Networks, Local Institutions and Agriculture in Africa: Notes Toward a Research Program

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July, 2009

1   Introduction

The World Development Report 2008 provides a vivid account of the recent history of agrarian change in sub-Saharan Africa.   Perhaps the most striking trio of figures in the document is reproduced here:
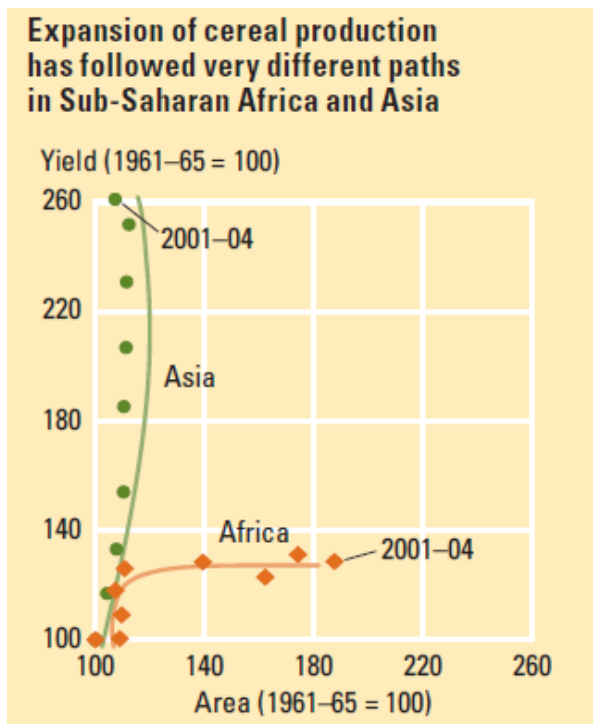

Expansion of cereal production has followed very different paths in Sub-Saharan Africa and Asia

Figure 2.3   Growth in agricultural GDP per agricultural population is lowest in Sub-Saharan Africa

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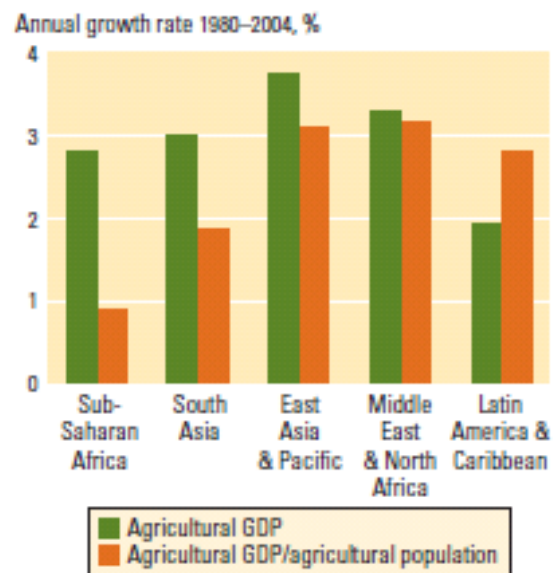
Figure 2.2 Modern inputs have expanded rapidly but have lagged in Sub-Saharan Africa

Irrigation

Region	Value
Sub-Saharan Africa	4
South Asia	39
East Asia & Pacific	29
Middle East & North Africa	33
Europe & Central Asia	11
Latin America & Caribbean	11

Arable and permanent cropland, %

Legend: 1962 1982 2002

Improved varieties of cereals

Region	Value
Sub-Saharan Africa	24
South Asia	77
East Asia & Pacific	85
Middle East & North Africa	48
Latin America & Caribbean	59

Cereal area, %

Legend: 1980 2000

Fertilizer use

Region	Value
Sub-Saharan Africa	13
South Asia	98
East Asia & Pacific	190
Middle East & North Africa	73
Europe & Central Asia	34
Latin America & Caribbean	81

Kg of nutrients per hectare of arable and permanent cropland

Legend: 1962 1982 2002

Sources: Evenson and Gollin 2003; FAO 2006a.

It is surely the case that one can quibble with the numbers that underlay these figures. Nevertheless, the overall conclusion is quite clear and remarkable. The first shows that over the past 40 years, agricultural yields have been remarkably low and slow growing in Africa: output growth has been a consequence of the extension of agriculture onto new land, rather than any increase in yields. The second shows that labor productivity in African agriculture has grown at a very slow rate. The third shows that the intensity of input application – irrigation, improved varieties, or fertilizer – has been similarly low and stable. These broad features of the recent past of agriculture in Africa cry out for explanation.

2   Understanding Low Yields in African Agriculture

Why are yields and input intensity into agriculture so dramatically lower in Africa than in other areas of the developing world? It is useful to recall the standard, workhorse agricultural house-

hold model to focus our discussion. The baseline agriculture household model with complete markets provides a useful starting place for thinking about features of the environment within which African farmers operate that provide initial hypotheses for why yields and input intensities are low. Further explanations begin to emerge when we enrich the model by considering some of the market imperfections that might be important for many farmers in Africa. Three possible imperfections are particularly salient. The possibilities that farmers face binding credit constraints, incomplete insurance markets, and hold insecure property rights emerge as potentially important explanations for the broad patterns we observe in African agriculture. As a consequence, we need a model that permits some dynamics and risk.

Therefore, consider a farmer with a planning horizon over periods $t \in T$ (say, $t = 0, 1, ...T$), and we index the potential states of nature that can occur in each period by $s \in S$. Let c_{st} be a vector of goods consumed by the farmer in state s of period t, and c be the concatenation of all those vectors. Similarly, let l_{st} be the leisure consumed by the farmer in state s of period t and l be the concatenation of those numbers. Let the farmers preferences over consumption and leisure, then, be summarized by the utility function $u(c, l)$.[1]

Farmers have access to a farming technology summarized by the production function $F_s(L_{st}, X_{st}, A_{st})$, which designates the amount of output produced in state s given inputs of labor L_{st}, nonlabor inputs (like fertilizer) X_{st} and land A_{st}. We assume that $F(.)$ is increasing in all its arguments, concave and continuously differentiable.

We start by assuming that the farmer is faced with complete markets, that is, there are complete product, labor and land rental markets, she can borrow or lend freely and can buy insurance for each state of nature. This is equivalent to assuming that there exist prices for each commodity and input in each period and each state. Designate the vector of these prices for consumption goods as p_{st}, inputs as q_{st}, labor as w_{st}, land as r_{st} and farm output as ρ_{st}. The farmer's endowment of land and labor are designated A_{st}^e and L_{st}^e.

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[1] A common special case specification would be von Neumann-Morgenstern preferences:

$$u(c, l) = \sum_{t=0}^{T} \beta^t \sum_{s \in S} \pi_{st} v(c_{st}, l_{st})$$

where π_{st} is the probability of state s occuring in period t.

In this case, the farmer's problem can be described as

$$\max_{c,l,L_{st},X_{st},A_{st}} u(c,l) \tag{1}$$

subject to

$$\sum_{s \in S, t \in T} [w_{st}L_{st}^e + r_{st}A_{st}^e + \Pi_{st} - p_{st}c_{st} - w_{st}l_{st}] \geq 0 \tag{2}$$

$$c, l, L_{st}, X_{st}, A_{st} \geq 0, l_{st} \leq L_{st}^e, \tag{3}$$

where

$$\Pi_{st} \equiv \rho_{st}F_{st}(L_{st}, X_{st}, A_{st}) - w_{st}L_{st} - q_{st}X_{st} - r_{st}A_{st}. \tag{4}$$

(2) is the full-income budget constraint: simply put, it states that the farmer's aggregate expenditure on consumption and leisure, overall the entire planning period and across all possible states of nature, must be no higher than the value of her endowment of land and labor, plus the profits she earns on her plot. In any state, and any period, those profits, in turn, are simply the value of output (at that state- and period- specific price) minus the cost of all inputs (including, of course, the farmer's own labor, which may be part of L_{st}).

In this case, the problem has the well-known recursive feature that leads to the separation of production from consumption decisions by the farmer. Notice that the farm input decisions $\{L_{st}, X_{st}, A_{st}\}$ appear only in (4) (and the non-negativity constraints), and that increases in Π_{st} relax the farmer's budget constraint. Hence, the farmer's problem can be written as

$$\max_{c,l} u(c,l) \tag{5}$$

subject to

$$\sum_{s \in S, t \in T} [w_{st}L_{st}^e + r_{st}A_{st}^e + \Pi_{st}^* - p_{st}c_{st} - w_{st}l_{st}] \geq 0 \tag{6}$$

and

$$c, l \geq 0, l_{st} \leq L_{st}^e.$$

Where the farmer chooses only consumption and leisure and the Π_{st} in equation (2) has been replaced by Π_{st}^*, which is the maximized value of profit:

$$\Pi_{st}^* = \max_{\{L_{st-1}, X_{st-1}, A_{st-1}\} \geq 0} \rho_{st} F_{st}(L_{s't-1}, X_{s't-1}, A_{st-1}) - w_{s't-1} L_{s't-1} - q_{s't} X_{s't-1} - r_{s't} A_{s't-1} \quad (7)$$

Production decisions, then, are separable from consumption choices: the farmer simply maximizes profits at the competitive market prices. Her preferences over risk, her impatience, her desire for leisure versus specific consumption goods are all irrelevant to the production choice. The farmer increases the intensity of use of any particular input until its marginal value product equals its cost. For example, if fertilizer is the ith element of X, then the farmer demands fertilizer up to the point at which $\rho_{st} \frac{\partial F_{st}}{\partial X_{s't-1}^i} = q_{s't-1}^i$.

In this setting three hypotheses immediately arise for potential explanations for low and stagnant yields and slow pace of intensification in African agriculture First, the production technology available to farmers in Africa may be particularly unproductive; it's just not possible to achieve high yields given existing technology. Alternatively, and almost indistinguishably, African soils or agroclimatic conditions may be such that high yields are not attainable given current technology. Third, prices of inputs and/or outputs might be such that low yields are profit-maximizing.

There is some evidence that the first pair of explanations may not be correct. Again the 2008 WDR makes the case.

Figure 2.13   Exploitable yield gaps are high for maize in Africa

Tons per hectare
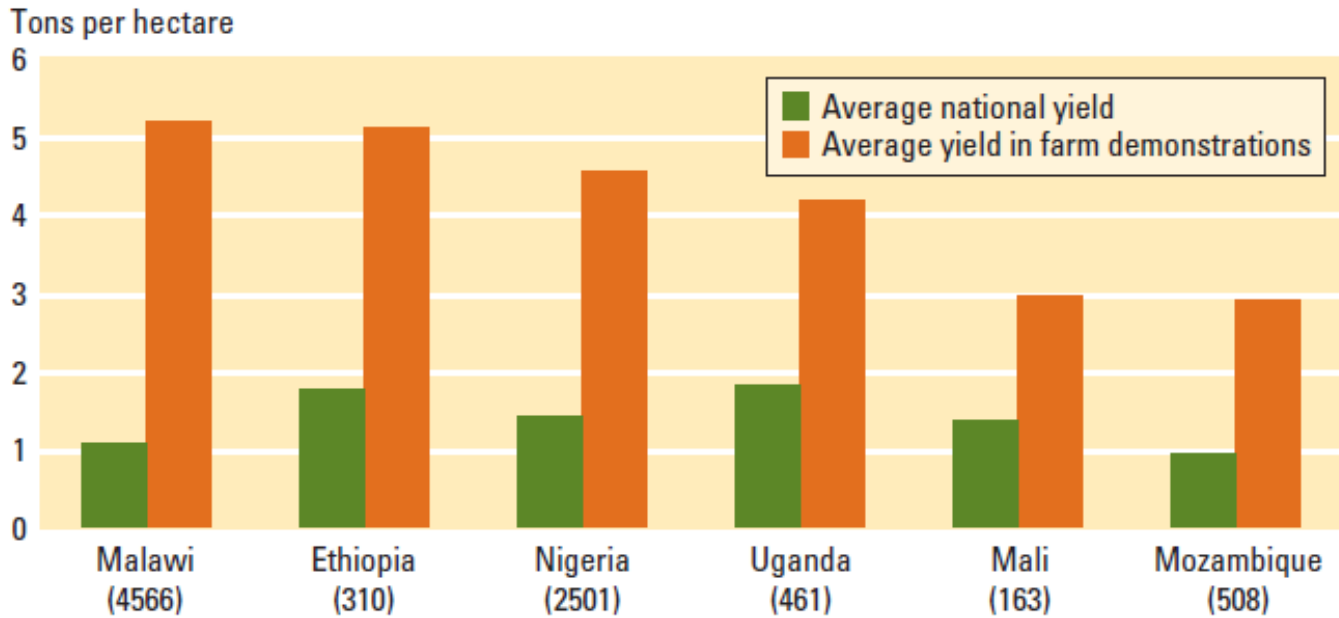
The claim, therefore, is that there exist unexploited opportunities to intensify production using currently available technologies.

If the technology available to farmers permits high yields, and farmers choose not to intensify production to obtain those yields, the most likely explanation for that choice is that it is not profitable. Prices, then, provide the key and most important explanation for the pattern of low and slowly growing yields in agriculture in Africa. This pattern of prices might be traced in turn to inadequate infrastructure. In particular bad roads and a poorly developed marketing system might keep the price of output ρ low relative to the prices of inputs q and w. The marginal product of, say, fertilizer is kept very high because its cost is high relative to the value of farm output. Similarly, poor infrastructure can raise the real cost of irrigation water and electricity, so those inputs are also not used intensively. Market failures: seed certification, lack of information about prices – think of this as raising the price and it fits; more sophisticated models would examine these market failures more directly.

Third, extending the model a bit, let the production function become $F_s(L_{st}, X_{st}, A_{st}; H_t)$, where H_t is the level of human capital of the farmer. Poor levels of education may be lowering yields directly, and if H_t is complementary with X_{st}, may be lowering the intensity of nonlabor

input use.

Fourth, it may be that farmers are not aware of the potential technologies that exist. Let $F_s(L_{st}, X_{st}, A_{st}; \kappa_t)$ be the output that can be produced by the farmer given his knowledge of the production process at time t. Increments to the stock of knowledge via extension, or observation of neighbors' production choices, or experimentation by the farmer herself could shift out the production frontier over time. The introduction of imperfect knowledge about technology is a very substantial change in the model outlined above, because it becomes imperative to think about farmer expectations concerning production possibilities, and about her choices with respect to investment in learning.

A second class of explanations for the low yields we observe focuses on a set of market failures that have been broadly observed in rural Africa. Credit constraints, imperfect insurance and imperfect property rights.

First credit constraints. A very simple framework in which to see this emerges if we take the model above and eliminate uncertainty, and reduce T to 2. Then,

$$\max_{c, L_1, X_1} u(c_1) + \beta u(c_2) \tag{8}$$

subject to

$$w_1 L_1^e + y_1 - w_1 L_1 - q_1 X_1 - p_1 c_1 \geq 0 \tag{9}$$

$$\rho_2 F(L_1, X_1, A_1^e) + y_2 - p_2 c_2 \geq 0 \tag{10}$$

and

$$c_t, L_1, X_1, A_1 \geq 0$$

Optimality implies

$$\frac{\rho_2}{p_2} \frac{\partial F}{\partial X_1} = \frac{q_1}{p_1} \frac{u'(c_1)}{\beta u'(c_2)}$$

and obviously profit maximization is violated. If period 1 consumption is relatively low (and thus the marginal utility of consumption in period 1 is high), then the farmer will choose a relatively low level of fertilizer input.

A number of mechanisms through which investment and increased yields might be hindered become apparent in this simple model. If period 1 is a lean season, characterized by hunger and heavy demands on household resources (relative to the immediate post-harvest period 2), then

farmers may need a very high return (high $\frac{\partial F}{\partial X}$) in order to induce investment in inputs such as fertilizer or hired labor. Stepping outside of the simple concave programming framework of this example, suppose that there is a minimum level of X, say $(X^{\min})$ that is required before the input starts generating returns (think of X in this case as tractor services, for example). Even if $\frac{\partial F(L_1^*, X_1^*, A^e)}{\partial X}$ is very high for some $X_1^* > X^{\min}$, financing that level of purchase of X may be so expensive that $u'(c_1)$ becomes prohibitively high and the farmer cannot make the investment.

At the same time, this model suggests that credit constraints, by themselves, may not be sufficient to understand the slow growth of agricultural productivity in Africa. Poverty implies that both c_1 and c_2 are low; the ratio of their marginal utilities may not be far from unity, which then would imply that input levels would not be far from their profit-maximizing levels. Moreover, think of a multiple period extension of ()-(). If relatively small investments in period t have high returns for output in period $t + 1$, then the household may be able to gradually move out of poverty with a small initial sacrifice. If credit constraints are a central part of the explanation for the persistence of low yields and poverty in agriculture, this is likely because they combine with other dimensions of the economic environment – like important seasonality, or fixed costs associated with relatively large-scale investments.

The combination of risk aversion and imperfect insurance will induce farmers to sacrifice expected profits in exchange for more certain returns. Consider a simplified version of the model above, with uncertainty, but only one period and only labor and land as inputs into farming. The farmer has no access to insurance, and has to choose labor inputs before the resolution of uncertainty (so $L_s = L$). To simplify calculations, suppose there is a single consumption good (so c_s is a scaler) and that labor is supplied inelastically. The farmer's problem is to

$$\max_{L \geq 0} \sum_{s \in S} \pi_s u(c_s) \tag{11}$$

subject to

$$c_s = F_s(L, A^e) - wL + wL^e. \tag{12}$$

If we summarize the uncertainty in production by $F_s(L, A^e) \equiv \theta_s F(L, A^e)$ with $\sum_s \pi_s \theta_s = 1$, then the optimal choice of labor input is summarized by

$$\sum_s \pi_s u'(c_s) \left(\theta_s \frac{\partial F(L, A^e)}{\partial L} - w \right) = 0 \tag{13}$$

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and we see that that farmer is not maximizing profits. After a few calculations, we see

$$\frac{\partial F(L, A^e)}{\partial L} \frac{cov(u'(c), \theta_s)}{\sum_s \pi_s u'(c_s)} = w - \frac{\partial F(L, A^e)}{\partial L}.^2 \tag{14}$$

Since $cov(u'(c), \theta_s) < 0$ (when θ_s is high, so is c_s, hence $u'(c_s)$ is low), we realize

$$w < \frac{\partial F(L, A^e)}{\partial L} \tag{15}$$

and as a consequence of risk aversion, the farm is cultivated less intensively than would be profit maximizing.

Insecure property rights may influence investment and productivity in agriculture through a variety of specific mechanisms. Farmers without clear title to the land they cultivate may not be able to use their land as collateral and thus might find it more difficult or expensive to access credit. Insecure property rights make it more difficult to capture the full gains from improved land (if it is difficult to sell or rent out the improved land, for example), thus reducing incentives to make improvements in the first place. Or, most directly, farmers might be reluctant to make investments in land if their tenure insecurity means that they might lose the land on which they have made improvements.

We thus have an array of possible features of the environment that might contribute to the low levels and slow growth of productivity of agriculture in Africa. Each of these explanations has a different set of implications for appropriate policy actions: the best policy response to insecure property rights is quite different from that which is appropriate if the key constraint is poor roads that lower the farm gate prices of agricultural output while raising fertilizer prices. In fact, each of these possibilities must be true in at least some instances, and in many places multiple imperfections undoubtedly exist. Yet research that maps out the constraints and opportunities facing agriculture is utterly inadequate. A proper defense of that last statement would require a thorough review. For now, I'll just cite an example. As of July 2009, Google Scholar shows $17,300$ papers/books/chapters on "Africa agriculture" listed since 2000. This might seem a substantial body of work, and indeed it does contain a wealth of information.

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[2] Start by rearranging and then subtracting $\frac{\partial F(L, A^e)}{\partial L} \sum_s \pi_s u'(c_s)$ from each side to find

$$\frac{\partial F(L, A^e)}{\partial L} \sum_s \pi_s u'(c_s)(\theta_s - 1) = \left[w - \frac{\partial F(L, A^e)}{\partial L} \right] \sum_s \pi_s u'(c_s).$$

Then recal that the expected value of θ_s is 1 and the argument is complete.

However, to put some perspective on this, over the same period a search in that database on "wall street" gets $383,000$ citations.

3   Research Programs

The remainder of this brief note will describe three ongoing research programs that may contribute to this effort to understand the environment within which farmers in Africa operate. In each case, I describe some completed research that suggests answers that are relevant in a specific context, and continuing research designed to explore more thoroughly some related issues.

3.1   Insurance, risk, and financial networks

Using data from 1980s in Burkina Faso, Kazinaga and Udry (2006) find that shocks to income due to both aggregate and idiosyncratic rainfall fluctuations translate directly into shocks to consumption. We find very little evidence of any consumption smoothing over time, or sharing of risk across households in a community. The main risk-coping strategies that are discussed in the literature are almost entirely absent. Christiaensen and Dercon (2007) and Dupas and Robinson (2009) also find evidence that standard mechanisms of risk sharing or consumption smoothing are not working in samples of households in Ethiopia and Kenya, respectively.

In Burkina Faso, Kazianga and Udry (1996) first show that rainfall variation is an important source of income variation. At the aggregate (village) level, the standard deviation of rainfall-induced income variation is more than half of mean income. There is also idiosyncratic (household) level variation in income due to rainfall variation because different households cultivate different types of land, and the responsiveness of income to rainfall varies across land types. This idiosyncratic rainfall-induced variation in income is also large: the standard deviation is between $1/4$ and $1/2$ of mean income.

Rainfall variation is publically observed, not subject to moral hazard, and driven by a reasonably stationary random process. All of these characteristics imply that it is a risk that should be relatively easy to handle. The idiosyncratic component, one might expect, could be smoothed within villages via informal insurance networks. The transitory component might be

handled through saving and dissaving, or through access to credit markets. In fact, we find that over 50% of the transitory variation in income attributable to rainfall variation translated directly into consumption variation. And over 40% of the idiosyncratic variation in income attributable to rainfall variation translated directly into consumption variation.

These are shocking numbers, because these households are very poor. The median calorie consumption at the time was under 2000 calories per adult equivalent, which is 30% below WHO recommendations for even moderate activity. So individuals in these households were already under nutritional stress, and when they were subject to large adverse shocks they were unable to respond by calling on social networks, or their savings, or credit markets to insulate their consumption from further reductions. Instead, they simply consumed less food. Thus we have dramatic evidence of a breakdown (or non-existence) of community risk-sharing mechanisms, confirmation that credit markets are not used to smooth consumption, and indications that even buffer-stock saving mechanisms were highly inadequate in rural Burkina Faso in the 1980s.

There are very different findings in other places, with strong evidence of substantial amounts of consumption smoothing provided by De Weerdt and Dercon (2006) for Tanzania; Suri (2008) for rural Kenya; Udry (1994) for northern Nigeria, and Fafchamps (2008) provides a useful review.

It is important that we understand the variation across Africa in the extent to which risk and imperfect insurance are driving production and consumption decisions. In particular, a key research agenda is to understand the how binding credit constraints and imperfect insurance influence input choice and/or technology adoption in agriculture. We saw above in simple models that explanations for a failure to adopt otherwise profitable technology or more intensive input use can include (a) binding credit constraints, or (b) imperfect insurance. In a collaboration between the Institute for Statistical, Social and Economic Research at the University of Ghana (ISSER) and Innovations for Poverty Action (IPA), we have begun a program of interventions for maize farmers near Tamale, Ghana to test for the presence of either of these imperfections, and to quantify their relative importance in driving production decisions.

Our research strategy is to work with a group of 500 maize farmers, who had previously been surveyed as part of an evaluation of the Millennium Challenge Corporation's (MCC) program in Ghana. We have randomly divided these farmers into four groups. One group serves as a

control group. Each farmers in a second group is receiving free rainfall insurance, based on the number of days of rain in each month at the rainfall station nearest his fields. Each farmer in the third group has received a substantial cash grant, sufficiently large to cover the costs of intensive cultivation (as described by the recommendations of the Ghana Ministry of Food and Agriculture) on a typically-sized plot. Farmers in the fourth group receive both the cash grant and the rainfall insurance.

These two independent sources of exogenous variation provide the instruments for distinguishing the effects on investment and technology choice of capital constraints from those of imperfect insurance and risk aversion. This project therefore provides the prospect of understanding, for at least one particular environment, how production decisions are being influenced by two of the market imperfections that have been hypothesized to lie at the root of the relatively poor performance of agriculture in Africa.

This project can be replicated in other situations where there are trials of rainfall or price insurance, or microfinance for agriculture. There is a stunning array of practical and conceptual hurdles involved in implementing this work, from the appropriate design of rainfall insurance, to building trust in the insurance project, to the standard issues of appropriate sample selection and survey design. It has proven very important that are collaboration is designed for the long term, providing us with the opportunity for experimentation and learning in our own research design.

3.2 Learning and Innovation

How important is imperfect information about technology in hindering productivity growth in African agriculture? Are farmers not using techniques claimed to be profitable because they are not aware of them, or because they do not know how to use them? This is the hypothesis that underlies programs of agricultural extension. Moreover, much agricultural policy relies on the notion of social learning: if one or a few key farmers in a community start using a new, profitable technology, other farmers will learn of this technology via these pioneers and the technology will diffuse. Conley and Udry (forthcoming) document the process of social learning about agrarian technology in southern Ghana. They find that farmers are indeed uncertain about the production technology for a new crop. In particular, they show that farmers are

uncertain about the productivity of fertilizer on pineapple plots. Conley and Udry find that farmers rely on the experiences of other farmers via a network of information connections to learn about the relative profitability of various alternative levels of fertilizer use under a variety of weather and other growing conditions. They show that this process of social learning is approximately as effective as learning from one's own experience, and that it is particularly important for novice farmers of pineapple.

Among small-scale commercial pineapple farmers in southern Ghana, Conley and Udry (forthcoming) show that learning from others is very important. Farmers in that environment adjust the amount of fertilizer they apply taking into account the lessons generated by the experience of others in their social networks, and in this way information about the productivity of new techniques diffuses across the community. In start contrast, Duflo, Kremer and Robinson (2006) provide quite convincing evidence that maize farmers in Busia, Kenya do *not* learn from each others' experience with fertilizer. They set up a program in which some farmers were randomly selected for an intensive extension experience in which their plots were used as demonstration plots for a profitable fertilizer application (involving top-dressing of a moderate amount of fertilizer). Although profits indeed increased on average for the 'treatment' farmers, the friends and neighbors were no more likely to use fertilizer in the future then were the friends and neighbors of the 'control' farmers who did not receive these extension services.

Social learning underpins extension strategies almost everywhere, so it is essential for us to understand why social learning is important in one context and not in the other. Why is the extent of social learning different in Busia, Kenya than in Nsawam, Ghana? Is it because the technology and crop are different? Does it have to do with the market environment? The nature of social interactions? More generally, how is information spread and knowledge generated about agriculture in rural communities?

Again in collaboration with ISSER at the University of Ghana, we have designed a research program to begin to disentangle these issues. The context is the evaluation of the MCC Ghana program. A key element of MCC program is business and technical training for farmers who are members of Farmer Based Organizations in three broad regions spread across Ghana. In order to permit an evaluation of the program, the MCC agreed to randomize the order in which FBOs received training; this randomization creates an opportunity to observe not only the effectiveness

of the training but also to measure the impact of the training on neighboring farmers who did not receive training themselves.

ISSER has implemented baseline surveys of farmers in the MCC program areas (of a random sample of farmers, and of FBO members) that provide information on production choices, social networks and geographic information. After the randomly-selected first wave of FBOs is trained, follow-up surveys will examine changes in production and investment of both FBO members and randomly-selected farmers. This will permit us to estimate not only the direct impact of the MCC program on participating farmers, but also the spillovers to neighboring farmers. This program covers a wide geographical area across a variety of socioeconomic environments, so we hope to make progress on understanding the sources of variation in the extent of social learning.

The fundamental design of this study is simple to replicate in other contexts. In particular, wherever extension programs do not have the resources to reach everyone at once it is in principle possible to design a study that will measure the extent to which non-participants learn from the direct recipients of the extension program. These kinds of studies will permit us to begin to understand the fundamental reasons for variation in the extent to which farmers learn from each others' experiences.

3.3 Property Rights

A third hypothesis for the low and slow growth of productivity of agriculture in Africa has to do with the idea that cultivators do not have secure property rights over land. There have been a number of research papers that attempt to investigate this possibility. Until recently, most of these papers "fail[ed] to find strong evidence of significant effects of property rights on investment" (Besley, 1998, 361).

In a recent paper Goldstein and Udry (2008) show, in contrast, a very large efficiency cost of insecure property rights on investment in soil fertility in southern Ghana. In this region, as in most of west Africa, rights to land are obtained via membership in a corporate group. In the particular region studied, that group is the matrilineage. This system of property rights has an important historical affect: it prevents the emergence of a landless class. If an individual finds himself without land to cultivate, he has the right to access to land via his membership in his matrilineage. This system clearly plays a role in the risk mitigation strategies of farmers, as it

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provides a minimal guaranteed amount of access to a key productive asset.

At the same time, this system does have an enormous cost in terms of the production choices of farmers. In the farming system of the region, soil fertility is maintained through a (bush) fallow system: after cultivating a plot for a single cycle of maize and cassava crops the plot is left fallow for a number of years. Farmers indicate in interviews that their ability to reestablish cultivation on a given plot after a fallow period is uncertain. This provides an incentive for the farmer to reduce the duration of fallow to maintain his or her control over the plot. As a consequence, fallow durations may be shorter than would be otherwise optimal.

Goldstein and Udry estimate hazard models of the probability that a plot will be lost in any given year while it is fallow in this region of Ghana and find remarkably large levels of insecurity. The most vulnerable are women, farming plots that come from outside their own matrilineage (usually obtained via their husbands, who are typically members of a different matrilineage), and who do not have a position of political power. Such individuals face an annual probability of 40% that a fallowed plot will be lost. Even the least vulnerable individuals (men, who hold a political office and who are farming land from their own matrilineage) face a 20% annual probability of losing a fallowed plot.

Such dramatic tenure insecurity has important consequences for agricultural investment. Those who hold political office and farm plots from their own matrilineages leave their land fallow, on average, for about 3 years longer than those without political office cultivating land from outside their own matrilineage. Goldstein and Udry find that yields are much lower on plots that are fallowed for shorter duration. Given the convexity of the agricultural production function, the variation in fallow durations (and associated variation in yields) is associated with an efficiency cost: perhaps as much as 1/3 of agricultural profits in this farming system are lost as a consequence of this tenurial insecurity.

Other studies find mixed evidence of property rights on investment in Africa. Brasselle, Gaspart and Platteau (2002) find little evidence of an effect of tenure security on investment in Burkina Faso. In contrast, Deininger and Ali (2008) find that farmers invest much more on plots over which they have ownership rights compared to plots on which they have only occupancy rights in Uganda.

There are difficult econometric problems associated with understanding the relationships

between land tenure and investment decisions, not the least of which is the likelihood that tenurial status is often endogenous to investment choices. There are two promising directions for further work on this. The first is to rely on rich datasets generated from surveys that are sensitive to the variation in tenurial security that is implicit in many informal land tenure systems. This entails a close reading of the literature on land tenure that is usually not produced within economics, and sufficient resources to ask the sort of questions that are required to document this kind of variation. This is an approach that we are implementing in the ISSER-Yale Economic Growth Center panel surveys in Ghana.

The second approach is to work with formal programs designed to change land tenure systems, often through titling. For example, Deininger, Ali and Alemu (2008) use information from a very large scale land registration program in Ethiopia to examine the immediate impact on investment of land registration (they find a large increase in conservation investment on registered plots). In Ghana, the Land Administration Project is issuing titles in selected districts. We hope t use the district boundary to separate treatment and control farmers; panel data to identify changes in investment, profits, and financial arrangements. Main difficulty with such a strategy is the possibility that other services change at the same district boundary, casting doubt on the identification assumption.

4   Research Clusters

The preceding makes it clear that there is a large set of inter-related research being undertaken on agriculture in Ghana. There are a number of advantages in developing this kind of research cluster, beyond the obvious factors of gaining familiarity with the broader context in which the phenomenon being studied takes place.

This cluster provides a 'lab' environment. The research infrastructure is already established, and it becomes easier to mobilize new studies. There can be dramatic economies associated with overlapping research of this kind, particularly in the context of data collection. ISSER and Yale have established an ambitious program of panel surveys: $5,000$ households over at least 12 years will be surveyed every 3 years on a wide range of topics. This data provides a foundation for a broad range of studies, including some of those discussed here.

It is possible to develop long-term collaborations with a wide range of institutions, and to develop and encourage connections between them. ISSER at the University of Ghana and Yale are collaborating extensively with the Ghana program of the MCC, with the Ghana Statistical Service, and with the Ministry of Food and Agriculture. In addition, a wide variety of NGOs and microfinance organizations operating in Ghana are involved in collaborations with one of these research studies.

A further hope is that this cluster of research activities can engender dialog on economic policy with government officials. This is one of the goals of the new International Growth Centre (http://www.theigc.org/), which is developing a program in Ghana.

Many elements of this clustering could be replicated in other places. An opportunity is provided by the Gates Foundation/World Bank initiative on Panel Surveys for Agriculture in Africa, which aims to implement several long-term panel surveys to monitor changes in rural economic organization over the next decade. This is the sort of long-term commitment that provides and opportunity for building extensive networks of collaboration between researchers from a variety of institutions. A similar opportunity is provided by the International Growth Centre country programs, which also envision multi-year programs of research.

5   References

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