Malawi and Uganda, poor households are also more likely to report working more to cope with a shock. This finding broadly holds when controlling for different types of shock.

Social assistance is most often informal, with very limited government assistance reported across the continent. The help that is provided to households that have experienced a shock is nearly always in the form of informal transfers from family and friends, rather than from governments or NGOs. The only country in which assistance from the government was more common than assistance from

family and friends is Ethiopia. Ethiopia is also the one country in the sample that has instituted a large safety net program that can increase the support provided to households that have experienced shocks. In every country except Nigeria, households in the bottom 40 percent were more likely to receive informal assistance than households in the top 60 percent.

Informal assistance is the most prevalent coping mechanism among households headed by women. Assistance from friends and family is almost two times more prevalent among households headed by women in Uganda and Ethiopia, and over two times more prevalent among female-headed households in Malawi. In Nigeria and Niger, relying on assistance from friends and family is 1.6 times more prevalent among households headed by women. This is also true when controlling for other household characteristics.

Government assistance is poorly targeted to poor households. When it is in place, government assistance is just as likely to target households in the top 60 percent as in the bottom 40 percent. There is no significant difference in Malawi, Niger, and Nigeria. In Ethiopia, households in the top 60 percent are more likely to receive support; in Uganda, households in the bottom 40 percent are more likely to receive support.

The Implications

This empirical review confirms the common perception that households face considerable risk in Africa. However, contrary to the common perception, it has been price shocks—sudden food price increases and sudden crop price reductions—not weather shocks, that have been the most frequent in recent years.

The study also finds that private savings and additional work are the most common means that households use to cope with shocks. Poor households are less able to use savings than richer households. Yet, government support is limited, despite growing attention to social safety nets (Honorati, Gentilini, and Yemtsov 2015) and poorly targeted to poor households.

Overall, better risk management has to be part and parcel of any development strategy to help households manage these shocks. The study findings suggest the following:

- Reducing the risks associated with agricultural income and helping households transition into less risky livelihoods are essential for establishing more stable income for households in Africa.
- Reducing risk in agriculture requires addressing market risk in addition to climate risk and crop disease.
- Strengthening the financial markets in many Sub-Saharan African settings could go a long way, by improving the use of financial products as buffers in periods of economic distress. This is especially important for poor households and in rural areas, where relying on the sales of assets represents the main coping mechanism.

- Improving and strengthening the national social protection systems as well as formalizing social transfers could also help the most vulnerable in smoothing the impact of risks.
- More could be done to improve data for further policy research—such as adopting uniform recall periods and categories of shocks and coping mechanisms.

Note

1. The exception is that in Tanzania theft is significantly more prevalent in urban areas; in Malawi, theft is reported significantly more often in rural areas.

Additional Reading

This chapter draws on:

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Das, Jishnu, Jeffrey Hammer, and Carolina Sánchez-Paramo. 2012. "The Impact of Recall Periods on Reported Morbidity and Health Seeking Behavior." *Journal of Development Economics* 98: 76–88.

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World Bank. 2014. *World Development Report 2014: Risk and Opportunity*. Washington, DC: World Bank.

———. 2017. *Accelerating Poverty Reduction in Africa*. Forthcoming Regional Report. World Bank, Washington, DC.

Remoteness and Maize Price Volatility in Burkina Faso

Moctar Ndiaye, Elodie Maître d'Hôtel, and Tristan Le Cotty

Overview

Common wisdom: *Price volatility in Africa arises mainly from international markets.*

Findings:

- *Markets located far from the major urban centers (Ouagadougou, Bobo-Dioulasso, or Koudougou) register the highest levels of price volatility. This result is robust to alternative measures of remoteness.*
- *Maize surplus markets and markets bordering Côte d'Ivoire, Togo, and Ghana have experienced more volatile prices than maize-deficit and nonbordering markets have.*
- *There is evidence of seasonal patterns in maize price volatility across Burkinabe markets. Maize price volatility is greater at the harvest season around October to December and in the lean period (June to September).*
- *External factors, such as exchange rates and international maize prices, do not seem to influence maize price volatility, running counter to conventional wisdom.*

Policy message: *Maize price volatility is greatest in remote markets. Given poor road quality and low storage capacity, these markets have limited capacity to access demand from urban markets. Enhanced road infrastructure would strengthen the links between rural and urban markets, thereby smoothing maize price volatility.*

The Issue: Does Remoteness Imply Greater Maize Price Volatility?

Burkina Faso is a landlocked and agriculture-dependent economy, with limited transportation infrastructure. As a result, transport costs (TCs) are high, which hampers farmers' participation in markets. Distance and a lack of appropriate

infrastructure reduce rural smallholders' ability to sell their goods on the markets, while traders from urban areas are discouraged from purchasing food items directly from rural farmers located in remote areas. Both (supply and demand) forces may combine to increase price volatility. So far, surprisingly few studies have theoretically or empirically explored this issue. Building on the literature, the distance to major cities (expressed in kilometers and hours) and road quality are used here as proxies for TCs between markets.

The study examines the effect of market remoteness on maize price volatility in Burkina Faso. Maize is widely consumed throughout the country. The production of maize has significantly increased recently, rising at a faster pace than sorghum, millet, and rice. Almost 15 percent of maize production is marketed, with an annual per capita average consumption of approximately 108 kilograms per capita per year. Although most of millet and sorghum production tends to be consumed by farmers, maize is mostly sold on markets. Thus, maize is one of the main sources of agricultural income in Burkina Faso, ranking second after cotton. As volatility may hinder investment in agricultural production, understanding the determinants of maize price volatility is of strategic importance in Burkina Faso, for food security as well as for rural development more broadly. Map 15.1 shows how the various maize markets are distributed geographically,

Map 15.1 Location of Maize Markets
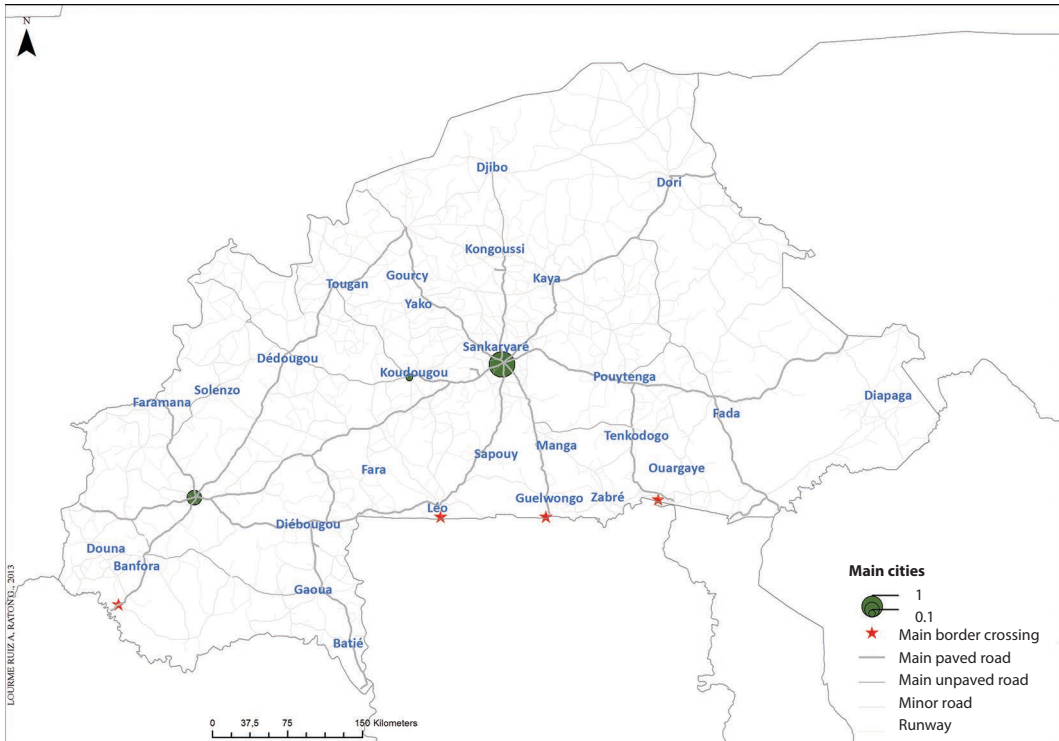
Note: The green dots indicate the main cities.

in relation to the major urban centers—namely, Ouagadougou, Bobo-Dioulasso, and Koudougou—and the border-crossing points for maize trade.

Burkina Faso is an interesting and informative country to study because of the nature of its maize market. Maize production is mostly located in the western and southern parts of the country (such as Fara, Faramana, and Solenzo), where pedo-climatic conditions are more favorable. Maize is mainly traded within the country, flowing from maize-surplus to maize-deficit regions. Depending on the level of national production, small amounts of maize exports can be recorded toward Niger and Mali, and even smaller amounts can be imported from Côte d'Ivoire, Ghana, and Togo.

The Analysis: Understanding the Links between Remoteness and Price Volatility

There are two major components to the analysis. The first is the theory—how might remoteness in principle have an effect on price volatility? The second is empirical—estimating the relationship between remoteness and maize price volatility in Burkina Faso.

The Theory

The study simplifies matters by considering two markets: an urban market, which is the predominant consumer (rather than producer) of maize, and a rural market, which is the principal supplier of maize. A trade model between a rural area and an urban area is used to show that TCs increase volatility in the rural market when the volatility is due to local supply or demand shocks in the rural area. The study then analyzes the role of TCs on the properties of an unexpected price shift occurring in a rural area (resulting from an unexpected supply shock). The analysis extrapolates the outcome to the relation between TCs and a succession of unexpected price shocks that produce price volatility. Excess demand for maize will characterize the urban market, and excess supply the rural market. In equilibrium, the excess supply in the rural market should equal the excess demand in the urban market. The existence of TCs between these markets will imply a gap in market-clearing prices, equivalent to the TCs per unit. Using this simplified specification of the real world, the study shows that:

- An increase in maize production in the rural area (such as a good harvest season) will reduce the maize price in both markets.
- The higher are the TCs between the rural market and the urban market, the lower is the price in the rural market.
- In general, farmers with no liquidity and no carryover sell more in the first month after the harvest, a bit less in the second month, and so forth. Thus, sales decrease with time, which induces an increasing trend in prices from the harvest to the lean season. Prices are lower in the harvest season, characterized by the abundance of products on the market, and higher in the lean season, featuring product scarcity.

• A positive supply shock generates an unexpected local price decrease, especially because TCs are high. Negative supply shocks generate an unexpected local price increase, especially because TCs are high. Thus, successive unexpected shocks produce a series of unexpected price shifts, which fuel rural price volatility. The magnitude of this volatility increases with TCs between this market and the related urban center.

The Empirical Estimation

The analysis relies on historical price data collected by the National Society for the Management of Food Stocks (Société Nationale de Gestion du Stock Alimentaire), which has managed its own market information system since 1992. The prices of the main agricultural commodities are collected weekly in 48 markets, and price averages are computed monthly. The study analyzes 28 markets with available data from July 2004 to November 2013. It sets aside markets where there are discontinuities in the price series. For each market, monthly maize prices are expressed in Communauté Financière d'Afrique francs per kilogram, and then deflated by the Burkinabe Consumer Price Index (2008 = 100), which is calculated monthly by the National Institute of Statistics and Demography (Institut National des Statistiques et de la Démographie).

• The methodology relies on an autoregressive conditional heteroskedasticity (ARCH) model to investigate the determinants of spatial price volatility (box 15.1).
• Spatial price volatility across markets is examined through time distance to major cities and maize border-crossing points, and considering that the market is in a deficit or surplus production area.

Box 15.1 Applying ARCH Models to Maize Price Series in Burkina Faso

ARCH Models

The autoregressive conditional heteroskedasticity (ARCH) model (after Engel 1982) assumes that the conditional variance depends on the lagged squared residuals of a price series over time. By including variables as regressors, the model can be used to identify potential determinants of the price level and volatility. The ARCH structure is given by:

$$Y_t = X_t \beta + \varepsilon_t \tag{B15.1.1}$$

with

$$\varepsilon_t | \Omega_{t-1} \sim N(0, h_t) \tag{B15.1.2}$$

$$h_t = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + v_t \, ; v_t \sim N(0, \sigma) \tag{B15.1.3}$$

box continues next page

Box 15.1 Applying ARCH Models to Maize Price Series in Burkina Faso *(continued)*

where Y_t is the dependent variable; X_t denotes the vector of explanatory variables; ε_t is the error component; h_t is the time-varying variance of the error; Ω_{t-1} is the information set available at $t-1$; and β, α_i, and ω are parameters. In the ARCH model, only recent errors have an impact on the time-varying variance. Equation B15.1.1 gives the conditional mean; equation B15.1.3 describes the evolution of the conditional variance. These equations are adapted to investigate the determinants of maize price volatility in Burkina Faso.

Model Specification

The study involves a two-step empirical approach. First, 28 maize markets are pooled to estimate the average effect of market remoteness (that is, transport cost and time distance between market *i* from Ouagadougou, Bobo-Dioulasso, and Koudougou (the major consumption centers) on the price level (equation B15.1.4). Second, the average effect on price volatility is estimated (equation B15.1.5):

$$lnP_{it} = \beta_0 + \beta_1 lnP_{it-1} + \beta_2 lnIP_t + \beta_3 lnER_t + \beta_4 lnBorder_i + \beta_5 lnTC_i$$

$$+ \beta_6 Surplus_i + \beta_7 Trend_t + \beta_8 Harvest_t + \beta_9 Lean_t + \sum_{j=1}^{28} \mho_j M_j \qquad \text{(B15.1.4)}$$

$$+ \varepsilon_{it}\,;\, \varepsilon_{it} \sim N(0, h_t)$$

$$h_{it} = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 lnP_{it-1} + \alpha_3 lnIP_t + \alpha_4 lnER_t + \alpha_5 lnBorder_i + \alpha_6 lnTC_i$$

$$+ \alpha_7 Surplus_i + \alpha_8 Trend_t + \alpha_9 Harvest_t + \alpha_{10} Learn_t + \sum_{j=1}^{28} \phi_j M_j + \upsilon_{it}\,; \qquad \text{(B15.1.5)}$$

$$\upsilon_{it} \sim N(0, \sigma)$$

Explanatory variables have been introduced in both the mean and variance equations. *Ln* P_{it} and *Ln* P_{it-1} are the natural logarithms of real maize price in market *i* at months *t* and *t–1*, respectively. *Trend*, *ER*, and *IP* represent the monthly trend, nominal exchange rate, and real international maize price, respectively. *Harvest* is a seasonal dummy variable that indicates the harvest time (October to December); *Lean* is a dummy variable that indicates the harvest season (June to September); M_j denotes the maize market dummy variables; and ε_{it} is the heteroscedastic error term. *Border* is the travel time between market *i* and the nearest cross-border maize point with Ghana, Côte d'Ivoire, or Togo. Transport cost is captured through three measures: time distance, kilometer distance, and road quality (whether the road is paved). *Surplus* is a dummy variable that indicates whether the market is in a surplus production area (= 1 for maize-surplus areas).

Predicted Effects

The estimated coefficient β_5 tests whether mean prices are different between remote markets and markets close to the main urban centers, and α_6 tests to what extent maize price series in remote markets are more volatile. Given the theory, maize prices are expected to be lower in remote markets ($\beta_5 < 0$), and theory would also suggest $\alpha_6 > 0$, that is, remote markets exhibit greater maize price volatility than markets located close to main consumption centers.

- The robustness of the results is assessed in three ways. First, alternative measures of market remoteness are used; second, the same analysis is carried out using nominal prices; and third, an alternative (generalized ARCH) estimator is used.

The Results: Remoteness Affects Price Volatility

Domestic prices in Burkina Faso are essentially disconnected from international prices. The Johansen cointegration test is used to determine whether international and domestic maize price series are cointegrated, meaning that there is a long-run relationship between the two variables. The results reject the null equation of cointegration between domestic and international maize prices in Burkina Faso. The explanation for the low transmission of international maize price variations to domestic markets in Burkina Faso may be related to poor regional integration, low import dependence (less than 1 percent of domestic production), and the existence of maize substitutes among the other cereals produced in the country.

Clearly, remoteness is an important factor. Map 15.2 presents the level of maize price volatility in each of the 28 Burkinabe markets over 2004–13. The map suggests that there are spatial differences in maize price volatility across markets.

Map 15.2 Spatial Volatility of the Price of Maize in Burkina Faso, 2004–13
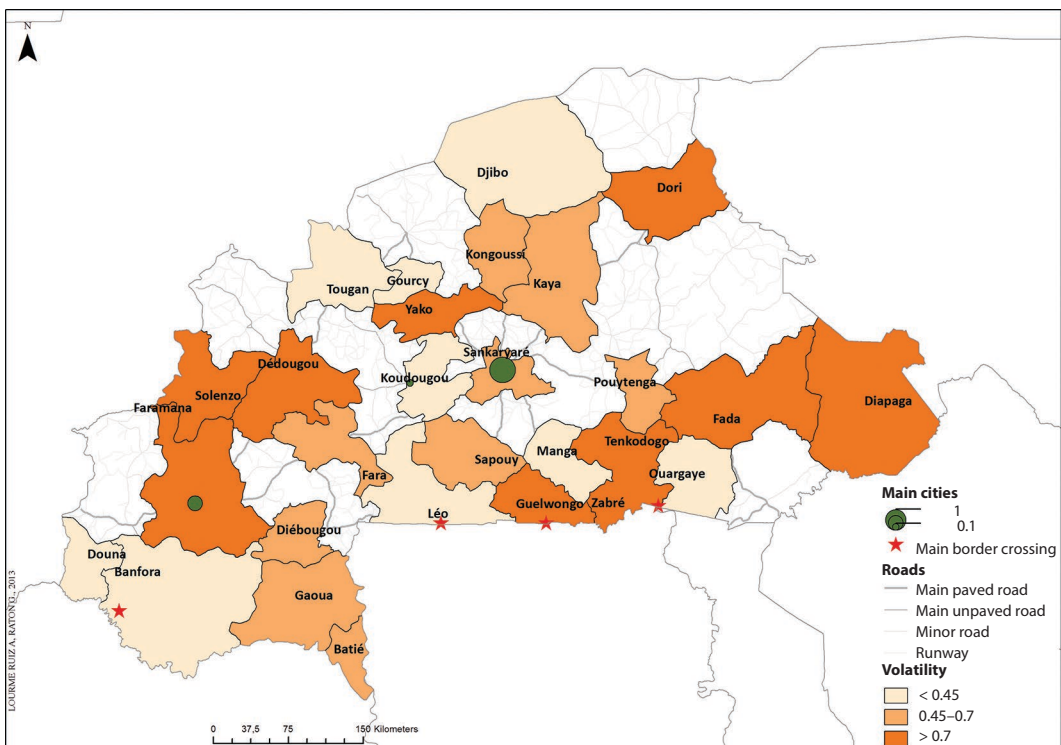
Markets located far from the closest urban center—Ouagadougou, Bobo-Dioulasso, or Koudougou—register the highest levels of price volatility. Markets close to the main cities, where quality road infrastructure is available, display less volatile price series. Markets that are located in maize-surplus regions and close to maize border-crossing points show more volatile prices than maize-deficit and nonbordering markets. The empirical challenge is to assess whether remoteness influences maize price volatility when all other factors are taken into account.

Several factors influence average prices. There is a strong autocorrelation in the monthly price series. On average, a 1 percent increase in the maize price in a market leads to a 0.9 percent increase in price the following month. The results also confirm a seasonal pattern in average maize prices—these being low during the harvest time and high during the lean season. There is no significant effect of the exchange rate and international maize prices on price levels in Burkina Faso, suggesting that such external factors are less important: maize prices are driven by domestic factors. Geographic location has a statistically significant (at the 5 percent level) effect on the domestic maize price level. For example, prices in maize-surplus markets are on average 9 percent lower than those prevailing in maize-deficit markets.

Several factors influence price volatility. Estimates from the variance equation confirm that the ARCH model is an appropriate empirical specification, which indicates that greater values of recent shocks produce higher present volatility. This result is statistically significant at the 1 percent level. Maize prices tend to be *more* volatile in:

- Maize-surplus markets, mainly because maize-deficit and -surplus markets are not well integrated.
- Remote markets, which tend to exhibit higher price volatility. Market isolation results in more volatile maize prices.
- Markets near border maize crossing points.

Market isolation should not only be viewed as simple geographic remoteness from domestic urban centers. Remoteness is also expressed through high transport costs, export prohibitions, and nontariff barriers to crossing the border, which all hamper maize marketing abroad.

Robustness checks. Given the significance of remoteness in determining maize price volatility, the study checks whether the way remoteness was defined influenced this finding. Two alternative measures of market remoteness are tested. The first is the distance in kilometers between a selected market and the nearest main consumption center. The second is the quality of the roads (whether paved) connecting the market with its main consumption center. The results are very similar. The positive and significant impact of travel time on maize price volatility holds when these alternative measures of remoteness are used.

In summary, the fact that prices in remote and disconnected markets are more volatile than in urban centers means that price volatility in rural areas is mainly

generated locally. This contradicts the common wisdom that price volatility mainly arises from international markets.

The Implications

The case of Burkina Faso shows that physical constraints, such as a large distance to major consumption centers or main roads, are fundamental factors influencing maize price volatility across markets. These findings suggest that policies targeted toward infrastructure development and better regional integration and economic development within the Economic Community of West African States area would reduce maize price volatility. For instance, the authorities could support remote markets by linking them through (better) road access to major consumption centers across the country, as well as in neighboring countries. Other studies have come to a similar policy conclusion about the importance of rural roads for rural development and poverty reduction (Kilima et al. 2008). This will be key to improving the commercialization of agricultural products in remote areas and reducing price volatility across markets in Burkina Faso.

Additional Reading

This chapter draws on:

Ndiaye, Moctar, Maître d'Hôtel Elodie, and Le Cotty Tristan. 2015. "Maize Price Volatility: Does Market Remoteness Matter?" Policy Research Working Paper 7202, World Bank, Washington, DC. doi: 10.1596/1813-9450-7202.

Other key references:

Abdulai, A. 2000. "Spatial Price Transmission and Asymmetry in the Ghanaian Maize Market." *Journal of Development Economics* 63: 327–49. doi:10.1016/S0304-3878(00)00115-2.

Badiane, O., and G. E. Shively. 1998. "Spatial Integration, Transport Costs, and the Response of Local Prices to Policy Changes in Ghana." *Journal of Development Economics* 56: 411–31. doi:10.1016/S0304-3878(98)00072-8.

Engel, R. F. 1982 "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation." *Econometrica* 50: 987–1007. doi:10.2307/1912773.

Kilima, F. T. M., C. Chanjin, K. Phil, and R. M. Emanuel. 2008. "Impacts of Market Reform on Spatial Volatility of Maize Prices in Tanzania." *Journal of Agricultural Economics* 59: 257–70. doi:10.1111/j.1477-9552.2007.00146.x.

Minot, N. 2014. "Food Price Volatility in Sub-Saharan Africa: Has It Really Increased?" *Food Policy* 45: 45–56. https://doi.org/10.1016/j.foodpol.2013.12.008.

A Refreshing Perspective on Seasonality

Luc Christiaensen, Christopher L. Gilbert, and Jonathan Kaminski

Overview

Conventional wisdom: *We all know about seasonality in rural livelihoods, but it is very unclear precisely what it is we know, and it is considered less and less frequently by development economists and policy makers.*

Findings:

- *The commonly used methods to estimate the seasonal gap in crop prices (dummy variable or moving average deviation) can yield substantial upward bias. This bias can be partially circumvented by using more parsimonious methods (trigonometric or sawtooth).*
- *Seasonal price variations are substantial and widespread. Prices during the peak months are on average estimated to be 28 percent higher than those during the troughs in the seven African countries examined. Food price volatility is much higher still, with seasonal variation explaining only a fraction of overall food price volatility (17 percent on average).*
- *Among staple crops, the seasonal gap is highest for maize (33 percent) and lowest for rice (16.5 percent). The gap is on average two and a half to three times larger than on the corresponding international reference market (South African Futures Exchange for maize, and Bangkok international market for rice). This finding suggests that there is substantial excess seasonality in African staple markets.*
- *Country-specific circumstances do not appear to affect the extent of seasonality— the main exception being maize prices in Malawi.*
- *Finally, evidence from Tanzania shows that food price seasonality can translate into seasonal variation in caloric intake, with seasonal differences in caloric intake of 10 percent among poor urban households and rural net food sellers.*

Policy message: *Seasonality in African staple prices is widespread, well above what is observed in international reference markets, and shown to affect caloric intake among certain population groups. These findings confirm that it is premature to ignore seasonality in the African development debate. Entry points for reducing food price seasonality include better access to financial markets for households, more secure storage at the village level, reduction in transport costs, and increased intra-African food trade. The relative effectiveness of these policies requires further investigation.*

The Issue: Is Seasonality in Food Prices and Food Consumption Important?

Seasonality in food prices and consumption was much studied in the 1990s, and was shown to be associated with significant fluctuations in hunger and nutrition. Since then, the topic has largely disappeared from the policy debate, especially among development economists. The general perception of improved integration of local food markets may have partly motivated this neglect. Nevertheless, substantial seasonality in price movements is still possible, even when domestic food markets are better integrated. This can happen, for example, if the timing of production is highly correlated across markets and commodities, and if domestic food markets are poorly integrated with world markets (or those in neighboring countries).

A certain degree of seasonality in food prices is unavoidable. Agricultural production is cyclical, necessitating intertemporal arbitrage. Storage costs ensue, driven by postharvest loss and the opportunity cost of capital. This drives a wedge between prices before and after the harvest. This price gap can be compounded by market power along the marketing chain and in storage, high transaction costs due to poor infrastructure and fuel costs, transport monopolies, and credit constraints for producers and traders.

Thus, seasonality is widely acknowledged to be part of African (rural) livelihoods. But what exactly do we know? The most salient aspect of seasonality in Africa is food price seasonality, as well as its effects on food consumption and nutrition.[1] Despite wide recognition that food prices are seasonal, there has been little systematic analysis of the extent of seasonal variation across countries and markets, or even how this should be measured. A companion study further assesses (for one country, Tanzania) whether seasonality in food prices also leads to similar variations in food consumption, on which there is even less evidence (Kaminski, Christiaensen, and Gilbert 2016). The findings show that it is premature to ignore seasonality in the African development debate.

The Analysis: Challenges in Estimating Seasonality

The Data

The study examines the extent of seasonal patterns in food prices for 13 crops and food products across 193 market locations in seven countries (Burkina Faso, Ethiopia, Ghana, Malawi, Niger, Tanzania, and Uganda). The data, which cover 2000–12, come mainly from national statistical offices and (in the case of Uganda)

a private marketing agency. They cover the most important staple cereals (maize, millet, rice, sorghum, and teff), cassava, several important fruits and vegetables, and eggs. The data set yields a total of 1,053 location-food crop pairs.

The problem of short data series. An important statistical problem that arises in analyzing seasonality is to disentangle seasonal movements from the longer-term trend in prices or consumption on the one hand, and irregular movements on the other. This problem is acute when the number of data points is small. For example, with 10 years of data, the study will have only 10 observations on January prices. Seasonality estimates could therefore be unduly influenced by irregular price movements. A second statistical problem is that data series are often incomplete. Sample start and end dates differ across series, but the more serious problem is gaps within the series. Short data samples and missing observations in monthly series are frequent challenges in representing seasonality in developing country prices, and this study is no exception. These challenges only multiply when analyzing seasonality in consumption, with only five years of monthly consumption data being available.

Which Empirical Approach to Take?

A measure that is commonly used in the development literature to characterize seasonality is the seasonal gap, that is, the ratio of the highest over the lowest monthly price (or consumption), or the ratio of the highest monthly deviation from the trend over the lowest monthly deviation. So, measuring seasonality requires estimating a trend and estimating the monthly deviation from it. A traditional approach to estimate the trend has been to use a 12-month centered moving average. This average has the advantage of enabling the annual increment to vary across time, but the approach is weak when the sample is short and there are missing values. For example, using moving averages sacrifices the initial and final six months of data, which is a major loss when time series are short. To calculate the moving average, data gaps must be filled (with little guidance on how to do so). Both disadvantages can be overcome by using a monthly dummy variable regression with a trend instead. The estimated monthly dummies then represent the deviations from the trend, that is, the seasonal factors. (When specified in first differences, the monthly dummy variable regression typically enables a stochastic trend as well.)

An important attraction of these unrestricted approaches to seasonality measurement is that no a priori structure is imposed on the form of seasonality (each month's deviation from the trend is calculated separately). The approach can then easily accommodate crops for which there are two annual harvests. The disadvantage is that a long time series is necessary to obtain accurate estimates, since only a single observation per year is used to estimate each seasonal factor/month. This is especially problematic when samples are short and the peak and trough months that are necessary to calculate the seasonal gap are not known a priori by the analyst, as is the case in many developing countries. Intuitively, although the empirical estimates of the seasonal factors (or monthly dummies) are each unbiased, each empirical estimate of a seasonal factor represents a draw

from a distribution, which usually deviates slightly from its true point value. As a result, by taking each time the maximum and minimum values of all the seasonal factors, the gap will be overestimated. The upward bias is larger the shorter is the sample and the less well defined is the seasonal pattern.

The extent of this problem is shown by the Monte Carlo simulations reported by Gilbert, Christiaensen, and Kaminski (2017). The dummy variable procedures perform poorly for samples of the length typically found in developing countries (about a decade or so). Taking 10 years of data with no seasonality genuinely present, apparent but spurious seasonal factors purport to imply a seasonal gap of 15 percentage points. When seasonality is genuinely present, biases are still likely with short data series, although much smaller (4 percentage points when using 10 years of data). The biases double again (to an estimated 8 percentage point gap) when seasonality is poorly defined. As predicted, the bias in the seasonal gap declines as sample size increases. Each seasonal factor is then estimated more precisely, such that the maximum and minimum identified by the data more likely represent the true peak and trough price months.

To mitigate such estimation bias in short samples, the study proposes the use of two more parsimonious approaches. By imposing a harvest-based pattern on the monthly seasonality factors, parsimonious seasonality models reduce the influence of any single monthly price. Consequently, there is a much lower probability of incorrect peak and trough identification (for example, through an error of a single month in either direction). Two alternative specifications are considered (box 16.1 provides further detail):

- *Trigonometric structure.* Here the analysis assumes that price variations follow a pure sine wave over time (defined by two cosine parameters). Although the trigonometric specification is parsimonious, it is restrictive in that the postharvest price decline is symmetric with respect to the preharvest price rise. In practice, for many crops, prices drop more rapidly postharvest than they rise in the remainder of the crop year.

Box 16.1 Metrics and Method

This box explains more rigorously the more parsimonious approaches to measuring seasonality in prices.

Trigonometric Seasonality

In this case, the seasonal pattern is defined by a pure sine wave. The simplest two-parameter sinusoidal trigonometric seasonality representation for month m is

$$s_m = \alpha \, \cos\!\left(\frac{m\pi}{6}\right) + \beta \, \sin\!\left(\frac{m\pi}{6}\right) \tag{B16.1.1}$$

box continues next page

Box 16.1 Metrics and Method *(continued)*

With trending data, the estimating equation for the price in month *m* of year *y* is

$$\Delta p_{ym} = \gamma + \Delta s_m + u_{ym} = \gamma + \alpha \Delta \cos\left(\frac{m\pi}{6}\right) + \beta \Delta \sin\left(\frac{m\pi}{6}\right) + u_{ym} \tag{B16.1.2}$$

where *u* is an error term.

Equation B16.1.2 is estimable by least squares. The seasonal factor, s_m, may be re-expressed as a pure cosine function:

$$s_m = \lambda \cos\left(\frac{m\pi}{6} - \omega\right) \tag{B16.1.3}$$

where $\lambda = \sqrt{\alpha^2 + \beta^2}$ and $\omega = tan^{-1}(\alpha/\beta)$. The parameter λ measures the amplitude of the seasonal cycle and implies a seasonal gap of 2λ. If the specification is valid, least squares estimation of equation B16.1.1 yields unbiased and consistent estimates of the *α* and *β* coefficients in equation B16.1.2. However, the implied seasonal gap, 2λ, is a nonlinear, nonnegative function of these estimates and will therefore also be biased upward. The trigonometric approach is illustrated using tomato price data from Morogoro, Tanzania (figure B16.1.1, panel a).

Sawtooth Seasonality

The pre- and postharvest price hike symmetry of the trigonometric specification limits its relevance to seasonality in Africa, where prices drop more rapidly than they rise. An alternative

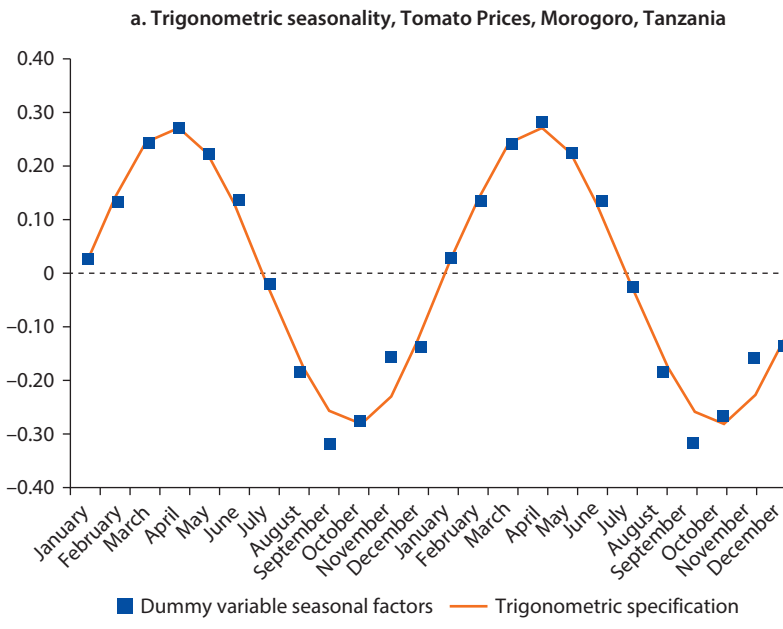**Figure B16.1.1 Illustrating Trigonometric and Sawtooth Seasonality**

a. Trigonometric seasonality, Tomato Prices, Morogoro, Tanzania

figure continues next page

box continues next page

Box 16.1 Metrics and Method *(continued)*

Figure B16.1.1 Illustrating Trigonometric and Sawtooth Seasonality *(continued)*

b. Sawtooth seasonality, Tomato Prices, Lira, Uganda

■ Dummy variable seasonal factors　——— Sawtooth specification
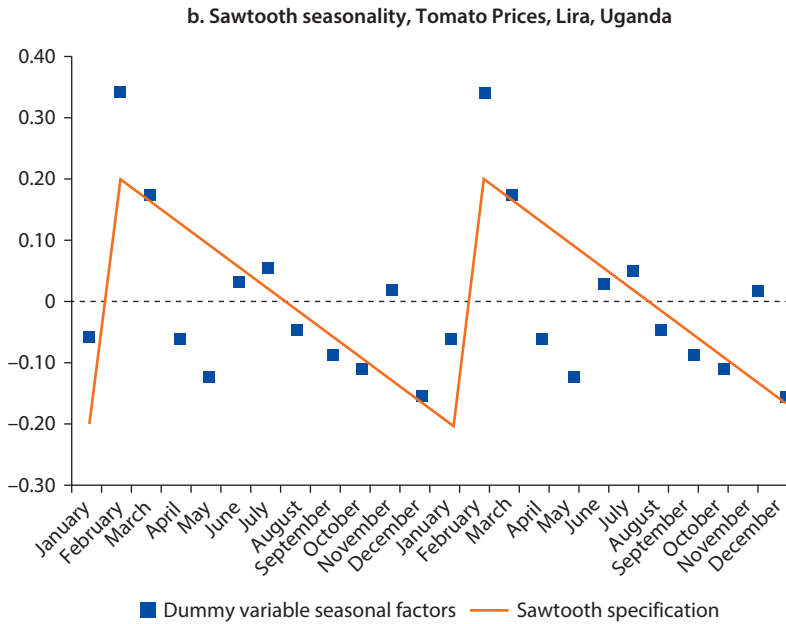
parametric specification is a sawtooth function in which prices fall sharply postharvest and then rise at a steady rate through the remainder of the crop year. Suppose the peak seasonal factor of λ occurs in month m^* and that price falls by the seasonal gap of 2λ to $-\lambda$ in the harvest month m^*+2. The seasonal factor then rises steadily by an amount $\dfrac{\lambda}{5}$ over the remainder of the year. Conditional on knowing the peak price month, m^*, the amplitude parameter λ may be estimated from the regression

$$\Delta p_{ym} = \gamma + \Delta s_m + u_{ym} = \gamma + \lambda \Delta z_m\left(m^*\right) + u_{ym} \qquad\qquad \text{(B16.1.4)}$$

Here, $\Delta z_m(m^*)$ equals -1 if $m = m^* + 1$ or $m = m^* + 2$ and $\dfrac{1}{5}$ otherwise. The study estimates by performing a grid search choosing the value for m^* that gives the maximum R^2 fit statistic. The illustration of sawtooth seasonality in figure B16.1.1, panel b, is for tomato price seasonality in Lira, Uganda.

- *Sawtooth structure.* This imposes an asymmetric variation in prices, a big drop at harvest, and a gradual recovery afterward. This variation fits most of the single annual harvest crops and locations.

Monte Carlo simulations show that parsimonious seasonal models are likely to be preferred to the standard dummy variable procedure for estimating the extent of seasonality when data samples are short or seasonal processes are

poorly defined. These are typical circumstances for developing country food crop price data. These procedures substantially reduce the bias resulting from the use of dummy variable estimators of the seasonal gap. Their limitation is that they will perform poorly for crops in which there are two harvests per year.

To discriminate between these empirical specifications, the preferred estimate is obtained by a three-step procedure:

- The estimates of the trigonometric and sawtooth specifications are compared with those of the dummy variable model. If the *F* test rejects both models, the dummy variable estimates are retained. This step helps for example to select the better (more flexible) model for location-crop pairs with two or more harvests.
- If the *F* test rejects one but not both parsimonious procedures, the nonrejected parsimonious model is taken as an acceptable simplification of the dummy procedure, reducing the bias in the seasonal gap estimates.
- Finally, if the *F* test fails to reject the trigonometric and sawtooth models, one of them is selected based on fit, as measured by the R^2 statistic.

Given different crops and agricultural settings, the preferred empirical approach will vary. Typically, the dummy variable model fits better when the seasonal pattern is well defined and does not conform to the sinusoidal or sawtooth patterns. This finding is generally true in cases when there are two harvests in the annual agricultural cycle. Using these rules, of the 1,053 location-food crop pairs, the dummy variable specification is preferred in 168 instances (many of which are in equatorial Uganda, where double cropping is common). The trigonometric specification is preferred in 625 instances, and the sawtooth specification in the remaining 260 instances. Although in a proportion of the cases, the success of the trigonometric model reflects a genuinely sinusoidal pattern, in other cases, in which the seasonal pattern is weakly defined or the data set is very short, the trigonometric specification may be chosen solely on the grounds of parsimony.

The Results: Seasonality Is Still Very Much Present

Because the sample size varies mainly by country, the seasonality estimates for the different commodities can be partially purged from potential overestimation by regressing the 1,053 estimated gaps for each commodity-location pair on the commodity type, the nature of the market (retail or wholesale), and a set of country dummies. The average estimated seasonal gap for each commodity is reported in table 16.1 (controlling for the nature of the market and country effects), together with the share of locations in which the null of no seasonality is rejected.

The study asks six questions:

- What is the extent of seasonality?
- How much of the overall price variation is due to seasonality?

Table 16.1 Average Estimated Seasonal Gap and Seasonal R^2, by Food Crop

| Food crop	Seasonal gap (%)	Seasonality significant (%)	Seasonal R^2
Tomatoes	60.8	64.0	0.21
Plantain/matoke	49.1	66.7	0.32
Oranges	39.8	50.0	0.16
Maize	33.1	93.2	0.25
Bananas	28.4	39.1	0.13
Teff	24.0	100.0	0.15
Beans	22.9	81.7	0.21
Sorghum	22.0	48.2	0.15
Millet	20.1	41.3	0.16
Cassava	18.8	26.9	0.08
Rice	16.6	68.2	0.17
Cowpeas	17.6	27.8	0.09
Eggs	14.1	64.0	0.18
Average	28.3	59.3	0.17

Note: The table reports the regression estimates of the average seasonal gap in wholesale markets, the proportion of locations for which the preferred gap estimate is based on coefficients that are significant at the 95 percent level, and seasonal R^2 by crop. The averages reported in the bottom row of the table are the unweighted averages across crops.

- Is measured seasonality excessive?
- Are seasonal price variations widespread?
- Are country effects important?
- Does price seasonality translate into seasonality of consumption?

What Is the Extent of Seasonality?

Fruits and vegetables are the most prone to seasonality. Fruits and vegetables have the highest gaps, as intuitively expected. Their production is highly seasonal, and they are highly perishable. Cassava and eggs, which are produced throughout the year, are among the commodities with the lowest seasonality (first column in table 16.1).

Maize also displays substantial seasonality. Among staples, the clearest evidence for seasonality is in maize prices (33 percent), for which seasonality is about twice as high as that of rice (17 percent). The higher seasonality of maize among the cereals is expected, given its lower storability and greater postharvest loss compared with millet and sorghum. With Africa being a growing importer of rice (which is becoming more important in urban diets), rice markets are more closely linked with the international markets. Part of African rice production is also irrigated. Figure 16.1 provides a visual summary of the distribution of the seasonal gap for maize in the seven countries. The vertical lines measure the

Figure 16.1 Maize Price Seasonal Gaps in Africa Are Well Above the International Benchmark
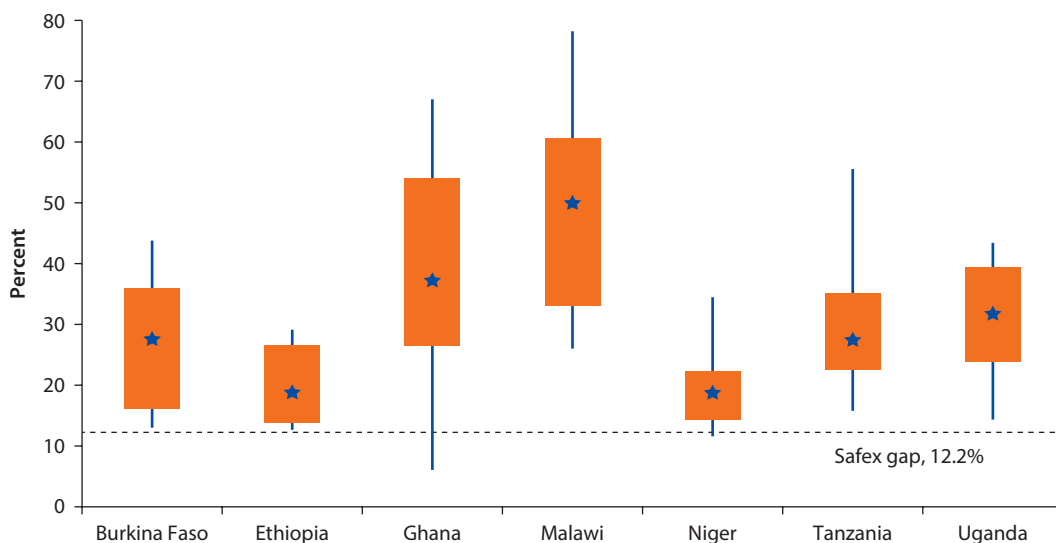
Source: Gilbert, Christiaensen, and Kaminski 2017.
Note: End points of the vertical lines indicate the maximum and minimum; the endpoints of the boxes, the 80 and 20 percentiles; and the stars, the median seasonal price gap across the different markets within each country.

range of the seasonal gap across markets in each country, which is the distance between the largest and smallest gaps. The rectangles demarcate the interdecile range between the 20 and 80 percent points in the gap distribution. The median gap is indicated by a star. Malawi has the highest median gap, but the Malawian gap distribution has substantial overlap with the Ghanaian and, to a lesser extent, the Tanzanian and Ugandan distributions.

What Is the Contribution of Seasonality?

How much of overall price variation is explained by seasonality? The final column of table 16.1 reports the seasonal R^2 statistics, which show the proportion of the monthly variation in food prices attributable to seasonality. Among crops, plantain/matoke and maize show the largest contribution (0.32 and 0.25, respectively), and cassava and cowpeas the lowest seasonal R^2 values (0.08 and 0.09, respectively). Across countries, seasonality appears to explain around 17 percent of overall price variability. It increases to 27.7 and 21.3 percent in Niger and Burkina Faso, respectively, where agriculture is mainly rainfed and highly seasonal. Although the bulk of intra-annual price variability is not related to seasonal fluctuations, for some crops (maize) and countries (especially in the Sahel), its contribution appears nonetheless non-negligible.

Are Seasonal Gaps Excessive?

The study compares estimated seasonal gaps in these countries with the gaps observed in two international markets: the Johannesburg futures market (SAFEX), providing the reference price for white maize in Southern and East Africa,

and the Bangkok spot rice price. The estimated seasonal gaps are 12.2 percent for SAFEX white maize and 5.1 percent for Bangkok rice. Typically, maize price seasonality is significantly greater than this (figure 16.1). The unsurprising conclusion is that maize prices in Sub-Saharan Africa show substantial seasonal variation, and this variation is on average two and a half times as large as that on world markets. The extent of regular seasonal variability in rice prices is around half that of maize prices, but is on average three times the size of the seasonal variability in world rice prices. There is substantial excess price seasonality in some of Africa's key staples.

How Widespread Is Seasonality?

Seasonality is larger than in the international reference market in virtually all the 133 wholesale maize markets and 107 wholesale rice markets examined. There are only two centers where the estimated gap for maize is lower than the SAFEX gap of 12.2 percent (Ho in Ghana and Niamey in Niger), and three where the gap is lower than the 5.1 percent gap in the Bangkok spot market for rice (Santhe, Lizulu, and Neno in Malawi). The occurrence of excess seasonality is widespread. Nonetheless, there is also substantial variation in the extent of seasonality across locations within countries, as in Malawi, Ghana, and Tanzania (for maize and rice). These findings counsel caution against overgeneralization from case studies, and underscore the need for differentiated and targeted interventions.

Are Country Effects Important?

The study shows that 30.4 percent of the variation in the preferred seasonal gap measure is attributable to the crop, 14.5 percent to the (market) location, and only 0.5 percent to the country and 0.4 percent to the market level (wholesale or retail). Country-specific variation is not statistically significant. But maize and especially Malawi are exceptions. Maize price seasonality is particularly striking in Malawi. This country effect is confirmed when comparing maize seasonal gaps across locations in Malawi and Tanzania close to their common border. The prevalence of high seasonal gaps throughout Malawi, together with the sharp drop in the gap moving north into Tanzania, suggests that the high Malawian gaps are the result of political or institutional factors specific to the country, rather than agroeconomic factors. To that extent, it should be possible to reduce some of the more extreme instances of seasonal maize price variation in Malawi, including by facilitating cross-country trading, which would also benefit Tanzania.

What Is the Effect on Food Consumption?

Follow-up analysis in Tanzania shows that caloric consumption also displays seasonal patterns, although limited on average, when looking across the country. This seasonal variation in caloric intake is further shown to be linked to seasonal fluctuations in Tanzania's maize and rice prices, indicating that households are on average not fully able to smooth their consumption. The urban poor and rural net food sellers are the most affected, with their caloric intake about 10 percent

higher during the peak month compared with the trough. Food price seasonality has real welfare effects.

The Implications

Policy pointers. Together, the findings indicate that the current neglect of seasonality in the policy debate is premature. Although it is not a major contributor to food price volatility, food price seasonality often proves substantial, with annual peak prices for maize across the countries studied on average 33 percent higher than those during the trough month. Moreover, the peak-trough markup is almost three times as high as the peak-trough markup observed in the international reference market, suggesting substantial excess seasonality. In some countries (especially Malawi) and several markets in the study countries, the gap is even higher. Food price seasonality at times also translates into seasonal variation in caloric intake. This is especially harmful when it affects children in their first 1,000 days of life. The findings draw attention to better access to financial markets for households, more secure storage at the village level, reduction in transport costs, and increased intra-African food trade as important policy areas and possible policy entry points. From a broader measurement perspective, the findings also underscore the importance of correcting for seasonality in food prices when constructing expenditure-based welfare and poverty measures, a largely ignored issue among poverty measurement practitioners so far.

Future research. Especially the results for seasonality in food consumption are based on limited data and are suggestive rather than conclusive. They are also based on a single country. Future work will bring in further survey waves and allow generalization to other Living Standards Measurement Study–Integrated Surveys on Agriculture countries. In the meantime, as long as time series remain limited (10 to 15 years), more use could be made of more parsimonious methods in measuring seasonality. It will also be important to extend the discussion to a wider range of welfare indicators, including indicators of longer-term impacts, such as child growth and nutrition.

Note

1. Other aspects include the supply and demand of labor, or the seasonal recurrence of certain diseases.

Additional Reading

This chapter draws on:

Gilbert, Christopher L., Luc Christiaensen, and Jonathan Kaminski. 2017. "Food Price Seasonality in Africa: Measurement and Extent." *Food Policy* 67: 119–32. doi 10.1016/j.foodpol.2016.09.016.

Kaminski, Jonathan, Luc Christiaensen, and Christopher L. Gilbert. 2016. "Seasonality in Local Food Markets and Consumption: Evidence from Tanzania." *Oxford Economic Papers* 68 (3): 736–57. doi 10.1093/oep/gpw013.

Other key references:

Dercon, S., and P. Krishnan. 2000. "Vulnerability, Seasonality and Poverty in Ethiopia." *Journal of Development Studies* 36: 25–53.

Ellis, F., and E. Manda. 2012. "Seasonal Food Crises and Policy Responses: A Narrative Account of Three Food Security Crises in Malawi." *World Development* 40: 1407–17.

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Goetz, S., and M. T. Weber. 1986. "Fundamentals of Price Analysis in Developing Countries' Food Systems: A Training Manual to Accompany the Microcomputer Software Program MSTAT." Working Paper 29, Michigan State University, East Lansing.

Sahn, D. E., and C. Delgado. 1989. "The Nature and Implications for Market Interventions of Seasonal Food Price Variability." In *Seasonality in Third World Agriculture*, edited by G. J. Gill, 179–95. Baltimore: International Food Policy Research Institute and Johns Hopkins University Press.

Food Loss: What Do African Farmers Say?

Jonathan Kaminski and Luc Christiaensen

Overview

Common wisdom: *Postharvest losses (PHL) of food are seriously large and harm food supplies.*

Findings:

- *The perceived reality appears quite different from the common wisdom—at least in Malawi, Tanzania, and Uganda. Farmers report PHL levels (for maize) that are significantly lower than previous estimates. Only a fifth of farmers report postharvest losses.*
- *The average loss ranges from just 1.4 percent of the maize harvest in Malawi to 5.9 percent in Uganda.*
- *But farmers who experience losses typically report substantial losses, amounting to between 20 and 27 percent of their harvests.*
- *How much PHL will occur depends on how long the food is stored, and thus on the decisions by farmers about whether to consume it or sell in the marketplace (and when).*
- *Most farmers report that most losses occur because of pests and insects.*
- *The study finds the extent of seasonality in food prices, the humidity and temperature of the environment, and the education level of the household head to be significant in explaining PHL.*

Policy message: *PHL seems to affect a minority of farmers. Targeting interventions to improve postharvest handling techniques (especially those on the farm) will be key. Moreover, scaling up these interventions must be based on a better understanding of the true extent of PHL. The use of nationally representative data is an important step in the right direction. The findings are suggestive that interventions encouraging the use of improved storage and crop protection technologies would be effective in reducing food loss. But this must be weighed against the cost.*

Interventions outside the sector are also highlighted—with better market access and postprimary education being critical.

The Issue: How Large is Postharvest Loss Really?

Since the world food crisis of 2007/08, global attention has focused on postharvest losses (PHL) of food production. Initial estimates suggested losses were high, especially in Sub-Saharan Africa (APHLIS 2013; FAO 2011; Lipinski et al. 2013). The oft-quoted Food and Agriculture Organization (FAO) estimate claimed that from farm to fork, these losses amounted to 37 percent of food production. Losses were thought to be so large that reducing them would go some way toward dealing with global shortages. Is this a myth or a reality?

Previous estimates were often based on tenuous assumptions and outdated and inappropriate data. Lipton (1982) already expressed doubts about the evidence for large PHL.[1] And a recent meta-analysis (Affognon et al. 2015) came to similar conclusions—there simply is not enough reliable evidence on PHL for policy and monitoring purposes.

The Analysis: Ask the Farmers

The study takes a fresh look at this situation by using nationally representative household survey data from three African countries (Malawi, Tanzania, and Uganda) collected under the Living Standards Measurement Study–Integrated Surveys on Agriculture initiative (LSMS-ISA). The PHL estimates from the Africa Post-Harvest Loss Information System (APHLIS) and FAO are based on national extrapolations from purposively sampled (and often older) in-depth case studies of on-farm and off-farm PHL. The estimates reported in this study are based on recent nationally representative samples, thus avoiding sample selection bias. This is important, as one is unlikely to go and study PHL in environments where one does not expect to find any.

The key departure from previous studies is that the estimates are obtained directly from the farmers and nationally representative surveys. In the surveys, farmers were asked about the crops grown and the amounts harvested. In addition, they were asked two simple questions: "Did you incur any PHL due to rodents, pests, insects, flooding, rotting, theft, and other reasons?" And if yes, "What proportion of the harvest was lost?"

- Three advantages: farmers know best and might give more accurate estimates of losses; the data provide insights into farmers' perceptions of the problem, which likely drive their storage and postharvest handling decisions; and the estimates are based on nationally representative data, minimizing sampling biases.
- Three limitations: only three countries are covered, so the results may not apply to Africa as a whole; the focus is on one (albeit a very important) food crop—maize; and it is not clear whether farmers are providing information just about on-farm losses, or including as well marketing losses.

The estimates reported in the study—based on the household surveys—complement and enrich existing information approaches, such as APHLIS. But even so, deriving robust estimates from the surveys is not easy (box 17.1).

Box 17.1 Estimating PHL from the Surveys

Given the survey design of the Living Standards Measurement Study–Integrated Surveys on Agriculture, households are visited only once, and that can be at any time in the agricultural cycle. This creates difficulties for estimating postharvest losses (PHL), since losses vary depending on how long ago the last harvest occurred. Some households will be interviewed close to the harvest, and others sometime later. Since the objective is to get good estimates of *annual* PHL for each household, the study adjusts their responses, to take into account when farmers were interviewed relative to the harvest. In adjusting the data, the study makes all households comparable in their PHL, as if they were all interviewed just *before* the new harvest of the next agricultural season.

The study therefore predicts what PHL households are likely to incur between the interview and the next harvest, and adds this to the reported PHL. To do so, the study exploits the fact that the survey has been carried out throughout the year. Although each household was surveyed only once, different households were surveyed at different points during the year, with the households sampled so that they would each time constitute a nationally representative sample. By making them observationally equivalent through (cross-sectional) regression analysis applied to the household survey data, the study predicts how much additional loss farmers would have incurred if their reported losses were recorded before the next harvest. The study does the following:

- Uses a Tobit regression to estimate the *additional* losses for those households reporting PHL at the time of their interview.
- Uses a probit regression to estimate the likelihood that households *not reporting losses* at the interview might incur PHL between the interview and the next harvest.

The key right-hand-side variable in these regressions is the number of months between the interview and the next harvest, so that the unobserved PHL can be attributed to each household. The regressions also control for other factors (household demographics, market access, climatic conditions, and agroecological zone), and are further used (for Tanzania) to gain a better understanding of the determinants of PHL.

So, what adjustments (or imputations) are made to the PHL reported by the farmers? For farmers who reported PHL at the time of the interview, their PHL is adjusted upward to account for the predicted additional losses between the interview and the next harvest—the latter being estimated to be a cutoff of 11.22 months since the previous harvest. The cutoff is needed because at that stage in the agricultural cycle, the PHL will begin to reflect the next harvest.

And for those who did not report a PHL at the interview, two imputations are made. The first is the likelihood that the farmers would incur PHL between the interview and the next harvest (the cutoff now being 11.64 months since the last harvest). The second is the average PHL the farmers would be predicted to incur in those months.


Georeferencing of all households enables merging the data with the agroeco-
logical and geographic characteristics of their habitats. This knowledge is
important, as temperature and humidity affect the storability of food when
storing in uncontrolled environments. About 90 percent of Ugandan house-
holds are in the humid agroecological zones (AEZs)—and 60 percent in the
warmer ones. In Tanzania, 65 percent of the households are in tropic warm
zones, and 25 percent in cool, subhumid AEZs. Around 10 percent are in semi-
arid AEZs. In Malawi, which is drier, 55 percent of the households are in semi-
arid AEZs (the vast majority in warm, semi-arid ones) and the remaining 45
percent are in subhumid zones.

The Results: Postharvest Loss Limited, But Concentrated

Are Food Losses Serious?

The farmers report much less PHL than previous estimates suggested (at least
for maize production and in these three countries). The proportion of the
total maize harvest lost, as reported by the farmers, is 1.4 percent for Malawi
in 2010/11, 4.4 percent and 2.9 percent (in 2008/9 and 2010/11, respec-
tively) for Tanzania, and 5.9 percent for Uganda in 2009/10 (figure 17.1).
These losses are likely to be mainly losses incurred during on-farm harvesting
and postharvest storage and handling, excluding losses incurred during mar-
keting. The losses are much lower than previous estimates—FAO (2011)
reports on-farm losses of 8 percent of food production in Sub-Saharan Africa;

Figure 17.1 Self-Reported On-Farm Postharvest Loss Is Low, but Concentrated
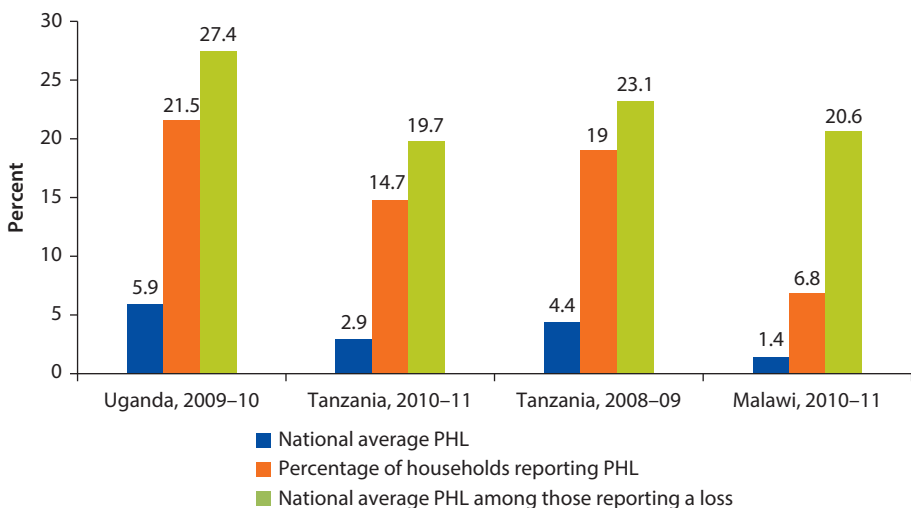
Source: Computations from LSMS-ISA data.
Note: PHL = postharvest losses.

APHLIS reports 14 percent for Tanzania, 18 percent for Malawi, and 20 percent for Uganda.

But these are just averages across households. Not all farmers suffer losses—only a minority of them (7 percent in Malawi, between 15 and 19 percent in Tanzania, and 22 percent in Uganda). This minority typically suffers losses ranging between 20 and 27 percent of the (maize) harvest. The overall average therefore is misleadingly low from the perspective of these households. For these farms, PHL is a serious issue, but less so for the farming population or the economy as a whole.

In policy circles, too often the overall food-production-consumption chain is taken to draw attention to PHL issues, while the recommended interventions only address issues related to a subset of the chain (in developing countries, typically on-farm losses). For evidence-based policy interventions, therefore, it makes more sense to focus on on-farm losses.

What Explains the Losses?

Although the measured losses in these three countries are much lower than those indicated by conventional wisdom, this does not do away with the fact that they can be a problem, especially for some farmers. Policy interventions should target these farmers. And policies must reflect the specific circumstances in which the losses are occurring. The wide variations in PHL that are observed (emphasized by Stathers, Lamboll, and Mvumi 2013) need to be understood. So what determines the losses?

For food crops, PHL depends on how long the food is stored. When production is marketed, storage time is likely to be short, resulting in less food loss. But this might then lead to other (nonfarm) losses—when transporting the food to the market. When the farm household consumes the food it produces (known as *autoconsumption*), these marketing losses are avoided, but at the expense of higher losses arising from storage, since food would have to be stored for longer. Household consumption will be spread many months after the harvest. The net effect of autoconsumption on food losses depends on which of these counteracting effects prevails—and that is an empirical matter. The use of improved technology in storage and crop treatment, other things equal, will reduce losses, especially when food is consumed by the household. For maize, biophysical studies indicate that without treatment or good storage facilities, losses typically increase rapidly after four months of storage. Consistently, the data suggest that the incentive to employ improved storage technology is greater when food must be stored for longer periods.

The proximate determinants of postharvest food losses (employed in the agronomic literature) are therefore:

- Storage time or, more specifically, the rate of storage depletion
- Choice between autoconsumption and marketing output
- Storage techniques and infrastructure
- Crop protection technology.

These factors are the outcomes of many decisions the farmers must make—how much to plant and harvest, whether to market or consume the food grown, and whether to improve storage or crop protection methods. These decisions in turn depend on farmers' agroecological and socioeconomic circumstances (for example, where they live, which affects how prone they are to crop deterioration), and the costs and opportunities they face when making these decisions. The study investigates this further through multivariate analysis of observed PHLs in Tanzania. The same probit and Tobit regressions that are used to adjust the PHL estimates for each household (discussed in box 17.1) also provide insights into the determinants of PHL.

In Tanzania, the study finds the following to be important.

- *Economic environment*: two factors play a key role:
  - *Closeness to markets*. Closeness to markets will encourage households to reduce PHL by marketing rather than consuming output (thereby reducing storage time).
  - *Seasonal price gap*. Postharvest prices tend to be low compared with those just before the next harvest (see chapter 16 for a discussion of estimating these seasonal price gaps). The higher opportunity cost of losses during storage (from having to buy maize on the market at a higher price if stocks run out prematurely, or from financial losses from foregoing higher sales prices later in the season) induces households to reduce their PHL. An increase in the seasonal wholesale price gap by one standard deviation reduces the likelihood of reporting PHL by 26 percentage points.
- *Agroecological environment*. The physical environment in which the farm operates also influences the decisions households make, and the consequent PHL outcome. It is the interaction between heat and humidity that is most challenging for preserving food. The effect of both factors is substantial. A 2.3-degree increase, which corresponds to one standard deviation of the average temperatures during the wettest quarter observed in the sample, increases the likelihood of PHL occurring by 21 percentage points, and the predicted level of PHL by 0.95 percentage point (that is, a 25 percent increase in PHL from the household-level annually adjusted average).
- *Household characteristics*. Finally, the characteristics of the farming households will influence the choices made, and their implications for PHL. Two important characteristics were found to be significantly associated with PHL:
  - *Gender*. Female-headed households were found to be less likely to suffer PHL compared with their male counterparts. Other things equal, female-headed households were 4.3 percent less likely to report PHL, and predicted levels of PHL in such households were 12 percent lower.
  - *Education*. PHLs were less likely to occur in households whose heads had postprimary education (not just completed primary). Such households were 8.7 percent less likely to report PHL, and predicted levels of PHL were 27 percent lower.

The Implications

Several messages for policy emerge from these findings.

Better information. These findings add an important note of caution to existing estimates of PHL. The principal concern is that they were often compiled from inappropriate data, using questionable assumptions. The use of *nationally representative* household survey data (such as the LSMS-ISA) is a step in the right direction, avoiding sampling errors and biases. Such data will complement and inform ongoing measurement approaches, such as APHLIS. But these data are not perfect either. Given the survey design, farmers' responses had to be adjusted to account for unobserved postinterview losses. And it is not entirely clear whether the farmers' estimates refer to on-farm losses (mostly storage), or also to losses incurred in marketing. Most estimates of PHL that are typically cited in policy circles cover the whole sequence of food loss, "from farm to fork," yet the policy preoccupation has been almost entirely with on-farm PHL. And even for the latter, the study's estimates are only half those currently reported.

Targeting is key. As only a small (although annually changing) proportion of households report a loss, "one-size-fits-all" approaches are bound to fail (as highlighted 30 years ago by Lipton). Understanding why some farmers suffer high levels of PHL and others do not is an essential step in designing the right policy interventions.

Policies outside the sector are important. That low levels of education and lack of market access lead to higher PHL (other things constant) suggests that policy interventions outside the agriculture sector are needed. Improving access to markets, which may also help reduce food price seasonality, and encouraging farmers (or rather their children) to continue to secondary schooling will reduce food waste in the long run.

Gender effect. It is not entirely clear why female-headed households are less prone to PHL than their male counterparts. The implication of this finding would be that extension services designed to influence postharvest practices need to be gender sensitive.

Technology. A range of better postharvest handling techniques is now being tested. In the past, their adoption has often failed. Incorporating farmers' insights on the benefits of these techniques on the ground when comparing them with the costs of rolling them out will be key.

Behavior. A deeper understanding of farmers' behavior is also called for. It may well be that farmers do not experience much loss because, in the absence of better storage techniques, they avoid storing beyond four months, when deterioration accelerates rapidly. PHL is then low, exactly because farmers deliberately avoid it, not because it is not an issue. If so, farmers could potentially benefit substantially from better postharvest handling techniques, especially when the seasonal price gaps are substantial (Gitonga et al. 2013).

Going beyond maize. This analysis has focused on maize, which is vital for most farms in Southern and East Africa. Similar work to inform policy is needed for other important staple crops.

Note

1. Following the world food crises of the early and late 1970s, postharvest losses surged to the top of the policy agenda, disappearing to the background again in the following years when food prices came down.

Additional Reading

This chapter draws on:

Kaminski, Jonathan, and Luc Christiaensen. 2014. "Post-Harvest Loss in Sub-Saharan Africa—What Do Farmers Say?" *Global Food Security* 3: 149–58. https://doi.org/10.1016/j.gfs.2014.10.002.

Other key references:

Affognona, Hippolyte, Christopher Mutungi, Pascal Sanginga, and Christian Borgemeister. 2015. "Unpacking Postharvest Losses in Sub-Saharan Africa: A Meta-Analysis." *World Development* 66: 49–68.

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Stathers, T. E., R. I. Lamboll, and B. M. Mvumi. 2013. "Postharvest Agriculture in Changing Climates: Its Importance to African Smallholder Farmers." *Food Security* 5: 361–92.

Stylized facts set agendas and shape debates. In rapidly changing and data-scarce environments, they also risk being ill-informed, outdated, and misleading. Following higher food prices since the 2008 world food crisis, robust economic growth and rapid urbanization, and climatic change, is conventional wisdom about African agriculture and rural livelihoods still accurate? Or is it more akin to myth than fact?

The essays in *Agriculture in Africa: Telling Myths from Facts* aim to set the record straight. They leverage newly gathered, nationally representative, georeferenced information, at the household and plot level, from six African countries. These data from the Living Standards Measurement Study—Integrated Surveys on Agriculture help query every aspect of farming and nonfarming life—ranging from the plots farmers cultivate, the crops they grow, the harvest that is achieved, and the inputs they use, to the other sources of income they rely on and the risks they face. Together, the surveys cover more than 40 percent of the Sub-Saharan African population.

In all, 16 points of conventional wisdom are examined, relating to four themes: the extent of farmer engagement in input, factor, and product markets; the role of off-farm activities; the technology and farming systems used; and the risks farmers face. Some striking surprises, in true myth-busting fashion, emerge. And a number of new issues are identified. The studies bring a more refined, empirically grounded understanding of the complex reality of African agriculture. They also confirm that investing in regular, nationally representative data collection yields high social returns.

This book is a game changer, destroying many myths about African agriculture with data and concluding, for example, that the labor productivity of smallholder farmers is not low, that they use improved seeds and fertilizers, that profitable use of fertilizers needs good agronomics, and that agroforestry is widespread. It should be required reading for anyone involved in African agriculture.

—Pedro Sanchez, World Food Prize winner and
currently Research Professor of Tropical Soils at the University of Florida

This lineup of distinguished agricultural economists has produced an exciting book on African agriculture that is a must-read for all policy makers and scholars interested in contributing to the understanding and development of agricultural input and product markets, as well as food security in the continent. Using very rich data sets, the book provides rare and detailed analyses of pertinent issues that facilitate the design of effective agricultural policies.

—Awudu Abdulai, University of Kiel, Germany, and Editor-in-Chief of *Agricultural Economics*

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