Integrated Development Program Discussion Paper 6

Do young farmers farm differently?

Evidence from sub-Saharan Africa

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CIMMYT
International Maize and Wheat Improvement Center

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The International Maize and Wheat Improvement Center (CIMMYT) is a non-profit international agricultural research and training organization. CIMMYT focuses on sustainable agri-food systems and improved livelihoods through research on maize, wheat and other food crops.

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The authors declare no conflicts of interest in the publication of this research.

Purpose of the series

CIMMYT's *Integrated Development Program Discussion Paper* series publishes preliminary research results and study protocols prior to finalizing them for submission as peer-reviewed journal articles. The discussion papers are intended to solicit discussion and comments from stakeholders and peers to improve the quality of the research outputs.

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Abstract/executive summary

The idea that African young people can be the agents for positive change in rural areas is in widely acknowledged. There are many stylized assumptions about youth in African agriculture. it has often been asserted that young people are innovative, risk-taking, early adopters of new technology, and eager to engage with non-traditional opportunities. This discussion paper explores the empirical basis for these stylized facts using a mixed methods approach. The question how we think about the notion that youth bring something new to farming can be answered with the data that indicates observe marginally higher propensities to engage with intensification practices and commercial orientations which are objectives of much current policy and programming. We discuss the opportunities and constraints associated with using currently available data sources to explore how young people in Africa farm. This helps to answer if African youth farm differently. The answer is that there is limited magnitude of age effects on management practices. Therefore, there are probably few viable policy avenues for unleashing the much vaunted, latent youth whirlwind of innovative effervescence.

Preface

Progress toward creating decent jobs and reducing rural poverty requires transformations of economies, rural spaces, and food systems. Economywide transformation brings changes in relative factor costs (i.e., land, labor, and capital), new patterns of consumption, and changes in opportunities for trade and specialization. Food system transformation is shaped by changing food demand, which creates investments and jobs in food value chains and increases commercial farming opportunities. Both transformations will have substantial effects on rural economies, but maximizing the positive effects requires attention to policies and investments.

PIM's Flagship 2 teams study these processes and analyze policy options to promote inclusive rural growth and transformation. Specific topics include assessment and implications of transformation processes, agri-food systems as source of jobs, key public and private investments to stimulate rural development, and the political economy of agricultural and food policy reforms.

The foresight team at CIMMYT has been contributing to the research on rural transformation with special emphasis on the development of farm size, rural migration, the effects of rural transformation on youth and the effects on gendered outcomes of these processes.

This discussion paper aims to contribute to the ongoing discussions of the role of rural transformation in overall development and the effects that this should have on agricultural research for development priorities.

Sieglinde Snapp

Director CIMMYT Integrated Development Program

1. Introduction

> *'Youth are at the forefront of championing the innovative technological, gender-aware, and climate-smart approaches that will help grow and modernize agriculture.'*
> – Young Africa Works Summit 2017, MasterCard Foundation[1]

> *'When the willingness of youth to contribute is matched with appropriate opportunities, they can have a transformative impact on the growth of agricultural productivity.'*
> – AGRA (2015, p.38)

In recent years, it has often been asserted that young people are innovative, risk-taking, early adopters of new technology, and eager to engage with non-traditional opportunities. Within the context of Sub-Saharan Africa (SSA), these putative essential features of rural young people have been proposed as a potential driver of change in agriculture and other parts of the rural economy (Africa Commission, 2009, FAO et al., 2014, AGRA, 2015). However, the argument continues, resource constraints and limited productive opportunities in SSA's rural areas limit the ability of youth to realise their potential as farmers, and increase the likelihood that talented young people abandon rural areas altogether. In this sense, rural-urban migration, as a conduit for rural youth away from agriculture, is often framed as having potential negative impacts on the agricultural sector and rural development (The World Bank, 2015, Deotti and Estruch, 2016, Thorsen and Yeboah 2021).[2] This article examines the empirical basis for this story, using a combination of approaches.

Specifically, we address three questions. The first is: how might we think about the notion that youth bring something new to farming? To address this, we examine the explicit and implicit assertions in the stylised statements which are made in policy and public discourse about young people and farming in SSA. This is partly a conceptual parsing of the different ways in which we might interpret claims about youth, and how these claims intersect. We complement this with a review of evidence about particular propositions (youth are innovative; youth will drive agricultural transformation) that appear in the literature, drawing on other recent studies.

Second, we address the question of what aspects of young people's farming are visible through existing empirical windows? Not all implied traits of youth as farmers are equally visible in household survey data. For example, the fact that agricultural decisions and outcomes are typically described at the farm or household level imposes challenges for linking such outcomes with youth, an attribute generally ascribed either to individuals within a household or to a whole demographic segment. We discuss the opportunities and constraints associated with using currently available data sources to explore how young people in Africa farm.

Third, given the caveats outlined in addressing the preceding questions, and conditional on the data that are currently available, we ask: do the young in SSA farm differently? We use recent nationally representative household survey data to address this question, focusing on observable

[1] https://mastercardfdn.org/yaw2017-infographic/
[2] To be fair, most assessments of rural youth outmigration evaluate it as an essentially positive part of the structural transformation process, although the potential for negative impacts on agricultural productivity is mentioned in many reports, usually operating through loss of productive labour (e.g. The World Bank, 2015, Deotti and Estruch, 2016, IADB et al., 2017, FAO et al., 2018).

farm-level practices which are generally linked with agricultural intensification. We find that younger households (whether evaluated by age of household head or average age of household adults) are characterised by structural differences, typically operating smaller farms, with fewer capital resources. However, farms operated by younger households are also slightly more likely to use intensification practices and be oriented toward markets. After controlling for farm endowments and other factors, we find evidence that younger households are significantly more likely to use intensification practices: age of head and age of workforce are both negatively associated with output marketing, high-value/non-traditional production portfolios and input usage. Interestingly, after controlling for age of the household head, we find a significant additional effect of the age of other household members, suggesting that relying exclusively on characteristics of the head as 'farm manager' may obscure important contributions to the making and operationalization of decisions by other young household members. However, while statistically significant, our results indicate that the 'age effect' in the use of intensification practices is very small in magnitude, implying that expectations of a youth-driven transformation of African agriculture must be examined critically.

2. Change in Africa’s rural economies

2.1. Young people as agents of change

The idea that African young people can be the agents for positive change in rural areas is in wide circulation. For some they are viewed as the only hope for achieving sustainable agricultural transformation, while for others, their positive influence is already being felt. These claims have been critically reviewed elsewhere and found wanting (Mabiso and Benfica, 2019, Sumberg and Hunt, 2019, Glover and Sumberg, 2020). Suffice it to say that there is little if any evidence - direct or indirect - from rural SSA that supports these kinds of propositions. Further, as shown by Sumberg and Hunt (2019):

> *The international research literature on the relationship between age and a number of indicators of creative and innovative behaviour, point to the conclusion that there is no clear or strong evidence for a simple and/or direct relationship. Further, in those individual studies where such relations are found, they are often influenced by context and sector, and individuals at the lower end of the youth age range are seldom the most innovative or creative.* (p.135)

In addition to the lack of evidence, the claims that young people are in pole position to transform African rural economies are undermined by three critical weaknesses. The first is the fact that they fall into the ‘essentialism trap’ by suggesting that young people, as a group, are hungry for change, innovative, quick to adopt new technology etc. This conception of youth as a uniform, undifferentiated group - across factors of social difference including gender, age, ethnicity, religion, level of formal schooling, wealth etc - flies in the face of the basic tenets of modern sociology.

The second weakness is muddled thinking, in which innovation and innovative behaviour are used interchangeably with, for example, trying new things, risk taking and entrepreneurship. The danger in using quite different ideas, such as these, as synonymous, is that we run the risk of devaluing important, long-standing analytical distinctions. This is clearly seen, for example, in the case of entrepreneurship, which in current usage in relation to youth in SSA, following the approach of the Global Entrepreneurship Monitor[3], is now often undifferentiated from any kind of self-employment (Kew et al., 2015).[4] Gough and Langevang (2017) capture this well: ‘In light of their limited possibilities to gain formal sector jobs in the public or private sector, young people are being encouraged to be “job creators” rather than “job seekers”, thus becoming self-employed “entrepreneurs”’ (p.1).

The third weakness stems from the fact that claims about young people’s potential to transform the rural economy are seldom if ever accompanied by an acknowledgement (much less any analysis) of the structural and political economy impediments that constrain their ability to drive change. In effect, the suggestion is that young people will drive system-level, transformational change, despite being young and inexperienced, without access to the full suite of resources required for meaningful innovation, and often being excluded from the fora and institutions where key decision are made.

[3] https://www.gemconsortium.org/

[4] Although see Margolis (2014) for discussion of some of the data-related reasons underlying such conflation.

2.2. Farming: the challenge of seeing the innovation through the difference

The notion of a farming system or a crop production system suggests it is possible and useful to categorise farming activity based on key indicators like scale, crop and/or livestock combination, commercial orientation[5], labour arrangements, and technology use. The objective in developing such system classifications is usually to maximise variation between while minimising it within the set of identified systems. While the expectation is that all farms within a given category are broadly similar, within any given category there will always be a degree of variation in structure, organisation, the use of technology, productivity and the like. Some of this within category (or within system) variation reflects different resource endowments and management preferences and capabilities: it would certainly be a mistake to read within category variation as direct evidence of innovation or innovative behaviour on the part of an individual or household.

The concept of innovation - simply put, 'improved products and processes' (Niosi et al., 1993) - has been central to the mainstream understanding of economic growth for many decades (Schumpeter, 1947). Nonetheless, perspectives on the relationship between African smallholder farmers and innovation have shifted dramatically since the colonial period. Initially, with farmers portrayed as backward, tradition-bound, and resistant to change (for more sympathetic early portrayals see Hill, 1963, Allan, 1965), it was the job of agricultural extension to introduce and promote modern ('rational') farming methods. Framed by diffusion of innovation theory, those who first adopted the new technologies and practices, i.e., they did what was being promoted, were termed 'innovators' (Rogers, 1983). It was not until some decades later that the existence and potential significance of farmers' own experimentation and innovation came briefly to the fore (e.g. Richards, 1986, Biggs, 1990, Sumberg and Okali, 1997).

Innovation is commonly used to refer to both the process through which new products and processes emerge, as well as the new products and processes themselves. The former is difficult to observe, particularly at farm-level, while the use and spread of new products (like crop varieties) or processes (like conservation agriculture) promoted by extension or development programmes are usually the focus of technology diffusion studies (Glover et al., 2019, Krishna et al., 2020).

For the purposes of our analysis, it is useful to think of innovation or innovative behaviour in relation to the rural economy - or young people's livelihoods - in terms of doing different things and/or doing things differently. A farmer who uses (not just tries) fertiliser when no one else does, might be considered innovative, as might one who applies fertiliser using a micro-dosing technique, when everyone else broadcasts. In addition to farm practices, innovation - doing different things and/or doing things differently - might be observed in the marketing or commercialisation of agricultural produce, in farm structure or organisation, in how agriculture is combined with other economic activities, or in any aspects of non-farm economic activities.

In this article, we are interested in generational differences in farming practice, but the danger of simply ascribing such differences to innovation or innovative behaviour can be illustrated with the example

[5] By commercial orientation, we refer to the degree to which the farm production portfolio is organised around generating marketable surplus (as opposed to satisfying household consumption requirements). Unless otherwise specified, we use a common shorthand measure of this: the share of total value of crop production which is sold (sometimes referred to as the household commercialisation index).

of young tomato growers in Brong Ahafo, Ghana (Sumberg and Okali, 2006, Okali and Sumberg, 2012). In the study site north of Techiman, tomatoes - up to three crops per year - are produced, as they have been for some years, by young people (primarily but not uniquely young men). Plots are relatively small, and the work is hard, particularly during the dry season when watering is required morning and evening. Many of the young tomato growers do not bother to grow food crops - having little if any household provision responsibilities - but focus solely on tomatoes because of the high potential return. Many rely on a mother or sister to feed them. The point is that the differences between the young tomato growers and the older generation, who grow a range of food crops and are unlikely to produce tomatoes, has little to do with innovation, and everything to so with the young people's physical strength, limited responsibility and desire to accumulate capital quickly. In this case, there is much more scope for looking at innovative behaviour among the tomato producers, where, for example, only a few make use of petrol pumps to facilitate irrigation or try to circumvent the women who control access to the market.

2.3. Evidence from technology adoption studies

The vast empirical literature on technology use offers decidedly mixed evidence about young farmers' inherent propensities to use modern intensification strategies. In a systematic literature review of the determinants of using conservation agriculture practices, Knowler and Bradshaw (2007) found that of 18 studies controlling for age of farmer, three found a negative relationship (i.e., younger farmers are more likely to adopt), five found a positive relationship, and 10 found no statistically significant relationship. Their review of the literature also indicated no consistent finding with respect to farmer age and propensity for technology adoption. Meijer et al.'s (2015) literature review of factors affecting the uptake of agricultural and agroforestry innovations among smallholder farmers in SSA found no consistent role of age of farmer. Kassie et al. (2015) found that after controlling for other factors, there was often a negative correlation between farmer age and adoption of different conservation agriculture practices in Kenya, Malawi, Ethiopia and Tanzania, although coefficient estimates were highly variable across practices and countries and not always significant. Other recent empirical efforts find little evidence for a 'youth effect' in agricultural intensification. Diao et al. (2019) find that younger farmers in Ghana are not more likely to intensify or use modern inputs, compared with older farmers; constraints to adoption seem non-age-specific (e.g. market access is important for technology adoption). Andersson Djurfeldt et al.'s (2019) mixed methods study in Zambia also found no age-related intensification or productivity relationship, which they attribute in part to the limited resources of younger household heads. In contrast, Guo et al.'s (2020) meta-analysis of thirty-three empirical studies found a significantly positive association between age and use of sustainable intensification practices in southern Africa.

3. Empirical windows on young farmers: data and measurement challenges

In order to begin to evaluate some of the claims made about young farmers and their potential contributions to the transformation of agriculture, we would ideally draw on well measured observations of such characteristics as energy, risk aversion, innovation, receptivity to new ideas, early use of new technologies and so on. Standard household survey instruments, however, generally afford few windows onto these characteristics and the outcomes potentially associated with them.

The propensity to innovate is often ascribed to young people as a key characteristic.[6] Innovation (like decision making) is not easily observable, almost by definition. Survey instruments are generally set up to track practices that are already on the radar, and pre-defined questions about farming practices will certainly miss innovation and experimentation at the margins. However, through these surveys we can generally observe a suite of intensification practices which are or have been promoted by extension and development programmes, including, for example, the use of improved crop varieties, inorganic fertiliser and other inputs. Increasingly surveys are also tracking practices that map onto more agroecological or 'climate smart' approaches to agriculture (Hammond et al., 2017, Ngoma et al., 2020).[7] So, a first approach to evaluating the propensity of young farmers to drive change might examine the use of these two kinds of practices.

A number of challenges arise in attempting to link individual attributes (age, gender, education level or any other property of youth) with practices and outcomes typically observed at the farm level (e.g. technology use, productivity or farm orientation). First, many outcomes are only reported at the household level. Second, while it is true that in some cases we observe plot-level practices and outcomes, which in theory could be linked with different 'managers' within the household, in practice, this does not generate much analytical purchase. This is because in Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) and similar datasets where plot-specific control and/or management is mapped to particular household members, the vast majority of plots are reported as being managed by the head, with the majority of the remainder mapped to the head's spouse(s). For example, using nationally representative samples, 90% of plots in Zambia were managed by the head, 8% by the spouse, and just 2% by other members, while in Tanzania and Ethiopia, the head was identified as the primary decision maker on 94% and 95% of cropped plots, respectively.[8]

In recognition of the limitations of assigning a single household member as plot manager, recent surveys are increasingly asking about multiple contributors to decision making. Table 1 shows the share of cropped plots with decisions made by different combinations of household members, when joint or consultative decision-making is recorded. While significantly more inclusive than descriptive statistics derived from a single

[6] Attitudes toward innovation, and the propensity to innovate, are ideas that partially overlap with other personality features, such as risk aversion, creativity and receptivity to new ideas. A number of empirical measures of risk aversion - a trait that maps onto some notions of entrepreneurial disposition - have been developed. These are not part of most large-scale household survey datasets, however, and so we do not discuss them in detail. Creativity and openness to new ideas are similarly measurable in principle, although typically not part of available survey data.

[7] Although see Hammond et al. (2017) for discussion of measurement challenges with tracking climate smart agricultural practices with existing household survey instruments.

[8] Data are from the 2015 Zambian RALS, 2012/2013 Tanzanian LSMS-ISA, and 2015/2016 Ethiopian LSMS-ISA surveys. For Zambia, responses to the question 'Who primarily decided how to use this field?' were asked for all fields reported by the household. For Tanzania, we report the first response to the question 'Who decided what to plant on this plot in the long rainy season?' asked for cropped plots (up to three members were possible joint decisionmakers). For Ethiopia, we report the response to the question 'Who in the household makes primary decisions concerning crops to be planted, input use, and the timing of cropping activities on this field?' asked for cropped plots.

manager, we still see relatively low incidence of members other than the head or spouse(s) recorded as contributing to decision-making, with less than a tenth of Tanzanian plots and less than a quarter of Ethiopian plots having recorded decision-making input from members other than the head and/or spouse.

Table 1: Share of cropped plots by household position of decision-maker (including joint or consultative decision-making)

Decision maker	**Tanzania**	**Ethiopia**
Head only	43%	30%
Spouse only	3%	1%
Head and spouse	45%	45%
Other household member, alone or with another member	9%	24%
Total	100%	100%

Notes: Data are from the 2012/2013 Tanzanian LSMS-ISA, and 2015/2016 Ethiopian LSMS-ISA surveys. For Tanzania, up to three household members are identified in response to the question 'Who decided what to plant on this plot in the long rainy season?' asked for cropped plots (up to three members were possible joint decisionmakers). For Ethiopia, for cropped plots, in addition to the to the question 'Who in the household makes primary decisions concerning crops to be planted, input use, and the timing of cropping activities on this field?', up to two other members could be identified as consulted by the primary decision-maker.

This regularity in farm survey data has several possible implications. First, taken at face value, it suggests that for the most part young people do not farm (other than by supplying unpaid or paid labour) until they become household heads or spouses. A second possibility is that young people are engaged in managerial decision-making on at least some plots, either solely or with other household members, but this managerial contribution remains opaque given a default preference to designate the head as plot manager. There are many reasons to suspect that the second of these alternatives is likely in many cases. Consider the not atypical case of a household with an aged patriarch, his wife or wives, and several adult children. Tradition may dictate that the patriarch is designated as the household head, even where the de facto management of many of the household's productive activities (on and off the farm) are in the hands of other members. To adequately explore this possibility, new modes of data collection will be needed that more carefully probe the locus (or loci) of decision-making within households. In the meantime, we might creatively reinterpret 'farmer age' (or another farmer characteristic) through an aggregate measure of the family farm workforce. We offer an example of one way to go about this in the next section. A third possibility, which is not mutually exclusive of the first two, is that young household members who are not the head or a spouse are farming on plots which do not show up in the household plot roster. To keep things tractable, the remainder of this paper focuses on the first two alternative readings of the data. However, an important avenue for future empirical work would be to test the assumption that information on all plots farmed by all household members is effectively captured by typical survey instruments.

4. Do the young farm differently? Available empirical evidence

Despite these acknowledged limitations, we use data from nationally representative surveys of rural farm households in Tanzania, Zambia and Ethiopia to explore the degree to which alternative measures of household age correspond to multiple agricultural practices and outcomes. First, we describe the association with farmer age and structural characteristics of farms, such as size of landholdings and value of productive assets. This allows us to engage with debates on whether young farmers consistently face constraints in accessing land and other productive resources. Then, after controlling for these factors, we explore whether younger farmers are more likely to engage in intensification, agroecological or climate smart practices.

The data we use for this analysis come primarily from the LSMS-ISA surveys for Ethiopia and Tanzania, and the Rural Agricultural Livelihoods Survey (RALS) for Zambia.[9] All are nationally-representative panel surveys, in which the same households were visited during the different waves of data collection. We use three waves of panel data for Ethiopia (2011/12, 2013/14 and 2015/16) and Tanzania (2008/09, 2010/11 and 2012/13) and two waves of data for Zambia (2011/12 and 2014/15). In Ethiopia, 3,969, 3,776 and 4,951 households appear in each respective wave, and in Tanzania, 3,265, 3,918 and 5,010 households appear in each wave. In Zambia, 8,839 households were surveyed in 2012, with 7,254 re-interviewed in 2015.

To address the issue raised in the previous section about a potential mismatch between the household head and the locus of managerial agency in a distributed or collective set of decisions, we define several measures of 'household age': age of the nominal household head; average age of all adult members; and average age of all adult members excluding the household head. The correlation between these is shown in Table 2, with very similar estimates for each country. We see that households with younger heads generally also have younger adult members, although this correlation is imperfect, suggesting that there may be value in evaluating alternative measures of household youthfulness.

We explore the proposition that younger farmers and households face particularly acute asset endowments, by plotting non-parametric associations between structural characteristics of farms and the age of the household. Figure 1 shows these relationships graphically for Tanzania, Zambia and Ethiopia (represented by panels a, b and c, respectively). Here we use age of household head as our measure of household age, but the use of average adult age yields very similar results. For all three countries, farm size, labour and capital endowments are generally increasing with household age. Vertical lines indicate 25th, 50th and 75th percentiles of household head age distributions. The positive relationship between per capita land endowments and household age indicates that as households age, landholdings are generally increasing faster than the increases in household size.

[9] The LSMS-ISA data were produced as part of a World Bank project, in collaboration with the Ethiopian Central Statistics Agency (CSA) and the Tanzanian National Bureau of Statistics (NBS). Detailed descriptions of instrument design, sampling frame and other aspects of data collection are provided for Ethiopia by CSA (2017) and for Tanzania by NBS (2014). The Zambian RALS was produced by the Indaba Agricultural Policy Research Institute (IAPRI), collaborating with the Zambia Central Statistical Office (CSO) and the Ministry of Agriculture (MoA). For more details on questionnaire and sampling design, see CSO (2012).

The value of productive assets (only available for Tanzania and Zambia) are also increasing with age. By focusing on the left-hand side of these graphs, we generally find descriptive support for the idea that younger households operate with fewer productive resources than do older households, on average. Interestingly, the graphs of value of crop production per hectare (one measure of farm productivity) generally show an inverse-U shape, indicating that while resources tend to increase throughout the range of household ages, land productivity follows a different pattern, first rising and then falling (although peaking at different ages in each of the countries).

Table 2: Correlation between alternative measures of ‘household age’

Country	Age of head	Avg. adult age	Avg. adult age (excluding head)
Tanzania			
Age of head	1		
Avg. adult age	0.7287***	1	
Avg. adult age (no head)	0.4056***	0. 8832***	1
Zambia			
Age of head	1		
Avg. adult age	0.7296***	1	
Avg. adult age (no head)	0.4650***	0.9056***	1
Ethiopia			
Age of head	1		
Avg. adult age	0. 6959***	1	
Avg. adult age (no head)	0. 2820***	0. 8367***	1

Note: Table shows pairwise Pearson correlation coefficients. *** indicates significance at p<0.001 level. Data are from the 2012/2013 Tanzanian LSMS-ISA, and 2015/2016 Ethiopian LSMS-ISA surveys.

To further examine some of these structural conditions, as well as the practices and outcomes of interest, we tabulate descriptive statistics covering a broad range of characteristics on the samples from the most recent wave from each country, and use quartiles of household average adult age to organise our findings (Table 3). Several things stand out from these unconditional descriptive statistics. The number of members is greatest in the second quartile, and is consistent with an inverse-U-shaped labour endowment which is lowest for very young and very old households. Farm size, farm size per household member, and productive assets all increase with age. Aligning with the findings in the graphs previously shown, we see that land endowments increase faster than labour endowments with age, meaning growing per capita land availability with age. The value of productive assets is highest in the middle range for Tanzania and increasing for Zambia (again, this variable is not available for Ethiopia). This is consistent with the stylized notion that many young households in rural Africa - and throughout the world - have relatively smaller asset endowments than older households.

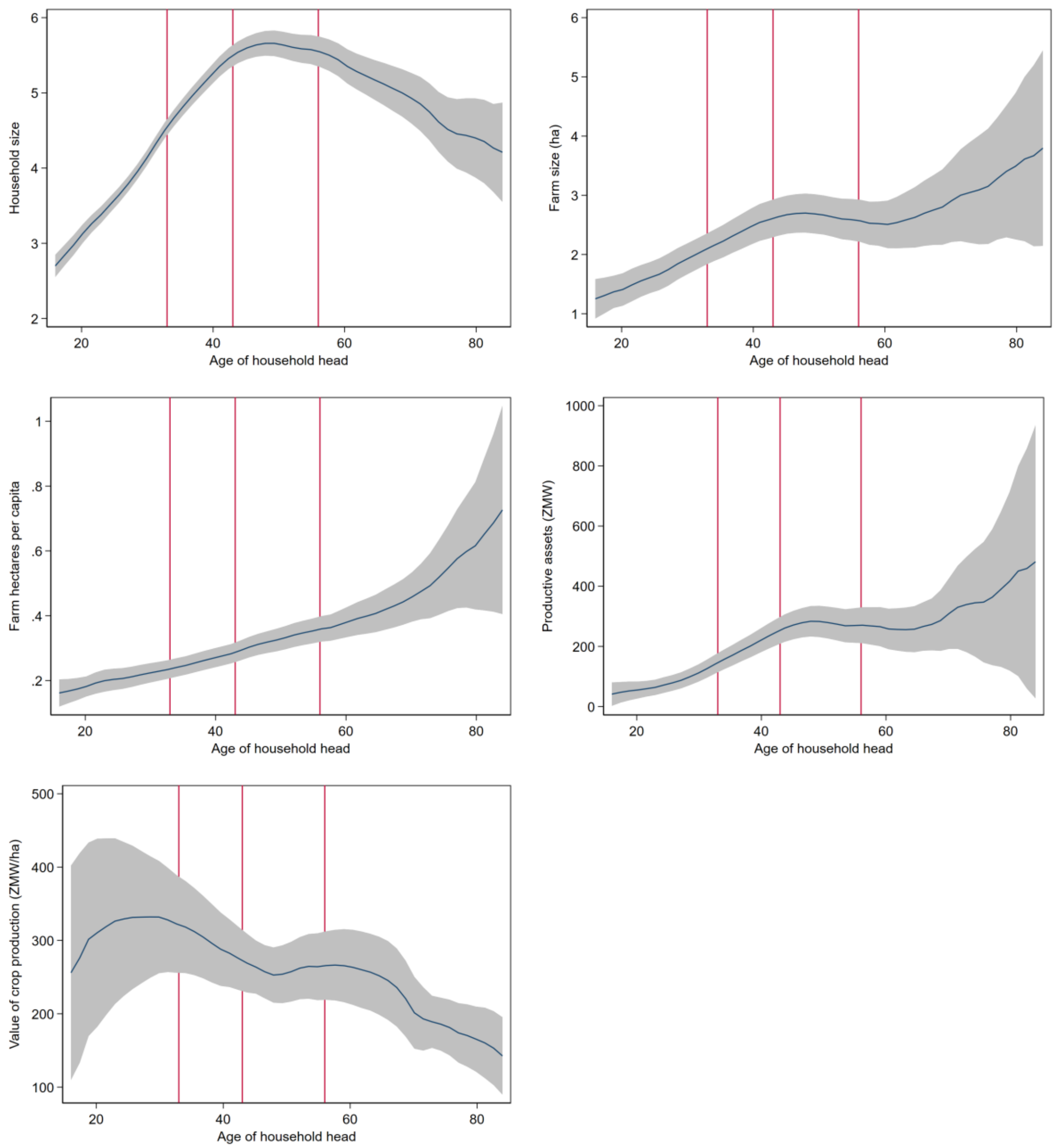

Figure 1-a: Farm characteristics by household head's age (Tanzania)
Note: Vertical lines indicate 25th, 50th and 75th percentiles of household head age distributions. Sample truncated at 99th percentile for graphs.

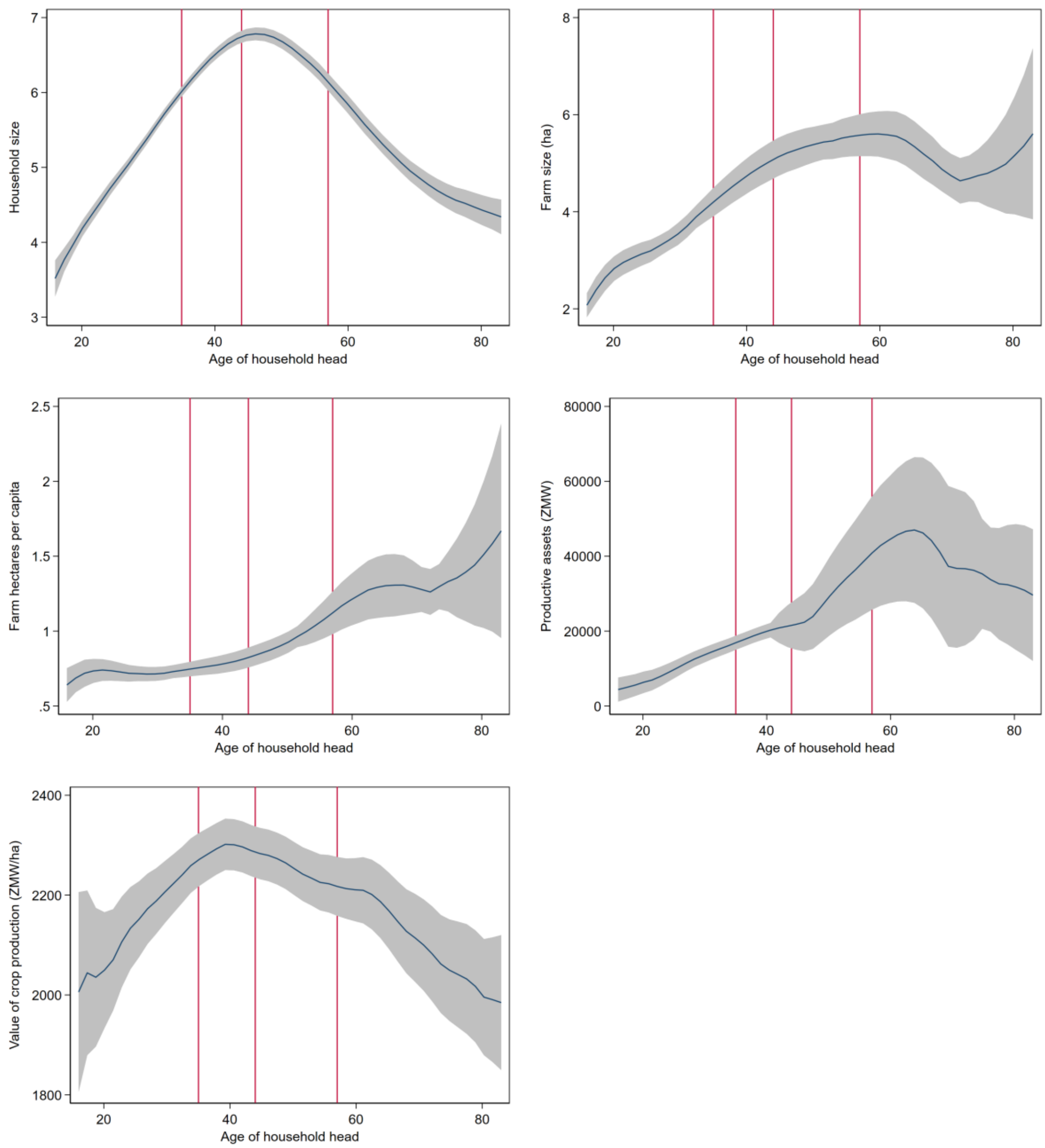

Figure 1-b: Farm characteristics by age of household head (Zambia)

Note: Vertical lines indicate 25th, 50th and 75th percentiles of household head age distributions. Sample truncated at 99th percentile for graphs.

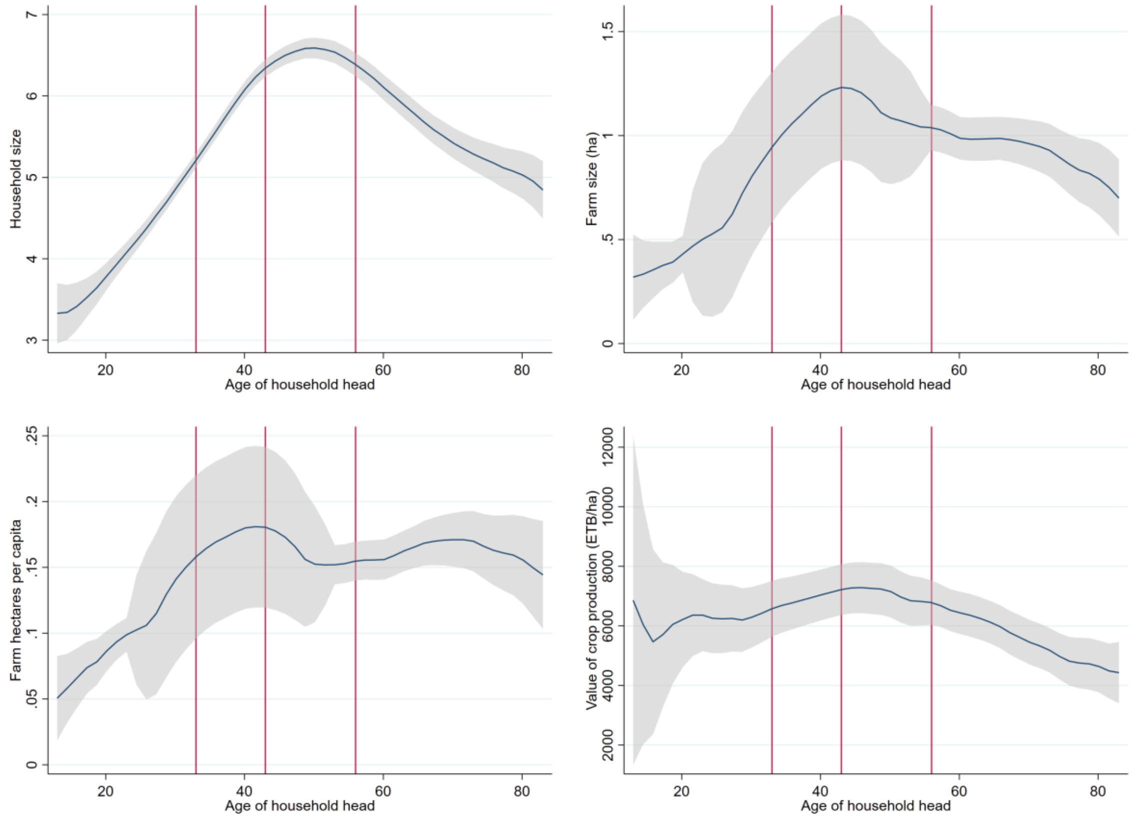

Figure 1-c: Farm characteristics by age of household head (Ethiopia)

Note: Vertical lines indicate 25th, 50th and 75th percentiles of household head age distributions. Sample truncated at 99th percentile for graphs.

To further examine some of these structural conditions, as well as the practices and outcomes of interest, we tabulate descriptive statistics covering a broad range of characteristics on the samples from the most recent wave from each country, and use quartiles of household average adult age to organise our findings (Table 3). Several things stand out from these unconditional descriptive statistics. The number of members is greatest in the second quartile, and is consistent with an inverse-U-shaped labour endowment which is lowest for very young and very old households. Farm size, farm size per household member, and productive assets all increase with age. Aligning with the findings in the graphs previously shown, we see that land endowments increase faster than labour endowments with age, meaning growing per capita land availability with age. The value of productive assets is highest in the middle range for Tanzania and increasing for Zambia (again, this variable is not available for Ethiopia). This is consistent with the stylized notion that many young households in rural Africa - and throughout the world - have relatively smaller asset endowments than older households.

Table 3-a: Descriptive statistics of sample, by quartile of household average adult age, Ethiopia

	Quartile of household average adult age				
	1st	**2nd**	**3rd**	**4th**	**Total**
Age of household head	33.7	42.6	49.0	60.5	46.4
Avg age: all members	19.0	21.4	24.7	38.8	25.8
Avg age: members aged 15+	25.4	30.2	35.1	49.7	34.9
Number of members	5.4	6.3	6.2	4.5	5.7
Number of members aged 15-64	3.3	3.6	3.4	2.1	3.1
Farm size (ha)	0.7	1.4	1.1	0.6	1.0
Number of plots	8.4	9.9	9.8	8.2	9.2
Landless households (%)	37	23	23	26	27
Farm ha/person	0.11	0.21	0.16	0.13	0.15
Value of crop production†	397.6	359.4	307.8	267.9	331.3
Marketed share of production (%)	10	9	8	7	8
High-value share of production (%)	20	21	19	17	19
Fertiliser (kg/ha)	443.1	252.0	786.4	145.5	414.3
Pesticide (avg. land share) (%)	8	9	8	6	8
Herbicide (avg. land share) (%)	24	22	23	15	21
Uses improved maize seed (%)	12	13	13	9	12

Note: † Values in 2015 USD. Quartiles of sample defined over average age of all household members aged 15 or more.

In terms of intensification practices and outcomes, technology usage is highest generally in the second quartile, rather than in the youngest quartile. Overall, management practices do not vary strongly by age category. Farm orientation does not change dramatically across age categories, although the youngest households market a marginally higher share of their production. The value of crop production per hectare is declining across all categories for Zambia and Ethiopia, but is highest in the middle ranges for Tanzania. These unconditional results indicate that the youngest households are not obviously at the forefront of agricultural change. This could reflect lower resource endowments but these young households are also likely to be less experienced and may, for example, have their eye on activities other than crop production.

Table 3-b: Descriptive statistics of sample, by quartile of household average adult age, Tanzania

	Quartile of household average adult age				
	1st	**2nd**	**3rd**	**4th**	**Total**
Age of household head	31.1	42.6	49.0	61.6	45.3
Avg age: all members	18.4	21.0	24.7	40.2	25.7
Avg age: members aged 15+	24.8	30.4	35.6	51.7	35.1
Number of members	4.4	6.1	5.9	4.1	5.1
Number of members aged 15-64	2.7	3.4	3.2	1.9	2.8
Farm size (ha)	2.2	3.5	3.2	2.5	2.8
Number of plots	2.0	2.4	2.4	2.2	2.3
Landless households (%)	48	36	29	20	34
Farm ha/person	0.19	0.32	0.38	0.58	0.36
Value of productive assets†	184	350	335	185	259
Value of crop production†	285	289	246	173	244
Marketed share of production (%)	36	33	31	23	30
High-value share of production (%)	14	17	17	14	15
Fertiliser (kg/ha)	11.9	16.3	9.5	10.1	11.8
Pesticide (avg. land share) (%)	3	3	3	2	3
Herbicide (avg. land share) (%)	11	11	11	10	10
Improved maize user (%)	56	64	59	52	58
Irrigation (%)	3	3	5	2	3
Hired labour (%)	44	45	43	43	44

Note: † Values in 2015 USD. Quartiles of sample defined over average age of all household members aged 15 or more.

Table 3-c: Descriptive statistics of sample, by quartile of household average adult age, Zambia

	Quartile of household average adult age				
	1st	**2nd**	**3rd**	**4th**	**Total**
Age of household head	35.2	42.8	48.2	62.6	47.0
Avg age: all members	17.1	19.4	22.3	37.2	23.9
Avg age: members aged 15+	25.4	29.8	34.4	49.9	34.7
Number of members	6.0	6.7	6.2	4.4	5.8
Number of members aged 15-64	3.3	3.5	3.1	2.0	3.0
Farm size (ha)	3.9	4.4	4.5	4.5	4.3
Number of plots	3.7	4.0	4.0	3.7	3.8
Landless households (%)	2	1	1	1	2
Farm ha/person	0.69	0.70	0.79	1.29	0.87
Value of productive assets†	1,831	2,073	2,827	2,944	2,413
Value of crop production†	238	237	228	211	229
Marketed share of production (%)	38	37	35	30	35
High-value share of production (%)	9	8	8	7	8
Fertiliser (kg/ha)	120.2	117.9	112.6	97.1	112.0
Pesticide (avg. land share) (%)	6.2	5.8	6.1	4.6	5.7
Herbicide (avg. land share) (%)	4.9	5.1	4.7	4.1	4.7
Uses improved maize seed (%)	65	66	64	56	63
Has irrigation (%)	19	20	17	14	17
Mechanized traction (own) (%)	0	0	1	1	1
Mechanized traction (hired) (%)	1	1	1	1	1
Animal traction (own) (%)	23	25	24	20	23
Animal traction (hired) (%)	1	1	1	1	1
Hired labour (%)	38	39	37	39	38
Practiced conservation tillage (%)	25	27	29	27	27
Practiced crop rotation (%)	43	47	46	44	45
Practices intercropping (%)	11	11	11	9	10
Uses crop residues (%)	49	51	51	51	51
Uses mulch (%)	12	14	15	13	14
Has erosion control structures (%)	24	24	23	20	23
Practices agroforestry (%)	5	5	4	4	5

Note: † Values in 2015 USD. Quartiles of sample defined over average age of all household members aged 15 or more.

To examine the relationship between household age and intensification practices and outcomes after controlling for these constraints, we specify a number of regression models which control for resource endowments and other observable characteristics (Table 4). The practices of interest in these regressions are fertiliser usage, pesticide usage. herbicide usage, and usage of improved maize seed, while the outcomes of interest are commercialised share of value of production and high value share of value of production.[10] For ease of exposition, we show only the coefficient of interest from model specifications that control for age of head (rows labelled 'a'), the average age of household adults, (rows labelled 'b'), and with simultaneous controls for age of head and average age of non-head members (rows labelled 'c'). Sex of household head, farm size, number of household members, the value of productive assets, distance from the nearest town of 50,000 or more inhabitants, year dummies and administrative control dummies (at the regional level for Tanzania and Ethiopia, and at the district level in Zambia).[11] The full estimation output for all specifications is provided in the Appendix Tables S1 - S3.

Beginning with the Ethiopia results in Table 4, we find negative correlations between the different measures of household age and the use of some inputs (pesticide and herbicide) and for commercialised share of production, although the significance of these estimates varies by the type of age indicator used. The generally insignificant findings for high-value share of production may have to do with a difficult distinctions between high-value and staples crops in Ethiopia, where some staples (e.g. teff, enset) have high commercial value and are widely marketed, and crops that are grown primarily for market in other countries (e.g. oilseeds) that are also widely grown for home consumption in Ethiopia. Similarly, Ethiopia's input acquisition context is somewhat different to other countries in the region: the vast majority of fertiliser and seed acquisitions by smallholders is via a highly regulated and centralised cooperative system, rather than via the private sector. Still, in comparing rows a and b, it is worth noting that not only are the coefficient estimates on age of head uniformly smaller than for the average age of the household workforce, the former are not always negative, while the latter are consistently negative (if not always significant). This evidence suggests that the 'age effect' on smallholder intensification and commercialisation is not confined to the age of the named household head.

Table 4: Influence of household age on farm orientation

[10] High value crops were defined as all non-staple crops, i.e., horticultural crops, high-value oilseeds, food crops such as sugarcane, and non-food crops such as tobacco and cotton.

[11] We also include time-averages of time-varying household characteristics to control for unobserved time-varying heterogeneity which may bias our results. This formulation, sometimes referred to as the Mundlak-Chamberlain device, is based on the assumption that time-averages are correlated with unobserved time-invariant factors (Mundlak, 1978, Chamberlain, 1984, Wooldridge, 2010) refers to this estimator as the correlated random effects model, and shows that it provides consistent estimates under the conditionality of its assumptions. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Standard errors are robust to clustering at the enumeration level.

		(1)	(2)	(3)	(4)	(5)	(6)
	Ethiopia	**Fertiliser (=1)**	**Pesticide (=1)**	**Herbicide (=1)**	**Improved maize seed (=1)**	**Commercialised share of prod.**	**High value share of prod.**
a)	Age of household head (years)	0.000121	-0.000401	-0.00133**	0.000213	-0.000519*	0.000052
		(0.000403)	(0.000393)	(0.000564)	(0.000528)	(0.000277)	(0.000266)
b)	Avg age of household adults	-0.00050900	-0.00111**	-0.00246***	-0.00010800	-0.00108***	-0.00000096
		(0.000606)	(0.000443)	(0.000817)	(0.000779)	(0.000407)	(0.000466)
c)	Age of head (years)	0.000276	-0.000095	-0.00103*	0.000297	-0.000472	0.000020
		(0.000459)	(0.000463)	(0.000609)	(0.000614)	(0.000296)	(0.000279)
	Avg age of other household adults	0.000461	-0.00127**	-0.00142	-0.000177	-0.000344	0.000529
		(0.000671)	(0.000553)	(0.000987)	(0.000965)	(0.000467)	(0.000641)
	Tanzania						
a)	Age of household head (years)	-0.000810**	-0.000320**	-0.000908***	-0.00172***	-0.00345***	-0.00103***
		(0.000349)	(0.000129)	(0.000204)	(0.000659)	(0.000286)	(0.000236)
b)	Avg age of household adults	-0.00136***	-0.000500***	-0.00127***	-0.00359***	-0.00387***	-0.00139***
		(0.000447)	(0.000165)	(0.000279)	(0.000848)	(0.000349)	(0.000286)
c)	Age of household head (years)	-0.000396	-0.000267*	-0.000738***	-0.0008	-0.00333***	-0.000813***
		(0.000402)	(0.000159)	(0.000240)	(0.000849)	(0.000335)	(0.000281)
	Avg age of other household adults	-0.000345	0.000049	-0.000545*	-0.00209*	-0.000709*	-0.000621*
		(0.000473)	(0.000222)	(0.000327)	(0.001130)	(0.000405)	(0.000318)
	Zambia						
a)	Age of household head (years)	-0.000054	-0.000438**	-0.000078	-0.000472	-0.00150***	-0.000690***
		(0.000319)	(0.000198)	(0.000138)	(0.000369)	(0.000194)	(0.000174)
b)	Avg age of household adults	0.000714	-0.000982***	0.000137	-0.000177	-0.00162***	-0.000972***
		(0.000436)	(0.000272)	(0.000179)	(0.000485)	(0.000269)	(0.000241)
c)	Age of household head (years)	-0.000777*	-0.000035	-0.000278	-0.000971**	-0.00138***	-0.000460**
		(0.000398)	(0.000246)	(0.000200)	(0.000443)	(0.000233)	(0.000195)
	Avg age of other household adults	0.00109**	-0.000697**	0.000548*	0.00056	-0.000252	-0.000144
		(0.000545)	(0.000341)	(0.000297)	(0.000558)	(0.000340)	(0.000278)

Notes: Each country panel shows coefficient estimates from three sets of specifications: a) controlling for age of household head only; b) controlling for average age of all adults in household; and c) controlling for both age of household head and average age of all other household adults. Other controls include household, farm and community-level controls, and district and year dummies. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation.

Turning to the Tanzania results in Table 4, we find a strong negative correlation between all measures of household age and the practices and commercial outcomes of interest. Comparing specifications using household head versus average age of the family workforce (rows a and b), we find that the coefficient estimates are consistently larger for the household average adult age than for the household head age (although the overall magnitude is small, a topic which we address further below). For example, in the model of improved maize seed usage (column 4), the estimated coefficient for average adult age is twice the size that of the coefficient for the age of the household head. This finding is consistent with the idea that some decision-making of young household members other than the head is important for the practices on which we have data. When we simultaneously control for age of head and average age of non-head adults (in row c), we find that while the coefficient for head's age is generally larger and more precisely estimated (as evidenced by small standard errors), the age of other adults does contribute further to explaining outcomes. Simply put, while younger heads do seem to have greater propensities to use modern inputs and have a more commercial orientation, there also appears to be additional impacts of a younger workforce on the use of these practices and on the commercial outcome. In other words, for two households identical in all respects, including the age of the head, but differing in the average age of the household labor force, the household with the younger work force is more likely to use modern inputs and engage more intensively with agricultural markets.

Findings for Zambia are remarkably similar to those for Tanzania. The only qualitative exception is the herbicide model results, which indicate that an older workforce is more likely to use herbicide. This result may reflect the labour-saving aspects of herbicide being particularly relevant for households with older members.

Table 5: Predicted farm orientation outcomes

	(1) Commercialised share of prod.	(2) High value share of prod.	(3) Fertiliser (=1)	(4) Pesticide (=1)	(5) Herbicide (=1)	(6) Improved maize seed (=1)
Tanzania						
(a) Predicted outcome | head age=20	0.400	0.171	0.180	0.041	0.128	0.491
(b) Predicted outcome | head age=30	0.366	0.161	0.172	0.038	0.118	0.474
(c) Predicted outcome | head age=40	0.331	0.151	0.163	0.034	0.109	0.457
Difference (b) – (a)	-0.034	-0.010	-0.009	-0.003	-0.009	-0.017
Difference p-value	(0.000)	(0.000)	(0.016)	(0.013)	(0.000)	(0.010)
Difference (c) – (a)	-0.068	-0.020	-0.017	-0.006	-0.018	-0.034
Difference p-value	(0.000)	(0.000)	(0.016)	(0.013)	(0.000)	(0.010)
Zambia						
(a) Predicted outcome | head age=20	0.348	0.195	0.524	0.131	0.0559	0.599
(b) Predicted outcome | head age=30	0.332	0.188	0.524	0.128	0.0551	0.591
(c) Predicted outcome | head age=40	0.317	0.181	0.523	0.124	0.0544	0.582
Difference (b) – (a)	-0.015	-0.007	-0.001	-0.004	-0.001	-0.008
Difference p-value	(0.000)	(0.000)	(0.867)	(0.071)	(0.591)	(0.031)
Difference (c) – (a)	-0.031	-0.014	-0.001	-0.007	-0.001	-0.017
Difference p-value	(0.000)	(0.000)	(0.867)	(0.071)	(0.591)	(0.031)

Notes: Each country panel shows predicted outcomes at different ages of household head, and the significance of differences between these predicted outcomes, after controlling for household, farm and community-level controls, and district and year dummies. P-values are shown in parenthesis.

These results are consistent with younger households being more likely to adopt modern practices and commercial farm orientations than older households, after controlling for resource endowments. However, the age effects we find are exceedingly small in magnitude. Table 5 shows estimated values of outcome variables at different ages of the household head (with other variable values at sample means). We find that even the strongest effects are relatively muted. For example, the expected share of marketed crop output for a 20-year-old head is only seven percent more than that of a 40-year-old head in Tanzania (and only three percent more likely in Zambia). Other variables show a much smaller age effect. For example, the likelihood of fertiliser use by a 20-year-old Tanzanian household head is less than two percent greater than that of a 40-year-old head (in Zambia the age difference is not statistically different from zero). Results using average age of adults instead of age of head are of similarly small magnitude.

Table 6: Correlates of factor scores (farm orientation)

	Intensification type A	**Intensification type B**
Age of head (years)	-0.00299***	-0.00368***
	(3.34e-06)	(1.33e-09)
Max educ. attainment	-0.0129***	0.0744***
	(0.000132)	(0)
Female head (1/0)	-0.132***	-0.0815***
	(3.90e-08)	(0.000942)
Farm size (ha)	0.00406***	-0.000201
	(0.00135)	(0.901)
HH members (count)	0.0181**	-0.0122
	(0.0293)	(0.147)
Productive assets (ZMW)	2.64e-07**	-1.31e-07
	(0.0269)	(0.249)
Hours to town of 50k+	3.66e-05	-6.93e-05***
	(0.181)	(0.00609)
Population density	0.382***	0.580***
	(0.000302)	(0)
Rainfall (mm)	0.000280***	0.000510***
	(0.00380)	(4.02e-09)
Intra-seasonal rainfall CV	0.798***	-0.0566
	(3.21e-05)	(0.708)
Observations	16,122	16,122
R-squared	0.272	0.312
District FE	Yes	Yes
Year FE	Yes	Yes
Mundlak-Chamberlain device	Yes	Yes

Notes: Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation.

Because farm orientation has multiple dimensions which are not always easy to treat discretely, we attempt to distil some of this variation using factor analysis on the Zambian data. This results in two different composite factors, which we refer to as intensification types A and B: higher scores for intensification type A indicate greater commercialisation of staple crops, fertiliser and improved maize seed usage, while higher scores for intensification type B indicate greater commercialisation of high-value crops (like cotton, tobacco and horticulture), and pesticide usage. These represent two different modes of intensification-commercialisation. Factor loadings for both types are shown in the Appendix Table S4.

Table 6 shows regression results for models in which the scores for factors A and B are the dependent variables. The age of the household head is negatively associated with both, indicating that younger households are more likely to be associated with both orientations.

Another way to examine ‘innovativeness’ is to examine whether the unexplained portion of variation in farm productivity, after controlling for input use and other observable time-varying conditions affecting production, is associated with farm household age. To do this, we estimated a production function for aggregate value of production per hectare using a fixed effects estimator. The individual fixed effects estimate from this model captures the portion of the variability in productivity outcomes which is associated with the individual, but not otherwise explained by model covariates (i.e. observed inputs and management decisions). This term has sometimes been interpreted as a latent measure of individual farming ability (e.g. Jin and Jayne 2013, Deininger et al. 2013, Chamberlin and Ricker-Gilbert 2016). We then calculated the correlation between this 'ability' proxy and our various measures of household age (Table 7). The correlation coefficients are all negative and highly significant, indicating that unobserved factors associated with land productivity are negatively associated with household age. One interpretation of this is that younger households are more productive, although in ways which are difficult to measure directly through existing household survey data.

Table 7: Correlation between unobserved household farming 'ability' and age

	Correlation coefficient
Age of head	-0.0417***
Aveage adult age	-0.0649***
Average adult age (excluding head)	-0.0307***

Note: Adults are members aged ≥15. 'Ability' is the recovered fixed effect estimate from a production function using the fixed effects estimator.

Much effort and resources have been expended to promote the use of so-called climate-smart and sustainable intensification (SI) production techniques in Zambia in recent years, although it should be noted that some of these same practices have been promoted over decades. To the extent that these practices represent non-traditional management choices, they may be taken as measures of 'doing things differently'. Table 8 shows regression results for Zambia for models in which the dependent variable is a farm-level measure of use of (1) minimum or zero tillage, (2) grain-legume crop rotation, (3) intercropping, (4) crop residue retention, (5) mulching, (6) erosion control structures, such as bunds or terraces, and (7) agroforestry. All practices were measured jointly in a Seemingly Unrelated Regressions (SUR) framework to allow for correlated error terms. Results indicate that age of head is positively associated with the use of most of these practices - agroforestry is the single exception. This suggests that younger households are not generally more likely to engage in such practices. However, it should be acknowledged that if SI promotion preferentially targets older farmers, then we might expect such associations, even if younger households might be more receptive to new practices in general.

Table 8: Correlates of sustainable land management practices in Zambia (standard errors in parentheses)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	**Min./zero tillage**	**Crop rotation**	**Inter-cropping**	**Crop residue**	**Mulching**	**Erosion control**	**Agro-forestry**
Age of household head (years)	0.00107***	0.00141***	0.000222	0.00126***	0.000504*	0.000197	-0.000515***
	(0.000332)	(0.000300)	(0.000282)	(0.000423)	(0.000286)	(0.000336)	(0.000182)
Max. educational attainment	0.00282*	0.00517***	0.00230*	0.00346	0.00217*	0.00166	0.00144
	(0.00163)	(0.00163)	(0.00131)	(0.00230)	(0.00128)	(0.00159)	(0.00104)
Female head (1/0)	-0.0169	0.0132	0.0128	-0.00535	-0.0126	-0.0242*	0.00352
	(0.0136)	(0.0120)	(0.00959)	(0.0166)	(0.00942)	(0.0131)	(0.00709)
Farm size (ha)	-0.000129	0.00175*	-0.000103	-0.000571	0.000181	-1.60e-05	-0.00108**
	(0.000364)	(0.00103)	(0.000316)	(0.000445)	(0.000325)	(0.000280)	(0.000471)
Household members (count)	-0.00616**	-0.00125	0.00222	0.00508	0.00133	0.00149	-0.00298
	(0.00298)	(0.00522)	(0.00172)	(0.00329)	(0.00155)	(0.00222)	(0.00435)
Productive assets (ZMW)	6.02e-09	6.25e-08	-1.77e-08	-4.33e-08	1.54e-08	-1.56e-08	2.92e-08
	(1.46e-08)	(5.69e-08)	(1.35e-08)	(2.95e-08)	(1.28e-08)	(1.96e-08)	(3.97e-08)
Hours to town of 50k+	2.31e-06	4.70e-06	6.15e-06	-1.88e-05	3.76e-06	-1.10e-05	2.36e-05***
	(1.10e-05)	(1.34e-05)	(9.45e-06)	(1.40e-05)	(9.04e-06)	(1.01e-05)	(7.16e-06)
Population density	0.00450	0.0547*	0.0135	0.123***	0.0850***	0.0673***	0.0399***
	(0.0458)	(0.0286)	(0.0326)	(0.0255)	(0.0235)	(0.0223)	(0.00944)
Rainfall (mm)	-0.000110***	7.30e-05	3.71e-05*	5.53e-07	-6.61e-05*	1.20e-05	-0.000126*
	(3.35e-05)	(7.35e-05)	(2.22e-05)	(5.40e-05)	(3.56e-05)	(2.44e-05)	(7.31e-05)
Intra-seasonal rainfall CV	-0.0322	-0.173	0.190***	0.179**	0.147***	0.0196	-0.0896
	(0.0724)	(0.118)	(0.0480)	(0.0822)	(0.0541)	(0.0450)	(0.150)
Constant	0.263	-0.425	-0.217	-0.266	-0.811***	-0.521**	-0.454***
	(0.379)	(0.259)	(0.290)	(0.292)	(0.206)	(0.257)	(0.116)
Observations	16,454	16,454	16,454	16,454	16,454	16,454	16,454
Mundlak-Chamberlain	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: The average age of other household adults is the average age of all members other than the head who are aged ≥15. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation.

Finally, much has been said about young people's affinity for modern technologies, including mobile phones and other ICTs (FAO et al., 2014, AGRA, 2015). In our dataset, we observe mobile phone usage reported along with the main purpose of usage. Table 9 shows regression results for Zambia for binary indicators of whether or not a household uses a mobile phone (1) for any purpose, (2) to call family and friends, or (3) for business activities, such as sending or receiving money, negotiating sales transactions or obtaining market information.[12] In the model in column 4, the dependent variable is the number of business activities for which mobile phone is used. Coefficient estimates indicate that households with younger heads are more likely to report using mobile phones than those with older heads, are more likely to use mobile phones for business activities, and on average use mobile phones for a greater variety of business activities. These results could be read as lending themselves to the conventional narrative of young farmers being more engaged with ICT in rural Africa, but caution is advised as we know little about who within the household is actually using the phone.

Table 9: Correlates of mobile phone usage in Zambia (standard errors in parentheses)

	(1)	(2)	(3)	(4)

[12] Note that these are linear probability models, given the binary outcomes.

VARIABLES	1=used mobile phone for any purpose	1=use phone: call family or friends	1=used mobile phone for any business activity	# of business activities for which mobile phone used
Age of household head (years)	-0.00152***	0.000624	-0.00234***	-0.00804***
	(0.000543)	(0.000385)	(0.000529)	(0.00138)
Max. educational attainment	0.0245***	-0.00205	0.0296***	0.109***
	(0.00251)	(0.00177)	(0.00234)	(0.00739)
Female head (1/0)	-0.0421**	0.0277**	-0.0746***	-0.199***
	(0.0197)	(0.0127)	(0.0190)	(0.0494)
Farm size (ha)	-0.00288*	-0.000235	-0.00247	-0.0196***
	(0.00156)	(0.000869)	(0.00158)	(0.00649)
Household members (count)	-0.0247***	-0.00811	-0.0179**	-0.0151
	(0.00898)	(0.00630)	(0.00857)	(0.0254)
Productive assets (ZMW)	1.96e-07	7.79e-08	1.64e-07	9.53e-07*
	(1.61e-07)	(4.95e-08)	(1.51e-07)	(5.57e-07)
Hours to town of 50k+	-7.10e-05***	2.71e-05*	-0.000106***	-0.000288***
	(2.14e-05)	(1.51e-05)	(2.08e-05)	(6.03e-05)
Population density	-0.0845*	-0.0215	-0.0943**	-0.0445
	(0.0434)	(0.0321)	(0.0399)	(0.145)
Rainfall (mm)	0.000472	7.84e-05	0.000577**	0.00150**
	(0.000305)	(0.000218)	(0.000286)	(0.000726)
Intra-seasonal rainfall CV	-0.238	0.0440	-0.235	0.159
	(0.555)	(0.379)	(0.508)	(1.569)
Observations	6,813	6,813	6,813	7,747
R-squared	0.164	0.215	0.140	0.172
Mundlak-Chamberlain	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes

Notes: The average age of other household adults is the average age of all members other than the head who are aged ≥15. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation.

Qualitative research supports the conclusion there is little evidence for an on-going, youth-led rural economic revolution (Yeboah et al., 2020, Flynn and Sumberg, 2021). The qualitative research provides little support for the idea that young people are using different agricultural technology or using technology differently. Further, while many young people market some of their agricultural produce, there is little evidence that young people are engaged in innovative processing activities or linking to value chains characterised by higher value products, value addition, safety requirements and quality differentiation (Reardon, 2015).

More broadly, while most young women and young men engage in one or more nonfarm income generating activities, overwhelmingly these tend to be the same low investment, low technology, and relatively low skill activities, including petty trading, food preparation, catering and artisanal trades, which dominate the rural opportunity landscape (Flynn and Sumberg, 2018, Yeboah et al., 2020, Flynn and Sumberg 2021). One suggestion is that even in areas of significant agricultural commercialisation, there are still relatively few meaningful opportunities for investment, skill upgrading and risk-taking. Another is that the intergenerational nature of much farm and nonfarm economic activity, and the importance of social relations for accessing land, capital and skill, effectively blurs the lines between youth and non-youth economic activity.

5. Discussion

Our empirical analysis suggests two conclusions which stand somewhat in counterpoint to each another. One the one hand, we do find fairly pronounced and widespread evidence that younger households are more likely to adopt modern practices and have more commercial orientations, compared with older households. This is despite the observable difference in resource endowments that also characterise young rural households. However, these effects are generally quite small in magnitude, even when the estimates are fairly precise. This suggests that rhetoric about unleashing a whirlwind of youth-led agricultural transformation is probably misplaced. Education, specialised training and access to credit and other investment resources may play roles in facilitating young farmers to realise their productive potential - but the same could certainly also be said for the non-young.

Our finding that household average adult age seems to offer more explanatory power than the age of the household head suggests that the default position of measuring 'farmer characteristics' in terms of the nominal household head requires further critical scrutiny. It is very likely that distributed models of decision making may better map onto the reality of smallholder households and their various agricultural and nonfarm activities. This is perhaps particularly true of contemporary SSA, where land constraints may keep adult children within natal households for longer than they might desire, and where traditional cultural norms may allocate nominal headship to individuals based on seniority, gender and genealogical position, even when the farm management aspects of headship have devolved to other members. There is some qualitative evidence that suggests this is the case, e.g., Andersson Djurfeldt et al.'s (2019) study on household positionality and intra-household participation in farm management in Zambia. Our argument in this respect is similar to arguments for more nuanced and creative collection of data on gendered patterns of intra-household resource control and decision making (Doss et al., 2018) and more general critiques of uncritical adoption of unitary household models of decision making (Agarwal, 1997). The intra-household resource allocation literature has focused much of its attention on gendered access to and control over household assets and the implications for individual and household welfare outcomes (e.g. Doss, 2013, Oduro et al., 2015). Similar critical reinterpretations of intra-household agency and dynamics with respect to farm management and production - and the role that young adults play therein - may be very illuminating. This will require more creative approaches to data collection. Recent efforts to collect multiple contributors to decision-making are a step in the right direction, but still offer limited insights into the agency of non-head members, and may poorly reflect more complex situations of collective intrahousehold agency and collaborative managerial decisions. Another issue is that plots which are entirely controlled by subordinate members of a household may not even show up in household rosters. Qualitative evidence such as that provided by Andersson Djurfeldt et al. (2019) suggests this is not unlikely for some types of households.[13]

[13] '[One] variety of positionality involves young men and their wives who live in extended, multi-generational families, where they together with their children constitute the middle segment of these families. They have been allocated family land by their parents and farm independently but continue to live close to the parental generation and view the patriarch as the household head, even if he is not involved in any of their production or marketing decisions and they are not accountable to him in terms of incomes raised and saved' (Andersson Djurfeldt et al., 2019 p.7), and 'a handful of respondents were also single, unmarried men who had been allocated land by their parents and continued living with their parents, but were farming independently and were not accountable to their

If we are serious about understanding how young people farm (and do other things), it is incumbent on us to do more critical evaluation of how well standard household instruments capture individual-level and collective economic activity.

We should acknowledge that the regression models we employ in this analysis use continuous linear measures of age, rather than discrete categories of 'young'. As such, the modelling portion of our analysis may be characterised as the exploration of age effects, rather than youth effects per se, in coinditioning our primary outcomes of interest. We note, however, that we did estimate alternative specifications for these models with discrete 'youth' dummies and the overall story is very consistent with the results presented here. Because the discrete definition of a 'youth' indicator is fundamentally arbitrary (Is 15-25 years of age a better definition than 15-28? Should we use the same definition of youth for heads and for household labor?), we have elected to restrict our discussion to the linear models as presented. We also estimated models with non-linear measures of age, but generally found that linear models performed as well or better and are more easily interpreted, particularly in the specification which includes the age of the head and the average age of the household adults. Further empirical work may examine alternative analytical approaches in more detail.

Another important point relates to the nature of the farming activities and outcomes we are able to examine with survey data. Ideally, we would like to say something about innovation, entrepreneurial disruption and the like, but we are limited in our ability to observe these. It may be the case that youth-driven changes are taking place that we simply are unable to observe because the right questions are not being asked. While this is a possibility, it would be a mistake to simply assume it is the case.

Finally, it is important to recognise that we only observe those who stay in farming. As such, our results are representative only of those who are actually farming, not of all the young people who might have farmed if things had been different (e.g. more access to land, fewer competing opportunities in urban areas). The individuals with the most transformative potential may not be the ones starting farm households (or staying on their parents' farms). That said, the standard conceptualisation of the structural transformation process suggests that the least efficient farmers will be the first to leave (Johnston and Mellor, 1961). If this is indeed the case, then policies that reduce barriers to farming (e.g. via land market promotion, resettlement schemes, credit facilitation) may induce entrance by individuals with lower inherent productive or innovative capacity. In any case, observational data may never be able to fully address the selection bias at work here, and there may be limited scope for experimental approaches. Nevertheless, thinking about this question more carefully may clarify new opportunities for empirical research.

parents' (ibid.). Given the low incidence of plots identified as controlled by members other than head and/or spouse in household survey data, it would seem that the types of households referred to above may not fully report on the land managed by all individuals identified as household members.

6. Conclusions

We find some support for many of the stylised assertions about youth in African agriculture. Younger household heads have smaller farms, smaller households, and fewer capital resources. However, after controlling for these constraints, we observe marginally higher propensities to engage with intensification practices and commercial orientations which are objectives of much current policy and programming. These findings are in line with the narrative of young people's inherent vim and vigour being an asset for agricultural growth and transformation in SSA.

That said, the very limited magnitude of these age effects suggests much caution should be exercised in making this argument. More work is needed to understand the conditions under which young farmers thrive. It is not clear that policies or programmes that target the land, capital or other endowments and constraints of young farmers will have bigger impacts than transformative investments (e.g.in infrastructure) that are accessible by all farmers. It is not very useful (and certainly not realistic) to divorce young people from their resource constraints: the implications of this are that there are probably few viable policy avenues for unleashing the much vaunted, latent youth whirlwind of innovative effervescence.

In any case, the locus of change in rural economies may be happening off the farm, and in ways that are opaque to our current ways of monitoring the system (i.e. household surveys). Examples include medium-scale farm investment, agribusiness and value chain expansion, urban demand and the supermarket revolution, lower barriers to global agricultural markets. It is not at all clear what role youth may play (if any) in such areas, but new ways and a different focus of research and data collecting may allow that question to be probed better than we are able to now.

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Appendices

Table S1: Correlates of farm orientation indicators in Ethiopia

VARIABLES	(1) Commercialized share of prod.	(2) High value share of prod.	(3) Fertilizer (=1)	(4) Pesticide (=1)	(5) Herbicide (=1)	(6) Improved maize seed (=1)
Age of head (years)	-0.000519*	5.16e-05	0.000121	-0.000401	-0.00133**	0.000213
	(0.000277)	(0.000266)	(0.000403)	(0.000393)	(0.000564)	(0.000528)
Max educational attainment	0.000489	0.00249	0.00656***	-0.00277	0.00370	0.00300
	(0.00253)	(0.00245)	(0.00253)	(0.00286)	(0.00321)	(0.00290)
Female head (1/0)	-0.0374	-0.0110	0.0241	-0.0500	-0.0213	0.0315
	(0.0263)	(0.0328)	(0.0398)	(0.0306)	(0.0444)	(0.0278)
Farm size (ha)	0.000164	0.000470	0.000967**	-0.000531	0.00140	0.000125
	(0.000285)	(0.000739)	(0.000376)	(0.000453)	(0.00122)	(0.000284)
HH members (count)	0.00422	-0.0122	0.0107	0.00235	-0.00928	0.00767
	(0.00619)	(0.00771)	(0.00751)	(0.00821)	(0.00780)	(0.00709)
Travel time to market	-1.72e-05	5.58e-05	-0.000566***	-0.000205**	-0.000343*	-0.000558***
	(6.59e-05)	(5.72e-05)	(0.000123)	(9.20e-05)	(0.000205)	(0.000177)
Observations	9,285	9,285	9,285	9,285	9,285	9,285
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
M-C device	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Results correspond to selected coefficients shown in Table 4. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation. M-C device is the Mundlak-Chamberlain device, under which time-averages of time-varying model covariates are included as additional controls for unobserved time-invariant heterogeneity.

Table S1 (continued): Correlates of farm orientation indicators in Ethiopia

VARIABLES	(7) Commercialized share of prod.	(8) High value share of prod.	(9) Fertilizer (=1)	(10) Pesticide (=1)	(11) Herbicide (=1)
Avg age of HH adults	-0.00108***	-9.64e-07	-0.000509	-0.00111**	-0.00246***
	(0.000407)	(0.000466)	(0.000606)	(0.000443)	(0.000817)
Max educational attainment	0.000214	0.00243	0.00634**	-0.00300	0.00323
	(0.00253)	(0.00244)	(0.00251)	(0.00288)	(0.00320)
Female head (1/0)	-0.0426	-0.0136	0.0239	-0.0514*	-0.0168
	(0.0261)	(0.0324)	(0.0388)	(0.0299)	(0.0436)
Farm size (ha)	0.000164	0.000470	0.000970**	-0.000530	0.00140
	(0.000288)	(0.000739)	(0.000379)	(0.000457)	(0.00122)
HH members (count)	0.00374	-0.0121	0.0104	0.00170	-0.0104
	(0.00619)	(0.00766)	(0.00754)	(0.00822)	(0.00789)
Travel time to market	-1.62e-05	5.53e-05	-0.000568***	-0.000205**	-0.000339*
	(6.56e-05)	(5.72e-05)	(0.000123)	(9.23e-05)	(0.000205)
Observations	9,297	9,297	9,297	9,297	9,297
Regional FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
M-C device	Yes	Yes	Yes	Yes	Yes

Notes: Results correspond to selected coefficients shown in Table 4. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation. M-C device is the Mundlak-Chamberlain device, under which time-averages of time-varying model covariates are included as additional controls for unobserved time-invariant heterogeneity.

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Table S1 (continued): Correlates of farm orientation indicators in Ethiopia

VARIABLES	(13) Commercialized share of prod.	(14) High value share of prod.	(15) Fertilizer (=1)	(16) Pesticide (=1)	(17) Herbicide (=1)	(18) Improved maize seed (=1)
Age of head (years)	-0.000472	1.97e-05	0.000276	-9.47e-05	-0.00103*	0.000297
	(0.000296)	(0.000279)	(0.000459)	(0.000463)	(0.000609)	(0.000614)
Avg age of other HH adults	-0.000344	0.000529	0.000461	-0.00127**	-0.00142	-0.000177
	(0.000467)	(0.000641)	(0.000671)	(0.000553)	(0.000987)	(0.000965)
Max educational attainment	0.000157	0.00193	0.00684**	-0.00261	0.00375	0.00297
	(0.00256)	(0.00249)	(0.00266)	(0.00297)	(0.00336)	(0.00300)
Female head (1/0)	-0.0391	-0.0224	0.0310	-0.0494	-0.0104	0.0363
	(0.0269)	(0.0333)	(0.0381)	(0.0320)	(0.0468)	(0.0307)
Farm size (ha)	0.000199	0.000540	0.000886**	-0.000554	0.00147	0.000140
	(0.000276)	(0.000835)	(0.000415)	(0.000457)	(0.00129)	(0.000304)
HH members (count)	0.00578	-0.0134	0.00823	0.00662	-0.0118	0.00744
	(0.00645)	(0.00815)	(0.00741)	(0.00856)	(0.00823)	(0.00750)
Travel time to market	-2.43e-05	6.38e-05	-0.000530***	-0.000220**	-0.000349	-0.000584***
	(6.97e-05)	(6.06e-05)	(0.000125)	(9.55e-05)	(0.000219)	(0.000187)
Observations	8,523	8,523	8,523	8,523	8,523	8,523
Regional FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
M-C device	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Results correspond to selected coefficients shown in Table 4. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation. M-C device is the Mundlak-Chamberlain device, under which time-averages of time-varying model covariates are included as additional controls for unobserved time-invariant heterogeneity.

Table S2: Correlates of farm orientation indicators in Tanzania

VARIABLES	(1) Commercialized share of prod.	(2) High value share of prod.	(3) Fertilizer (kg/ha)	(4) Pesticide (=1)	(5) Herbicide (=1)	(6) Improved maize seed (=1)
Age of head (years)	-0.00344***	-0.00103***	-3.120*	-0.000320**	-0.000908***	-0.00172***
	(0.000286)	(0.000236)	(1.638)	(0.000129)	(0.000204)	(0.000659)
Female head (1/0)	0.0145	-0.0317*	12.22	0.00209	0.0118	-0.00250
	(0.0331)	(0.0184)	(17.49)	(0.0111)	(0.0295)	(0.0767)
Farm size (ha)	0.00393**	0.00198*	-1.469	0.000721	0.00127	0.0145***
	(0.00153)	(0.00118)	(1.393)	(0.000527)	(0.00175)	(0.00431)
HH members (count)	-0.00314	-0.00277	-12.71	-0.000165	0.00671*	0.0132
	(0.00399)	(0.00304)	(16.65)	(0.00168)	(0.00349)	(0.0128)
value of productive assets	2.62e-09	1.13e-09	3.83e-06	1.47e-09	6.53e-10	1.05e-08
	(4.22e-09)	(3.64e-09)	(4.44e-06)	(2.42e-09)	(3.02e-09)	(1.37e-08)
Travel time to market	0.000200***	0.000125*	-0.378	-9.86e-05***	-2.06e-05	-0.000389**
	(7.40e-05)	(7.31e-05)	(0.290)	(3.12e-05)	(7.21e-05)	(0.000176)
Observations	10,009	10,009	10,009	10,009	10,009	10,009
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
M-C device	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Results correspond to selected coefficients shown in Table 4. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation. M-C device is the Mundlak-Chamberlain device, under which time-averages of time-varying model covariates are included as additional controls for unobserved time-invariant heterogeneity.

Table S2 (continued): Correlates of farm orientation indicators in Tanzania

VARIABLES	(7) Commercialized share of prod.	(8) High value share of prod.	(9) Fertilizer (kg/ha)	(10) Pesticide (=1)	(11) Herbicide (=1)	(12) Improved maize seed (=1)
Avg age of HH adults	-0.00386***	-0.00139***	-3.747*	-0.000500***	-0.00127***	-0.00359***
	(0.000349)	(0.000285)	(2.097)	(0.000165)	(0.000279)	(0.000848)
Female head (1/0)	0.0142	-0.0323*	10.96	0.00189	0.0115	-0.00516
	(0.0329)	(0.0181)	(17.83)	(0.0111)	(0.0297)	(0.0771)
Farm size (ha)	0.00393**	0.00198*	-1.555	0.000720	0.00126	0.0145***
	(0.00159)	(0.00119)	(1.392)	(0.000531)	(0.00176)	(0.00435)
HH members (count)	-0.00860**	-0.00472	-18.02	-0.000865	0.00492	0.00827
	(0.00411)	(0.00308)	(17.42)	(0.00169)	(0.00349)	(0.0127)
value of productive assets	2.89e-09	1.23e-09	4.15e-06	1.51e-09	7.38e-10	1.08e-08
	(4.23e-09)	(3.64e-09)	(4.46e-06)	(2.42e-09)	(3.01e-09)	(1.37e-08)
Travel time to market	0.000205***	0.000125*	-0.374	-9.86e-05***	-1.98e-05	-0.000394**
	(7.55e-05)	(7.40e-05)	(0.289)	(3.12e-05)	(7.22e-05)	(0.000176)
Observations	10,009	10,009	10,009	10,009	10,009	10,009
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
M-C device	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Results correspond to selected coefficients shown in Table 4. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation. M-C device is the Mundlak-Chamberlain device, under which time-averages of time-varying model covariates are included as additional controls for unobserved time-invariant heterogeneity.

Table S2 (continued): Correlates of farm orientation indicators in Tanzania

VARIABLES	(13) Commercialized share of prod.	(14) High value share of prod.	(15) Fertilizer (kg/ha)	(16) Pesticide (=1)	(17) Herbicide (=1)	(18) Improved maize seed (=1)
Age of head (years)	-0.00333***	-0.000811***	-1.841	-0.000267*	-0.000738***	-0.000800
	(0.000336)	(0.000280)	(1.228)	(0.000159)	(0.000240)	(0.000849)
Avg age of other HH adults	-0.000705*	-0.000620*	-0.484	4.94e-05	-0.000545*	-0.00209*
	(0.000406)	(0.000318)	(0.867)	(0.000222)	(0.000327)	(0.00113)
Female head (1/0)	0.0266	-0.0456**	19.86	0.00965	0.0222	0.00101
	(0.0393)	(0.0208)	(18.71)	(0.0132)	(0.0250)	(0.0845)
Farm size (ha)	0.00378**	0.00211*	-1.641	0.000656	0.00122	0.0144***
	(0.00150)	(0.00118)	(1.358)	(0.000515)	(0.00174)	(0.00424)
HH members (count)	-0.00492	-0.00423	-14.02	-0.000832	0.00616	0.0156
	(0.00438)	(0.00315)	(17.70)	(0.00185)	(0.00381)	(0.0135)
value of productive assets	2.52e-09	9.61e-10	5.05e-06	1.55e-09	6.60e-10	9.53e-09
	(4.26e-09)	(3.66e-09)	(4.67e-06)	(2.43e-09)	(3.05e-09)	(1.37e-08)
Travel time to market	0.000219***	0.000143**	-0.146	-0.000101***	-1.99e-05	-0.000407**
	(7.43e-05)	(7.18e-05)	(0.169)	(3.38e-05)	(7.40e-05)	(0.000187)
Observations	9,048	9,048	9,048	9,048	9,048	9,048
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
M-C device	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Results correspond to selected coefficients shown in Table 4. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation. M-C device is the Mundlak-Chamberlain device, under which time-averages of time-varying model covariates are included as additional controls for unobserved time-invariant heterogeneity.

Table S3: Correlates of farm orientation indicators in Zambia

VARIABLES	(1) Commercialized share of prod.	(2) High value share of prod.	(3) Fertilizer (kg/ha)	(4) Pesticide (=1)	(5) Herbicide (=1)	(6) Improved maize seed (=1)
Age of head (years)	-0.00153***	-0.000682***	-0.220***	-0.000386***	-0.000123	-0.000629*
	(0.000194)	(0.000174)	(0.0826)	(9.96e-05)	(9.53e-05)	(0.000373)
Max educational attainment	0.0119***	-0.00309***	10.54***	-0.000673	0.00412***	0.0309***
	(0.00120)	(0.000905)	(0.617)	(0.000483)	(0.000748)	(0.00169)
Female head (1/0)	-0.0426***	-0.0186**	-2.689	-0.0181***	-0.00416	-0.0602***
	(0.00761)	(0.00761)	(3.518)	(0.00355)	(0.00364)	(0.0144)
Farm size (ha)	0.00142**	0.00113**	-0.755***	0.000152	0.000451*	0.000120
	(0.000623)	(0.000443)	(0.201)	(0.000142)	(0.000249)	(0.000694)
HH members (count)	0.000133	0.00748***	-2.685**	0.000287	0.000871	-0.00307
	(0.00262)	(0.00247)	(1.240)	(0.00128)	(0.00195)	(0.00472)
Productive assets (ZMW)	3.68e-08	3.28e-08	-6.97e-05***	3.74e-08	1.02e-07**	-3.75e-08
	(3.18e-08)	(2.02e-08)	(2.46e-05)	(2.99e-08)	(4.95e-08)	(5.08e-08)
Hours to town of 50k+	9.04e-07	-8.02e-06	-0.0166***	7.01e-06*	1.19e-05***	-5.59e-05***
	(7.37e-06)	(6.25e-06)	(0.00424)	(3.89e-06)	(3.26e-06)	(1.52e-05)
Population density	0.184***	0.0738**	54.85***	0.0529***	0.0353***	0.341***
	(0.0216)	(0.0330)	(8.538)	(0.0157)	(0.0134)	(0.0186)
Rainfall (mm)	0.000230***	8.03e-05**	0.0236**	1.19e-05	-1.71e-05	0.000127**
	(2.96e-05)	(3.59e-05)	(0.0118)	(1.19e-05)	(1.34e-05)	(5.67e-05)
Intraseasonal rainfall CV	0.0136	0.259***	11.38	0.0781***	-0.0532	-0.0434
	(0.0581)	(0.0577)	(20.58)	(0.0264)	(0.0324)	(0.106)
Observations	16,273	16,273	16,273	16,273	16,273	16,273
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
M-C device	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Results correspond to selected coefficients shown in Table 4. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation. M-C device is the Mundlak-Chamberlain device, under which time-averages of time-varying model covariates are included as additional controls for unobserved time-invariant heterogeneity.

Table S3 (continued): Correlates of farm orientation indicators in Zambia

VARIABLES	(7) Commercialized share of prod.	(8) High value share of prod.	(9) Fertilizer (kg/ha)	(10) Pesticide (=1)	(11) Herbicide (=1)	(12) Improved maize seed (=1)
Avg age of HH adults	-0.00164***	-0.000966***	0.0655	-0.000655***	5.65e-05	-0.000292
	(0.000270)	(0.000241)	(0.117)	(0.000141)	(0.000122)	(0.000488)
Max educational attainment	0.0109***	-0.00369***	10.60***	-0.00109**	0.00418***	0.0308***
	(0.00124)	(0.000930)	(0.632)	(0.000513)	(0.000776)	(0.00172)
Female head (1/0)	-0.0505***	-0.0213***	-4.906	-0.0198***	-0.00542	-0.0672***
	(0.00749)	(0.00744)	(3.447)	(0.00354)	(0.00363)	(0.0142)
Farm size (ha)	0.00158**	0.00116***	-0.710***	0.000175	0.000377*	0.000170
	(0.000620)	(0.000442)	(0.194)	(0.000135)	(0.000208)	(0.000663)
HH members (count)	-0.00180	0.00632***	-3.170**	-0.000849	0.000704	-0.00511
	(0.00255)	(0.00244)	(1.245)	(0.00126)	(0.00189)	(0.00468)
Productive assets (ZMW)	3.76e-08	3.45e-08*	-7.01e-05***	3.78e-08	1.01e-07**	-3.76e-08
	(3.13e-08)	(1.97e-08)	(2.46e-05)	(3.00e-08)	(4.89e-08)	(5.07e-08)
Hours to town of 50k+	7.76e-07	-8.16e-06	-0.0162***	6.65e-06*	1.18e-05***	-5.51e-05***
	(7.41e-06)	(6.30e-06)	(0.00419)	(3.96e-06)	(3.28e-06)	(1.51e-05)
Population density	0.185***	0.0743**	54.67***	0.0536***	0.0351***	0.341***
	(0.0215)	(0.0329)	(8.540)	(0.0156)	(0.0134)	(0.0188)
Rainfall (mm)	0.000235***	7.98e-05**	0.0251**	1.37e-05	-1.54e-05	0.000127**
	(2.91e-05)	(3.54e-05)	(0.0121)	(1.18e-05)	(1.32e-05)	(5.45e-05)
Intraseasonal rainfall CV	0.0133	0.256***	13.94	0.0777***	-0.0541*	-0.0374
	(0.0571)	(0.0579)	(22.02)	(0.0265)	(0.0325)	(0.105)
Observations	16,433	16,433	16,433	16,433	16,433	16,433
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
M-C device	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Results correspond to selected coefficients shown in Table 4. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation. M-C device is the Mundlak-Chamberlain device, under which time-averages of time-varying model covariates are included as additional controls for unobserved time-invariant heterogeneity.

Table S3 (continued): Correlates of farm orientation indicators in Zambia

VARIABLES	(13) Commercialized share of prod.	(14) High value share of prod.	(15) Fertilizer (kg/ha)	(16) Pesticide (=1)	(17) Herbicide (=1)	(18) Improved maize seed (=1)
Age of head (years)	-0.00141***	-0.000454**	-0.416***	-0.000224*	-0.000289**	-0.00111**
	(0.000233)	(0.000195)	(0.109)	(0.000118)	(0.000137)	(0.000446)
Avg age of other HH adults	-0.000261	-0.000141	0.352**	-0.000336*	0.000452**	0.000636
	(0.000339)	(0.000278)	(0.158)	(0.000175)	(0.000205)	(0.000551)
Max educational attainment	0.0119***	-0.00315***	11.38***	-0.000889	0.00488***	0.0321***
	(0.00133)	(0.00101)	(0.661)	(0.000564)	(0.000880)	(0.00178)
Female head (1/0)	-0.0505***	-0.0185**	-4.759	-0.0193***	-0.00311	-0.0569***
	(0.00869)	(0.00759)	(4.293)	(0.00431)	(0.00426)	(0.0165)
Farm size (ha)	0.00166***	0.00110**	-0.635***	0.000155	0.000431*	8.28e-05
	(0.000581)	(0.000455)	(0.190)	(0.000159)	(0.000238)	(0.000761)
HH members (count)	0.000689	0.00647**	-1.454	-0.000271	0.00116	-0.00206
	(0.00281)	(0.00267)	(1.428)	(0.00143)	(0.00199)	(0.00516)
Productive assets (ZMW)	3.13e-08	3.30e-08*	-7.39e-05***	4.05e-08	9.19e-08**	-4.17e-08
	(3.33e-08)	(2.00e-08)	(2.49e-05)	(3.16e-08)	(4.45e-08)	(5.09e-08)
Hours to town of 50k+	-4.07e-06	-5.96e-06	-0.0181***	7.25e-06*	1.11e-05***	-6.62e-05***
	(7.59e-06)	(6.14e-06)	(0.00444)	(3.90e-06)	(3.14e-06)	(1.56e-05)
Population density	0.189***	0.0729**	61.59***	0.0586***	0.0391***	0.355***
	(0.0224)	(0.0296)	(9.164)	(0.0165)	(0.0145)	(0.0175)
Rainfall (mm)	0.000234***	8.67e-05**	0.0202	1.33e-05	-1.96e-05	0.000112*
	(3.08e-05)	(3.39e-05)	(0.0129)	(1.26e-05)	(1.47e-05)	(6.04e-05)
Intraseasonal rainfall CV	0.00327	0.279***	11.33	0.0857***	-0.0528	-0.0165
	(0.0614)	(0.0552)	(22.26)	(0.0273)	(0.0346)	(0.112)
Observations	15,178	15,178	15,178	15,178	15,178	15,178
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
M-C device	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Results correspond to selected coefficients shown in Table 4. Each set of outcomes for a given specification is estimated using a seemingly unrelated regression (SUR) framework, to address correlation in the error terms associated with each outcome. Cluster robust standard errors, shown in parentheses, are robust to heteroskedasticity and within-cluster correlation. M-C device is the Mundlak-Chamberlain device, under which time-averages of time-varying model covariates are included as additional controls for unobserved time-invariant heterogeneity.

Table S4: Factor loadings for modernization variables, Ethiopia

variable	Factor 1	Factor 2
Commercialized share of prod.	0.2738	0.2317
High value share of prod	-0.0582	0.4112
Fertilizer (kg/ha)	0.3737	-0.0641
Pesticide (farm share)	-0.0323	0.4177
Herbicide (farm share)	0.0690	0.0537
Improved maize seed (=1)	0.4139	-0.0541

Note: Table shows the loadings from a factor analysis of the correlation matrix between values observed on six modernization variables, where the table shows the matrix of correlations following varimax rotation. Loadings indicate how the variables are weighted for each factor, and also the correlation between each variable and factor.

Notes

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