ESSAYS ON AGRICULTURAL PRODUCTIVITY, YOUTH EMPLOYMENT, AND HUMAN CAPITAL INVESTMENT IN SUB–SAHARAN AFRICA

By

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ABSTRACT

ESSAYS ON AGRICULTURAL PRODUCTIVITY, YOUTH EMPLOYMENT, AND HUMAN CAPITAL INVESTMENT IN SUB–SAHARAN AFRICA

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This dissertation focuses on the intersection of agricultural productivity, youth employment, and investments in human capital development in Sub–Saharan Africa (SSA). Agriculture is a dominant employer and source of income in SSA, and plays an important role in youth employment and educational attainments.

In Chapter 1, we study the role of structural transformation in the labor reallocation between the farm and the non–farm sector and the consequential impact on worker demographics. Specifically, we investigate whether agricultural productivity differentially reallocates labor by age and gender. We develop a theoretical model where increased land productivity leads to younger individuals sorting into the non–farm sector while older individuals sort into agriculture. We then use data from Zambia in our empirical analysis. Our main results show some evidence of productivity affecting labor reallocation within recent productivity lags (last 2 years) but not when longer productivity lags (4 or 6) are considered. Specifically, consistent with our model prediction, a 10% increase in a 2–year lagged moving average of productivity decreases the probability of farming by 0.3 percentage points among youth (15–24) and older youth (25–34). We also show that youth (15–24) also exit farming following increased productivity. Increased productivity tends to reduce the intensity of farming across all age groups but the reduction is relatively larger among the youth. In addition, young men are more likely to exit business activity as productivity increases relative to young women – across all productivity lags. In the short term (2–lags), while youth exit farming, there is no differential outcome between genders. However, among older youth, males

are more likely to exit farming compared to women. Finally, males mainly drive the reduction in intensity of farming. Overall, while we find some evidence in favor of our hypotheses, the evidence is generally limited to the short term and the marginal effects are quantitatively small.

Chapter 2 investigates the impact of agricultural productivity on human capital investments in Tanzania. Agriculture remains a major source of employment and income in Tanzania. Therefore, any agricultural productivity shocks are likely to affect educational investment decisions. Our results provide evidence that increased agricultural productivity boosts spending on uniform, contributions and total academic expenses. We find positive but statistically non–significant effects of productivity on study times. In addition, we find no evidence of heterogeneous effects by student gender. We show evidence that productivity effects are smaller in female–headed households. Finally, we find some evidence that post–primary students experience larger impacts compared to primary school students.

In Chapter 3, I investigate the impact of primary school electrification on academic outcomes in Kenya. Between 2014 and 2016, the number of primary schools with electricity rose from 56% to 94%. Schools near the grid network were connected to grid electricity while those further received solar photovoltaics. Using this rapid electrification expansion as a source of identifying variation in a panel fixed effects model, the paper estimates the impact on school test scores, enrollment, and completion. The paper also attempts to quantify the effects of lighting on education performance by relying on the off–grid (solar) electricity coefficients. Using a universe of 8^{th} grade students in public schools in Kenya, the paper finds no evidence that electricity affects test scores or enrollment in the short run. However, off–grid electrification increases completion by 1%. Using off–grid estimates, the paper concludes that lighting has a small positive impact on completion but not on test scores or enrollment.

This dissertation is dedicated to my family, grandfather, and grandmother.
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I. INTRODUCTION

According to the Food and Agriculture Organization of the United Nations (FAO), one of the major challenges in food security is demographic changes due to population growth, urbanization, and ageing (FAO, 2014). Specifically, by 2050 there will be approximately nine billion people mostly in developing countries. In addition, due to accelerated urbanization, by 2050 70% of this population will be living in urban areas. FAO estimates that this expanding population will require up to a 60% increase in food production. FAO suggests that African farmers are also ageing rapidly. Specifically, the average farmer age is approximately 60 in Africa, as in the highly industrialized United States, despite the fact that 60% of African population is below 24 years of age. Some studies find similar average age of 60 for farmers (Gorman, 2013; Vos, 2015). This ageing threatens the ability of future farmers to meet the increasing demands for food. However, recent work by Yeboah and Jayne (2018), shows that while there is rapid movement from agriculture to non–farm sectors, agriculture remains a major source of employment, and the mean farmer age remains stable generally in sub–Saharan Africa. This paper seeks to understand the role of agricultural productivity on the dynamics of age and gender of workers in each respective sector as this process unfolds.

It has long been recognized that agriculture can play an important role both in the early and latter stages of economic development (Lewis, 1954; Hirschman, 1958; Johnston and Mellor, 1961). Agriculture tends to be the major source of employment in initial stages of development. As agricultural productivity increases, it can release excess labor from low productivity agricultural activities into the non–farm sector. In addition, agriculture also provides strong linkages to the non–farm sector. Specifically, high agricultural productivity raises income that subsequently increases demand for non–food goods and services. This increased demand

eventually stimulates the expansion of the non–farm sector. Recent studies have found no alternative development path for Africa without serious agricultural innovation and growth (Diao et al. 2010). The role of agriculture has been recently illustrated by the Green Revolution that contributed to a number of Asian countries moving from slow to high growth trajectories. Unfortunately, other developing countries, particularly in Africa have not experienced such a revolution illustrating the complex ways in which agricultural driven development can depend on context.

Current studies on agricultural transformation have largely focused on movement of labor between farm and non–farm sectors. However, research has paid little attention to the heterogeneous labor reallocation. Foster and Rosenzweig (2007), argue that important aspects of exit of labor from the agriculture to the non–farm sector, such as selectivity in human capital, are less studied and less understood. We further argue that other selective aspects such as age and gender, and their interactions with human capital, are equally important. It is thus necessary to understand the impact of structural transformation on demographic composition of farm and non–farm workers (age and gender). This will guide economic growth policy formulation. The idea that farmers are ageing in Sub–Saharan Africa requires a thorough examination before any serious conclusions and policy recommendations can be drawn.

Our hypothesis is that, seemingly paradoxically, sustained agricultural productivity will drive young people away from agriculture through three channels. First, agricultural productivity relaxes the financial constraints that prohibit individuals from migrating in search of better opportunities. High agricultural productivity thus provides extra resources that allow individuals to migrate. We believe that young people have higher mobility and are likely to migrate due to the educational attainments that may be required in blue–collar and white collar jobs, and also

because young people do not have familial constraints (people with families may have difficulties relocating the entire family). Second, and the focus of our theoretical model, agricultural productivity can generate strong multiplier effects (Snyder et al., 2019). Agricultural productivity increases disposable income for farmers. These incomes can not only increase regular consumption but also expand the consumption set for the household. Farmers may now demand more food and non–food goods and services. Recent research is showing that increased farm incomes lead to greater food expenditures of commodities that the farm household does not produce itself (processed foods, tinned fish, coffee, etc.). Such increased demand can lead to creation of new and expansion of existing businesses. Sustained productivity can therefore lead to structural transformation that can see expansion of non–farm job opportunities. These job opportunities may require skills and higher educational levels that are typically abundant among the youth. Consequently, the new job opportunities might draw younger farmers away from agriculture. Finally, agricultural productivity also provides households with additional incomes that can make it possible to keep their children consistently in school and attend better quality schools, which increases the probability that these children will wind up in non–farm jobs. Foster and Rosenzweig (2007) find that an increase in agricultural productivity led to increased schooling in India following the introduction of High–Yielding–Variety rice. Overall, we would expect to see increases in agricultural productivity resulting in the average age of a farmer going up, and a wider difference between the mean ages of individuals in non–farm versus farm employment. Rather than viewing this as a problem, it would be a positive indicator of structural transformation associated with higher living standards. One day, if the mean age of Africans in farming becomes too high, we might need to address it, but as of now, there is no indication that the mean age of

people in farming is more than 1 or 2 years higher than the mean age of people in off–farm employment (Yeboah and Jayne, 2018).

This paper seeks to understand how structural transformation affects the age and gender composition of farmers (and non–farm workers). Instead of simply testing whether the mean age of farmers is rising, we explore the dynamics of labor movement in and out of farm and non–farm sectors by gender and age groups (15–24, 25–34, and 35–65) among working–age adults. It will provide answers as to whether structural transformation drives young labor away from farming or into farming. This study focuses on Africa as previous research has shown that economic growth experiences can be context specific. For instance, the Green Revolution pushed several Asian countries into new periods of rapid growth while at the same time lifting billions out of poverty. Unfortunately, this technological shock has not been felt in the context of Africa. This paper focuses on age and gender because these demographic characteristics are especially relevant in Africa. Several studies show evidence of gender effects in diverse settings and it is thus highly probable that structural transformation will have important gender dimensions (Duflo and Udry, 2004; Foster and Rosenzweig, 2002; Goldestein and Udry 2008). We investigate whether women are left in low–productivity agricultural activities and, subsequently, make policy recommendations that ensure equitable benefits of development. Gender dynamics also has potential spillovers. Research on household bargaining models document evidence that gender of income earners influences household consumption and investment in children as discussed in the next section. In my second dissertation essay, we investigate the impact of agricultural productivity shocks on investment in human capital. This work, together, will provide insights on whether structural transformation leaves women in less productive activities while at the same time

lowering investments in girls – a problem that can lead to a persistent poverty trap. Migration is left out for future research work.

To test our hypothesis, this paper focuses on long term agricultural productivity shocks in Zambia. We first develop a model that explains how labor will be reallocated following productivity shocks. We borrow from previous literature that has developed models that incorporate the roles played by factors such as labor pull, local demand effects, liquidity constraints, and sectoral linkages in determining labor reallocation (Emerick 2018; Harris and Todaro, 1970; Foster and Rosenzweig, 2007; Bryan et al. 2014). In our model, we focus on the multipliers on the non–farm sector generated by increased farm income. These multipliers occur when increased income generates demand for non–farm goods and services, which in turn stimulates the growth and expansion of firms and enterprises that supply them. The model predicts that high long–term productivity will drive youth away from farming resulting in an increase in the mean age of those participating in farming. Conversely, low productivity in agriculture fails to spur non–farm growth and thereby failing to release labor into the non–farm sector. In the model, labor is selectively reallocated depending on the stock of human capital acquired (skills and education). This is the primary reason why younger people would be driven away from agriculture. Since women and girls tend to receive less investment in education in Sub–Saharan Africa, we hypothesize that women will be disadvantaged relative to men and will experience little movement out of agriculture.

In our main empirical results, we find some evidence of productivity affecting labor reallocation within recent productivity lags (last 2 years) but not when longer (4 or 6) productivity lags are considered. Specifically, consistent with our model prediction, a 10% increase in a 2–year lagged moving average of productivity decreases the probability of farming by 0.3 percentage

points among youth (15–24) and older youth (25–34). We also show that youth (15–24) also exit farming following increased productivity. Increased productivity tends to reduce the intensity of farming across all age groups but the reduction is relatively larger among the youth. Considering gender, we find that young men are more likely to exit business activity as productivity increases relative to young women – across all productivity lags. In the short term (2–lags), while both youth exit farming, there is no differential outcome between genders. However, among older youth, males are more likely to exit farming compared to women. Finally, males mainly drive the reduction in intensity of farming. Overall, while we find some evidence in favor of our hypotheses, the evidence is generally limited to the short term and the marginal effects are quantitatively small.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 provides a brief theoretical motivation for our model and subsequently develops the model tested in this paper. Section 4 discusses the data while section 5 provides our empirical methodology. We present the results in section 6 before a brief discussion on our results and directions for future research in section 7. Section 8 concludes the paper.

II. LITERATURE REVIEW

The impact of agricultural shocks on employment and sectoral labor reallocation have been studied in different contexts with differing and sometime contradictory findings. Below we review related literature and their findings and try to put this study into context and highlight our contributions.

The closest work to this paper is Emerick (2018) who investigates the role of agricultural productivity on labor reallocation in rural India. This paper shows that increased productivity caused by abnormally high rainfall leads to an increase in the labor share of the non–agricultural sector. Individuals are more likely to engage in a primary activity in the non–farm sector and decrease days devoted to agricultural activities. This is consistent with rainfall shocks increasing

agricultural incomes and generating positive spillovers into the non–farm sector. This paper finds evidence of results being driven by local demand effects that yield multipliers in the non–farm sector. These effects are, however, transitory and driven by recent shocks within the previous two years. Yeboah and Jayne (2018) show that the rate at which labor force is moving out of agriculture is strongly and positively linked to lagged farm productivity growth rate. Our analysis moves further and considers age and gender dynamics in labor reallocation driven by long–term productivity (4–lags, and 6–lags of productivity). In addition, recent work by Snyder et al. (2019) find that in Zambia, increases in lagged multi–year district–level agricultural productivity leads to increased household farm income. In addition, increases in district–level agricultural productivity measures among small farms (less than 2 hectares) results in increased off–farm incomes.

While empirical evidence confirms the presence of agricultural multiplier effects, their strength depends in part on the structure of the economy since non–tradable goods will generate more local economic activity (Schneider and Gugerty, 2011). Emerick (2018) shows that the labor reallocated from farming is mostly devoted to the non–tradable sector, which is not surprising given that the labor reallocation occurs within a short period of the rainfall shock. Structural transformation is a process, however, that takes long and may require sustained productivity levels to affect the tradable sectors. This implies that we may only detect short–term transitory effects, in our context, if labor reallocation is concentrated in the non–tradeable sector. Agricultural productivity shocks may therefore only cause temporary changes in the structure of the local economy. Similar studies find that high agricultural productivity results in the non–tradeable sector expanding the most (Foster and Rosenzweig, 2004: McMillan and Harttgen, 2014). Further, Foster and Rosenzweig (2004) show that the positive relationship between agricultural productivity and nonfarm employment only holds for the local non–tradeable services sector while the converse

holds for the tradeable sector (factory employment). In subsequent work, Foster and Rosenzweig (2007) show that the introduction of High–Yielding–Variety (HYV) rice in India resulted in non–farm (factory) employment increase in areas with low agricultural productivity. They argue that this is consistent with factories which are labor seeking. This relationship between agricultural productivity and non–farm factory employment highlights the importance of capital mobility. Finally, the Foster and Rosenzweig (2007) results are consistent with the modelling by Matsuyama (1992) that predicts a positive relationship between agricultural productivity and growth in closed economies and the opposite in open economies. Our results will therefore be influenced by the prevalence of tradeable vis–à–vis non–tradeable sectors.

The context and the nature of agricultural productivity shock has important consequences on the labor reallocation within the economy (Bustos et al., 2016; Irz et al., 2001; Schneider and Gugerty, 2011). Bustos et al. (2016) investigates the impacts of factor–biased agricultural technical change in the case of Brazil in an open economy set up. Brazil experienced technical changes stemming from introduction of genetically engineered soybeans (labor saving) and adoption of double planting of maize (land saving). They find that soybean–growing areas experienced rapid growth in employment and reduction in wages in the industrial sector. On the other hand, maize growing regions experienced the opposite with labor intensity in farming increasing, wages rising, and labor moving out of the industrial sector. These results, however, depend on the strength in complementarities between factors (weak complementarities weaken the results), and labor immobility across regions.

Rural towns and urban areas play an important role in structural transformation. Shilpi and Emran (2016), using rainfall as an instrument for agricultural productivity, find a significant positive effect of agricultural productivity growth on growth of informal (small–scale),

manufacturing and skilled services employment, mainly in education and health services. For formal employment, the effect of agricultural productivity growth on employment is found to be largest in the samples that include urban areas and rural towns compared with rural areas alone. Agricultural productivity growth is found to induce structural transformation within the services sector with employment in formal/skilled services growing at a faster pace than that of low skilled services. These findings suggests that the growth and expansion of rural towns and urban centers can facilitate structural transformation. Such findings motivate our assumption that the youth, who are relatively more skilled than the old, will selectively move out of agriculture into the non–farm sector as it expands following productivity shocks.

Structural transformation is particularly important for developing countries where there is a huge labor productivity gap between the farm and the non–farm sector. Structural transformation can thus lead to large development gains by reallocating labor away from agriculture especially in developing countries where agricultural share of employment is very high (Gollin et al, 2014). The persistence in these gaps can be partly explained by institutional quality, labor mobility, and selection on unobservable skill (Gollin et al., 2014, Lagakos and Waugh, 2013). An example of institutional failures concerns insecure property rights particularly on land tenure. Gottlieb and Grobovšek (2019) show that, in Ethiopia, communal land ownership weakens individual land rights and the land rental market. This in turn distorts the labor allocation between highly skilled individuals and low–skilled individuals, and between land rich and land–poor individuals. Several studies estimate large increases in agricultural productivity if wedges in land allocation were removed in order to shift land from unskilled to skilled farmers in Malawi, China and Ethiopia (Restuccia and Santaeulàlia–Llopis, 2017; Adamopoulos et al., 2017; Chen et al., 2017). Adamopolous et al (2017) further argue that misallocation of land leads to misallocation of

workers between sectors. Taken together, these studies indicate that structural transformation will release labor into the non–farm sector from the segment of the population that has skills needed in the non–farm sector. These individuals are likely to be younger with higher education levels — Foster and Rosenzweig (2007) show that agricultural productivity resulted in out–migration by the highly educated. Such a movement of labor will mitigate some of the distortion inherent in many countries where land markets are poorly developed or institutionally restricted communally or by the government.

Land is a major factor of production in agriculture. However, land market frictions, population growth and intense land subdivision is threatening the future of agriculture as sustainable enterprise and source of employment (Jayne, Mather, and Mghenyi, 2010; Muyanga and Jayne 2014). Kosec et al. (2018) show that in Ethiopia, land market frictions affect migration and employment decisions. They find a negative relationship between expected land inheritance and migration and non–farm employment. This effect is strongest in areas with low land rental activity and is primarily driven by the youth, and males. These findings indicate that distortion in factor markets can result in factor markets dictating labor allocation across sectors in an inefficient manner. The factor markets failure imply that low–skilled youth with little land access will find themselves in the non–farm sector while some high–skilled youth may remain in farming. In addition, individuals with comparative advantage in farming may be locked out of farming all together.

Some of the studies above document outcomes that differ by gender. We believe that these gendered outcomes are driven by difference in skills, human capital, and incomes. Qian (2008) provides a useful empirical example that motivates our analysis along gender dimension. Qian (2008) finds that in post–Mao China increases in sex–specific agricultural income had sex–specific

outcomes on survival and education. Specifically, holding total household income fixed, female income improved survival rates for girls, while male income worsened survival rates for girls. In addition female income increased educational attainment of all children, while male income decreases educational attainment for girls with no impact on boys. Foster and Rosenzweig (2007) find that agricultural productivity resulted in selective out–migration by gender and education attainment. Males, and the highly educated, were more likely to migrate. Given the prevalence of gender–specific difference in human capital investment in many developing countries, women are more likely to have fewer skills and hence have a lower comparative advantage in the non–farm sector. Male household members in sub–Saharan Africa commonly control land and this implies that increases in agricultural income is likely to accrue to male members. The little land access among female household members diminishes agricultural income from increased agricultural productivity. This, in addition to the low capital accumulation by female household members, imply little opportunities in the non–farm (high skill) sector and low returns to migration. Consequently, female members will gain little from agricultural driven structural transformation.

III. THEORY AND THE MODEL

In this section, I briefly abstract and motivate a few ways in which agricultural productivity can reallocate labor across economic sectors and influence sorting by age and gender, before discussing the focus of the model. First, agricultural productivity can relax financial constraints and consequently encourage migration in search of better opportunities. Individuals may desire to migrate from rural areas in search of better–paying jobs (typically non–farm) in urban areas. However, migration entails costs that can be overcome due to income increases from positive agricultural shocks. To motivate the age and gender dynamics, we assume that the non–farm sector requires skills and human capital that are largely endowed to younger individuals and likely more

endowed to male than females. This differential endowment in human capital implies the youth (relative to the old), and males (relative to women) have a comparative advantage in non–farm jobs while the older persons (and women) have a comparative advantage in farming. This distribution of human capital endowment should result in sorting of individuals across the farm and the non–farm sector. However, the extent of sorting may be limited by other market failures, such as financial constraints and factor misallocation, which may inhibit an efficient sorting. Therefore, young and old individuals may end up misallocating their labor across sectors due to push factors. For instance, financial constraints may lead to excessive presence of youth in farming if the youth cannot invest in the non–farm sector or migrate to participate in urban employment. In addition, factor market failures may imply that the older individuals may end up engaging in suboptimal participation in farming in areas where tenure security is not guaranteed. A positive productivity shock may thus alleviate such land pressures and misallocation by allowing the youth to migrate, or enter the non–farm sector while the old move into or expand activities in farming. A similar analogy follows along gender dimensions. The model we develop below does not account for migration, financial constraints, and factor market failures.

Second, the inherent comparative advantage that is differential between age cohorts can result in differential sorting in the local economy in the short term even without the expansion of the non–farm sector. An increase in agricultural productivity will increase demand for agricultural labor and subsequently an increase in wages. Assuming that wages are equalized across the local economy, local wages rise and labor supply increases in the agricultural sector. The increase in agricultural labor may lead to sorting. Specifically, agricultural productivity increases will disproportionately attract the labor of individuals with a comparative advantage in agriculture (the old) and less labor from those with comparative advantage in the non–farm sector. Overall, while

labor supply in agriculture increases, this labor will be largely supplied by the old. On the non–farm sector, young individuals reallocate little labor to agriculture while filling the vacancies left by the old in the non–farm economy. The result is more older people engaging in the farming sector compared to younger individuals. In other words, a positive agricultural shock results in a higher rate of departure of older individuals from the non–farm sector compared to the youth. These types of movements may be transitory in nature if push factors dictate labor allocation. Once again, we do not model this type of outcome. Instead, we focus on the longer term where agricultural productivity multipliers leads to the reduction in agricultural employment and an increase in non–farm sector employment.

Our model is motivated by the fact that agriculture may play a very important role in advancing the non–farm sector through agricultural income multipliers that result in the growth of the non–farm sector. Agricultural productivity shocks increase household incomes. As incomes grow, the elasticity of demand for food becomes less than one following Engel's Law. Households start spending on non–farm goods and services. This demand can result in the creation and expansion of the non–farm sector. With this expansion comes jobs that, we argue, require higher skills and education levels. Since we assume the youth to be endowed with higher levels of human capital, the non–farm sector expansion will draw away young individuals from farming. As the youth leave farming, farming employment opportunities open up for older individuals both on the extensive and intensive margins. If factor markets are inefficient and factors are misallocated across sectors, the agricultural driven non–farm expansion may mitigate this problem and lead to outcomes that are more efficient. The overall result is the age of farmers rising with productivity and the age of non–farm workers declining. Therefore, observing farmers' ages rising over time is not necessarily a bad thing as long as this is driven by agricultural productivity. On the other end,

declining farmer age may imply some sort of poverty trap if agriculture is persistently unproductive and thus unable to push skilled youth out of agriculture. In the next subsection, we model how agricultural productivity shocks influences labor reallocation through income multipliers in the non–farm sector. We show how this in turn affects sorting of workers by age and gender. This model is a very basic, illustrative model that does not capture all the intricacies of labor reallocation across various sectors of the economy.

Theoretical Model: Agricultural productivity shocks and the non–farm sector expansion

There are several ways to model agricultural driven transformation (Kongsamut, Rebelo, and Xiem 2001; Gollin, Parentem and Rogerson, 2002; Shilpi and Emran 2016; Emerick, 2018). We follow the Shilpi and Emran (2016) model and adapt it to fit our goals. Specifically, we restrict analysis to the case with labor mobility across sectors but not across regions, and a two–sector model in a rural setting. Our main innovation to the model is the inclusion of heterogeneous agent types that differ in productivity levels in the non–farm sector but are otherwise homogeneous in the agricultural sector. This closely mirrors the situation in rural Africa where daily agricultural wage is the same regardless of skill level in the non–farm sector.

Our model provides hypotheses on how agricultural productivity encourages youth to move into (or stay in) the non–farm sector while the old move into (or stay in) agriculture using a general equilibrium approach. For simplicity, we describe this process as happening in two stages. First, agricultural productivity stimulates demand for the non–farm goods and services that lead to expansion of the non–farm sector. In the second stage the youth (old) sort into the non–farm (farm) sector based on the comparative advantage. Our assumption is that the youth (old) have comparative advantage in the non–farm (farm) sector. We consider the youth as the high–

skill/high–productivity type in the non–farm sector and the old as the low–skill/low–productivity type in the non–farm sector. While both agents are equally productive in the agricultural sector, the high skill type is more productive in the non–farm compared to the low–skill types.

We assume the existence of two representative agents for each skill type (high–skill/young and low–skill/old), each participating in two sectors of the economy. Each individual is endowed with $\boldsymbol{L}$ units of labor that can be split between the agricultural and the non–farm sectors. The individuals own the production of the farm good. They can also sell labor to the agricultural sector in exchange for wage *w* or work in the non–farm sector and receive $\boldsymbol{w_H}$ if highly skilled, or $\boldsymbol{w_L}$ otherwise. The agent derives utility from consumption of a farm good $\boldsymbol{C_a}$ and the non–farm good $\boldsymbol{C_n}$. The agricultural good is the numeraire while the non–farm good costs *p* per unit. We assume the utility function is of Stone–Geary form. This functional from provides a close approximation of structural transformation in the United States (Herrendorf, Rogerson, and Valentinyi, 2013). In our model, household preferences play a significant role in driving our results. Two examples of preferences that can generate an increase in non–agricultural sector labor following an increase in agricultural productivity are constant elasticity of substitution (CES) and Stone–Geary preferences. For CES, the positive relationship between agricultural productivity and non–farm employment will hold if the agricultural good and the non–agricultural good are complementary. On the other hand, Stone–Geary preferences with steep Engel curves will yield similar results. Other preferences such as Cobb–Douglas will result in independence between non–farm employment and agricultural productivity. In our model, the objective function for the agent is then:

$$\max_{\{C_{ai},C_{ni}\}} U(C_{ai},C_{ni}) = v_a \ln(C_{ai}-\gamma_{ai}) + v_n \ln(C_{ni}-\gamma_n) \ \text{s.t} \ C_{ai} + pC_{ni} = I \quad (1)$$

where:

$$\mathrm{I} = \pi_{\mathrm{a}} + \bar{\mathrm{w}}_{\mathrm{i}}\,\mathbf{L}$$

i is the agent type, high–skill (H) or low–skill (L), and $\bar{\mathrm{w}}_{\mathrm{i}}$ is the equilibrium wage for agent type i. γ can be seen as the subsistence requirements needed. For simplicity we assume that there is no subsistence requirement for the non–farm good and thus $\gamma_n = 0$. $\boldsymbol{I}$ represents income and consists of agricultural profits, and labor income derived from wage activity. v_a, v_n are scalar parameters for utility weights whose sum equals to unity, $v_a + v_n = 1$. Labor is assumed to be mobile across sectors in the local rural economy so that wages are equalized across the sectors in equilibrium for at least one type of worker (either for the high–skill or the low–skill type).

Solving the above problem yields the following:

$$\mathrm{C}^{*}_{\mathrm{ai}} = \mathrm{v_a I} + \mathrm{v_n}\gamma_{\mathrm{a}} \qquad (2)$$

$$\mathrm{C}^{*}_{\mathrm{ni}} = \frac{\mathrm{v_n}(\mathrm{I} - \gamma_{\mathrm{a}})}{\mathrm{p}} \qquad (3)$$

The agricultural sector uses land, *A*, and labor L_f to produce the farm good. The production function is defined by:

$$Y_{ai} = \theta\, A^{\alpha} L_{fi}^{1-\alpha}$$

where θ is the productivity parameter. This is the key parameter of interest when investigating the effect of productivity on employment.

Since the farmer's objective is to maximize profit, the objective function is given by:

$$\max_{\mathrm{L_{fi}}} \pi_{ai} = \theta\, A^{\alpha} L_{fi}^{1-\alpha} - wL_{fi} \qquad (4)$$

Solving first order conditions for this equation indicates that the optimal **labor input demand,** $\boldsymbol{L_{fi}^{d*}}$, in the farm sector is:

$$L_{fi}^{d*} = \theta^{\frac{1}{\alpha}} A \left(\frac{1-\alpha}{w}\right) \qquad (5)$$

$$Y_{ai}^{*} = A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}}$$

The non–farm sector has production function with $\phi_H > 1, \phi_L = 1$ as the productivity parameters and only requires labor as its input:

$$Y_{ni}^{*} = \begin{cases} \phi_H L_{ni} & \text{if } i = \text{H} \\ L_{ni} & \text{if } i = L \end{cases}$$

The objective of the firm is to maximize profits as follows:

$$\max_{L_{ni}} \pi_{ni} = p\ \phi_i L_{ni}\ -\ w_i\ L_{ni}$$

The firm's optimal labor demand can derived as:

$$L_{ni}^{d*} = \begin{cases} 0 & if\ p\phi_i < w_i \\ x \in [0, \infty] & if\ p\phi_i = w_i \\ \infty & if\ p\phi_i > w_i \end{cases} \qquad (6)$$

However, with positive consumption of the non–farm good, and the market clearing conditions that non–farm output must equal non–farm good consumption, the equilibrium non–farm labor demand is determined by $p\ \phi_i\ =\ w_i$.

Equilibrium

Notice that we have two possible labor equilibria since we have two wages in the non–farm sector and one wage in the agricultural sector. At equilibrium, the agricultural wage must equal one of the two non–farm wages. Specifically in equilibrium:

$$p\ \phi_H\ =\ w_H = w \quad or\ \ p = w_L = w \qquad (7)$$

Equilibrium 1: $p\ \phi_H\ =\ w_H = w$

In this equilibrium, the prevailing wage rate in the non–agricultural sector is equal to the high–skill wage in the non–farm sector. The high skill workers are then indifferent between the two sectors. However, the agricultural wage is higher than the low–skill non–farm wage since $w =$

$w_H = p\,\phi_H > p = w_L$ and thus the low–skill workers engage exclusively in the agricultural sector. The equilibrium **labor supply** is then:

$$[L^*_{fi}, L^*_{ni}] = \begin{cases} [\boldsymbol{L}, 0] & \text{if } i = \text{L} \\ [x, \boldsymbol{L} - x] : x \in [0, \boldsymbol{L}] & \text{if } i = H \end{cases} \qquad (8)$$

All non–farm product is paid out to labor as the non–farm sector is assumed to be competitive with zero profits. Hence :

$$p\,\phi_H\,L^*_{nH} = wL^*_{nH}$$

and considering the market clearing requirement that $C^*_n = C^*_{nH} + C^*_{nL} = Y^*_n = Y^*_{nH} + Y^*_{nL} = \phi_H\,L^*_n$, this condition becomes:

$$pC^*_n = wL^*_{nH}$$

where $pC^*_{ni} = v_n(I_i - \gamma_a)$ and hence after substitution:

$$L^*_{nH} = \frac{v_n}{w}\,(I_L + I_H - 2\gamma_a) \qquad (9)$$

Whereas:

$$L^*_{nL} = 0$$

The market clearing conditions require that consumption is equivalent to output and labor demand is equal to labor supply:

$$Y^*_a = Y^*_{aH} + Y^*_{aL} = C^*_{aH} + C^*_{aL} = C^*_a$$

$$Y^*_n = Y^*_{nH} + Y^*_{nL} = C^*_{nH} + C^*_{nL} = C^*_n$$

$$\boldsymbol{L} = L^*_{ni} + L^*_{fi} \qquad (10)$$

Letting d denote demand, so that $L^{d*}_{ni}\ and\ L^{d*}_{fi}$ are the nonfarm and farm labor demand of type *i* skill respectively, the equilibrium labor market clearing condition requires labor demand to equal labor supply:

$$L^{d*}_{nL} + L^{d*}_{nH} = L^*_{nL} + L^*_{nH}$$

$$L_{fL}^{d*} + L_{fH}^{d*} = L_{fL}^{*} + L_{fH}^{*}$$

Using the production first order conditions (5) and (6), the income constraint is given by:

$$I_i = \pi_i^* + w\boldsymbol{L} = \alpha\, A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + w\boldsymbol{L} \qquad (11)$$

Combining the market clearing conditions for agricultural good and the optimal consumption conditions:

$$Y_a^* = Y_{aH}^* + Y_{aL}^* = C_{aH}^* + C_{aL}^* = C_a^*$$

$$Y_a^* = 2v_a\left(\alpha\, A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + w\boldsymbol{L}\right) + 2\, v_n\gamma_a \quad (12)$$

We can simplify this further using equation (5) by noting that the aggregate agricultural output is $Y_a^* = 2A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}}$,

$$v_a w\boldsymbol{L} - (1-\alpha v_a)A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} = -v_n\,\gamma_a \quad (13)$$

Rewriting the above equation (13) as $F(w,\theta) = 0$ and implicitly differentiating:

$$F(w,\theta) = v_a w\boldsymbol{L} - (1-\alpha v_a)A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + \, v_n\,\gamma_a = 0$$

$$\frac{\partial w}{\partial \theta} = -\frac{\partial F(w,\theta)/\partial\theta}{\partial F(w,\theta)/\partial w}$$

$$\frac{\partial w}{\partial \theta} = \frac{[1\, -\alpha\, v_a\,](1-\alpha)^{\frac{1-\alpha}{\alpha}} A\,\theta^{\frac{1-\alpha}{\alpha}} w^{-\frac{1}{\alpha}+1}}{\alpha\, v_a\boldsymbol{L} + [1-\alpha\, v_a](1-\alpha)^{\frac{1}{\alpha}} A\,\theta^{\frac{1}{\alpha}} w^{-\frac{1}{\alpha}}} > 0 \qquad (14)$$

We can also derive the equilibrium labor allocation, starting from (12):

$$Y_a^* \, = 2v_a\left(\alpha\, A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + w\boldsymbol{L}\right) + 2v_n\gamma_a = \alpha v_a Y_a^* + 2v_a\, w\boldsymbol{L} + 2v_n\gamma_a$$

and after rearranging:

$$Y_a^* = 2\frac{v_a\, w\boldsymbol{L} + v_n\gamma_a}{1 - \alpha v_a}$$

Notice that since the high–skill (young) and the low–skill (old) face the same agricultural production function, land access, and agricultural wage, the optimal agricultural labor demand is identical so that:

$$L_{fL}^d = L_{fH}^d$$

Since, from production first order conditions, $wL_f^{d*} = w(L_{fL}^{d*} + L_{fH}^{d*}) = (1-\alpha)Y_a^*$:

$$L_f^{d*} = \frac{(1-\alpha)(Y_a^*)}{w} = 2\frac{1-\alpha}{1-\alpha v_a}(v_a\boldsymbol{L} + \frac{v_n\gamma_a}{w}) \qquad (15)$$

L_f^{d*} is the aggregate agricultural labor demand.

To derive the equilibrium farm labor allocation for each type of agent, we use the fact that in this equilibrium all individuals with low skill in the non–farm sector only work in the agricultural sector. This implies that the low–skill type supplies **L** while the net amount of labor is supplied by the high–skill type is:

$$L_{fL}^* = \boldsymbol{L}$$

$$L_{fH}^* = L_f^{d*} - L_{fL}^* = (1-\alpha)\frac{(Y_a^*)}{w} = 2\frac{(1-\alpha)}{1-\alpha v_a}(v_a\,\boldsymbol{L} + \frac{v_n\,\gamma_a}{w}) - \boldsymbol{L} \qquad (16\,a)$$

Similarly, we can use market–clearing conditions for labor to pin down equilibrium labor allocation in the non–farm sector. Note that since all labor not devoted to agriculture goes to the non–farm sector, it is sufficient to derive the equilibrium farm labor supply, which has been accomplished above.

$$L_{ni}^* = \boldsymbol{L} - L_{fi}^*$$

Alternatively, we can simply follow the same steps above, starting from (9) and after some algebra, we can derive:

$$L_{nH}^{*} = \frac{2}{1-\alpha v_a}\left(v_n L - \frac{(1-\alpha)v_n\gamma_a}{w}\right) \qquad (16\ b)$$

Note that in this equilibrium we had:

$$L_{nL}^{*} = 0$$

By differentiation, we can now inspect the effect of agricultural productivity on agricultural employment:

$$\frac{\partial L_{fL}^{*}}{\partial \theta} = \frac{\partial \boldsymbol{L}}{\partial \theta} = 0 \qquad (17)$$

while:

$$\frac{\partial L_{fH}^{*}}{\partial \theta} = 2\frac{(1-\alpha)}{[1-\alpha v_{a]}}\left(v_a\ \frac{\partial \boldsymbol{L}}{\partial \theta} - \frac{v_n\ \gamma_a}{w^2}\frac{\partial w}{\partial \theta}\right)$$

$$\frac{\partial L_{fH}^{*}}{\partial \theta} = -2\frac{(1-\alpha)}{[1-\alpha v_{a]}}\frac{v_n\ \gamma_a}{w^2}\frac{\partial w}{\partial \theta} < 0$$

This is negative because from (14) $\frac{\partial w}{\partial \theta}$ is positive and labor is fixed at **L**. On the other hand:

$$\frac{\partial L_{nL}^{*}}{\partial \theta} = 0$$

and:

$$\frac{\partial L_{nH}^{*}}{\partial \theta} = \frac{2(1-\alpha)}{[1-\alpha v_{a]}}\frac{v_n\ \gamma_a}{w^2}\frac{\partial w}{\partial \theta} > 0 \qquad (18)$$

And therefore, **a higher agricultural productivity pushes high–skilled labor out of the agriculture to the non–agricultural sector**.

We can investigate the effect of productivity on household income:

$$I_i = \alpha A\ \theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + w\boldsymbol{L} = 0.5\ \alpha\ Y_a^{*} + w\boldsymbol{L} = \frac{\alpha v_n\gamma_a + \ w\boldsymbol{L}}{1-\alpha v_a}$$

$$\frac{\partial I_i}{\partial \theta} = \frac{\boldsymbol{L}}{1-\alpha\, v_a}\frac{\partial w}{\partial \theta} > 0 \quad (19)$$

In this first equilibrium, an increase in productivity results in the high skill individuals leaving agriculture and entering the non–farm sector. Since we assumed, the young individuals have higher–skills in the non–farm sector, a positive productivity shock will therefore result in more young people in the non–farm sector. On the other hand, the older individuals devote all their labor to the agricultural sector and an increase in agricultural productivity does not affect their labor supply. The overall effect of the departure of the young is the increase in the mean age of farmers and a decline in the mean age of those in the non–farm sector. There is no change in labor supply by older individuals. This type of equilibrium is in line with our hypothesis.

Finally, we show the conditions necessary for this equilibrium to hold. Note from (8) that under this first equilibrium the total labor supply in the farm sector is $L_f^* = \boldsymbol{L} + x \geq \boldsymbol{L}$. Since in equilibrium labor supply must equal labor demand, we can combine this condition with the labor demand equations (5):

$$L_f^* = L_{fL}^{d*} + L_{fH}^{d*} \geq \boldsymbol{L}$$

Which implies:

$$2\theta^{\frac{1}{\alpha}} A\left(\frac{1-\alpha}{w}\right) \geq \boldsymbol{L}$$

and thus the necessary condition for equilibrium I is :

$$w \leq \theta^{\frac{1}{\alpha}} A\left(\frac{1-\alpha}{L}\right)$$

This equilibrium is consistent with the observed employment behavior of adults. Specifically, in Sub–Saharan Africa, there is a high prevalence of youth leaving agricultural employment in search of non–farm sector employment.

On the other hand, similar analysis shows that we get the second equilibrium discussed below when:

$$w \geq \theta^{\frac{1}{\alpha}} A \left(\frac{1-\alpha}{L}\right)$$

Equilibrium 2: $p = w_L = w$

In this equilibrium, the prevailing wage rate in the non–agricultural sector is equal to the low–skill wage in the non–farm sector. The low–skill workers are then indifferent between the two sectors. However, the agricultural wage is lower than the high–skill non–farm wage since $w_H = p\phi_H > p = w_L = w$ and thus the high–skill workers engage exclusively in the non–farm sector and receive a higher wage w_H. The equilibrium labor supply is then:

$$[L_{fi}^*, L_{ni}^*] = \begin{cases} [x, \boldsymbol{L} - x] : x \in [0, \boldsymbol{L}] & \text{if } i = \text{L} \\ [0, \boldsymbol{L}] & \text{if } i = H \end{cases} \qquad (20)$$

All non–farm product is paid out to labor as the non–farm sector is assumed to be competitive with zero profits. Notice, that unlike in the previous equilibrium, there are two wages – the high type receive $\boldsymbol{w_H}$ while the low type receive the equilibrium market wage of $\boldsymbol{w}$. Hence:

$$p\phi_H \, L_{nH}^* = w_H L_{nH}^* = w_H \boldsymbol{L}$$

$$p \, L_{nL}^* = w L_{nL}^* \quad (21)$$

and considering the market clearing requirement that:

$$C_n^* = C_{nH}^* + C_{nL}^* = Y_n^* = Y_{nH}^* + Y_{nL}^* = \phi_H \, \boldsymbol{L} \, + \, L_{nL}^*,$$

this implies:

$pC_n^* = w_H \boldsymbol{L} + w L_{nL}^*$ where $pC_{ni}^* = v_n(I_i - \gamma_a)$ and hence after substitution:

$$L_{nL}^* = \frac{v_n}{w}(I_L + I_H - 2\gamma_a) - \frac{w_H \boldsymbol{L}}{w} \qquad (22)$$

$$L_{nH}^* = \boldsymbol{L}$$

The market clearing conditions require that consumption is equivalent to output and labor demand is equal to labor supply:

$$Y_a^* = Y_{aH}^* + Y_{aH}^* = C_{aH}^* + C_{aL}^* = C_a^*$$

$$Y_n^* = Y_{nH}^* + Y_{nH}^* = C_{nH}^* + C_{nL}^* = C_n^*$$

$$\boldsymbol{L} = L_{ni}^* + L_{fi}^* \qquad (23)$$

$$L_{nL}^{d*} + L_{nH}^{d*} = L_{nL}^* + L_{nH}^*$$

$$L_{fL}^{d*} + L_{fH}^{d*} = L_{fL}^* + L_{fH}^*$$

Using the production first order conditions (5) and (6), the income constraint is given by:

$$I_H \pi_H^* + w_H \boldsymbol{L} = \alpha\, A\theta^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + w_H \boldsymbol{L}$$

$$I_L = \pi_L^* + w_L \boldsymbol{L} = \alpha\, A\theta^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + w\boldsymbol{L}$$

Combining the market clearing conditions for agricultural good, the budget constraint, and the optimal consumption conditions:

$$Y_a^* = Y_{aH}^* + Y_{aL}^* = C_{aH}^* + C_{aL}^* = C\text{^}*\_a$$

$$Y_a^* = Y_{aH}^* + Y_{aL}^* = v\_a(I_L + I_H) + 2v_n\gamma_a$$

$$Y_a^* = v_a(2\alpha\, A\theta^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + (w\_H + w)\boldsymbol{L}) + 2v_n\gamma_a \quad (24)$$

We can simplify this further using equation (5) by noting that $Y_a^* = Y_{aH}^* + Y_{aL}^* = 2A\theta^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}}$,

$$v_a(w_H + w)\boldsymbol{L} - 2(1-\alpha\, v_a)A\theta^{\frac{1}{\alpha}} \left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} = -2v_n\gamma_a$$

Since market clearing equilibrium conditions imply $w = p$ and $w_H = p\phi$, we can substitute $w_H = \phi\, w$ into the equation above to get:

$$(1+\phi)v_a w\boldsymbol{L} - 2(1-\alpha\, v_a)A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} = -2v_n\gamma_a \qquad (25)$$

Rewriting equation (25) as $F(w,\theta)=0$ and implicitly differentiating yields the effect of productivity on wage:

$$F(w,\theta) = (1+\phi)v_a w\boldsymbol{L} - 2(1-\alpha v_a)A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + 2v_n\gamma_a$$

$$\frac{\partial w}{\partial \theta} = -\frac{\partial F(w,\theta)/\partial\theta}{\partial F(w,\theta)/\partial w}$$

$$\frac{\partial w}{\partial \theta} = \frac{2[1\ -\alpha\, v_a](1-\alpha)^{\frac{1-\alpha}{\alpha}} A\,\theta^{\frac{1-\alpha}{\alpha}}\ w^{-\frac{1}{\alpha}+1}}{(1+\phi)\alpha\, v_a\boldsymbol{L} + 2[1-\alpha\, v_a](1-\alpha)^{1/\alpha}A\,\theta^{\frac{1}{\alpha}}w^{-\frac{1}{\alpha}}} > 0 \qquad (26)$$

We can also derive the equilibrium labor allocation, starting with (24):

$$Y_a^* = v_a\left(2\alpha\, A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + (w_H+w)\boldsymbol{L}\right) + 2v_n\gamma_a = 2\alpha\, v_a Y_a^* + v_a(w_H+w)\boldsymbol{L} + 2v_n\,\gamma_a$$

$$Y_a^* = \frac{(1+\phi)v_a w\boldsymbol{L} + 2v_n\gamma_a}{1-\alpha v_a} \qquad (27)$$

Since, from production first order conditions, $wL_f^{d*} = w(L_{fL}^{d*} + L_{fH}^{d*}) = (1-\alpha)Y_a^*$:

$$L_f^{d*} = \frac{(1-\alpha)(Y_a^*)}{w} = \frac{(1-\alpha)}{1-\alpha\, v_a}((1+\phi)v_a\boldsymbol{L} + 2\frac{v_n\gamma_a}{w}) \qquad (28)$$

L_f^{d*} is the aggregate labor demand in the farm sector. To derive equilibrium labor demand in the non–farm sector, we can use market–clearing conditions for labor. In addition, in this second equilibrium, all labor by those with high non–farm skills (the young) is devoted to the nonfarm sector. Note that since all labor not devoted to agriculture goes to the non–farm sector, it is sufficient to derive the equilibrium farm labor supply. Therefore:

$$L_{nH}^* = \boldsymbol{L}$$

$$L_{f,H}^{*} = \boldsymbol{L} - L_{n,H}^{*} = 0$$

$$L_{fL}^{*} = L_{f}^{d*} = \frac{(1-\alpha)}{1-\alpha\, v_a}((1+\phi)v_a\, \boldsymbol{L} + 2\frac{v_n\gamma_a}{w})$$

$$L_{nL}^{*} = \boldsymbol{L} - L_{fL}^{*} = \boldsymbol{L} - \frac{(1-\alpha)}{1-\alpha\, v_a}((1+\phi)v_a\, \boldsymbol{L} + 2\frac{v_n\gamma_a}{w}) \qquad (29)$$

By differentiation, we can now inspect the effect of agricultural productivity on employment:

$$\frac{\partial L_{fL}^{*}}{\partial\theta} = \frac{(1-\alpha)}{1-\alpha\, v_a}\left((1+\phi)v_a\frac{\partial \boldsymbol{L}}{\partial\theta} - 2\frac{v_n\gamma_a}{w^2}\frac{\partial w}{\partial\theta}\right)$$

$$\frac{\partial L_{fL}^{*}}{\partial\theta} = -2\frac{(1-\alpha)}{1-\alpha\, v_a}\frac{v_n\gamma_a}{w^2}\frac{\partial w}{\partial\theta} < 0 \qquad (30)$$

This is negative because $\frac{\partial w}{\partial\theta} > 0$ is positive and labor is fixed at **L**. Given that $L_{ni} = \boldsymbol{L} - L_{fi}$

$$\frac{\partial L_{n,L}^{*}}{\partial\theta} = -\frac{\partial L_{fL}^{*}}{\partial\theta} > 0 \qquad (30)$$

Therefore, agricultural productivity leads to an increase in non–farm employment among low–skill workers, and an overall increase in non–farm employment and a decline in agricultural employment.

We can investigate the effect of productivity on household income:

$$I_H = \alpha A A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + w_H\boldsymbol{L} = 0.5\alpha\, Y_a^{*} + \phi\, w\, \boldsymbol{L} = \frac{0.5(1+\phi)\alpha\, v_a w\boldsymbol{L} + \alpha\, v_{n\gamma_a}}{1-\alpha v_a} + \phi\, w\, \boldsymbol{L}$$

$$\frac{\partial I_H}{\partial\theta} = \left(\frac{0.5(1+\phi)\alpha\, v_a\boldsymbol{L}}{1-\alpha v_a} + \phi\, \boldsymbol{L}\right)\frac{\partial w}{\partial\theta} > 0$$

$$I_L = \alpha A A\theta^{\frac{1}{\alpha}}\left(\frac{1-\alpha}{w}\right)^{\frac{1-\alpha}{\alpha}} + w\boldsymbol{L} = 0.5\,\alpha Y_a^{*} + w\boldsymbol{L} = \frac{0.5(1+\phi)\alpha\, v_a w\boldsymbol{L} + \alpha v_n\gamma_a}{1-\alpha\, v_a} + w\boldsymbol{L}$$

$$\frac{\partial I_L}{\partial\theta} = (\frac{0.5(1+\phi)\alpha v_a\boldsymbol{L}}{1-\alpha v_a} + \boldsymbol{L})\frac{\partial w}{\partial\theta} > 0$$

In this second equilibrium, the young always work in the non–farm sector. Following an agricultural productivity shock, the old (low skill) reallocate labor away from agriculture towards the non–farm sector, with no effect on labor supply among the youth. In this case, it is possible that the mean age in the non–farm sector will actually rise over time and the differences in the mean age of workers in each sector will grow close together. However, if the level of skill needed in the non–farm sector is decreasing in age, then it is likely that the marginal worker that leaves the agricultural sector is likely to be among the youngest within the old–group (say a 40–year old instead of a 65–year old). In this case, the mean age in the non–farm sector could rise slightly but at a slower pace compared to the mean age within the farm sector. This is likely to be the case because the marginal individual departing from agriculture to enter the non–farm sector may require high education and related skills typically found among relatively younger individuals within any age group.

In summary, under the assumption that younger individuals have a comparative advantage in the non–farm sector, the marginal young worker always has an incentive to reallocate labor away from the farm whenever possible. On the other hand, our model yields an equilibrium in which the marginal old worker either stays in farming or reallocates labor to the non–farm sector. We show that under a number of assumptions, the equilibrium average age of farmers goes up with increased productivity. Outcomes along gender dimensions follow similar patterns as individuals try to match their skills with a particular sector. Lower skills would discourage labor reallocation. As the literature has documented several instances of women having limited human capital, we would expect their comparative advantage to be in farming. On the margin, young women may move out of agriculture but at a slower pace compared to their male counterparts due to lack or

limited non–farm sector skills. This raises an issue of feminization of agriculture and prospects of women being stuck in poverty and low–productivity activities.

IV. DATA

This paper utilizes data from several sources. First, we use a three–wave panel survey from the Rural Agricultural Livelihoods Survey (RALS) covering the 2010/11, 2013/14, and the 2017/18 agricultural years (October–September) and the subsequent marketing years (May–April of 2011/12, 2014/15, and 2018/19 respectively). The RALS data were collected in June–July 2012, 201, and 2019 by the Indaba Agricultural Policy Research Institute (IAPRI) in collaboration with the Zambia Central Statistical Office (CSO) and Ministry of Agriculture (MoA). This is a nationally representative survey of smallholder farm households covering 72 districts initial districts (from 2012) and 8 provinces. The dataset contains the outcomes of interest and several controls variables used in our analysis. The survey covers approximately 8,000 households.

Second, we use the annual Zambian Crop Forecast Surveys (CFS), from the CSO and MoA, covering the years 2006 to 2018. This survey captures agricultural productivity is representative at the district and national level. We use this dataset to create our measures of agricultural productivity. The data are collected in late March/early April before the main harvest period begins in May. They are based on farmers' expected quantity yields. We can generate productivity values that are representative at the district level. This survey also covers approximately 8,000 to 13,000 households.

Third, rainfall data is from version 2.0 of Climate Hazards Center InfraRed Precipitation with Station data (CHIRPS). CHIRPS provide rainfall satellite imagery with a 0.05° resolution

that combine both satellite images and rainfall station data. We then process these images into monthly rainfall data values that we subsequently use in our analyses.

Table 1.1 below show that summary statistics for the key variables of interest. Productivity, measured as value of all agricultural output per hectare is approximately 4,000 Kwacha (approximately $300 in real 2019 values). We do not calculate total factor productivity or labor productivity due to concerns about measurement errors in labor input. There is a low participation in wage activity. Older youth (25–34) and the old (35–65) have a participation rate of approximately 12% in wage/salary activity. The young youth (15–24) have the lowest participation rate of 4% in wage activity and 3 % in business activity. It appears that participation in business activity increases with age given that 21% of the older youth engage in business activity compared to 31% of the old (35–65).

Participation in farming activities is very high, at 98%, and does not vary among the age groups. However, the intensity of farming shows some variance. Specifically, while a 70% of younger youth (15–24) spend greater than 20 days in farming per agricultural season, over 90% of the older youth and the old spend more than 90 days in farming per agricultural season.

A large proportion of rural households in Africa engage in both farm and non–farm activities. The summary statistics show that farming is the primary major activity, especially for the older individuals. Non–farm primary activity decreases with age as 37% of 15–24 year olds, 11% of 24–35 year olds, and only 8% of 35–65 year olds engage in a primary economic activity in the non–farm sector. These employment measures are from the demographic module.

Table 1.2 reports the different employment combinations as adults in rural areas often engage in multiple employment types. These data are from the employment module. The module contains lists of household members who earned income from wage/salary and/or business

activities. There is low reported unemployment rate of below 3 percent across all age–groups. Exclusive employment in farming is the most dominant employment type with a participation rate of 90% among the youth (15–24), 67% among the older youth (25–34) and 29% among the old (35–65). The second most prevalent employment type involves joint farming and business activities. However, this type of employment is prevalent among the older youth and the old. It is uncommon for individuals to be employed in all three activities considered (farming, business and wage/salary) and very rare for individuals to participate in business and/or wage/salary activities only.

Table 1.1: Summary Statistics (Means)

Variable	Mean		Standard Deviation
Productivity (Kwacha/Ha): 2-Year Moving Average	4,318		1,590
Productivity (Kwacha/Ha): 4-Year Moving Average	4,579		1,658
Productivity (Kwacha/Ha): 6-Year Moving Average	4,460		1,539
	Means by Age Category		
	15-24	25-34	35-65
Wage/Salary Activity	0.04	0.11	0.12
Business Activity	0.03	0.21	0.31
Farming	0.97	0.98	0.98
Farming: Less than 20 days	0.26	0.08	0.05
Farming: Greater than 20 days	0.70	0.90	0.93
Primary Activity: Farming	0.54	0.84	0.88
Primary Activity: Non-farm	0.37	0.11	0.08
Relationship to Head (Base: Head)			
Spouse	0.04	0.33	0.37
Child (own/step)	0.70	0.28	0.03
Relative	0.24	0.11	0.03
Unrelated	0.01	0.02	0.02
Marital Status (Base: monogamously married)			
Polygamously/Divorced/Separated etc	0.03	0.18	0.29
Never Married	0.85	0.24	0.02
Highest Education Attained (Base:None)			
Primary	0.53	0.52	0.62
Junior High	0.28	0.21	0.15
Senior High	0.14	0.15	0.08
College and above	0.01	0.03	0.02
Head Age	50.58	43.33	50.61
Head Marital Status (Base: monogamously married)			
Polygamously/Divorced/Separated etc	0.32	0.28	0.29
Never Married	0.01	0.01	0.01
Head Education Attained (Base: None)			
Primary	0.57	0.55	0.59
Junior High	0.17	0.19	0.17
Senior High	0.11	0.12	0.11
College and above	0.04	0.04	0.03
Household size	8.86	7.69	8.10
Male childred	2.33	1.90	2.14
Land owned (Ha)	5.83	5.16	5.67
Female Head	0.18	0.15	0.14
Tropical Livestock Units	4.35	3.27	3.63
Cell Phone	0.72	0.68	0.68
Solar/Generator	0.45	0.43	0.43
HH has bank account	0.18	0.16	0.17
House characteristics			
Cement floor	0.34	0.30	0.31
Permanent wall	0.51	0.47	0.49
Observations	26,984	12,191	23,684

Note that the employment shares in Table 1.2 may not necessarily match those in Table 1.1 due to the different modules that are used to capture the data, and the slight variations in definitions. However, only the data from the employment module is disaggregated enough to allow for the categorizations in Table 1.2.

Table 1.2: Employment Combinations (Proportion)

	Age Category		
Variable	15-24	25-34	35-65
None	0.03	0.02	0.01
Farm only	0.90	0.67	0.56
Farm & Business	0.03	0.18	0.29
Farm & Wage/Salary	0.04	0.09	0.09
Farm, Business, & Wage/Salary	0.005	0.03	0.04
Business or Wage	0.002	0.01	0.01
Observations	16,440	6,865	15,415

V. METHODS

To test our hypotheses we implement panel fixed effects methods on pooled probit models. Specifically

$$Y_{dhit} = \beta_0 + \beta_1 \overline{Prod_{dt-J}} + \boldsymbol{X_{dht}\beta_3} + \boldsymbol{X_{dhit}\beta_4} + \delta_t + \delta_d + \epsilon_{dhit} \quad (31)$$

where Y_{dhit} is the outcome of interest for individual *i* living in household h in district d during the survey period t. Our primary outcomes of interest include, participation in wage activity, participation in business activity, participation in farming, number of days spent in farming, and the choice of primary activity in either farm or non–farm sectors. Note that these outcomes are binary in nature and hence the choice of probit models in our analyses. $\overline{Prod_{dt-J}}$ is a real measure of lagged agricultural productivity at the district level – we define productivity as the gross value of production per hectare at the district level. The productivity measure is as simple moving average (MA) of various lags lengths (2–year, 4–year or 6–year lagged average):

$$\overline{Prod_{dt-J}} = \frac{1}{J}\sum_{i=1}^{J} Prod_{dt-i} \ where\ J \in \{2,4,6\}$$

We generate and separately use each of the three measures of productivity in regressions on equation (31). $\boldsymbol{X_{dht}}$ and $\boldsymbol{X_{dhit}}$ are household and individual vector controls respectively. δ_t and δ_d are time and district fixed effects respectively while ϵ_{dhit} is the error term. The individual controls include sex, marital status, relationship to household head, and highest education attained. The household controls include household head characteristics (sex, marital status, highest education attainment), household size, number of male children, size of land owned, Tropical Livestock Units (TLUs), assets (phone, solar/generator, bank account), lineage, and house characteristics (cement floor, permanent wall, permanent roof).

We use lagged productivity to address endogeneity and reverse causality. Using same period productivity measurement can bias results because some unobservable factors that affect productivity may also affect the employment outcomes. Reverse causality can occur because increased labor intensity in the agricultural sector can increase yields and hence agricultural land productivity. However, our goal is to determine how land productivity affects employment. Productivity is calculated by taking the aggregate value of district harvests and dividing by the aggregate land cultivated at the district. We believe that labor reallocation across sectors takes time and requires persistent productivity levels. Therefore, our measure of agricultural productivity relies on district 2–year, 4–year, and 6–year simple moving averages (MA) of productivity lags. As defined above, an N–year MA is calculated by taking the average of each district's N lags with equal weighting. However, in future analysis, we plan to experiment with using different weights in generating the productivity MA measures. We chose to focus on productivity at the district level

because we believe that structural transformation occurs at a regional level. Using districts for this type of analysis is not new to our paper (see Emerick (2018)).

Our approach addresses a number of endogeneity concerns using household and individual controls. In addition, we mitigate identification challenges from unobserved factors that may drive the results by using fixed effects. Our time fixed effects control for unobservable factors common to all individuals at a specified time (wave). The district fixed effects absorb unobserved time–invariant characteristics that are common to all individuals within a district. Our identifying assumption is that conditional on the observed controls, the district fixed effects, and the time fixed effects, the impact of productivity on employment outcomes is exogenous. Ideally, an instrumental variables approach would have been preferred. In the literature, rainfall is typically used as an instrument from agricultural productivity. Unfortunately, in our context different measures of rainfall did not yield strong first stage results. As a result, our analysis does not provide the benefits of IV techniques.

VI. RESULTS – POOLED PROBIT WITH TIME AND DISTRICT FIXED EFFECTS

Main Results

In this section, we report our estimates based on a pooled probit model with time and district fixed effects. Note that all the dependent variable are binary in nature and hence the choice of probit analysis. The analysis is at the individual level but the productivity measure – value of yields per hectare – is at the district level. We perform our analysis first using 2–year lagged productivity average, then repeat the analysis using 4–year lagged productivity average, and finally using 6–year lagged productivity average. We use the moving averages because we believe that productivity may have different effects in the short term and in the long run. Our data limits us to a maximum of 6 lags. We estimate the main model (31) among three age categories: 15–24 (youth),

25–34 (older youth), and 35–65 (the old). Our goal is to test whether agricultural productivity differentially reallocates labor based on age. The general prediction of our model is that increased agricultural productivity may increase youth participation in the non–farm sector while increasing participation in agriculture for the old.

In the tables, below we focus on the marginal effects of productivity shocks for each age–category. Table 1.3 estimates the impact of agricultural productivity on different types of employment based on the average of the previous 2 lags of productivity. In the first specification, productivity has a positive but non–significant effect on participation in wage/salary activities. There is no significant different in outcomes across age categories. In the second specification, a 10% increase in productivity reduces the probability of participation in business activity among the youth by 0.3 percentage points but has no significant effect for older youth and the old. Next, we investigate the impact on farming, and intensity of farming (number of days spent on farming), and primary economic activity. Due to data limitations resulting from the questionnaire design, the number of days spent on farming are categorical (0, between 0 and 20, greater than 20). In addition, these latter outcomes, in specifications (3) – (7), are only captured in the last two survey waves only. We perform our analysis for each of these categories. We define participation in farming as spending more than zero days on farming. Specification (3), consistent with our model, shows a statistically significant decline in participation among the youth and older youth of 0.3 percentage points, following a 10% increase in agricultural productivity, with no effect on the old. In specification (4), while agricultural productivity increases spending non–zero but less than 20 days in farming, the corresponding marginal effect is 0.3 and 0.4 for the older youth and the old when productivity increases by 10%. However, a 10% increase in productivity decreases the likelihood of spending more than 20 days in farming for each age. While the effect diminishes

with rising age, the differences between age groups is not statistically significant. Together with the latter finding, this result suggest farmers reduce the intensity of farming following positive productivity shocks.

Employment in rural sub–Saharan Africa tends be mixed in nature. Specifically, individuals rarely practice one type of activity but may mix both farm and non–farm occupations. The final two specifications focus on primary economic activity. Primary activity is the activity on which a person spends the most time. We exclude the cases where the individual devoted equal amounts of time to farm and non–farm activities. While we find no statistically significant effects, the results suggest that increased agricultural productivity reallocates labor away from farming as a primary activity to the non–farm sector across all age groups.

In Table 1.4 and 1.5, we repeat the analysis with a moving average of previous 4 lags and 6 lags of productivity respectively. The results become less precise and estimates are no longer statistically significant. However, a few suggestive patterns continue to hold. The youth are relatively more likely to leave business activity following positive productivity shocks. In addition, there suggestive evidence that farmers may reduce intensity of farming from more than 20 days to less than 20 days of farming in an agricultural season. Our results are therefore more pronounced in the short term but diminish when additional productivity lags are considered.

Overall, our findings show that productivity changes have significant effects only within the recent short term (2–lags). We find younger youth reduce participation in business activities. In addition, as predicted by our model, young youth (15–24) and older youth (25–34) decrease participation in farming. While all age–categories reduce the number of days devoted to farming following favorable productivity, the effects are relatively higher among the youth and older youth. The exit of younger youth (15–24) from both business and farming employment may indicate that

their participation in employment activities is due to push factors. As agricultural income increase, the push factors and income constraints are relaxed and these younger youth leave employment. This is not surprising since younger youth (15–24) are typically engaged in academic activities and are not yet gainfully employed.

Table 1.3: Agricultural Productivity and Employment Participation by Age–Group (2–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Non-zero farming days			
	Wage/ Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 2 Year MA							
15-24	0.002	-0.033*	-0.026**	0.038	-0.057**	-0.053	0.044
	(0.10)	(-1.83)	(-2.19)	(1.43)	(-2.18)	(-0.95)	(0.76)
25-34	0.019	-0.004	-0.026*	0.032*	-0.048**	-0.047	0.036
	(0.65)	(-0.18)	(-1.67)	(1.87)	(-2.50)	(-1.45)	(1.19)
35-65	0.011	0.003	-0.013	0.035**	-0.036*	-0.039	0.046
	(0.39)	(0.17)	(-0.61)	(2.17)	(-1.88)	(-1.04)	(1.36)
Observations	63260	63260	38982	38982	38982	38982	38982

Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Table 1.4: Agricultural Productivity and Employment Participation by Age–Group (4–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Non-zero farming days			
	Wage/ Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 4 Year MA							
15-24	0.003	-0.028	-0.008	0.022	-0.028	-0.002	0.016
	(0.18)	(-1.58)	(-0.97)	(0.73)	(-0.83)	(-0.06)	(0.40)
25-34	0.017	-0.003	-0.007	0.015	-0.021	-0.003	0.014
	(0.77)	(-0.14)	(-0.53)	(0.57)	(-0.64)	(-0.10)	(0.56)
35-65	0.004	0.002	0.015	0.015	-0.003	0.016	0.012
	(0.22)	(0.09)	(0.97)	(0.65)	(-0.10)	(0.52)	(0.48)
Observations	63260	63260	38982	38982	38982	38982	38982

Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Table 1.5: Agricultural Productivity and Employment Participation by Age–Group (6–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Non-zero farming days			
	Wage/ Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 6 Year MA							
15-24	-0.002	-0.028*	-0.003	0.021	-0.021	0.011	-0.009
	(-0.10)	(-1.72)	(-0.29)	(0.58)	(-0.52)	(0.27)	(-0.34)
25-34	0.013	0.004	-0.003	0.017	-0.021	0.003	0.002
	(0.48)	(0.22)	(-0.22)	(0.56)	(-0.55)	(0.09)	(0.08)
35-65	-0.004	0.014	0.024	0.012	0.004	0.026	-0.001
	(-0.14)	(0.68)	(1.25)	(0.45)	(0.12)	(0.72)	(-0.04)
Observations	63260	63260	38982	38982	38982	38982	38982

Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Heterogeneity by Gender

Our previous analysis may mask heterogeneous gender outcomes. In the following tables, 1.6 – 1.8, we repeat the main analysis and estimate gender effects. We do not report a number of control variables for the ease of readership but full first–stage probit tables are available in the appendix.

Table 1.6 reports results for marginal effects using a 2–year measure of productivity. We do not detect any effects on wage/salary activities. We also find no differences in wage/salary employment between genders within any age–category following productivity shocks. Agricultural productivity decreases employment participation among 15–24–year–old male youth, but there is no effect on females in this age category. Specifically, a 10% increase in productivity reduces the likelihood of business activity by 0.5 percent for both male youth. We see no statistically and quantitatively significant effects among the older youth and old individuals. In farming, the overall impact of productivity increases is a decline in participation and intensity in farming (greater than 20 days). Within each age group, women are more likely to stay in farming and to spend more than 20 days in agriculture compared to their male counterparts but these

differences tend to be small or statistically non–significant. Finally, specification (6) shows that among the youth (15–24), men are less likely to engage in farming as a primary economic activity compared to women – but the effects are not statistically significant.

Table 1.7 repeats the analysis above using 4–year lags of productivity. Though generally statistically insignificant, the results are qualitatively consistent. We find that among the youth (15–24), women are more likely to engage in business activity compared to men following increased agricultural productivity. Specifically, a 10% increase in agricultural productivity reduces the probability of male youth (15–24) participating in farming by 0.5 percentage points with no effect on women business participation. However, this difference is relatively smaller in magnitude as longer lags of productivity are considered. We also find that productivity gains encourage higher participation in farming, increased intensity of farming, and choice of farming as a primary economic activity among women within each age–group. These differences in employment activity are larger in farming than in business activity. Table 1.8 uses six years of productivity. The results here are largely imprecise but the results remain consistent for business activity. Male youth are more likely to leave business employment than female youth following increased agricultural productivity. The effects on the other outcomes are statistically non–significant.

Judging by point estimates, the overall results suggest that while increased agricultural productivity may encourage exit from business and farming activity among the youth, women are more likely to remain in farming compared to men. These results are similar consistent within each age group, and are in–line with some of our model predictions. However, this evidence is not strong since differences are either quantitatively small or not statistically significant.

Table 1.6: Agricultural Productivity and Employment Participation by Age–Group and Gender (2–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Non-Zero Farming Days			
	Wage/ Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 2 Year MA							
15-24 # Male	0.001	-0.054**	-0.028**	0.044*	-0.066**	-0.075	0.058
	(0.05)	(-2.50)	(-2.32)	(1.65)	(-2.45)	(-1.25)	(0.93)
15-24 # Female	0.003	-0.006	-0.021*	0.026	-0.042	-0.019	0.023
	(0.18)	(-0.39)	(-1.78)	(0.96)	(-1.58)	(-0.38)	(0.44)
25-34 # Male	0.028	-0.002	-0.032*	0.028	-0.049**	-0.046	0.029
	(0.73)	(-0.06)	(-1.93)	(1.54)	(-2.29)	(-1.36)	(0.92)
25-34 # Female	0.010	-0.004	-0.017	0.037*	-0.045*	-0.047	0.043
	(0.46)	(-0.18)	(-1.03)	(1.69)	(-1.85)	(-1.33)	(1.31)
35-65 # Male	0.012	0.006	-0.021	0.038**	-0.046**	-0.051	0.049
	(0.37)	(0.28)	(-0.86)	(2.17)	(-2.41)	(-1.29)	(1.33)
35-65 # Female	0.009	0.001	-0.003	0.032*	-0.023	-0.025	0.043
	(0.40)	(0.04)	(-0.15)	(1.68)	(-1.00)	(-0.64)	(1.30)
Observations	63260	63260	38982	38982	38982	38982	38982

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Table 1.7: Agricultural Productivity and Employment Participation by Age–Group and Gender (4–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Non-Zero Farming Days			
	Wage/ Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 4 Year MA							
15-24 # Male	0.004	-0.050**	-0.012	0.028	-0.038	-0.026	0.028
	(0.19)	(-2.09)	(-1.39)	(0.92)	(-1.07)	(-0.63)	(0.65)
15-24 # Female	0.002	-0.002	-0.002	0.012	-0.013	0.032	-0.001
	(0.14)	(-0.11)	(-0.21)	(0.40)	(-0.38)	(0.95)	(-0.04)
25-34 # Male	0.023	-0.004	-0.011	0.015	-0.026	0.001	0.009
	(0.78)	(-0.16)	(-0.79)	(0.56)	(-0.78)	(0.02)	(0.35)
25-34 # Female	0.010	-0.001	0.000	0.014	-0.013	-0.006	0.019
	(0.60)	(-0.04)	(0.00)	(0.51)	(-0.36)	(-0.19)	(0.66)
35-65 # Male	0.004	0.010	0.008	0.017	-0.013	0.001	0.016
	(0.18)	(0.48)	(0.45)	(0.68)	(-0.40)	(0.03)	(0.61)
35-65 # Female	0.005	-0.007	0.023	0.011	0.010	0.035	0.007
	(0.27)	(-0.35)	(1.35)	(0.49)	(0.32)	(1.01)	(0.25)
Observations	63260	63260	38982	38982	38982	38982	38982

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Table 1.8: Agricultural Productivity and Employment Participation by Age–Group and Gender (6–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Non-Zero Farming Days			
	Wage/ Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 6 Year MA							
15-24 # Male	-0.003	-0.050**	-0.007	0.028	-0.032	-0.017	0.007
	(-0.11)	(-2.21)	(-0.71)	(0.77)	(-0.77)	(-0.40)	(0.23)
15-24 # Female	-0.001	-0.004	0.004	0.009	-0.003	0.051	-0.031
	(-0.07)	(-0.29)	(0.34)	(0.26)	(-0.08)	(1.42)	(-1.19)
25-34 # Male	0.017	0.009	-0.007	0.019	-0.028	0.009	-0.000
	(0.48)	(0.33)	(-0.46)	(0.60)	(-0.72)	(0.21)	(-0.02)
25-34 # Female	0.009	0.003	0.003	0.014	-0.011	-0.001	0.003
	(0.42)	(0.13)	(0.17)	(0.44)	(-0.27)	(-0.02)	(0.12)
35-65 # Male	-0.005	0.025	0.017	0.014	-0.005	0.008	0.005
	(-0.17)	(1.07)	(0.82)	(0.49)	(-0.13)	(0.22)	(0.26)
35-65 # Female	-0.002	0.003	0.030	0.009	0.016	0.047	-0.008
	(-0.08)	(0.13)	(1.46)	(0.33)	(0.44)	(1.21)	(-0.35)
Observations	63260	63260	38982	38982	38982	38982	38982

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Employment Combinations

It is typical for rural households to engage in multiple employment pursuits. An alternative means of measuring employment outcomes is to use the combination of the three main activities: farming, business activity, and wage/salary activity. In this subsection, we divide employment categories into six distinct groups: none (no employment), farming only, farming and business activities, farming and wage/salary activities, farm and business and wage/salary activities, and, farming and/or wage/salary activities. Each individual falls into only one of these six mutually exclusive employment groups. Notice that we lump together business and wage/salary activities because the share of individuals who only work in business or wage/salary activities is extremely low. Due to data limitations, we can only do this exercise using the last two survey waves only.

Table 1.9, using 2–year lags of productivity, indicates that increased productivity increases the likelihood of youth and older youth exiting all employment types. A 10% increase in

agricultural productivity increases the likelihood of reporting no employment by 0.25, and 0.21 percentage points for youth (15–24) and older youth (25–34), respectively, with no effect on the old (35–65). We find no statistically significant differences in effects on farming–only employment between age groups. On the other hand, a 10% increase in agricultural productivity decreases likelihood of engaging in farming and business activities by 0.3 percentage points among youth. We find no discernible differences between age–categories in employment in farming and wage/salary activities. As reported in specification (5), there is a small decline in participation in all three activities among individuals, but the effect is statistically significant for youth only. Finally, we show no evidence of productivity affecting participation in business and/or wage/salary activity.

Table 1.9: Agricultural Productivity and Multiple Employment Participation by Age–Group (2–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)
	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 2 Year MA						
15-24	0.025**	0.006	-0.033**	-0.010	-0.017**	0.001
	(2.34)	(0.19)	(-2.09)	(-0.64)	(-1.96)	(0.23)
25-34	0.021*	0.026	-0.012	-0.032	-0.011	0.006
	(1.65)	(0.69)	(-0.52)	(-1.53)	(-0.85)	(1.08)
35-65	0.006	0.009	0.010	-0.028	-0.015	0.002
	(0.32)	(0.26)	(0.55)	(-1.52)	(-1.51)	(0.34)
Observations	38982	38982	38982	38982	38777	31998

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Table 1.10 repeats the analysis using 4–year productivity lags. In this table, we show productivity no longer increases unemployment among the youth and older youth. A 10 % increase in productivity increases the likelihood of engaging in farming only by 0.5 percentage points. Consistent with the previous table, productivity reduces the likelihood of engaging in joint farm

and business activities but only among 15–24 year olds. We find no statistically significant differences in outcomes among the other employment combinations. Under longer productivity lags (6–lags), in Table 1.11, we find the results are consistent as those under 4–lag productivity measures reported in Table 1.10. In addition, increased productivity now has a negative and statistically significant effect on participating in both farm and business activities for both the youth and older adults. The other results remain largely unchanged.

Table 1.10: Agricultural Productivity and Multiple Employment Participation by Age–Group (4–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)
	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 4 Year MA						
15-24	0.008	0.019	-0.038**	0.001	-0.006	0.000
	(1.04)	(0.83)	(-2.54)	(0.06)	(-0.60)	(0.08)
25-34	0.002	0.048*	-0.025	-0.016	-0.006	0.007
	(0.22)	(1.74)	(-1.47)	(-0.61)	(-0.53)	(1.02)
35-65	-0.021	0.025	0.002	-0.019	-0.010	0.002
	(-1.55)	(1.05)	(0.13)	(-0.93)	(-1.26)	(0.24)
Observations	38982	38982	38982	38982	38777	31998

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Table 1.11: Agricultural Productivity and Multiple Employment Participation by Age–Group (6–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)
	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 6 Year MA						
15-24	0.005	0.040	-0.050***	0.003	-0.006	-0.002
	(0.55)	(1.40)	(-3.00)	(0.14)	(-0.61)	(-0.53)
25-34	0.000	0.072**	-0.043**	-0.016	-0.006	0.004
	(0.03)	(2.04)	(-2.27)	(-0.51)	(-0.48)	(0.41)
35-65	-0.026	0.036	-0.006	-0.018	-0.011	-0.005
	(-1.50)	(1.08)	(-0.39)	(-0.72)	(-1.16)	(-0.37)
Observations	38982	38982	38982	38982	38777	31998

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Employment Combinations by Gender

In this sub–section, we repeat the preceding analysis but explore heterogeneous effects by gender. Starting with Table 1.12, we find that within each age category, men are more likely than women to be unemployed following an increase in agricultural productivity. However, the differences tend to be small in magnitude. We find no significant impact of productivity on the likelihood of engaging in farming only both within and across age groups. The table also shows that young males (15–24) tend to reduce likelihood of participation in both farming and business activities following productivity shocks. Productivity tends to reduce the likelihood of participation in three economic activities – farming, business, and wage/salary – but the coefficients are generally statistically insignificant and there are no heterogeneous outcomes among genders. In the remaining employment combinations, we find no statistically significant effects.

Table 1.13 uses productivity measures derived from 4–year lags. We show, in the first column, that increases in agricultural productivity generally reduces the likelihood of unemployment among old women. Our results remain consistent for those pursuing farming only. The results on joint farm and business employment remain consistent with young men (15–24) being more likely to abandon this joint activity as productivity increases. In the remaining employment combinations, we find no significant differences in outcomes. These results change a little but generally remain consistent even when we consider longer lags of productivity – as seen in Table 1.14. One notable difference is that productivity encourages participation in farming only for older youth with marginal effect being slightly higher for men. In addition, older youth males are likely to reduce joint employment in farming and business.

Table 1.12: Agricultural Productivity and Multiple Employment Participation by Age–Group and Gender (2–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)
	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 2 Year MA						
15-24 # Male	0.027**	0.021	-0.054***	-0.018	-0.021	0.003
	(2.41)	(0.65)	(-2.81)	(-0.96)	(-1.60)	(0.76)
15-24 # Female	0.023**	-0.015	-0.004	-0.001	-0.012*	-0.002
	(2.03)	(-0.48)	(-0.25)	(-0.05)	(-1.72)	(-0.84)
25-34 # Male	0.025*	0.031	-0.022	-0.043	-0.015	0.011*
	(1.69)	(0.72)	(-0.94)	(-1.49)	(-0.94)	(1.75)
25-34 # Female	0.016	0.020	-0.003	-0.021	-0.007	0.002
	(1.20)	(0.51)	(-0.13)	(-1.17)	(-0.59)	(0.35)
35-65 # Male	0.021	0.012	0.008	-0.037	-0.017	0.001
	(0.93)	(0.33)	(0.36)	(-1.54)	(-1.50)	(0.10)
35-65 # Female	-0.005	0.004	0.013	-0.019	-0.013	0.003
	(-0.27)	(0.12)	(0.63)	(-1.27)	(-1.28)	(0.55)
Observations	38982	38982	38982	38982	38777	31998

*Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.*

Table 1.13: Agricultural Productivity and Multiple Employment Participation by Age–Group and Gender (4–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)
	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 4 Year MA						
15-24 # Male	0.011	0.033	-0.059***	-0.005	-0.004	0.002
	(1.40)	(1.14)	(-3.06)	(-0.22)	(-0.29)	(0.49)
15-24 # Female	0.003	0.003	-0.009	0.007	-0.007	-0.002
	(0.35)	(0.13)	(-0.59)	(0.48)	(-1.14)	(-0.50)
25-34 # Male	0.004	0.054	-0.031	-0.024	-0.010	0.012
	(0.36)	(1.56)	(-1.45)	(-0.71)	(-0.82)	(1.46)
25-34 # Female	-0.002	0.042	-0.020	-0.008	-0.001	0.004
	(-0.16)	(1.44)	(-0.99)	(-0.37)	(-0.13)	(0.54)
35-65 # Male	-0.006	0.021	0.006	-0.027	-0.011	0.001
	(-0.41)	(0.67)	(0.34)	(-1.01)	(-1.17)	(0.05)
35-65 # Female	-0.033**	0.029	-0.002	-0.010	-0.009	0.004
	(-2.16)	(1.32)	(-0.15)	(-0.65)	(-1.23)	(0.49)
Observations	38982	38982	38982	38982	38777	31998

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Table 1.14: Agricultural Productivity and Multiple Employment Participation by Age–Group and Gender (6–Lags Moving Average)

	(1)	(2)	(3)	(4)	(5)	(6)
	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 6 Year MA						
15-24 # Male	0.008	0.059	-0.077***	-0.002	-0.005	-0.001
	(0.91)	(1.62)	(-3.61)	(-0.09)	(-0.33)	(-0.17)
15-24 # Female	-0.000	0.018	-0.014	0.008	-0.006	-0.004
	(-0.01)	(0.72)	(-0.83)	(0.47)	(-0.98)	(-0.96)
25-34 # Male	0.001	0.083*	-0.050**	-0.023	-0.011	0.009
	(0.10)	(1.90)	(-2.11)	(-0.59)	(-0.80)	(0.82)
25-34 # Female	-0.002	0.063*	-0.035	-0.008	-0.000	0.000
	(-0.15)	(1.75)	(-1.59)	(-0.32)	(-0.03)	(0.03)
35-65 # Male	-0.011	0.033	-0.003	-0.028	-0.012	-0.008
	(-0.55)	(0.80)	(-0.13)	(-0.83)	(-1.11)	(-0.54)
35-65 # Female	-0.037**	0.038	-0.009	-0.008	-0.009	-0.001
	(-1.99)	(1.31)	(-0.48)	(-0.44)	(-1.11)	(-0.08)
Observations	38982	38982	38982	38982	38777	31998

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Sensitivity to Functional Forms – Linear Probability Models (LPM)

We repeat the analysis in Table 1.3 – 1.5 to check whether our results are sensitive to the functional forms employed. Note that to obtain the coefficients for each age category, one must add the main productivity coefficient to the marginal co–efficient for each age category in the following tables. Table 1.15 repeats the analysis in Table 1.3. Consistent with initial results, we find no effect of productivity on wage/salary employment. We find that younger youth decrease participation in business activity while older youth and the old increase participation in business activities. While both younger and older youth decrease participation in farming following agricultural productivity increases, the old experience no impact of productivity on farming participation (consistent with our previous results). Specifications (4) and (5) show that while all age categories reduce intensity in farming, the greatest decline is among the youth relative to the old. Specifications (6) and (7)

show that productivity increases the likelihood of older individuals engaging in farming as a primary activity and reducing the likelihood of engaging in non–farm primary activity.

Results on wage/salary and business activities remain consistent once longer lags are considered (Table 1.16 – 1.17). The impacts of productivity on farming participation weaken among the youth but strengthen among the old. Impacts of productivity on intensity weakens for the youth but the old increase intensity of farming in longer lags. Results remain statistically non–significant for the youth on primary activity. However, with longer lags of productivity, older youth report engaging in farming as a primary activity while older individuals report an even higher likelihood of engaging in farming as a primary activity.

Overall, while we observe little differences in results over longer lags, we find that our results are quantitatively and qualitatively consistent when we employ LPM techniques.

Table 1.15: Agricultural Productivity and Employment Participation by Age–Group – LPM (2–Lags Moving Average)

				Non-Zero Farming Days			
	Wage/Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Productivity: Log Value of Yields per Ha - 2 Year MA							
Productivity	0.007	-0.050***	-0.029***	0.065**	-0.093***	-0.080	0.072
	(0.37)	(-2.82)	(-2.78)	(2.19)	(-2.89)	(-1.35)	(1.18)
25-34 Year Olds # Productivity	0.005	0.061***	0.018**	-0.044	0.062**	0.058	-0.055
	(0.46)	(3.81)	(2.34)	(-1.57)	(2.08)	(1.57)	(-1.64)
35-65 Year Olds # Productivity	-0.005	0.085***	0.033***	-0.053**	0.086***	0.076**	-0.057*
	(-0.46)	(3.82)	(4.01)	(-2.24)	(3.11)	(2.31)	(-1.93)
Observations	63260	63260	38982	38982	38982	38982	38982

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Table 1.16: Agricultural Productivity and Employment Participation by Age–Group – LPM (4–Lags Moving Average)

				Non-Zero Farming Days			
	Wage/Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Productivity: Log Value of Yields per Ha - 4 Year MA							
Productivity	0.010	-0.056***	-0.016*	0.055*	-0.071*	-0.042	0.049
	(0.65)	(-2.94)	(-1.76)	(1.76)	(-1.93)	(-1.12)	(1.23)
25-34 Year Olds # Productivity	-0.002	0.066***	0.015*	-0.060**	0.075***	0.070**	-0.063**
	(-0.22)	(4.79)	(1.83)	(-2.34)	(2.77)	(2.11)	(-2.09)
35-65 Year Olds # Productivity	-0.016	0.091***	0.030***	-0.067***	0.097***	0.089***	-0.069**
	(-1.26)	(4.16)	(3.88)	(-2.76)	(3.53)	(3.07)	(-2.51)
Observations	63260	63260	38982	38982	38982	38982	38982

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

Table 1.17: Agricultural Productivity and Employment Participation by Age–Group – LPM (6–Lags Moving Average)

				Non-Zero Farming Days			
	Wage/Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Productivity: Log Value of Yields per Ha - 6 Year MA							
Productivity	0.004	-0.063***	-0.010	0.058	-0.068	-0.034	0.031
	(0.22)	(-3.71)	(-1.02)	(1.59)	(-1.62)	(-0.91)	(1.12)
25-34 Year Olds # Productivity	0.004	0.082***	0.012	-0.064**	0.076**	0.075**	-0.066**
	(0.33)	(5.96)	(1.37)	(-2.33)	(2.63)	(2.13)	(-2.14)
35-65 Year Olds # Productivity	-0.013	0.122***	0.030***	-0.076***	0.106***	0.098***	-0.072**
	(-0.99)	(5.97)	(3.66)	(-2.79)	(3.48)	(3.18)	(-2.59)
Observations	63260	63260	38982	38982	38982	38982	38982

Table shows probit marginal effects of productivity on each of the binary outcomes outlined above. Includes household and individual controls, and, survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use all three survey waves while the remaining specifications use only the latest two waves. T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01.

VII. GENERAL DISCUSSION AND DIRECTION FOR FUTURE RESEARCH

Our main aim was to test our hypothesis that agricultural driven agricultural driven structural transformation would have different effects on the youth compared to the old, and investigate respective gender outcomes. Previous literature usually stops at testing for evidence of structural transformation and does not go further at investigating the impact for various demographic groups.

Structural transformation is a gradual process and hence we tested the impact of productivity over varied durations. Our findings show some evidence of differences between the youth and the old in labor reallocation. However, these differences are not very large and tend to be transitory in nature. We do not find strong evidence that increased agricultural productivity releases young labor into the non–farm sector while leaving/drawing old labor in the agricultural sector. We identify a few differences along gender dimensions. Specifically, young males are more likely to exit business activities as agricultural productivity increases. We also find suggestive evidence that men are more likely to exit or reduce days devoted to farming in response to favorable agricultural outcomes. However, these differences tend to be quantitatively small. Our results are similar to those in recent work by Emerick (2018) who finds labor reallocation to be transitory in India following agricultural productivity shocks. While we do not find effects in the longer term, we believe this is partly explained by context. Structural transformation requires additional factors such as stronger institutions, markets, and credit access among others. As a developing country, Zambia still faces many economic challenges that may inhibit the process of structural transformation. An alternative explanation is that productivity have to reach certain thresholds before the positive spillovers in the non–farm sector can be achieved. The reliance on rainfed agriculture and low fertilizer usage in Zambia and in sub–Saharan Africa may result in lower overall agricultural productivity that keeps the economy from reaching these productivity thresholds and unleashing expansion of the non–farm sector and the accompanying economic transformation. Another potential explanation is that, while we try to capture long–term productivity effects, our results may be driven by transitory productivity shocks and hence transitory responses are optimal.

There are a few potential lines for future research to improve on current work. First, future work can explore the possibility that agricultural productivity induces structural transformation only beyond certain thresholds. Such work can use spline and quantile regression techniques to measure effects based on productivity levels. Second, while our probit pooled panel fixed effects model addresses some of the common identification challenges, we cannot rule out the presence of other omitted factors that can bias the results. In addition, it is likely that only low productivity individuals will be reallocating labor from one sector to another and thus mechanically increasing productivity over time. For instance if individuals with low productivity in agriculture exit, then the mean productivity in the agricultural sector increases. Our instrumental variable estimates using rainfall shocks did not yield satisfactory results and are thus not reported. Part of this failure is likely driven by the fact that rainfall shocks are transitory in nature and thus are not appropriate instruments for long–term productivity. Instruments that shift total factor productivity in agriculture like the HYV rice in Asia and genetically engineered soybeans in Brazil would be ideal. The introduction of orange–fleshed sweet potato in Zambia provides a candidate instrument – but unfortunately, take up has been dismal.

Finally, future work should consider using alternative measures of productivity. Specifically, conversion of yields into nominal values can induce measurement error that may lead to attenuation bias. One such measure is yields per hectare as a measure or agricultural productivity. If this approach yields differences with our results, then it will indicate that conversion of yields to nominal values requires careful approaches. However, if the results are consistent, then it will imply that when price data is absent or poor, using yields as a measure of productivity may be sufficient to yield unbiased estimates. One candidate is maize yields. Maize is an ideal crop because over the study period between 85% and 90% of the farmers cultivated the crop (share of

cultivated hectares devoted to maize is between 55%–60%). However, a robust measure will require approaches that apportion yields from other crops into the productivity measure.

VIII. CONCLUSION

This paper investigated heterogeneous movement of labor between the agricultural and the non–agricultural sector. We created a model that hypothesizes that increased agricultural productivity may drive youth from the farm into the non–farm sector. The consequence of this labor movement is concentration of younger workers in the non–farm sector and an aging farmer population. The overall results suggest that while increased agricultural productivity may encourage exit from business and farming activity among the youth, women are more likely to remain in farming compared to men. These results are consistent within each age group, and are in–line with some of our model predictions. While we find evidence of differential labor reallocation by age and gender, our empirical tests do not provide sufficient evidence to support our hypothesis. We believe that our results may be driven by the lack of a robust environment to facilitate structural transformation. Specifically, agricultural productivity remains low in Zambia while the institutional environment and market frictions may limit the ability of agriculture to be an engine of economic growth. Another potential explanation is that, while we try to capture long–term productivity effects, our results may be driven by transitory productivity shocks and hence transitory responses are optimal. Despite our current results, we believe that our paper provides a valuable new extended model that can be used to explore similar topics in different contexts.

APPENDIX

Table A 1.1: Agricultural Productivity and Employment Participation – First Stage Probit (2–Lags Moving Average)

	Wage/Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 2 Year MA	0.019	-0.208*	-0.579**	0.164	-0.245**	-0.173	0.157
	(0.10)	(-1.82)	(-2.21)	(1.43)	(-2.17)	(-0.94)	(0.76)
25-34 Year Olds # Log Value of Yields per Ha - 2 Year MA	0.108	0.190***	0.131	0.051	-0.027	-0.033	0.038
	(1.42)	(2.68)	(0.99)	(0.45)	(-0.25)	(-0.30)	(0.35)
35-65 Year Olds # Log Value of Yields per Ha - 2 Year MA	0.057	0.222***	0.433***	0.050	0.071	0.019	0.067
	(0.65)	(2.85)	(3.95)	(0.71)	(0.93)	(0.23)	(0.82)
25-34 Year Olds	-0.628	-1.195**	-1.244	-0.856	0.562	0.765	-0.872
	(-0.98)	(-2.02)	(-1.13)	(-0.89)	(0.62)	(0.85)	(-0.95)
35-65 Year Olds	-0.247	-1.388**	-4.023***	-0.770	-0.420	0.173	-0.971
	(-0.34)	(-2.13)	(-4.43)	(-1.31)	(-0.66)	(0.25)	(-1.41)
Female	-0.382***	-0.193***	-0.010	0.096***	-0.090***	-0.052**	0.033
	(-9.77)	(-7.32)	(-0.21)	(4.68)	(-4.51)	(-2.15)	(1.55)
Relation to HH Head (base: Head)							
Spouse	-0.346***	-0.341***	0.096	-0.254***	0.230***	0.231***	-0.280***
	(-10.11)	(-11.84)	(1.55)	(-5.81)	(5.56)	(6.62)	(-6.66)
Child (own/step)	-0.404***	-0.867***	-0.601***	0.188***	-0.375***	-0.198***	0.107**
	(-8.02)	(-21.52)	(-7.29)	(3.60)	(-6.91)	(-4.54)	(2.24)
Relative	-0.589***	-1.054***	-0.571***	0.174***	-0.353***	-0.150***	0.064
	(-11.89)	(-29.38)	(-6.48)	(2.82)	(-5.71)	(-3.11)	(1.23)
Unrelated	-0.217**	-0.635***	0.509***	0.007	0.066	0.259*	-0.232
	(-2.28)	(-7.86)	(3.08)	(0.08)	(0.87)	(1.65)	(-1.46)
Marital Status:base -Monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	-0.093***	-0.062*	-0.104	-0.011	-0.041	-0.033	-0.035
	(-2.80)	(-1.72)	(-1.55)	(-0.21)	(-0.93)	(-0.90)	(-0.86)
Never Married	-0.191***	-0.433***	-0.240***	0.532***	-0.535***	-0.679***	0.637***
	(-5.13)	(-17.40)	(-4.16)	(10.91)	(-12.87)	(-15.48)	(12.51)
Education Attained:base-None							
Primary	0.026	0.151***	0.333***	0.130**	0.030	-0.031	0.184***
	(0.64)	(4.70)	(4.48)	(2.29)	(0.53)	(-0.59)	(3.59)
Junior High	0.074	0.238***	0.453***	0.208***	-0.012	-0.113*	0.284***
	(1.52)	(6.43)	(5.70)	(3.58)	(-0.20)	(-1.82)	(4.62)
Senior High	0.251***	0.196***	0.372***	0.382***	-0.191***	-0.278***	0.443***
	(4.40)	(4.99)	(4.11)	(6.29)	(-3.17)	(-4.61)	(7.47)
College and above	1.186***	-0.066	0.014	0.878***	-0.748***	-0.984***	1.123***
	(14.02)	(-0.87)	(0.12)	(8.44)	(-8.26)	(-10.18)	(11.20)
Log Head Age	-0.176***	-0.264***	-0.060	-0.152***	0.140**	0.212***	-0.221***
	(-4.03)	(-6.83)	(-0.65)	(-2.63)	(2.42)	(4.24)	(-4.52)
Head Marital Status: base monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	0.040	0.055	0.025	-0.044	0.049	0.019	-0.003
	(1.03)	(1.60)	(0.32)	(-1.16)	(1.18)	(0.68)	(-0.10)
Never Married	0.049	0.405***	0.071	-0.330**	0.307**	0.431***	-0.348***
	(0.48)	(3.94)	(0.27)	(-2.28)	(2.13)	(4.47)	(-3.13)
Head Education: base-None							
Primary	-0.073**	0.007	0.005	0.017	-0.009	0.001	-0.013
	(-2.28)	(0.23)	(0.07)	(0.41)	(-0.21)	(0.04)	(-0.35)
Junior High	-0.089*	0.005	-0.076	0.087*	-0.094*	-0.080*	0.071
	(-1.74)	(0.13)	(-0.83)	(1.71)	(-1.86)	(-1.72)	(1.44)
Senior High	-0.112**	-0.070*	-0.086	0.054	-0.062	-0.050	-0.009
	(-1.99)	(-1.68)	(-0.85)	(1.04)	(-1.19)	(-1.21)	(-0.21)
College and above	-0.074	-0.048	-0.142	0.200**	-0.233***	-0.257***	0.168**
	(-0.90)	(-0.73)	(-0.90)	(2.33)	(-2.66)	(-3.50)	(2.44)
Log Household Size	0.011	-0.023	-0.083	0.037	-0.049	-0.018	0.001
	(0.38)	(-0.93)	(-1.23)	(1.08)	(-1.46)	(-0.50)	(0.02)
Log Male Children	-0.057***	-0.065***	0.096***	-0.001	0.030	0.018	0.005
	(-2.60)	(-4.31)	(2.71)	(-0.03)	(1.14)	(0.89)	(0.20)
Log Land Owned (Ha)	-0.042***	0.008	0.033***	-0.035***	0.041***	0.034***	-0.031***
	(-8.47)	(1.41)	(2.75)	(-3.73)	(4.32)	(4.59)	(-4.59)
Female Head	0.142***	0.226***	0.005	-0.061	0.062	0.080**	-0.071*
	(4.35)	(6.79)	(0.06)	(-1.36)	(1.31)	(2.16)	(-1.79)
Log TLUs	-0.159***	-0.010	0.058**	-0.029**	0.039***	0.050***	-0.037**
	(-11.90)	(-1.05)	(2.11)	(-2.11)	(3.19)	(2.88)	(-2.25)
Cell Phone	-0.046**	0.095***	0.001	0.048*	-0.043	-0.060***	0.075***
	(-1.96)	(4.73)	(0.03)	(1.68)	(-1.51)	(-2.63)	(3.15)
Solar/Generator	-0.094***	0.077***	0.043	-0.024	0.031	0.035	-0.043*
	(-4.86)	(3.45)	(0.83)	(-0.81)	(0.97)	(1.30)	(-1.91)
HH Bank Account	0.237***	-0.013	-0.118**	0.054	-0.076**	-0.096***	0.098***
	(8.26)	(-0.51)	(-2.19)	(1.50)	(-2.12)	(-3.20)	(3.57)
House Type							
Cement Floor	-0.068***	-0.003	-0.180***	0.072***	-0.112***	-0.118***	0.093***
	(-2.72)	(-0.13)	(-3.62)	(2.97)	(-4.69)	(-4.53)	(3.26)
Permanent Roof	-0.097***	-0.027	0.015	0.037	-0.031	-0.050*	0.053*
	(-4.39)	(-1.27)	(0.26)	(1.08)	(-0.94)	(-1.70)	(1.87)
Observations	63260	63260	38982	38982	38982	38982	38982

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use three survey waves while the remaining specifications use the latest two waves.

Table A 1.2: Agricultural Productivity and Employment Participation – First Stage Probit (4–Lags Moving Average)

	Wage/Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 4 Year MA	0.028	-0.178	-0.182	0.095	-0.121	-0.008	0.056
	(0.18)	(-1.57)	(-0.98)	(0.73)	(-0.83)	(-0.06)	(0.40)
25-34 Year Olds # Log Value of Yields per Ha - 4 Year MA	0.082	0.165**	0.067	0.002	0.004	-0.006	0.019
	(1.01)	(2.48)	(0.50)	(0.02)	(0.03)	(-0.06)	(0.18)
35-65 Year Olds # Log Value of Yields per Ha - 4 Year MA	0.003	0.186**	0.356***	-0.006	0.107	0.071	0.003
	(0.03)	(2.34)	(3.34)	(-0.08)	(1.39)	(0.79)	(0.03)
25-34 Year Olds	-0.416	-0.997*	-0.713	-0.452	0.304	0.545	-0.715
	(-0.60)	(-1.78)	(-0.63)	(-0.50)	(0.34)	(0.60)	(-0.81)
35-65 Year Olds	0.196	-1.099*	-3.393***	-0.302	-0.724	-0.261	-0.439
	(0.24)	(-1.65)	(-3.80)	(-0.48)	(-1.13)	(-0.35)	(-0.60)
Female	-0.382***	-0.192***	-0.008	0.095***	-0.090***	-0.052**	0.033
	(-9.76)	(-7.32)	(-0.18)	(4.65)	(-4.47)	(-2.14)	(1.54)
Relation to HH Head (base: Head)							
Spouse	-0.346***	-0.341***	0.093	-0.253***	0.229***	0.230***	-0.279***
	(-10.09)	(-11.84)	(1.50)	(-5.80)	(5.53)	(6.56)	(-6.63)
Child (own/step)	-0.404***	-0.868***	-0.602***	0.187***	-0.374***	-0.197***	0.106**
	(-8.00)	(-21.62)	(-7.33)	(3.60)	(-6.92)	(-4.52)	(2.21)
Relative	-0.589***	-1.054***	-0.573***	0.174***	-0.353***	-0.149***	0.064
	(-11.89)	(-29.53)	(-6.51)	(2.82)	(-5.71)	(-3.09)	(1.22)
Unrelated	-0.221**	-0.632***	0.523***	-0.007	0.081	0.272*	-0.244
	(-2.33)	(-7.79)	(3.05)	(-0.08)	(1.11)	(1.68)	(-1.50)
Marital Status:base -Monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	-0.096***	-0.063*	-0.105	-0.013	-0.040	-0.030	-0.039
	(-2.85)	(-1.72)	(-1.57)	(-0.26)	(-0.88)	(-0.82)	(-0.95)
Never Married	-0.192***	-0.431***	-0.241***	0.530***	-0.534***	-0.678***	0.636***
	(-5.14)	(-17.47)	(-4.15)	(10.88)	(-12.81)	(-15.61)	(12.51)
Education Attained:base-None							
Primary	0.027	0.152***	0.336***	0.132**	0.029	-0.033	0.185***
	(0.67)	(4.71)	(4.58)	(2.32)	(0.52)	(-0.61)	(3.61)
Junior High	0.075	0.239***	0.457***	0.210***	-0.013	-0.115*	0.285***
	(1.54)	(6.41)	(5.82)	(3.60)	(-0.21)	(-1.84)	(4.62)
Senior High	0.252***	0.197***	0.376***	0.383***	-0.190***	-0.279***	0.444***
	(4.41)	(4.99)	(4.19)	(6.31)	(-3.17)	(-4.60)	(7.44)
College and above	1.187***	-0.064	0.017	0.878***	-0.746***	-0.984***	1.123***
	(14.06)	(-0.85)	(0.15)	(8.49)	(-8.30)	(-10.16)	(11.18)
Log Head Age	-0.176***	-0.264***	-0.060	-0.153***	0.141**	0.212***	-0.221***
	(-4.01)	(-6.82)	(-0.65)	(-2.64)	(2.43)	(4.22)	(-4.52)
Head Marital Status: base monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	0.041	0.055	0.029	-0.044	0.050	0.019	-0.003
	(1.07)	(1.60)	(0.38)	(-1.17)	(1.20)	(0.69)	(-0.11)
Never Married	0.049	0.407***	0.078	-0.330**	0.308**	0.432***	-0.348***
	(0.48)	(3.96)	(0.29)	(-2.28)	(2.13)	(4.51)	(-3.16)
Head Education: base-None							
Primary	-0.074**	0.007	0.005	0.017	-0.008	0.002	-0.014
	(-2.31)	(0.22)	(0.07)	(0.40)	(-0.20)	(0.06)	(-0.36)
Junior High	-0.090*	0.005	-0.077	0.086*	-0.093*	-0.079*	0.070
	(-1.75)	(0.13)	(-0.85)	(1.70)	(-1.84)	(-1.69)	(1.41)
Senior High	-0.113**	-0.071*	-0.087	0.055	-0.063	-0.051	-0.009
	(-2.00)	(-1.69)	(-0.87)	(1.05)	(-1.20)	(-1.21)	(-0.20)
College and above	-0.075	-0.048	-0.147	0.200**	-0.234***	-0.257***	0.168**
	(-0.92)	(-0.74)	(-0.93)	(2.34)	(-2.66)	(-3.50)	(2.44)
Log Household Size	0.011	-0.023	-0.082	0.037	-0.050	-0.018	0.001
	(0.38)	(-0.93)	(-1.21)	(1.10)	(-1.48)	(-0.50)	(0.03)
Log Male Children	-0.057***	-0.064***	0.096***	-0.001	0.030	0.018	0.004
	(-2.60)	(-4.31)	(2.69)	(-0.04)	(1.15)	(0.89)	(0.20)
Log Land Owned (Ha)	-0.042***	0.008	0.033***	-0.035***	0.041***	0.034***	-0.031***
	(-8.42)	(1.40)	(2.74)	(-3.70)	(4.28)	(4.52)	(-4.53)
Female Head	0.143***	0.226***	0.001	-0.060	0.061	0.079**	-0.070*
	(4.39)	(6.74)	(0.01)	(-1.36)	(1.29)	(2.16)	(-1.80)
Log TLUs	-0.159***	-0.010	0.057**	-0.029**	0.039***	0.050***	-0.037**
	(-11.96)	(-1.02)	(2.10)	(-2.10)	(3.17)	(2.84)	(-2.23)
Cell Phone	-0.047**	0.095***	0.001	0.048*	-0.043	-0.060***	0.074***
	(-1.98)	(4.74)	(0.01)	(1.67)	(-1.51)	(-2.62)	(3.14)
Solar/Generator	-0.094***	0.077***	0.042	-0.024	0.031	0.035	-0.044*
	(-4.87)	(3.45)	(0.81)	(-0.81)	(0.98)	(1.30)	(-1.91)
HH Bank Account	0.237***	-0.013	-0.114**	0.054	-0.075**	-0.095***	0.098***
	(8.26)	(-0.52)	(-2.12)	(1.51)	(-2.12)	(-3.15)	(3.57)
House Type							
Cement Floor	-0.068***	-0.004	-0.180***	0.073***	-0.113***	-0.119***	0.093***
	(-2.68)	(-0.15)	(-3.62)	(2.98)	(-4.69)	(-4.56)	(3.30)
Permanent Roof	-0.097***	-0.027	0.014	0.037	-0.031	-0.050*	0.053*
	(-4.36)	(-1.27)	(0.26)	(1.09)	(-0.95)	(-1.69)	(1.87)
Observations	63260	63260	38982	38982	38982	38982	38982

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use three survey waves while the remaining specifications use the latest two waves.

Table A 1.3: Agricultural Productivity and Employment Participation – First Stage Probit (6–Lags Moving Average)

	Wage/Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 6 Year MA	-0.020	-0.180*	-0.061	0.091	-0.090	0.036	-0.031
	(-0.10)	(-1.71)	(-0.29)	(0.58)	(-0.52)	(0.27)	(-0.34)
25-34 Year Olds # Log Value of Yields per Ha - 6 Year MA	0.106	0.199***	0.008	0.020	-0.028	-0.022	0.040
	(1.28)	(2.99)	(0.05)	(0.18)	(-0.25)	(-0.18)	(0.36)
35-65 Year Olds # Log Value of Yields per Ha - 6 Year MA	-0.006	0.240***	0.335***	-0.018	0.111	0.064	0.028
	(-0.05)	(3.29)	(2.88)	(-0.21)	(1.28)	(0.64)	(0.30)
25-34 Year Olds	-0.617	-1.272**	-0.211	-0.601	0.570	0.674	-0.885
	(-0.88)	(-2.28)	(-0.17)	(-0.64)	(0.61)	(0.68)	(-0.96)
35-65 Year Olds	0.266	-1.548**	-3.222***	-0.206	-0.761	-0.200	-0.649
	(0.31)	(-2.54)	(-3.30)	(-0.29)	(-1.05)	(-0.24)	(-0.84)
Female	-0.382***	-0.192***	-0.008	0.095***	-0.090***	-0.052**	0.033
	(-9.77)	(-7.32)	(-0.18)	(4.66)	(-4.47)	(-2.14)	(1.56)
Relation to HH Head (base: Head)							
Spouse	-0.346***	-0.343***	0.093	-0.252***	0.229***	0.230***	-0.279***
	(-10.10)	(-11.88)	(1.49)	(-5.80)	(5.53)	(6.56)	(-6.64)
Child (own/step)	-0.405***	-0.868***	-0.603***	0.187***	-0.374***	-0.197***	0.106**
	(-8.01)	(-21.63)	(-7.34)	(3.58)	(-6.89)	(-4.51)	(2.19)
Relative	-0.590***	-1.055***	-0.573***	0.174***	-0.353***	-0.149***	0.063
	(-11.88)	(-29.60)	(-6.52)	(2.80)	(-5.69)	(-3.08)	(1.20)
Unrelated	-0.221**	-0.632***	0.520***	-0.008	0.081	0.270*	-0.242
	(-2.32)	(-7.75)	(3.03)	(-0.09)	(1.11)	(1.67)	(-1.48)
Marital Status:base -Monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	-0.096***	-0.061*	-0.106	-0.013	-0.039	-0.031	-0.037
	(-2.86)	(-1.68)	(-1.59)	(-0.27)	(-0.88)	(-0.84)	(-0.92)
Never Married	-0.192***	-0.428***	-0.242***	0.530***	-0.534***	-0.678***	0.637***
	(-5.14)	(-17.49)	(-4.17)	(10.85)	(-12.78)	(-15.61)	(12.55)
Education Attained:base-None							
Primary	0.027	0.150***	0.336***	0.132**	0.029	-0.033	0.185***
	(0.68)	(4.68)	(4.57)	(2.33)	(0.51)	(-0.61)	(3.61)
Junior High	0.075	0.237***	0.456***	0.210***	-0.013	-0.115*	0.285***
	(1.54)	(6.40)	(5.82)	(3.60)	(-0.22)	(-1.84)	(4.64)
Senior High	0.252***	0.196***	0.375***	0.383***	-0.191***	-0.279***	0.444***
	(4.42)	(4.98)	(4.19)	(6.32)	(-3.18)	(-4.61)	(7.46)
College and above	1.187***	-0.067	0.016	0.878***	-0.748***	-0.985***	1.124***
	(14.03)	(-0.89)	(0.14)	(8.51)	(-8.33)	(-10.17)	(11.21)
Log Head Age	-0.176***	-0.262***	-0.060	-0.153***	0.141**	0.213***	-0.221***
	(-4.01)	(-6.80)	(-0.65)	(-2.63)	(2.43)	(4.22)	(-4.50)
Head Marital Status: base monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	0.042	0.054	0.029	-0.044	0.050	0.019	-0.004
	(1.08)	(1.57)	(0.38)	(-1.17)	(1.20)	(0.69)	(-0.12)
Never Married	0.049	0.406***	0.078	-0.330**	0.309**	0.432***	-0.350***
	(0.48)	(3.94)	(0.29)	(-2.29)	(2.14)	(4.51)	(-3.18)
Head Education: base-None							
Primary	-0.074**	0.007	0.006	0.017	-0.008	0.002	-0.014
	(-2.30)	(0.25)	(0.08)	(0.39)	(-0.19)	(0.06)	(-0.36)
Junior High	-0.090*	0.006	-0.077	0.086*	-0.093*	-0.079*	0.070
	(-1.76)	(0.16)	(-0.84)	(1.69)	(-1.83)	(-1.68)	(1.40)
Senior High	-0.113**	-0.070*	-0.086	0.054	-0.063	-0.051	-0.009
	(-2.00)	(-1.68)	(-0.85)	(1.04)	(-1.19)	(-1.21)	(-0.20)
College and above	-0.075	-0.047	-0.146	0.200**	-0.233***	-0.257***	0.168**
	(-0.92)	(-0.73)	(-0.93)	(2.34)	(-2.66)	(-3.49)	(2.43)
Log Household Size	0.012	-0.023	-0.081	0.037	-0.050	-0.017	0.000
	(0.39)	(-0.92)	(-1.20)	(1.10)	(-1.47)	(-0.49)	(0.01)
Log Male Children	-0.057***	-0.064***	0.096***	-0.001	0.030	0.018	0.005
	(-2.59)	(-4.30)	(2.68)	(-0.04)	(1.15)	(0.89)	(0.21)
Log Land Owned (Ha)	-0.042***	0.008	0.033***	-0.035***	0.041***	0.034***	-0.031***
	(-8.39)	(1.40)	(2.74)	(-3.69)	(4.27)	(4.52)	(-4.52)
Female Head	0.142***	0.226***	0.001	-0.060	0.061	0.079**	-0.070*
	(4.38)	(6.72)	(0.01)	(-1.37)	(1.29)	(2.16)	(-1.81)
Log TLUs	-0.159***	-0.010	0.057**	-0.029**	0.039***	0.050***	-0.036**
	(-12.01)	(-1.02)	(2.10)	(-2.09)	(3.15)	(2.85)	(-2.22)
Cell Phone	-0.046**	0.095***	-0.000	0.048*	-0.043	-0.061***	0.075***
	(-1.96)	(4.73)	(-0.00)	(1.68)	(-1.52)	(-2.62)	(3.14)
Solar/Generator	-0.094***	0.077***	0.041	-0.024	0.031	0.035	-0.043*
	(-4.86)	(3.46)	(0.79)	(-0.81)	(0.97)	(1.30)	(-1.91)
HH Bank Account	0.237***	-0.013	-0.113**	0.054	-0.075**	-0.095***	0.098***
	(8.26)	(-0.51)	(-2.09)	(1.50)	(-2.10)	(-3.16)	(3.57)
House Type							
Cement Floor	-0.068***	-0.004	-0.180***	0.073***	-0.113***	-0.119***	0.093***
	(-2.69)	(-0.15)	(-3.61)	(2.97)	(-4.67)	(-4.55)	(3.29)
Permanent Roof	-0.097***	-0.027	0.015	0.037	-0.030	-0.049*	0.053*
	(-4.37)	(-1.25)	(0.26)	(1.08)	(-0.93)	(-1.68)	(1.85)
Observations	63260	63260	38982	38982	38982	38982	38982

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use three survey waves while the remaining specifications use the latest two waves.

Table A 1.4: Agricultural Productivity and Employment Participation by Gender – First Stage Probit (2–Lags Moving Average)

	Wage/ Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 2 Year MA	0.019	-0.205*	-0.659**	0.189	-0.287**	-0.227	0.187
	(0.10)	(-1.76)	(-2.42)	(1.54)	(-2.37)	(-1.16)	(0.84)
15-24 # Female # Log Value of Yields per Ha - 2 Year MA	0.001	0.016	0.196**	-0.063	0.105**	0.134**	-0.075
	(0.01)	(0.26)	(2.16)	(-1.19)	(2.15)	(2.14)	(-1.13)
25-34 # Male # Log Value of Yields per Ha - 2 Year MA	0.108	0.175**	0.125	0.053	-0.033	-0.039	0.041
	(1.37)	(2.50)	(0.95)	(0.47)	(-0.31)	(-0.36)	(0.37)
25-34 # Female # Log Value of Yields per Ha - 2 Year MA	0.105	0.201**	0.339**	-0.003	0.071	0.092	-0.033
	(1.32)	(2.01)	(2.01)	(-0.02)	(0.50)	(0.60)	(-0.21)
35-65 # Male # Log Value of Yields per Ha - 2 Year MA	0.056	0.200**	0.417***	0.056	0.060	0.009	0.071
	(0.63)	(2.54)	(3.80)	(0.78)	(0.80)	(0.11)	(0.87)
35-65 # Female # Log Value of Yields per Ha - 2 Year MA	0.059	0.239**	0.635***	-0.018	0.181*	0.153	-0.011
	(0.62)	(2.48)	(4.29)	(-0.18)	(1.67)	(1.25)	(-0.09)
25-34	-0.616	-1.111*	-1.257	-0.900	0.618	0.831	-0.895
	(-0.93)	(-1.90)	(-1.14)	(-0.95)	(0.69)	(0.94)	(-0.98)
35-65	-0.251	-1.306**	-3.954***	-0.765	-0.400	0.213	-0.979
	(-0.34)	(-1.99)	(-4.38)	(-1.30)	(-0.64)	(0.31)	(-1.41)
Female	-0.390	-0.414	-1.706**	0.620	-0.979**	-1.171**	0.660
	(-0.59)	(-0.79)	(-2.24)	(1.42)	(-2.41)	(-2.25)	(1.21)
Relation to HH Head (base: Head)							
Spouse	-0.350***	-0.404***	-0.003	-0.205***	0.153***	0.181***	-0.245***
	(-9.82)	(-12.08)	(-0.04)	(-3.46)	(2.79)	(3.85)	(-4.66)
Child (own/step)	-0.407***	-0.889***	-0.620***	0.214***	-0.406***	-0.219***	0.121**
	(-8.18)	(-22.62)	(-7.19)	(4.00)	(-7.09)	(-4.88)	(2.54)
Relative	-0.592***	-1.071***	-0.588***	0.199***	-0.382***	-0.169***	0.078
	(-11.90)	(-30.60)	(-6.53)	(3.17)	(-5.92)	(-3.42)	(1.47)
Unrelated	-0.219**	-0.670***	0.479***	0.026	0.036	0.248	-0.223
	(-2.24)	(-8.36)	(2.73)	(0.31)	(0.51)	(1.60)	(-1.40)
Marital Status:base -Monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	-0.097***	-0.092***	-0.147**	0.006	-0.069	-0.051	-0.022
	(-2.82)	(-2.59)	(-2.01)	(0.11)	(-1.36)	(-1.24)	(-0.52)
Never Married	-0.193***	-0.462***	-0.254***	0.540***	-0.547***	-0.687***	0.643***
	(-4.98)	(-18.14)	(-4.37)	(10.95)	(-13.30)	(-16.14)	(12.70)
Education Attained:base-None							
Primary	0.027	0.157***	0.338***	0.127**	0.035	-0.028	0.181***
	(0.67)	(4.95)	(4.52)	(2.23)	(0.62)	(-0.52)	(3.53)
Junior High	0.076	0.247***	0.461***	0.203***	-0.005	-0.108*	0.280***
	(1.54)	(6.75)	(5.74)	(3.49)	(-0.08)	(-1.74)	(4.55)
Senior High	0.253***	0.207***	0.383***	0.376***	-0.182***	-0.271***	0.438***
	(4.36)	(5.40)	(4.18)	(6.14)	(-3.01)	(-4.54)	(7.40)
College and above	1.188***	-0.047	0.026	0.869***	-0.735***	-0.975***	1.116***
	(14.00)	(-0.63)	(0.22)	(8.33)	(-8.08)	(-10.05)	(11.13)
Log Head Age	-0.176***	-0.271***	-0.070	-0.149***	0.133**	0.208***	-0.218***
	(-4.01)	(-6.84)	(-0.76)	(-2.59)	(2.34)	(4.17)	(-4.47)
Head Marital Status: base monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	0.042	0.075**	0.038	-0.048	0.056	0.024	-0.007
	(1.07)	(2.14)	(0.50)	(-1.22)	(1.33)	(0.85)	(-0.20)
Never Married	0.050	0.420***	0.071	-0.324**	0.301**	0.428***	-0.345***
	(0.50)	(4.05)	(0.27)	(-2.23)	(2.09)	(4.45)	(-3.10)
Head Education: base-None							
Primary	-0.074**	0.004	0.005	0.019	-0.010	0.000	-0.013
	(-2.30)	(0.13)	(0.07)	(0.43)	(-0.25)	(0.00)	(-0.33)
Junior High	-0.090*	0.001	-0.076	0.089*	-0.097*	-0.083*	0.073
	(-1.75)	(0.02)	(-0.84)	(1.75)	(-1.91)	(-1.78)	(1.47)
Senior High	-0.113**	-0.076*	-0.087	0.057	-0.066	-0.054	-0.007
	(-2.00)	(-1.83)	(-0.87)	(1.08)	(-1.25)	(-1.29)	(-0.16)
College and above	-0.075	-0.057	-0.144	0.203**	-0.237***	-0.261***	0.171**
	(-0.91)	(-0.87)	(-0.91)	(2.34)	(-2.69)	(-3.55)	(2.46)
Log Household Size	0.013	-0.018	-0.085	0.035	-0.048	-0.016	-0.000
	(0.44)	(-0.72)	(-1.25)	(1.03)	(-1.41)	(-0.46)	(-0.00)
Log Male Children	-0.057***	-0.066***	0.095***	-0.001	0.028	0.018	0.005
	(-2.59)	(-4.41)	(2.65)	(-0.02)	(1.09)	(0.86)	(0.22)
Log Land Owned (Ha)	-0.042***	0.008	0.034***	-0.035***	0.041***	0.034***	-0.031***
	(-8.51)	(1.44)	(2.77)	(-3.74)	(4.34)	(4.61)	(-4.60)
Female Head	0.137***	0.184***	-0.021	-0.050	0.043	0.066*	-0.062
	(4.19)	(5.14)	(-0.24)	(-1.09)	(0.89)	(1.74)	(-1.53)
Log TLUs	-0.159***	-0.011	0.057**	-0.028**	0.038***	0.049***	-0.036**
	(-11.99)	(-1.10)	(2.10)	(-2.04)	(3.10)	(2.83)	(-2.21)
Cell Phone	-0.047**	0.094***	0.001	0.048*	-0.043	-0.061***	0.075***
	(-1.96)	(4.71)	(0.02)	(1.68)	(-1.52)	(-2.66)	(3.17)
Solar/Generator	-0.094***	0.077***	0.043	-0.024	0.031	0.036	-0.044*
	(-4.85)	(3.45)	(0.84)	(-0.81)	(0.98)	(1.32)	(-1.91)
HH Bank Account	0.237***	-0.013	-0.119**	0.054	-0.076**	-0.096***	0.098***
	(8.27)	(-0.52)	(-2.21)	(1.50)	(-2.12)	(-3.19)	(3.57)
House Type							
Cement Floor	-0.068***	-0.003	-0.181***	0.073***	-0.113***	-0.119***	0.093***
	(-2.72)	(-0.13)	(-3.63)	(2.98)	(-4.71)	(-4.54)	(3.26)
Permanent Roof	-0.097***	-0.027	0.014	0.037	-0.030	-0.049*	0.053*
	(-4.38)	(-1.27)	(0.24)	(1.07)	(-0.93)	(-1.68)	(1.86)
Observations	63260	63260	38982	38982	38982	38982	38982

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use three survey waves while the remaining specifications use the latest two waves.

Table A 1.5: Agricultural Productivity and Employment Participation by Gender – First Stage Probit (4–Lags Moving Average)

	Wage/ Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 4 Year MA	0.030	-0.167	-0.266	0.118	-0.163	-0.064	0.082
	(0.19)	(-1.41)	(-1.38)	(0.84)	(-1.05)	(-0.48)	(0.55)
15-24 # Female # Log Value of Yields per Ha - 4 Year MA	-0.003	-0.006	0.209**	-0.058	0.106*	0.139**	-0.067
	(-0.03)	(-0.09)	(2.19)	(-0.98)	(1.94)	(2.21)	(-1.03)
25-34 # Male # Log Value of Yields per Ha - 4 Year MA	0.082	0.154**	0.062	0.005	-0.002	-0.013	0.021
	(0.97)	(2.33)	(0.46)	(0.05)	(-0.02)	(-0.12)	(0.20)
25-34 # Female # Log Value of Yields per Ha - 4 Year MA	0.076	0.157	0.287*	-0.045	0.102	0.124	-0.044
	(0.91)	(1.60)	(1.68)	(-0.34)	(0.76)	(0.86)	(-0.32)
35-65 # Male # Log Value of Yields per Ha - 4 Year MA	0.002	0.165**	0.340***	-0.001	0.097	0.062	0.006
	(0.02)	(2.08)	(3.19)	(-0.02)	(1.28)	(0.68)	(0.07)
35-65 # Female # Log Value of Yields per Ha - 4 Year MA	0.002	0.182*	0.570***	-0.070	0.219**	0.211*	-0.067
	(0.02)	(1.79)	(3.79)	(-0.67)	(1.97)	(1.80)	(-0.57)
25-34	-0.405	-0.943*	-0.720	-0.501	0.363	0.612	-0.734
	(-0.57)	(-1.70)	(-0.64)	(-0.56)	(0.41)	(0.67)	(-0.83)
35-65	0.191	-1.030	-3.325***	-0.288	-0.712	-0.228	-0.442
	(0.23)	(-1.55)	(-3.75)	(-0.45)	(-1.11)	(-0.30)	(-0.60)
Female	-0.360	-0.228	-1.819**	0.580	-0.986**	-1.222**	0.594
	(-0.52)	(-0.40)	(-2.28)	(1.18)	(-2.19)	(-2.32)	(1.11)
Relation to HH Head (base: Head)							
Spouse	-0.351***	-0.404***	-0.007	-0.204***	0.151***	0.180***	-0.244***
	(-9.78)	(-12.04)	(-0.09)	(-3.46)	(2.78)	(3.83)	(-4.69)
Child (own/step)	-0.407***	-0.890***	-0.622***	0.214***	-0.406***	-0.218***	0.121**
	(-8.17)	(-22.71)	(-7.22)	(4.01)	(-7.10)	(-4.86)	(2.51)
Relative	-0.592***	-1.072***	-0.589***	0.199***	-0.382***	-0.168***	0.077
	(-11.88)	(-30.69)	(-6.55)	(3.17)	(-5.93)	(-3.39)	(1.45)
Unrelated	-0.224**	-0.670***	0.496***	0.011	0.054	0.264*	-0.235
	(-2.31)	(-8.23)	(2.73)	(0.13)	(0.79)	(1.65)	(-1.44)
Marital Status:base -Monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	-0.100***	-0.093***	-0.149**	0.004	-0.068	-0.048	-0.026
	(-2.88)	(-2.58)	(-2.04)	(0.06)	(-1.33)	(-1.17)	(-0.60)
Never Married	-0.195***	-0.461***	-0.255***	0.539***	-0.546***	-0.686***	0.641***
	(-4.99)	(-18.40)	(-4.37)	(10.93)	(-13.25)	(-16.27)	(12.70)
Education Attained:base-None							
Primary	0.028	0.157***	0.341***	0.128**	0.035	-0.029	0.183***
	(0.70)	(4.96)	(4.64)	(2.25)	(0.61)	(-0.54)	(3.55)
Junior High	0.077	0.248***	0.465***	0.205***	-0.005	-0.109*	0.282***
	(1.56)	(6.73)	(5.88)	(3.51)	(-0.09)	(-1.76)	(4.56)
Senior High	0.253***	0.208***	0.387***	0.377***	-0.182***	-0.272***	0.440***
	(4.38)	(5.39)	(4.27)	(6.16)	(-3.02)	(-4.54)	(7.37)
College and above	1.189***	-0.046	0.031	0.868***	-0.733***	-0.974***	1.117***
	(14.05)	(-0.62)	(0.26)	(8.39)	(-8.13)	(-10.03)	(11.12)
Log Head Age	-0.176***	-0.271***	-0.071	-0.150***	0.134**	0.208***	-0.218***
	(-3.99)	(-6.83)	(-0.76)	(-2.60)	(2.34)	(4.15)	(-4.47)
Head Marital Status: base monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	0.044	0.076**	0.042	-0.048	0.057	0.024	-0.007
	(1.11)	(2.13)	(0.55)	(-1.24)	(1.35)	(0.86)	(-0.21)
Never Married	0.051	0.421***	0.078	-0.324**	0.301**	0.428***	-0.345***
	(0.50)	(4.07)	(0.29)	(-2.23)	(2.09)	(4.48)	(-3.12)
Head Education: base-None							
Primary	-0.074**	0.004	0.006	0.018	-0.010	0.001	-0.013
	(-2.33)	(0.12)	(0.07)	(0.42)	(-0.24)	(0.02)	(-0.34)
Junior High	-0.090*	0.001	-0.077	0.088*	-0.095*	-0.081*	0.071
	(-1.77)	(0.02)	(-0.85)	(1.73)	(-1.88)	(-1.73)	(1.44)
Senior High	-0.113**	-0.076*	-0.088	0.057	-0.066	-0.054	-0.007
	(-2.01)	(-1.84)	(-0.88)	(1.09)	(-1.26)	(-1.29)	(-0.16)
College and above	-0.076	-0.057	-0.149	0.203**	-0.238***	-0.261***	0.171**
	(-0.92)	(-0.88)	(-0.94)	(2.35)	(-2.70)	(-3.55)	(2.46)
Log Household Size	0.013	-0.018	-0.084	0.036	-0.049	-0.016	0.000
	(0.44)	(-0.73)	(-1.23)	(1.05)	(-1.42)	(-0.45)	(0.00)
Log Male Children	-0.057***	-0.066***	0.095***	-0.001	0.028	0.017	0.005
	(-2.59)	(-4.41)	(2.63)	(-0.03)	(1.09)	(0.85)	(0.23)
Log Land Owned (Ha)	-0.042***	0.008	0.033***	-0.035***	0.041***	0.034***	-0.031***
	(-8.47)	(1.43)	(2.76)	(-3.71)	(4.30)	(4.53)	(-4.54)
Female Head	0.137***	0.183***	-0.025	-0.050	0.043	0.066*	-0.062
	(4.22)	(5.10)	(-0.28)	(-1.10)	(0.89)	(1.75)	(-1.55)
Log TLUs	-0.159***	-0.010	0.057**	-0.028**	0.038***	0.049***	-0.036**
	(-12.05)	(-1.07)	(2.09)	(-2.03)	(3.08)	(2.80)	(-2.20)
Cell Phone	-0.047**	0.094***	0.001	0.048*	-0.043	-0.061***	0.075***
	(-1.98)	(4.72)	(0.01)	(1.67)	(-1.52)	(-2.65)	(3.17)
Solar/Generator	-0.094***	0.078***	0.042	-0.024	0.031	0.036	-0.044*
	(-4.86)	(3.45)	(0.82)	(-0.82)	(0.99)	(1.32)	(-1.92)
HH Bank Account	0.237***	-0.013	-0.116**	0.054	-0.076**	-0.095***	0.098***
	(8.26)	(-0.52)	(-2.14)	(1.51)	(-2.12)	(-3.15)	(3.57)
House Type							
Cement Floor	-0.067***	-0.004	-0.181***	0.073***	-0.113***	-0.119***	0.094***
	(-2.69)	(-0.15)	(-3.64)	(3.00)	(-4.71)	(-4.56)	(3.30)
Permanent Roof	-0.097***	-0.027	0.014	0.037	-0.030	-0.049*	0.053*
	(-4.36)	(-1.27)	(0.24)	(1.07)	(-0.93)	(-1.67)	(1.86)
Observations	63260	63260	38982	38982	38982	38982	38982

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use three survey waves while the remaining specifications use the latest two waves.

Table A 1.6: Agricultural Productivity and Employment Participation by Gender – First Stage Probit (6–Lags Moving Average)

	Wage/ Salary	Business	Farming	Farming <20 days	Farming >=20 days	Primary Activity - Farm	Primary Activity - Non-Farm
Log Value of Yields per Ha - 6 Year MA	-0.021	-0.160	-0.144	0.120	-0.137	-0.031	0.008
	(-0.11)	(-1.43)	(-0.66)	(0.71)	(-0.74)	(-0.22)	(0.07)
15-24 # Female # Log Value of Yields per Ha - 6 Year MA	0.006	-0.026	0.202*	-0.071	0.116*	0.162**	-0.094
	(0.07)	(-0.38)	(1.88)	(-1.07)	(1.95)	(2.54)	(-1.42)
25-34 # Male # Log Value of Yields per Ha - 6 Year MA	0.107	0.193***	0.000	0.023	-0.035	-0.029	0.042
	(1.24)	(2.94)	(0.00)	(0.21)	(-0.32)	(-0.24)	(0.38)
25-34 # Female # Log Value of Yields per Ha - 6 Year MA	0.109	0.176*	0.219	-0.040	0.080	0.130	-0.052
	(1.27)	(1.75)	(1.21)	(-0.28)	(0.56)	(0.84)	(-0.35)
35-65 # Male # Log Value of Yields per Ha - 6 Year MA	-0.007	0.222***	0.316***	-0.013	0.100	0.053	0.032
	(-0.07)	(3.02)	(2.73)	(-0.15)	(1.17)	(0.53)	(0.35)
35-65 # Female # Log Value of Yields per Ha - 6 Year MA	0.002	0.218**	0.539***	-0.094	0.232*	0.225*	-0.070
	(0.02)	(2.19)	(3.23)	(-0.79)	(1.88)	(1.76)	(-0.56)
25-34	-0.609	-1.265**	-0.202	-0.654	0.633	0.747	-0.909
	(-0.84)	(-2.30)	(-0.16)	(-0.70)	(0.69)	(0.75)	(-0.98)
35-65	0.264	-1.496**	-3.131***	-0.195	-0.740	-0.158	-0.655
	(0.31)	(-2.45)	(-3.22)	(-0.27)	(-1.02)	(-0.19)	(-0.85)
Female	-0.433	-0.058	-1.762*	0.690	-1.074**	-1.414***	0.830
	(-0.56)	(-0.10)	(-1.95)	(1.25)	(-2.17)	(-2.65)	(1.51)
Relation to HH Head (base: Head)							
Spouse	-0.351***	-0.405***	-0.005	-0.204***	0.151**'	0.180***	-0.243***
	(-9.81)	(-11.97)	(-0.06)	(-3.47)	(2.80)	(3.84)	(-4.69)
Child (own/step)	-0.408***	-0.890***	-0.622***	0.213***	-0.405**	-0.218***	0.120**
	(-8.17)	(-22.67)	(-7.23)	(3.99)	(-7.08)	(-4.84)	(2.49)
Relative	-0.593***	-1.072***	-0.589***	0.198***	-0.381**	-0.167***	0.076
	(-11.84)	(-30.68)	(-6.55)	(3.16)	(-5.91)	(-3.38)	(1.43)
Unrelated	-0.223**	-0.673***	0.495***	0.008	0.055	0.266*	-0.237
	(-2.28)	(-8.19)	(2.72)	(0.10)	(0.82)	(1.67)	(-1.44)
Marital Status:base -Monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	-0.100***	-0.091**	-0.149**	0.003	-0.068	-0.049	-0.024
	(-2.89)	(-2.54)	(-2.06)	(0.06)	(-1.33)	(-1.20)	(-0.57)
Never Married	-0.195***	-0.458***	-0.256***	0.539***	-0.546**	-0.687***	0.643***
	(-4.99)	(-18.41)	(-4.39)	(10.90)	(-13.23)	(-16.26)	(12.74)
Education Attained:base-None							
Primary	0.028	0.156***	0.341***	0.128**	0.034	-0.029	0.182***
	(0.71)	(4.93)	(4.63)	(2.26)	(0.61)	(-0.54)	(3.55)
Junior High	0.077	0.246***	0.464***	0.205***	-0.006	-0.109*	0.281***
	(1.56)	(6.73)	(5.87)	(3.52)	(-0.09)	(-1.77)	(4.58)
Senior High	0.254***	0.207***	0.386***	0.377***	-0.182**	-0.272***	0.439***
	(4.39)	(5.38)	(4.26)	(6.16)	(-3.03)	(-4.54)	(7.39)
College and above	1.190***	-0.049	0.029	0.869***	-0.734**	-0.974***	1.116***
	(14.04)	(-0.66)	(0.24)	(8.42)	(-8.17)	(-10.05)	(11.14)
Log Head Age	-0.176***	-0.270***	-0.070	-0.149***	0.134**	0.208***	-0.218***
	(-3.99)	(-6.80)	(-0.76)	(-2.59)	(2.34)	(4.15)	(-4.45)
Head Marital Status: base monogamously married							
Polygamous/Widowed/Divorced/Separated/Cohabit	0.044	0.075**	0.042	-0.048	0.057	0.023	-0.007
	(1.12)	(2.10)	(0.55)	(-1.24)	(1.35)	(0.86)	(-0.22)
Never Married	0.050	0.422***	0.077	-0.324**	0.302**	0.428***	-0.346***
	(0.50)	(4.06)	(0.29)	(-2.23)	(2.09)	(4.47)	(-3.14)
Head Education: base-None							
Primary	-0.075**	0.004	0.006	0.018	-0.010	0.001	-0.013
	(-2.32)	(0.15)	(0.08)	(0.42)	(-0.23)	(0.02)	(-0.33)
Junior High	-0.091*	0.002	-0.077	0.088*	-0.095*	-0.081*	0.071
	(-1.77)	(0.05)	(-0.85)	(1.73)	(-1.88)	(-1.74)	(1.44)
Senior High	-0.113**	-0.075*	-0.087	0.057	-0.066	-0.054	-0.007
	(-2.01)	(-1.83)	(-0.87)	(1.09)	(-1.26)	(-1.29)	(-0.15)
College and above	-0.076	-0.056	-0.148	0.204**	-0.238**	-0.261***	0.171**
	(-0.92)	(-0.86)	(-0.94)	(2.36)	(-2.70)	(-3.54)	(2.46)
Log Household Size	0.013	-0.018	-0.083	0.036	-0.049	-0.016	-0.001
	(0.45)	(-0.72)	(-1.22)	(1.05)	(-1.42)	(-0.45)	(-0.02)
Log Male Children	-0.057***	-0.066***	0.095***	-0.001	0.028	0.017	0.005
	(-2.59)	(-4.40)	(2.62)	(-0.03)	(1.09)	(0.85)	(0.23)
Log Land Owned (Ha)	-0.042***	0.008	0.033***	-0.035***	0.041**'	0.034***	-0.031***
	(-8.44)	(1.43)	(2.77)	(-3.70)	(4.29)	(4.54)	(-4.53)
Female Head	0.137***	0.183***	-0.024	-0.050	0.043	0.066*	-0.062
	(4.23)	(5.05)	(-0.27)	(-1.11)	(0.89)	(1.76)	(-1.55)
Log TLUs	-0.160***	-0.010	0.057**	-0.028**	0.038**'	0.049***	-0.036**
	(-12.10)	(-1.07)	(2.09)	(-2.02)	(3.06)	(2.80)	(-2.19)
Cell Phone	-0.047**	0.094***	0.000	0.048*	-0.043	-0.061***	0.075***
	(-1.96)	(4.71)	(0.00)	(1.68)	(-1.53)	(-2.64)	(3.17)
Solar/Generator	-0.093***	0.078***	0.042	-0.024	0.031	0.036	-0.044*
	(-4.84)	(3.46)	(0.80)	(-0.82)	(0.99)	(1.32)	(-1.92)
HH Bank Account	0.237***	-0.013	-0.115**	0.053	-0.075**	-0.096***	0.098***
	(8.27)	(-0.52)	(-2.11)	(1.49)	(-2.10)	(-3.16)	(3.57)
House Type							
Cement Floor	-0.068***	-0.004	-0.181***	0.073***	-0.114**	-0.119***	0.093***
	(-2.69)	(-0.15)	(-3.63)	(2.99)	(-4.70)	(-4.56)	(3.30)
Permanent Roof	-0.097***	-0.027	0.014	0.037	-0.030	-0.049*	0.053*
	(-4.36)	(-1.25)	(0.25)	(1.07)	(-0.92)	(-1.66)	(1.84)
Observations	63260	63260	38982	38982	38982	38982	38982

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, the first two specifications use three survey waves while the remaining specifications use the latest two waves.

Table A 1.7: Agricultural Productivity and Multiple Employment Participation – First Stage Probit (2–Lags Moving Average)

	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 2 Year MA	0.648**	0.024	-0.236**	-0.103	-0.510**	0.089
	(2.34)	(0.19)	(-2.07)	(-0.64)	(-2.03)	(0.24)
25-34 # Log Value of Yields per Ha - 2 Year MA	-0.202	0.059	0.181**	-0.127	0.320*	0.288
	(-1.30)	(0.80)	(2.01)	(-1.40)	(1.71)	(0.83)
35-65 # Log Value of Yields per Ha - 2 Year MA	-0.565***	0.003	0.281***	-0.116	0.221	0.012
	(-4.24)	(0.04)	(3.15)	(-1.06)	(1.31)	(0.05)
25-34	1.798	-0.924	-1.079	1.336*	-2.343	-2.078
	(1.40)	(-1.51)	(-1.44)	(1.77)	(-1.52)	(-0.72)
35-65	5.108***	-0.530	-1.819**	1.180	-1.574	0.344
	(4.63)	(-0.74)	(-2.47)	(1.32)	(-1.13)	(0.16)
Female	0.025	0.272***	-0.212***	-0.365***	-0.275***	-0.169**
	(0.51)	(10.99)	(-6.52)	(-8.72)	(-4.45)	(-1.99)
Relation to HH Head (base: Head)						
Spouse	0.145*	0.454***	-0.204***	-0.218***	-0.349***	-0.182*
	(1.75)	(13.71)	(-5.03)	(-4.87)	(-5.60)	(-1.66)
Child (own/step)	0.953***	0.706***	-0.766***	-0.174***	-0.491***	-0.193
	(12.36)	(19.12)	(-16.81)	(-2.89)	(-7.06)	(-1.05)
Relative	0.941***	0.863***	-0.946***	-0.343***	-0.609***	-0.413**
	(11.23)	(18.30)	(-19.43)	(-5.28)	(-8.02)	(-2.42)
Unrelated	-0.449*	0.642***	-0.493***	-0.074	-0.251***	-0.130
	(-1.72)	(10.83)	(-6.16)	(-0.95)	(-3.16)	(-0.48)
Marital Status:base -Monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabi	0.101	0.052	-0.016	-0.089**	-0.078	0.097
	(1.21)	(1.39)	(-0.34)	(-2.18)	(-1.34)	(0.72)
Never Married	0.249***	0.205***	-0.389***	-0.134***	-0.331***	0.118
	(3.83)	(7.74)	(-9.62)	(-3.16)	(-3.86)	(0.58)
Education Attained:base-None						
Primary	-0.386***	-0.023	0.138***	-0.054	0.093	-0.007
	(-4.69)	(-0.70)	(3.64)	(-1.13)	(1.30)	(-0.06)
Junior High	-0.516***	-0.047	0.212***	-0.015	0.060	-0.053
	(-5.75)	(-1.28)	(4.68)	(-0.27)	(0.76)	(-0.38)
Senior High	-0.422***	-0.073**	0.135***	0.105*	0.124	-0.011
	(-4.18)	(-1.98)	(2.70)	(1.71)	(1.32)	(-0.06)
College and above	-0.226	-0.510***	-0.487***	0.848***	0.688***	0.623***
	(-1.61)	(-8.12)	(-3.62)	(8.91)	(6.45)	(2.71)
Log Head Age	0.085	0.228***	-0.172***	-0.076	-0.305***	0.009
	(0.90)	(4.80)	(-3.70)	(-1.38)	(-3.09)	(0.06)
Head Marital Status: base monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabi	-0.035	-0.019	-0.012	0.036	0.086	0.007
	(-0.46)	(-0.65)	(-0.29)	(0.76)	(1.24)	(0.05)
Never Married	-0.185	-0.112	0.313***	0.036	0.082	0.228
	(-0.72)	(-1.01)	(3.23)	(0.27)	(0.38)	(0.58)
Head Education: base-None						
Primary	-0.005	-0.001	0.015	-0.004	-0.082	-0.092
	(-0.06)	(-0.03)	(0.36)	(-0.12)	(-1.31)	(-0.63)
Junior High	0.060	-0.017	-0.020	-0.022	0.013	-0.017
	(0.66)	(-0.41)	(-0.41)	(-0.43)	(0.17)	(-0.12)
Senior High	0.079	0.050	-0.082	-0.053	-0.023	-0.011
	(0.86)	(0.96)	(-1.43)	(-0.76)	(-0.24)	(-0.06)
College and above	0.163	-0.036	-0.014	-0.086	-0.004	-0.206
	(1.03)	(-0.46)	(-0.19)	(-0.81)	(-0.04)	(-0.93)
Log Household Size	0.097	0.002	-0.018	0.009	-0.090*	0.039
	(1.42)	(0.06)	(-0.57)	(0.31)	(-1.93)	(0.37)
Log Male Children	-0.102***	0.095***	-0.055**	-0.058**	-0.054*	-0.035
	(-2.77)	(5.17)	(-2.56)	(-2.54)	(-1.74)	(-0.52)
Log Land Owned (Ha)	-0.028**	0.026***	0.018**	-0.040***	-0.020**	-0.033**
	(-2.20)	(4.17)	(2.07)	(-6.40)	(-2.34)	(-2.50)
Female Head	-0.031	-0.135***	0.248***	0.046	0.182***	0.215*
	(-0.34)	(-3.70)	(5.49)	(1.03)	(2.58)	(1.69)
Log TLUs	-0.040	0.078***	0.000	-0.170***	-0.049**	-0.111**
	(-1.52)	(7.10)	(0.04)	(-10.03)	(-2.49)	(-2.50)
Cell Phone	0.001	-0.034	0.107***	-0.083***	-0.018	-0.026
	(0.01)	(-1.37)	(4.43)	(-2.84)	(-0.41)	(-0.32)
Solar/Generator	-0.048	0.001	0.103***	-0.120***	-0.086**	-0.002
	(-0.91)	(0.02)	(4.96)	(-4.22)	(-2.36)	(-0.03)
HH Bank Account	0.064	-0.110***	-0.023	0.167***	0.130**	0.267***
	(1.05)	(-4.44)	(-0.86)	(5.01)	(2.47)	(3.89)
House Type						
Cement Floor	0.189***	-0.016	0.011	-0.051	-0.117**	0.101
	(3.76)	(-0.77)	(0.40)	(-1.64)	(-2.33)	(1.34)
Permanent Roof	-0.016	0.042*	0.024	-0.098***	-0.110***	-0.007
	(-0.29)	(1.85)	(0.83)	(-3.16)	(-2.72)	(-0.07)
Observations	38982	38982	38982	38982	38777	31998

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, we use only the latest two survey waves.

Table A 1.8: Agricultural Productivity and Multiple Employment Participation – First Stage Probit (4–Lags Moving Average)

	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 4 Year MA	0.197	0.082	-0.269**	0.010	-0.167	0.041
	(1.05)	(0.83)	(-2.52)	(0.06)	(-0.60)	(0.08)
25-34 # Log Value of Yields per Ha - 4 Year MA	-0.150	0.070	0.153	-0.124	0.071	0.417
	(-0.97)	(0.94)	(1.59)	(-1.23)	(0.35)	(1.26)
35-65 # Log Value of Yields per Ha - 4 Year MA	-0.479***	-0.004	0.276***	-0.157	-0.027	0.068
	(-3.74)	(-0.04)	(2.80)	(-1.38)	(-0.14)	(0.28)
25-34	1.373	-1.023*	-0.848	1.315	-0.282	-3.186
	(1.06)	(-1.65)	(-1.05)	(1.56)	(-0.17)	(-1.15)
35-65	4.415***	-0.476	-1.791**	1.529	0.482	-0.129
	(4.13)	(-0.67)	(-2.19)	(1.62)	(0.30)	(-0.06)
Female	0.023	0.272***	-0.211***	-0.365***	-0.275***	-0.169**
	(0.48)	(11.00)	(-6.51)	(-8.75)	(-4.44)	(-1.99)
Relation to HH Head (base: Head)						
Spouse	0.148*	0.454***	-0.204***	-0.218***	-0.350***	-0.183*
	(1.79)	(13.75)	(-5.04)	(-4.87)	(-5.60)	(-1.66)
Child (own/step)	0.956***	0.706***	-0.768***	-0.174***	-0.492***	-0.193
	(12.42)	(19.16)	(-16.93)	(-2.87)	(-7.06)	(-1.04)
Relative	0.943***	0.864***	-0.947***	-0.342***	-0.607***	-0.414**
	(11.25)	(18.33)	(-19.50)	(-5.26)	(-8.09)	(-2.41)
Unrelated	-0.465*	0.641***	-0.491***	-0.066	-0.239***	-0.129
	(-1.73)	(10.78)	(-6.15)	(-0.85)	(-2.80)	(-0.48)
Marital Status:base -Monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabi	0.102	0.052	-0.016	-0.091**	-0.084	0.098
	(1.22)	(1.39)	(-0.33)	(-2.25)	(-1.46)	(0.73)
Never Married	0.251***	0.204***	-0.385***	-0.135***	-0.336***	0.118
	(3.85)	(7.66)	(-9.53)	(-3.17)	(-3.96)	(0.58)
Education Attained:base-None						
Primary	-0.389***	-0.023	0.139***	-0.053	0.099	-0.008
	(-4.79)	(-0.71)	(3.63)	(-1.11)	(1.39)	(-0.06)
Junior High	-0.521***	-0.047	0.213***	-0.015	0.065	-0.052
	(-5.87)	(-1.28)	(4.67)	(-0.26)	(0.82)	(-0.37)
Senior High	-0.426***	-0.073**	0.135***	0.106*	0.130	-0.011
	(-4.27)	(-1.98)	(2.70)	(1.73)	(1.40)	(-0.07)
College and above	-0.230	-0.510***	-0.485***	0.850***	0.692***	0.626***
	(-1.64)	(-8.12)	(-3.61)	(8.92)	(6.53)	(2.74)
Log Head Age	0.085	0.229***	-0.171***	-0.076	-0.305***	0.009
	(0.90)	(4.80)	(-3.68)	(-1.39)	(-3.09)	(0.06)
Head Marital Status: base monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabi	-0.041	-0.019	-0.013	0.040	0.094	0.006
	(-0.53)	(-0.68)	(-0.30)	(0.84)	(1.38)	(0.05)
Never Married	-0.196	-0.110	0.311***	0.036	0.089	0.228
	(-0.76)	(-1.00)	(3.20)	(0.26)	(0.41)	(0.58)
Head Education: base-None						
Primary	-0.006	-0.001	0.015	-0.005	-0.085	-0.091
	(-0.08)	(-0.03)	(0.37)	(-0.13)	(-1.36)	(-0.62)
Junior High	0.062	-0.017	-0.020	-0.021	0.011	-0.017
	(0.69)	(-0.41)	(-0.41)	(-0.42)	(0.16)	(-0.11)
Senior High	0.080	0.051	-0.083	-0.053	-0.025	-0.010
	(0.88)	(0.97)	(-1.45)	(-0.76)	(-0.27)	(-0.05)
College and above	0.168	-0.036	-0.014	-0.087	-0.005	-0.209
	(1.07)	(-0.46)	(-0.20)	(-0.82)	(-0.06)	(-0.94)
Log Household Size	0.096	0.002	-0.018	0.009	-0.091*	0.040
	(1.40)	(0.08)	(-0.58)	(0.29)	(-1.95)	(0.38)
Log Male Children	-0.102***	0.095***	-0.055**	-0.058**	-0.054*	-0.035
	(-2.75)	(5.17)	(-2.53)	(-2.55)	(-1.74)	(-0.54)
Log Land Owned (Ha)	-0.028**	0.026***	0.018**	-0.040***	-0.020**	-0.033**
	(-2.19)	(4.17)	(2.07)	(-6.41)	(-2.35)	(-2.50)
Female Head	-0.025	-0.135***	0.248***	0.045	0.177**	0.216*
	(-0.27)	(-3.70)	(5.49)	(0.99)	(2.54)	(1.70)
Log TLUs	-0.039	0.078***	0.001	-0.170***	-0.048**	-0.111**
	(-1.49)	(7.04)	(0.08)	(-10.03)	(-2.42)	(-2.51)
Cell Phone	0.002	-0.035	0.108***	-0.082***	-0.018	-0.028
	(0.04)	(-1.40)	(4.44)	(-2.85)	(-0.42)	(-0.34)
Solar/Generator	-0.047	0.000	0.104***	-0.120***	-0.085**	-0.002
	(-0.89)	(0.01)	(4.95)	(-4.21)	(-2.33)	(-0.03)
HH Bank Account	0.060	-0.109***	-0.023	0.167***	0.130**	0.268***
	(0.98)	(-4.40)	(-0.86)	(5.02)	(2.47)	(3.84)
House Type						
Cement Floor	0.189***	-0.015	0.010	-0.052*	-0.119**	0.102
	(3.78)	(-0.74)	(0.38)	(-1.66)	(-2.37)	(1.36)
Permanent Roof	-0.015	0.042*	0.024	-0.098***	-0.108***	-0.007
	(-0.28)	(1.86)	(0.82)	(-3.15)	(-2.68)	(-0.08)
Observations	38982	38982	38982	38982	38777	31998

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, we use only the latest two survey waves.

Table A 1.9: Agricultural Productivity and Multiple Employment Participation – First Stage Probit (6–Lags Moving Average)

	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 6 Year MA	0.123	0.169	-0.354***	0.028	-0.176	-0.318
	(0.55)	(1.40)	(-2.99)	(0.14)	(-0.61)	(-0.52)
25-34 # Log Value of Yields per Ha - 6 Year MA	-0.114	0.063	0.155	-0.140	0.077	0.565*
	(-0.68)	(0.77)	(1.55)	(-1.31)	(0.39)	(1.65)
35-65 # Log Value of Yields per Ha - 6 Year MA	-0.469***	-0.057	0.328***	-0.170	-0.031	0.094
	(-3.42)	(-0.64)	(3.30)	(-1.39)	(-0.16)	(0.37)
25-34	1.071	-0.967	-0.867	1.451	-0.339	-4.453
	(0.75)	(-1.41)	(-1.04)	(1.62)	(-0.20)	(-1.54)
35-65	4.344***	-0.029	-2.229***	1.633	0.512	-0.356
	(3.77)	(-0.04)	(-2.70)	(1.61)	(0.32)	(-0.16)
Female	0.024	0.271***	-0.211***	-0.365***	-0.275***	-0.169**
	(0.49)	(11.01)	(-6.51)	(-8.75)	(-4.44)	(-2.00)
Relation to HH Head (base: Head)						
Spouse	0.148*	0.454***	-0.205***	-0.218***	-0.351***	-0.183*
	(1.80)	(13.75)	(-5.04)	(-4.87)	(-5.60)	(-1.66)
Child (own/step)	0.958***	0.706***	-0.768***	-0.173***	-0.493***	-0.198
	(12.48)	(19.17)	(-16.92)	(-2.87)	(-7.08)	(-1.06)
Relative	0.945***	0.864***	-0.947***	-0.342***	-0.608***	-0.418**
	(11.31)	(18.34)	(-19.50)	(-5.25)	(-8.10)	(-2.42)
Unrelated	-0.466*	0.638***	-0.490***	-0.066	-0.236***	-0.125
	(-1.74)	(10.66)	(-6.12)	(-0.85)	(-2.72)	(-0.46)
Marital Status:base -Monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabi	0.102	0.050	-0.013	-0.092**	-0.084	0.096
	(1.23)	(1.33)	(-0.28)	(-2.27)	(-1.45)	(0.72)
Never Married	0.251***	0.201***	-0.382***	-0.135***	-0.336***	0.118
	(3.85)	(7.60)	(-9.46)	(-3.17)	(-3.97)	(0.58)
Education Attained:base-None						
Primary	-0.388***	-0.022	0.137***	-0.052	0.099	-0.008
	(-4.76)	(-0.68)	(3.60)	(-1.10)	(1.40)	(-0.06)
Junior High	-0.520***	-0.046	0.212***	-0.014	0.065	-0.051
	(-5.85)	(-1.27)	(4.66)	(-0.26)	(0.83)	(-0.36)
Senior High	-0.425***	-0.073**	0.135***	0.106*	0.131	-0.011
	(-4.25)	(-1.97)	(2.69)	(1.73)	(1.40)	(-0.06)
College and above	-0.228	-0.509***	-0.487***	0.850***	0.692***	0.632***
	(-1.63)	(-8.10)	(-3.62)	(8.92)	(6.53)	(2.76)
Log Head Age	0.085	0.229***	-0.171***	-0.076	-0.305***	0.009
	(0.90)	(4.80)	(-3.68)	(-1.39)	(-3.10)	(0.06)
Head Marital Status: base monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabi	-0.041	-0.018	-0.014	0.040	0.095	0.009
	(-0.53)	(-0.62)	(-0.35)	(0.85)	(1.37)	(0.07)
Never Married	-0.195	-0.108	0.309***	0.036	0.088	0.233
	(-0.76)	(-0.98)	(3.17)	(0.27)	(0.41)	(0.59)
Head Education: base-None						
Primary	-0.007	-0.001	0.015	-0.005	-0.085	-0.091
	(-0.09)	(-0.04)	(0.38)	(-0.13)	(-1.36)	(-0.62)
Junior High	0.062	-0.018	-0.020	-0.022	0.011	-0.016
	(0.68)	(-0.42)	(-0.40)	(-0.43)	(0.15)	(-0.11)
Senior High	0.078	0.051	-0.083	-0.053	-0.025	-0.010
	(0.86)	(0.97)	(-1.45)	(-0.77)	(-0.27)	(-0.05)
College and above	0.168	-0.036	-0.015	-0.087	-0.006	-0.210
	(1.07)	(-0.46)	(-0.20)	(-0.83)	(-0.07)	(-0.95)
Log Household Size	0.095	0.003	-0.019	0.009	-0.091*	0.040
	(1.40)	(0.09)	(-0.59)	(0.29)	(-1.95)	(0.38)
Log Male Children	-0.102***	0.095***	-0.055**	-0.058**	-0.054*	-0.035
	(-2.75)	(5.17)	(-2.52)	(-2.55)	(-1.75)	(-0.53)
Log Land Owned (Ha)	-0.028**	0.026***	0.018**	-0.040***	-0.020**	-0.032**
	(-2.19)	(4.17)	(2.07)	(-6.41)	(-2.35)	(-2.48)
Female Head	-0.025	-0.135***	0.248***	0.045	0.177**	0.215*
	(-0.27)	(-3.71)	(5.49)	(0.99)	(2.54)	(1.69)
Log TLUs	-0.039	0.078***	0.001	-0.170***	-0.048**	-0.112**
	(-1.48)	(7.04)	(0.08)	(-10.04)	(-2.43)	(-2.56)
Cell Phone	0.003	-0.035	0.108***	-0.083***	-0.018	-0.028
	(0.05)	(-1.41)	(4.44)	(-2.87)	(-0.43)	(-0.34)
Solar/Generator	-0.046	0.000	0.104***	-0.120***	-0.086**	-0.001
	(-0.88)	(0.00)	(4.96)	(-4.21)	(-2.34)	(-0.01)
HH Bank Account	0.059	-0.110***	-0.023	0.168***	0.131**	0.267***
	(0.96)	(-4.41)	(-0.84)	(5.04)	(2.49)	(3.91)
House Type						
Cement Floor	0.189***	-0.015	0.010	-0.051*	-0.119**	0.102
	(3.78)	(-0.73)	(0.37)	(-1.65)	(-2.36)	(1.35)
Permanent Roof	-0.016	0.042*	0.024	-0.098***	-0.109***	-0.007
	(-0.29)	(1.87)	(0.81)	(-3.15)	(-2.68)	(-0.07)
Observations	38982	38982	38982	38982	38777	31998

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, we use only the latest two survey waves.

Table A 1.10: Agricultural Productivity and Multiple Employment Participation by Gender – First Stage Probit (2–Lags Moving Average)

	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 2 Year MA	0.732**	0.044	-0.244**	-0.129	-0.488*	0.131
	(2.56)	(0.35)	(-2.05)	(-0.84)	(-1.93)	(0.34)
15-24 # Female # Log Value of Yields per Ha - 2 Year MA	-0.200**	-0.060	0.058	0.072	-0.033	-0.121
	(-2.19)	(-1.32)	(0.90)	(0.80)	(-0.32)	(-0.68)
25-34 # Male # Log Value of Yields per Ha - 2 Year MA	-0.198	0.065	0.148*	-0.126	0.296	0.301
	(-1.29)	(0.88)	(1.65)	(-1.33)	(1.58)	(0.88)
25-34 # Female # Log Value of Yields per Ha - 2 Year MA	-0.418**	0.011	0.224**	-0.061	0.301	0.173
	(-2.34)	(0.13)	(2.02)	(-0.69)	(1.46)	(0.47)
35-65 # Male # Log Value of Yields per Ha - 2 Year MA	-0.536***	0.013	0.247***	-0.110	0.193	0.020
	(-4.03)	(0.16)	(2.72)	(-1.00)	(1.16)	(0.08)
35-65 # Female # Log Value of Yields per Ha - 2 Year MA	-0.762***	-0.052	0.333***	-0.051	0.209	-0.114
	(-4.73)	(-0.57)	(2.95)	(-0.50)	(1.02)	(-0.38)
25-34	1.836	-0.996	-0.871	1.349*	-2.253	-2.175
	(1.42)	(-1.63)	(-1.17)	(1.72)	(-1.46)	(-0.76)
35-65	4.958***	-0.586	-1.648**	1.173	-1.486	0.315
	(4.54)	(-0.82)	(-2.22)	(1.30)	(-1.09)	(0.15)
Female	1.755**	0.773**	-0.810	-0.922	-0.255	0.897
	(2.29)	(2.05)	(-1.50)	(-1.24)	(-0.30)	(0.60)
Relation to HH Head (base: Head)						
Spouse	0.266**	0.471***	-0.286***	-0.173***	-0.456***	-0.142
	(2.47)	(11.77)	(-5.99)	(-3.51)	(-6.54)	(-1.12)
Child (own/step)	0.987***	0.720***	-0.791***	-0.166***	-0.501***	-0.190
	(11.67)	(19.24)	(-17.64)	(-2.75)	(-7.08)	(-1.04)
Relative	0.970***	0.875***	-0.965***	-0.335***	-0.613***	-0.414**
	(11.00)	(17.66)	(-19.83)	(-5.10)	(-8.15)	(-2.46)
Unrelated	-0.397	0.644***	-0.540***	-0.036	-0.314***	-0.130
	(-1.56)	(9.74)	(-6.63)	(-0.45)	(-3.75)	(-0.46)
Marital Status:base -Monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabit	0.143*	0.058	-0.054	-0.068	-0.142**	0.121
	(1.65)	(1.54)	(-1.14)	(-1.52)	(-2.31)	(0.83)
Never Married	0.260***	0.210***	-0.421***	-0.122***	-0.379***	0.129
	(3.97)	(7.57)	(-10.15)	(-2.76)	(-4.39)	(0.63)
Education Attained:base-None						
Primary	-0.392***	-0.025	0.143***	-0.057	0.103	-0.009
	(-4.74)	(-0.75)	(3.77)	(-1.20)	(1.44)	(-0.07)
Junior High	-0.525***	-0.049	0.221***	-0.020	0.078	-0.058
	(-5.79)	(-1.35)	(4.93)	(-0.36)	(0.96)	(-0.41)
Senior High	-0.435***	-0.075**	0.147***	0.100	0.144	-0.018
	(-4.25)	(-2.02)	(2.99)	(1.62)	(1.53)	(-0.11)
College and above	-0.240*	-0.515***	-0.468***	0.843***	0.713***	0.615***
	(-1.69)	(-8.23)	(-3.48)	(8.92)	(6.59)	(2.66)
Log Head Age	0.095	0.229***	-0.183***	-0.067	-0.328***	0.019
	(1.00)	(4.84)	(-3.93)	(-1.28)	(-3.32)	(0.12)
Head Marital Status: base monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabit	-0.046	-0.022	0.013	0.024	0.131*	-0.006
	(-0.61)	(-0.72)	(0.31)	(0.49)	(1.83)	(-0.04)
Never Married	-0.189	-0.112	0.328***	0.032	0.110	0.226
	(-0.74)	(-1.01)	(3.35)	(0.24)	(0.50)	(0.58)
Head Education: base-None						
Primary	-0.006	-0.000	0.012	-0.003	-0.088	-0.091
	(-0.07)	(-0.01)	(0.30)	(-0.08)	(-1.41)	(-0.63)
Junior High	0.059	-0.016	-0.024	-0.020	0.003	-0.014
	(0.66)	(-0.39)	(-0.49)	(-0.40)	(0.04)	(-0.10)
Senior High	0.079	0.052	-0.089	-0.050	-0.036	-0.006
	(0.86)	(1.00)	(-1.55)	(-0.73)	(-0.39)	(-0.03)
College and above	0.163	-0.034	-0.022	-0.085	-0.019	-0.201
	(1.03)	(-0.43)	(-0.30)	(-0.80)	(-0.21)	(-0.91)
Log Household Size	0.101	-0.000	-0.014	0.008	-0.085*	0.036
	(1.47)	(-0.02)	(-0.46)	(0.26)	(-1.82)	(0.35)
Log Male Children	-0.102***	0.094***	-0.058***	-0.056**	-0.059*	-0.033
	(-2.77)	(5.23)	(-2.65)	(-2.52)	(-1.88)	(-0.49)
Log Land Owned (Ha)	-0.029**	0.025***	0.018**	-0.040***	-0.020**	-0.033**
	(-2.24)	(4.15)	(2.10)	(-6.40)	(-2.28)	(-2.48)
Female Head	-0.012	-0.126***	0.196***	0.069	0.100	0.238*
	(-0.13)	(-3.42)	(3.96)	(1.52)	(1.21)	(1.81)
Log TLUs	-0.040	0.079***	-0.000	-0.170***	-0.050**	-0.110**
	(-1.51)	(7.10)	(-0.03)	(-9.99)	(-2.55)	(-2.48)
Cell Phone	0.000	-0.034	0.107***	-0.082***	-0.019	-0.025
	(0.01)	(-1.37)	(4.42)	(-2.84)	(-0.43)	(-0.31)
Solar/Generator	-0.048	0.000	0.104***	-0.120***	-0.085**	-0.003
	(-0.92)	(0.02)	(4.98)	(-4.20)	(-2.33)	(-0.05)
HH Bank Account	0.065	-0.110***	-0.023	0.167***	0.131**	0.269***
	(1.06)	(-4.47)	(-0.86)	(5.00)	(2.51)	(3.90)
House Type						
Cement Floor	0.192***	-0.016	0.011	-0.051	-0.118**	0.100
	(3.81)	(-0.78)	(0.38)	(-1.63)	(-2.33)	(1.33)
Permanent Roof	-0.015	0.042*	0.024	-0.098***	-0.110***	-0.007
	(-0.27)	(1.83)	(0.82)	(-3.16)	(-2.72)	(-0.07)
Observations	38982	38982	38982	38982	38777	31998

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, we use only the latest two survey waves.

Table A 1.11: Agricultural Productivity and Multiple Employment Participation by Gender – First Stage Probit (4–Lags Moving Average)

	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 4 Year MA	0.293	0.089	-0.260**	-0.022	-0.145	0.051
	(1.51)	(0.84)	(-2.24)	(-0.14)	(-0.52)	(0.10)
15-24 # Female # Log Value of Yields per Ha - 4 Year MA	-0.236**	-0.020	0.009	0.088	-0.044	-0.031
	(-2.50)	(-0.34)	(0.12)	(0.91)	(-0.40)	(-0.17)
25-34 # Male # Log Value of Yields per Ha - 4 Year MA	-0.147	0.070	0.130	-0.125	0.049	0.423
	(-0.95)	(0.95)	(1.37)	(-1.18)	(0.25)	(1.28)
25-34 # Female # Log Value of Yields per Ha - 4 Year MA	-0.402**	0.057	0.157	-0.042	0.044	0.385
	(-2.23)	(0.59)	(1.26)	(-0.44)	(0.19)	(1.06)
35-65 # Male # Log Value of Yields per Ha - 4 Year MA	-0.450***	0.002	0.249**	-0.152	-0.053	0.075
	(-3.53)	(0.02)	(2.52)	(-1.32)	(-0.29)	(0.31)
35-65 # Female # Log Value of Yields per Ha - 4 Year MA	-0.712***	-0.023	0.285**	-0.076	-0.048	0.033
	(-4.41)	(-0.22)	(2.19)	(-0.68)	(-0.20)	(0.11)
25-34	1.409	-1.049*	-0.723	1.342	-0.217	-3.218
	(1.08)	(-1.71)	(-0.91)	(1.53)	(-0.13)	(-1.16)
35-65	4.261***	-0.493	-1.675**	1.526	0.553	-0.157
	(4.04)	(-0.69)	(-2.07)	(1.61)	(0.36)	(-0.08)
Female	2.064***	0.440	-0.405	-1.062	-0.160	0.140
	(2.61)	(0.87)	(-0.64)	(-1.31)	(-0.17)	(0.09)
Relation to HH Head (base: Head)						
Spouse	0.273**	0.470***	-0.285***	-0.174***	-0.459***	-0.147
	(2.54)	(11.75)	(-5.96)	(-3.53)	(-6.55)	(-1.16)
Child (own/step)	0.989***	0.719***	-0.792***	-0.165***	-0.502***	-0.193
	(11.71)	(19.30)	(-17.79)	(-2.74)	(-7.06)	(-1.05)
Relative	0.972***	0.875***	-0.965***	-0.335***	-0.611***	-0.416**
	(11.00)	(17.67)	(-19.86)	(-5.08)	(-8.23)	(-2.46)
Unrelated	-0.417	0.647***	-0.543***	-0.026	-0.308***	-0.120
	(-1.59)	(9.81)	(-6.59)	(-0.32)	(-3.43)	(-0.42)
Marital Status:base -Monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabit	0.146*	0.058	-0.053	-0.070	-0.151**	0.120
	(1.68)	(1.53)	(-1.11)	(-1.57)	(-2.46)	(0.82)
Never Married	0.262***	0.209***	-0.416***	-0.123***	-0.387***	0.129
	(4.00)	(7.46)	(-10.07)	(-2.78)	(-4.50)	(0.63)
Education Attained:base-None						
Primary	-0.395***	-0.025	0.144***	-0.056	0.109	-0.010
	(-4.87)	(-0.76)	(3.77)	(-1.18)	(1.53)	(-0.08)
Junior High	-0.530***	-0.049	0.222***	-0.019	0.082	-0.057
	(-5.94)	(-1.35)	(4.91)	(-0.35)	(1.02)	(-0.40)
Senior High	-0.440***	-0.075**	0.148***	0.101*	0.150	-0.018
	(-4.35)	(-2.02)	(2.98)	(1.66)	(1.59)	(-0.11)
College and above	-0.246*	-0.514***	-0.468***	0.846***	0.717***	0.618***
	(-1.74)	(-8.22)	(-3.49)	(8.99)	(6.65)	(2.69)
Log Head Age	0.096	0.230***	-0.183***	-0.068	-0.328***	0.019
	(1.00)	(4.84)	(-3.90)	(-1.28)	(-3.33)	(0.12)
Head Marital Status: base monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabit	-0.051	-0.023	0.013	0.028	0.142**	-0.007
	(-0.67)	(-0.74)	(0.30)	(0.57)	(2.01)	(-0.05)
Never Married	-0.200	-0.111	0.327***	0.031	0.118	0.224
	(-0.78)	(-1.00)	(3.34)	(0.23)	(0.54)	(0.57)
Head Education: base-None						
Primary	-0.006	-0.000	0.012	-0.004	-0.091	-0.090
	(-0.08)	(-0.01)	(0.30)	(-0.11)	(-1.45)	(-0.62)
Junior High	0.061	-0.016	-0.024	-0.020	0.002	-0.015
	(0.68)	(-0.39)	(-0.49)	(-0.40)	(0.03)	(-0.10)
Senior High	0.079	0.052	-0.089	-0.051	-0.038	-0.007
	(0.88)	(1.00)	(-1.55)	(-0.74)	(-0.41)	(-0.03)
College and above	0.169	-0.034	-0.022	-0.087	-0.019	-0.205
	(1.08)	(-0.43)	(-0.30)	(-0.82)	(-0.21)	(-0.93)
Log Household Size	0.100	0.000	-0.015	0.007	-0.086*	0.038
	(1.46)	(0.01)	(-0.48)	(0.24)	(-1.84)	(0.37)
Log Male Children	-0.102***	0.094***	-0.057***	-0.056**	-0.059*	-0.034
	(-2.75)	(5.23)	(-2.63)	(-2.53)	(-1.88)	(-0.51)
Log Land Owned (Ha)	-0.029**	0.025***	0.018**	-0.040***	-0.020**	-0.033**
	(-2.22)	(4.15)	(2.10)	(-6.41)	(-2.29)	(-2.49)
Female Head	-0.006	-0.126***	0.197***	0.067	0.094	0.238*
	(-0.06)	(-3.42)	(3.96)	(1.47)	(1.14)	(1.81)
Log TLUs	-0.039	0.078***	0.000	-0.170***	-0.049**	-0.111**
	(-1.48)	(7.02)	(0.02)	(-10.02)	(-2.46)	(-2.50)
Cell Phone	0.002	-0.035	0.108***	-0.082***	-0.019	-0.027
	(0.03)	(-1.40)	(4.42)	(-2.85)	(-0.44)	(-0.33)
Solar/Generator	-0.047	0.000	0.104***	-0.120***	-0.085**	-0.003
	(-0.90)	(0.00)	(4.98)	(-4.20)	(-2.30)	(-0.04)
HH Bank Account	0.062	-0.110***	-0.023	0.167***	0.131**	0.269***
	(1.00)	(-4.42)	(-0.87)	(5.01)	(2.52)	(3.84)
House Type						
Cement Floor	0.192***	-0.015	0.010	-0.052*	-0.120**	0.102
	(3.83)	(-0.75)	(0.36)	(-1.66)	(-2.37)	(1.35)
Permanent Roof	-0.015	0.042*	0.023	-0.098***	-0.109***	-0.007
	(-0.27)	(1.85)	(0.81)	(-3.15)	(-2.69)	(-0.07)
Observations	38982	38982	38982	38982	38777	31998

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, we use only the latest two survey waves.

Table A 1.12: Agricultural Productivity and Multiple Employment Participation by Gender – First Stage Probit (6–Lags Moving Average)

	None	Farm only	Farm & Business	Farm & Wage/Salary	Farm, Business, & Wage/Salary	Business or Wage
Log Value of Yields per Ha - 6 Year MA	0.219	0.181	-0.348***	-0.007	-0.157	-0.319
	(0.96)	(1.39)	(-2.75)	(-0.04)	(-0.53)	(-0.52)
15-24 # Female # Log Value of Yields per Ha - 6 Year MA	-0.232**	-0.033	0.025	0.095	-0.021	-0.003
	(-2.15)	(-0.49)	(0.30)	(0.87)	(-0.18)	(-0.01)
25-34 # Male # Log Value of Yields per Ha - 6 Year MA	-0.109	0.065	0.129	-0.141	0.051	0.570*
	(-0.65)	(0.79)	(1.30)	(-1.26)	(0.26)	(1.65)
25-34 # Female # Log Value of Yields per Ha - 6 Year MA	-0.359*	0.039	0.171	-0.052	0.068	0.560
	(-1.90)	(0.36)	(1.33)	(-0.51)	(0.29)	(1.46)
35-65 # Male # Log Value of Yields per Ha - 6 Year MA	-0.438***	-0.050	0.298***	-0.164	-0.063	0.103
	(-3.20)	(-0.56)	(2.94)	(-1.32)	(-0.34)	(0.40)
35-65 # Female # Log Value of Yields per Ha - 6 Year MA	-0.695***	-0.087	0.349***	-0.081	-0.035	0.088
	(-3.92)	(-0.81)	(2.68)	(-0.64)	(-0.14)	(0.28)
25-34	1.084	-1.003	-0.716	1.479	-0.232	-4.472
	(0.76)	(-1.48)	(-0.86)	(1.58)	(-0.14)	(-1.55)
35-65	4.172***	-0.060	-2.085**	1.626	0.632	-0.392
	(3.66)	(-0.08)	(-2.50)	(1.59)	(0.41)	(-0.18)
Female	2.026**	0.546	-0.534	-1.120	-0.352	-0.097
	(2.25)	(0.98)	(-0.77)	(-1.21)	(-0.36)	(-0.06)
Relation to HH Head (base: Head)						
Spouse	0.271**	0.470***	-0.285***	-0.174***	-0.460***	-0.148
	(2.52)	(11.74)	(-5.95)	(-3.53)	(-6.55)	(-1.17)
Child (own/step)	0.991***	0.719***	-0.791***	-0.164***	-0.503***	-0.198
	(11.76)	(19.32)	(-17.78)	(-2.73)	(-7.07)	(-1.07)
Relative	0.973***	0.875***	-0.965***	-0.334***	-0.612***	-0.420**
	(11.04)	(17.68)	(-19.83)	(-5.07)	(-8.23)	(-2.47)
Unrelated	-0.421	0.642***	-0.539***	-0.024	-0.300***	-0.112
	(-1.62)	(9.72)	(-6.53)	(-0.30)	(-3.26)	(-0.39)
Marital Status:base -Monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabit	0.146*	0.055	-0.050	-0.071	-0.151**	0.119
	(1.68)	(1.46)	(-1.05)	(-1.59)	(-2.46)	(0.81)
Never Married	0.263***	0.206***	-0.413***	-0.124***	-0.387***	0.130
	(4.00)	(7.39)	(-9.99)	(-2.78)	(-4.51)	(0.63)
Education Attained:base-None						
Primary	-0.394***	-0.024	0.143***	-0.056	0.109	-0.010
	(-4.83)	(-0.73)	(3.74)	(-1.17)	(1.54)	(-0.08)
Junior High	-0.528***	-0.049	0.222***	-0.019	0.082	-0.056
	(-5.91)	(-1.33)	(4.90)	(-0.34)	(1.03)	(-0.39)
Senior High	-0.438***	-0.075**	0.147***	0.102*	0.150	-0.017
	(-4.32)	(-2.01)	(2.98)	(1.67)	(1.60)	(-0.10)
College and above	-0.243*	-0.513***	-0.469***	0.846***	0.717***	0.625***
	(-1.72)	(-8.20)	(-3.49)	(9.00)	(6.67)	(2.72)
Log Head Age	0.095	0.230***	-0.182***	-0.068	-0.328***	0.019
	(1.00)	(4.83)	(-3.90)	(-1.29)	(-3.34)	(0.12)
Head Marital Status: base monogamously married						
Polygamous/Widowed/Divorced/Separated/Cohabit	-0.051	-0.020	0.011	0.028	0.141**	-0.004
	(-0.67)	(-0.68)	(0.25)	(0.57)	(2.00)	(-0.03)
Never Married	-0.198	-0.109	0.324***	0.032	0.117	0.228
	(-0.77)	(-0.98)	(3.30)	(0.23)	(0.54)	(0.58)
Head Education: base-None						
Primary	-0.007	-0.001	0.013	-0.004	-0.091	-0.090
	(-0.09)	(-0.02)	(0.31)	(-0.11)	(-1.45)	(-0.61)
Junior High	0.061	-0.017	-0.024	-0.020	0.001	-0.015
	(0.68)	(-0.39)	(-0.49)	(-0.41)	(0.02)	(-0.10)
Senior High	0.078	0.052	-0.089	-0.051	-0.039	-0.007
	(0.86)	(1.00)	(-1.55)	(-0.75)	(-0.41)	(-0.03)
College and above	0.168	-0.034	-0.022	-0.087	-0.021	-0.206
	(1.07)	(-0.43)	(-0.30)	(-0.82)	(-0.23)	(-0.93)
Log Household Size	0.100	0.001	-0.016	0.007	-0.086*	0.038
	(1.46)	(0.02)	(-0.49)	(0.24)	(-1.84)	(0.36)
Log Male Children	-0.102***	0.094***	-0.057***	-0.056**	-0.059*	-0.034
	(-2.74)	(5.23)	(-2.62)	(-2.53)	(-1.88)	(-0.50)
Log Land Owned (Ha)	-0.029**	0.025***	0.018**	-0.040***	-0.020**	-0.032**
	(-2.24)	(4.16)	(2.11)	(-6.41)	(-2.29)	(-2.47)
Female Head	-0.007	-0.127***	0.198***	0.067	0.094	0.237*
	(-0.07)	(-3.44)	(3.98)	(1.47)	(1.15)	(1.79)
Log TLUs	-0.039	0.078***	0.000	-0.170***	-0.049**	-0.112**
	(-1.47)	(7.02)	(0.02)	(-10.03)	(-2.48)	(-2.55)
Cell Phone	0.002	-0.035	0.108***	-0.082***	-0.019	-0.028
	(0.04)	(-1.41)	(4.43)	(-2.86)	(-0.45)	(-0.34)
Solar/Generator	-0.046	-0.000	0.104***	-0.120***	-0.085**	-0.002
	(-0.89)	(-0.00)	(4.98)	(-4.20)	(-2.31)	(-0.03)
HH Bank Account	0.061	-0.110***	-0.023	0.168***	0.132**	0.268***
	(0.98)	(-4.42)	(-0.85)	(5.02)	(2.53)	(3.91)
House Type						
Cement Floor	0.192***	-0.015	0.010	-0.051*	-0.120**	0.102
	(3.82)	(-0.74)	(0.34)	(-1.65)	(-2.36)	(1.35)
Permanent Roof	-0.016	0.042*	0.023	-0.098***	-0.109***	-0.007
	(-0.28)	(1.85)	(0.81)	(-3.15)	(-2.69)	(-0.07)
Observations	38982	38982	38982	38982	38777	31998

T–Statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes survey wave and district fixed effects. Errors are clustered at the district level (72 districts). Due to data limitation, we use only the latest two survey waves.

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Chapter 2 :

Does Agricultural Productivity Translate to Increased Human Capital Investment? Impacts of Productivity Shocks on Education Expenses and School Outcomes in Tanzania

I. INTRODUCTION

The World Bank data indicate that agriculture remains a major source of livelihood in Tanzania and a number of countries in Sub–Saharan Africa (World Bank, 2020). In Tanzania, the World Bank estimates that in 2013 agriculture contributed 27% of value added to the GDP and accounted for 69% of employment. While agriculture continues to play an important role, high population growth rate and a bulging youth population imply that agriculture alone will not be sufficient to meet the future needs of the continent. Countries that have successfully developed have done so, in part, through increased productivity and investment in human capital. Consequently, this paper investigates the impact of agricultural productivity shocks on investments in human capital and school outcomes.

Rural households in Sub–Saharan Africa are highly dependent on agriculture and thus any expenditure decisions are highly tied to agricultural income. In this paper, I investigate whether positive productivity shocks, at the household level, lead to increased expenditure on education and study time. Unlike in the previous chapter where we focused on productivity at the district level, in this chapter we focus on productivity at the household level. Agriculture can affect outcomes through two major channels. First, increased productivity relaxes financial constraints facing the household. Assuming that education is a normal good, higher productivity can induce increased schooling expenditures on items such as fees, uniforms, books, among others. Second, child labor is very common among developing countries. Increased productivity can have a number of countervailing effects on school attendance, progression, and study times. If increased farm productivity creates a demand within the household for additional farm labor, the demand for child labor could increase, leading to absenteeism, withdrawal, and even drop outs (Beegle et al., 2006; Dureya and Arends–Kuenning, 2003; Kruger, 2007). On the other hand, increased farm

productivity might entail the adoption of new labor–saving technologies such as mechanization, hence freeing up child labor and encouraging school attendance. In addition, higher incomes resulting from gains in farm productivity could enable households to hire labor to substitute for child family labor and encourage school attendance. The net impact of changes in agricultural productivity on child labor, and school expenditure, is thus an empirical question. Few related studies on these issues have access to high quality nationally representative data. Finally, this paper looks at the role of gender of students in outcomes and on whether productivity shocks have differential impacts depending on the gender of the household head. Specifically, are boys and girls affected differently? Are the results different when female–headed households experience productivity shocks than when male–headed households experience similar shocks? This is in the spirit of the literature that has found gender to be important in affecting household decisions (Duflo, 2003; Thomas, 1990, 1994).

We make a few contributions to the existing literature. First, we provide empirical estimates on the role of agricultural productivity growth in human capital investment particularly in Sub–Saharan Africa. Second, we provide insights on the dynamics of agricultural productivity and child labor and its consequences on study time. Third, we develop a theoretical model and empirically explore the impacts of productivity along gender lines of school–age children. Fourth, we contribute to the literature on household bargaining models by investigating whether the productivity shocks have any differential effects on investment in education and education outcomes depending on the gender of the household head. Finally, we contribute to the debate on whether agricultural productivity shocks are procyclical in early childhood and countercyclical later by comparing effects of productivity on primary school versus post–primary school students.

Our results provide evidence that increased agricultural productivity boosts spending on uniform, contributions and total academic expenses. A 10% increase in land productivity results in 9%, 16%, and 6% increase in uniform, contribution, and total school expenditures respectively. In addition, a 10% increase in labor productivity leads to a 19%, 31%, and 12% increase in uniform, contribution, and total school expenditure. We find positive but statistically non–significant effects of productivity on study times. In addition, we find no evidence of heterogeneous effects by student gender. We show evidence that productivity effects are smaller in female–headed households. Finally, we find some evidence that post–primary students experience larger impacts compared to primary school students.

The rest of the paper is organized as follows. In section 2, we review related literature to motivate our analysis and put our contributions in context. We then provide a brief theoretic model to guide our empirical analysis in section 3. In section 4, we discuss the data and the empirical methodology. Section 5 provides results while section 6 discusses our robustness checks. Section 7 concludes the analysis.

II. LITERATURE REVIEW

The goal of this paper is to estimate the direct impact of productivity shocks on household investment in child education expenses, and time devoted to studying. In addition, we will investigate heterogeneous effects by gender of the child as well as the gender of the household head. We briefly review some of the existing literature related to our study. The literature focuses on the various mechanisms, such as income, nutrition, health, and child labor, through which agricultural income shocks affect schooling outcomes. They also provide evidence that the gender of the household head and the child may lead to heterogeneous impacts of shocks.

In Tanzania, as in many developing countries, agriculture is a major source of income. Consequently, any productivity shocks will affect income and hence spending on education. The role of income in determining access to education has been documented in the literature (e.g. Deininger, 2003; Grimm 2011). Deininger (2003) shows that the introduction of free primary education in Uganda increased enrollment and decreased academic expenditure. While the quality of education arguably declined due to congestion, the study shows that costs of schooling can be an impediment to school access. Grimm (2011), similarly, shows that a decline in household income by 10% decreases enrollment rates of children (6–13 years) by 2.5 percentage points for boys and 3 percentage points for girls. In other words, shocks to agricultural income can not only reduce school investment but also lead to complete withdrawal from school.

While income shocks may have immediate impact on school outcomes, some studies show long–term effects. In Indonesia, Maccini and Yang (2009) show that early life negative rainfall shocks have adverse impacts on women's long–term health, assets, and education attainment. They attribute these to the positive impacts of rainfall on agricultural output that result in higher incomes, food access, and better health for infant girls. Some studies show that investment in human capital is procyclical in early life but become countercyclical afterwards (Shah and Steinberg, 2017; DeSalle, 2020). Shah and Steinberg (2017) show that Indian children report lower likelihood of work in drought years and higher school attendance. In the long run, adults who experienced higher rainfall during school years have lower total years of schooling and lower wages. Rosales–Rueda (2018), finds that children exposed to El Nino flooding (in–utero) experience poor health, are shorter in stature five to seven years later, and score lower on cognitive tests in Ecuador.

Child labor is another important channel through which agricultural productivity shocks affect education outcomes. The extent of child labor largely depends on the income and substitution

effects. Specifically, increased productivity can increase household incomes leading to increased school expenditure and school attendance. On the other hand, increased productivity can be accompanied by agricultural wage increases that increase the opportunity cost of school attendance for children and hence can decrease enrollment. The net effect depends on the strength of the income and substitution effects. Dureya and Arends–Kuenning (2003) provide evidence that improved local labor market conditions increases opportunity costs of schooling and results in higher incidence of child labor and discontinuation of schooling in Brazil. Kruger (2007) finds short–term variation in local economic conditions – proxied by coffee production – led to more child labor among middle–income boys and girls and school withdrawals of poor children in Brazil. In Tanzania, the focus of our study, DeSalle (2020) finds that favorable early life productivity shocks have a positive effect on development of future cognitive skills of the child but if positive shocks occur during school–age time, they increase child labor and reduce academic performance.

The most common evidence in the literature tend to find that child labor is driven by push factors due to negative productivity shocks in agricultural households. In essence, these shocks can constrain household incomes and force households to deploy children to pursue paid work or use child labor as a substitute for adult labor in household chores. Child labor tends to act as insurance against negative shocks either due to lack of access to credit or incomplete credit markets (Jacoby and Skoufias, 1997; Beegle et al., 2006). Jacoby and Skoufias (1997) show that child labor is a form of household self–insurance for poor households in rural India. Beegle et al. (2006) find that, in Kagera region of Tanzania, child labor acts as a buffer against transitory shocks. They show that access to credit can reduce the need for child labor during periods of crop failure. One positive finding is that school enrolment decreased less than expected because many children were

able to combine school and work. However, the study does not provide any evidence that increased child labor does not affect child school performance. More evidence from Edmonds (2005) documents the impact of the introduction of the elderly pension program to black families in Post–Apartheid South Africa. When an elderly male becomes eligible for the pension program in a black family, there are large increases in school attendance and decline in child labor. This evidence points to liquidity constraints among black families. The paper further shows that the impacts were more sensitive to income for boys than for girls. The authors argue that their findings indicate differences in credit access by gender.

Given our interest in heterogeneity by gender, we provide additional empirical evidence that show that productivity shocks can have different impacts depending on the gender of the household head as well as the gender of the child. Dammert (2010) studies gender and sibling differences in time allocation within households in Nicaragua and Guatemala. She shows that older boys spend more time engaged in market and domestic work, while older girls spend more time in domestic work compared to their younger siblings. While this paper does not investigate impacts of agricultural productivity shocks, it indicates that the impacts can vary by gender given the documented evidence of gender differences in time allocation. Cameron and Worswick (2001) find that households with girls have a higher propensity to cut back on schooling expenditure following crop loss shocks in Indonesia. Marchetta et al. (2019) show that negative rainfall deviations and cyclones reduce test scores, and school enrollment in Madagascar. While both boys and girls are likely to engage in work following these shocks, the show that girls experience a larger adverse effect.

Some evidence, following from household bargaining theory, suggest that the gender of the household head has important consequences on investment in education. The seminal paper by

Qian (2008) provides strong empirical evidence of the significance of gender. She shows that an increase in sex–specific incomes has different impacts on boys and girls in China. While an increase in female income increases survival rates for girls, the impact is adverse when male income increases. Female income increases educational attainment for girls. However, male income worsens attainment among girls with no impact on boys. Related literature, show that women empowerment has positive impacts on child welfare (Saenz and Thompson, 2016; Wiig, 2013; Reggio, 2011). Saenz and Thompson (2016) show that the Zambian crop input subsidy program resulted in a greater reduction in crop diversification in male–headed households than in female–headed households. This reflects different cropping decisions by gender and possibly differential impact of weather shocks. It is likely that female–headed households may be less susceptible to crop losses due to weather and pests, and consequently these shocks have different impacts on educational outcomes for their children. Wiig (2013) finds evidence that joint titling of land improved women empowerment in rural Peru. This evidence suggests that empowered women may play a large role in income allocation compared to less–empowered women. This will likely result in different decision making during periods of agricultural productivity shocks. For instance, Reggio (2011) shows that, in Mexico, an increase in a mother's bargaining power results in lower working hours for daughters than for sons.

Our study has a few strengths. First, we take advantage of a large nationally representative individual panel data spanning three survey waves. We add to the few literature on impacts of agricultural shocks on education outcomes in Africa. Unlike several past studies, this study provides evidence on study time and disaggregated individual–level school expenditure data. Our paper is one of the few studies that focus on causal effects of productivity shocks on schooling outcomes in Sub–Saharan Africa (Beegle et al., 2006; Boozer and Suri, 2001). Others related

studies directly focus on impacts of weather shocks on school outcomes (Jensen, 2000; World Bank, 2007; Marchetta et al., 2019). Finally, more broadly, we contribute to the literature on household bargaining models.

III. THEORETICAL MODEL

We start with a simple two–period household model where a household head decides the level of household consumptions, education investment, and labor input. We assume that preferences for education differ according to the gender of the household head and the gender of the child. Specifically, we assume male heads prefer investing in male children while female heads put equal value in educating a child regardless of gender. These preferences are assumed to be driven by two factors. First, educating a child yields immediate bragging rights in period 1. Second, investment in education yields returns in the second period and these investments will vary based on the expected return to education for a particular child. In other words, both gender discrimination/bias and differential expectation of returns influence levels of investments in education levels.

We assume a representative household with a boy and a girl. The general household problem is as follows:

$$\max_{c_1,c_2,L_b,L_g} U_p(C_1, C_2, L_b, L_g) = U_1(C_1 - \gamma_c, L_b + L_g) + \beta EU_2(C_2 - \gamma_c)$$

s.t. $C_1 + f * (L_b + L_g) = \lambda Y_1 + w(2L - L_b - L_g)$

$C_2 = Y_2 + G_{\{p.b\}}(L_b) + G_{\{p,g\}}(L_g)$

$L_g > 0 \ , L_b > 0$[1] (1)

[1] L_b and L_g are assumed to be strictly positive to reflect the mandated minimum education requirements per child. Governments in developing countries have attempted to put in place mandatory school attendance for children especially for pre–secondary levels.

where a household head p in period 1 chooses consumption for period 1 and 2 (C_1, C_2), and investment in education by choosing labor allocated to school activities for boys (L_b) and girls (L_g) subject to the intertemporal household budget constraint. First, the household must meet subsistence consumption needs γ_{c1}, γ_{c2}. Second, the household faces a budget constraint where in each period *i* it receives an exogenous income Y_i. λ is a hicks–neutral productivity shifter. In the empirical analysis, we use rainfall, which is arguably a hicks–neutral technical factor, as an instrument for agricultural productivity. In addition, the household derives wage income from time not spent doing education related chores while in the second period the household derives additional income from returns to schooling $G_{p,i}(.)$, where G is a concave function with a normally distributed error term with a mean of zero. We further assume that education returns are increasing in the level of exogenous income levels in period 1 to reflect the idea that higher household income provides quality education etc. The expected returns to education depend on gender of the head and the gender of the student *b (boy)/g (girl).* The household head's investment choices in education depends on beliefs on expected returns to education for a child of each gender. The direct costs of schooling is assuming to be fixed at *f* with an indirect opportunity cost of *w* per unit of labor allocated to education activities – this can be the agricultural wage or the shadow agricultural wage. For simplicity, we assume the functional form of the returns to education as

$$G_{p,i}(L_b) = \theta_{p,i}(L_b)$$

We specify a simple utility function similar to those of Stone–Geary preferences. For simplicity, we assume away the error term and let *G* to be deterministic. In particular, a household head solves the objective function in equation (2). δ_i denotes the weight on the utility derived from educating a child of gender *i*. Notice that the optimal consumption and investment levels are pinned downed by choosing L_b, L_g:

$$\max_{L_b, L_g} U_p(C_1, C_2, L_b, L_g) = ln(C_1 - \gamma_c) + \delta_b\, ln(L_b) + \delta_g\, ln(L_g) + \beta\, ln(C_2 - \gamma_c) \quad (2)$$

s.t. $$C_1 = \lambda Y_1 + w\left(2L - L_b - L_g\right) - f * \left(L_b + L_g\right)$$

$$C_2 = Y_2 + \theta_{p,b} * (L_b) + \theta_{p,g} * \left(L_g\right)$$

$$L_g > 0 \ , L_b > 0$$

The first order conditions are given by:

$$\mathrm{L_g}: \frac{w + f}{C_1 - \gamma_c} = \frac{\delta_g}{L_g} + \beta \frac{1}{C_2 - \gamma_c} \theta_{p,g} \quad (3)$$

$$\mathrm{L_b}: \frac{w + f}{C_1 - \gamma_c} = \frac{\delta_b}{L_b} + \beta \frac{1}{C_2 - \gamma_c} \theta_{p,b} \quad (4)$$

Equations (3) and (4) indicate that the optimal education labor investment equalizes the marginal utility cost of academic labor and the marginal utility benefit of education. The marginal benefit is the sum of period 1 marginal utility from bragging rights and the period 2 discounted marginal utility from consumption from returns to education. If either the bragging rights or returns to education are higher, then the investments in education are high.

Combining the first order conditions:

$$\frac{\delta_b}{L_b} - \frac{\delta_g}{L_g} = \beta \frac{1}{C_2 - \gamma_c} [\theta_{p,g} - \theta_{p,b}] (5a)$$

Equation (5a) shows the tradeoffs between investing in education for a boy and a girl. This equation pins down the relationship between L_b and $\mathrm{L_g}$. At the optimum, the marginal benefit of a boy's education net of foregone marginal benefits of investing in a girl's education must equal the discounted difference in the net benefit of education returns between boys and girls in period 2.

Alternatively, the marginal utility from investing in a boy must equal the marginal utility in investing in a girl.

$$\frac{\delta_b}{L_b} + \beta \frac{1}{C_2 - \gamma_c} \theta_{p,b} \quad = \frac{\delta_g}{L_g} + \beta \frac{1}{C_2 - \gamma_c} \theta_{p,g} \; (5b)$$

If a parent (or household) receives larger bragging benefits from educating a boy, and/or have expectations of higher returns from educating a boy, then the parent (or household) will invest more in boys than in girls. The converse is true. If a parent (or household head) places equal weights on both the bragging benefits and expected returns from educating a child, regardless of gender, then the household will invest equal amounts in both genders.

Finally, we can perform comparative statics to investigate the impact of productivity shocks on the investment in boys and girls. From (3) and (4) we can show, respectively, that:

$$\frac{\partial \mathrm{L_g}}{\partial \lambda} = \frac{\frac{w+f}{(C_1 - \gamma_c)^2} Y_1}{\frac{w+f}{(C_1 - \gamma_c)^2} w + \frac{\delta_g}{{L_g}^2} + \frac{\beta}{(C_2 - \gamma_c)^2} {\theta_{p,g}}^2} > 0$$

$$\frac{\partial \mathrm{L_b}}{\partial \lambda} = \frac{\frac{w+f}{(C_1 - \gamma_c)^2} Y_1}{\frac{w+f}{(C_1 - \gamma_c)^2} w + \frac{\delta_b}{{L_b}^2} + \frac{\beta}{(C_2 - \gamma_c)^2} {\theta_{p,b}}^2} > 0$$

For simplicity, we can assume that δ_g and δ_b are relatively smaller compared to $\theta_{p,b}$ and $\theta_{p,g}$. Then we can show that under our assumptions while boys enjoy higher levels of education investments, girls' investments are more responsive to productivity shocks:

$$\frac{\frac{\partial \mathrm{L_g}}{\partial \lambda}}{\frac{\partial \mathrm{L_b}}{\partial \lambda}} = \frac{\frac{w+f}{(C_1 - \gamma_c)^2} w + \frac{\delta_b}{{L_b}^2} + \frac{\beta}{(C_2 - \gamma_c)^2} {\theta_{p,b}}^2}{\frac{w+f}{(C_1 - \gamma_c)^2} w + \frac{\delta_g}{{L_g}^2} + \frac{\beta}{(C_2 - \gamma_c)^2} {\theta_{p,g}}^2} > 1 \qquad (5c)$$

Empirically, differences in levels of investments in education between boys and girls will indicate a likelihood of existence of discriminatory bragging rights and/or different expected returns to education by gender. In addition, we expect girls' education expenses to be relatively more responsive to productivity shocks. This theoretical exercise is meant to motivate our

empirical analysis but is not meant to perfectly model all factors at play in household decisions on education. Our empirical analysis cannot distinguish the roles of discrimination and differences in expected returns to education in investment choices.

IV. DATA AND METHODS

Data for this analysis is from the World Bank's Living Standards Measurements Survey (LSMS) in Tanzania. We use data from the first three waves 2008/09, 2010/11, and 2012/13. This data has a rich education module that captures individual level school expenses over the previous 12 months and study time in the previous 7 days from the date of the survey. Consequently, we restrict our sample to individuals who are currently in school or were in school the previous academic year. The study time variable is only available for students who are enrolled in school. We use these waves to create individual panels. Productivity is measured as the gross value of all crop output produced on the farm per hectare planted or per labor–day (family and hired). Note that all labor including child labor, both family and hired, is treated equally. We also use alternative measures of productivity for robustness checks – gross crop income, net crop income per hectare planted, and net crop income. The net values subtracts explicit cash costs from gross values. We measure productivity at the household level. Table 2.1 shows the summary statistics for the main outcomes and dependent variables as well as the control variables.

We estimate a panel fixed effects model at the individual level

$$y_{iht} = \beta_0 + \beta_1 lnProd_{ht} \; + \boldsymbol{X_{iht}\beta_2} + \gamma_i + \delta_t + \varepsilon_{iht} \qquad (6)$$

Where *y* are the set of outcomes – education expenses and study time – , *iht* represents individual *i* in household *h* at time *t. prod* is the household harvest value per hectare or per labor–day. **X** is a vector of household and individual controls, γ_i is an individual fixed effect while $\delta_t$is a time fixed effect. Two measures of productivity are land productivity (Tsh/Ha) and labor productivity

(Tsh/Days of Labor). The time fixed effects, δ_t, control for factors that are invariant across all individuals within time *t*. On the other hand, the individual fixed effects, γ_i, controls for individual factors that are constant over time. The fixed effects identification relies on the assumption that conditional on the observed characteristics and fixed effects, the unobserved components are orthogonal to productivity. Unfortunately, the identification strategy above does not control for relevant unobserved time–varying factors that are correlated with productivity and affect outcomes of interest. This is one shortcoming of our models (FE and IV).

To address some endogeneity concerns, we complement the FE estimation strategy above by using rainfall to instrument for productivity. The IV also addresses simultaneity concerns since labor use, and hence time use, and productivity are simultaneously determined. Increased productivity can lead to increased demand for labor resulting in decreased study–time, school participation, and school expenses. On the other hand, increasing farm labor input, and hence reduced study time, school participation, and expenses, can lead to increased productivity. Similarly, cutting down on school expenses to hire more inputs can increase land productivity. In addition, there can be a mechanical relationship between labor and productivity measures. Specifically, if school child labor leaves then land productivity drops. In a similar vein, and considering that child labor is relatively less productive, reduction in child labor mechanically increases productivity. These introduce identification problems as they also contributes to reverse causality. The mechanical relationship between productivity and schoolchild labor may not be severe if children are able to combine school and work in presence of shocks. Beegle et al. (2006) argue that when households experienced crop loss shocks in Tanzania, school enrolment decreased less than expected because many children were able to combine school and work. To solve the concerns raised above we instrument for productivity using district rainfall during the wettest

quarter during the long rain seasons (March to May). We also use district quarterly deviations of rainfall as a robustness check. These rainfall shocks create exogenous variations in the productivity measures. We expect that the variations in productivity due to weather shocks to be relatively larger than those driven mechanically by labor changes.

The corresponding first stage equation is given by:

$$lnProd_{ihdt} = \alpha_0 + \alpha_1 lnRain_{dt} + \boldsymbol{X_{ihdt}\alpha_2} + \rho_i + \sigma_t + \varepsilon_{ihdt} \quad (7)$$

Where *i* is individual, $Prod_{ihdt}$ is the productivity at household *h* in district *d* at time *t*, *Rain* is total rainfall during the months of March to May (wettest quarter during long rains), $\boldsymbol{X}$ are a vector of household and individual characteristics, ρ_i are individual fixed effects and σ_t are the time fixed effects. Note that productivity only varies at the household level while rainfall varies at the district level. Table A 2.1 shows that the instrument is a strong predictor of agricultural productivity. The second requirement for instrument validity is that rainfall is exogenous. That is, the only way through which rainfall affects educational outcomes is only through its impact on agricultural productivity. Tanzania is a largely agricultural middle income country that relies heavily on rainfall for agricultural activities. Since our study relies on rainfall deviations and not extreme weather events, we argue that the main impact of rainfall on educational activities and spending is mostly through its impact on agricultural productivity and incomes. Several studies have also used rainfall as an instrument for agricultural productivity (e.g. Emerick, 2019).

Our second stage equation is given by:

$$y_{ihdt} = \beta_0 + \beta_1 \widehat{lnProd}_{hdt} + \boldsymbol{X_{ihdt}\beta_2} + \gamma_i + \delta_t + \varepsilon_{ihdt} \quad (8)$$

Table 2.1: Summary Statistics

Variable	Obs	Mean	Std. Dev.
Land Productivity (Tsh/Ha)	11,061	529,663	791,106
Labor Productivity (Tsh/Man Days)	11,061	4,356	6,643
Student Characteristics			
Fee Expenses (Tsh)	11,061	25,297	120,175
Book Expenses (Tsh)	11,061	7,677	13,289
Uniform Expenses (Tsh)	11,061	11,513	11,054
Transport Expenses (Tsh)	11,061	1,894	12,412
Tuition Expenses (Tsh)	11,061	3,283	12,904
Contribution Expenses (Tsh)	11,061	6,534	15,386
Food Expenses (Tsh)	11,061	5,802	25,978
Total School Expenses (Tsh)	11,061	66,504	183,636
Study time (Minutes)	7,882	89	209
In School	11,061	0.91	0.29
Female	11,061	0.49	0.50
Relationship to Head			
Child	11,061	0.76	0.43
Grandchild	11,061	0.16	0.37
Relative	11,061	0.07	0.26
Non-Relative	11,061	0.005	0.068
Marital Status			
Married	11,061	0.003	0.05
Other Status	11,061	0.003	0.05
Female Head	11,061	0.21	0.40
Adult Equivalent	11,061	6.35	3.23
Head Characteristics			
Primary	11,061	0.66	0.47
Secondary	11,061	0.11	0.31
Post Secondary	11,061	0.005	0.07
Age	11,061	50	13.00
Formal Land Rights	11,061	0.18	0.38
Tropical Livestock Units	11,061	3.32	23.88
Farm Size	11,061	2.73	3.38
Value of Crop Yields	11,061	914,089	1,503,416
Wage Income	11,061	52,973	199,753
Income Transfers	11,061	48,832	201,552
Non-Farm Income	11,061	3,786,434	13,500,000

V. RESULTS

a. Overall Results

The following tables are shortened but full tables are available in the appendix section. Table 2.2 shows the effects of land productivity on education expenditure and study time. The results indicate that while productivity has positive effects on expenditure, it is only statistically significant for school fees. In particular, a 10% increase in land productivity yields a 0.6% increase in education spending on fees. The effect on study times is quantitative small and statistically insignificant. Table 2.3 shows consistent findings for labor productivity. The fixed effects estimates are qualitatively similar to those for land productivity.

Table 2.2: Effects of Land Productivity on School Expenditure and Study Times (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.059*** **	**0.001**	**0.026**	**0.018**	**-0.026**	**0.020**	**0.020**	**-0.007**
	(3.26)	**(0.04)**	**(1.26)**	**(1.42)**	**(-1.13)**	**(1.08)**	**(1.51)**	**(-0.34)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.3: Effects of Labor Productivity Expenditure and Study Times (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.055***	**0.012**	**0.007**	**0.025**	**-0.022**	**0.040**	**0.026**	**-0.013**
	(1.87)	**(0.50)**	**(0.23)**	**(1.17)**	**(-0.62)**	**(1.36)**	**(1.33)**	**(-0.37)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.4 shows the IV estimates. These estimates are more encouraging. Increased land productivity results in increased spending on uniform, school contribution, and total school

expenditures. A 10% increase in land productivity results in 9%, 16%, and 6% increases in uniform, contribution, and total school expenditures respectively. The results also indicate that land productivity has a positive impact on book spending and total study time but the results are not statistically significant.

Table 2.5, shows that the IV estimates using labor productivity are qualitatively similar to those for land productivity but the estimates are much larger. Specifically, a 10% increase in labor productivity leads to a 19%, 31%, and 12% increase in uniform, contribution and total school expenditure. In addition, a 10% increase in labor productivity increases study time by 10% but latter finding is not statistically significant.

Taken together and focusing on the IV estimates, we find that both land and labor productivity results in increased expenditure on school with a potential to increase study times. In addition, labor productivity has a larger impact on outcomes.

The labor productivity coefficients tend to be larger compared to the land productivity coefficients. One potential explanation is that the benefits of high labor productivity tend to be immediate and allows households to respond quickly and easily to positive shocks. Labor productivity frees up resources that can be used to increase school expenses and study times. On the hand, the benefits of increased yields (land productivity) may not materialize until harvests are completed and hence the impacts on educational investments may be relatively lower.

Table 2.4: Effects of Land Productivity on School Expenditure and Study Times (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.217**	**0.320**	**0.938****	**0.205**	**1.552*****	**0.267**	**0.617***	**0.354**
	(-0.65)	**(1.00)**	**(2.21)**	**(1.08)**	**(2.64)**	**(0.80)**	**(1.88)**	**(1.28)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.5: Effects of Labor Productivity on School Expenditure and Study Times (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.433**	**0.638**	**1.873****	**0.410**	**3.097****	**0.532**	**1.232***	**1.029**
	(-0.64)	**(0.99)**	**(2.02)**	**(1.06)**	**(2.31)**	**(0.79)**	**(1.77)**	**(1.17)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

b. Results by Student Gender

The overall results may hide heterogeneity in effects by gender. Table 2.6–2.9 repeats the previous analysis while interacting the productivity variable with the gender dummy variable. In Table 2.6–2.7, the fixed effects estimate show that land and labor productivity tend to have statistically non–significant effects on outcomes. We therefore focus on the preferred IV estimates in Table 2.8–2.9.

Table 2.6: Effects of Land Productivity on School Expenditure and Study Times by Gender (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.043***	**0.006**	**0.000**	**-0.008**	**-0.033**	**0.036**	**0.015**	**-0.040**
	(1.89)	**(0.25)**	**(0.01)**	**(-0.47)**	**(-1.02)**	**(1.48)**	**(0.72)**	**(-1.51)**
Female X Log Labor Productivity	**0.033**	**-0.010**	**0.052**	**0.052****	**0.013**	**-0.032**	**0.011**	**0.068***
	(0.89)	**(-0.33)**	**(1.28)**	**(2.15)**	**(0.29)**	**(-0.86)**	**(0.41)**	**(1.71)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.7: Effects of Labor Productivity on School Expenditure and Study Times by Gender (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.063**	**0.051**	**-0.037**	**-0.016**	**-0.043**	**0.073***	**0.022**	**-0.026**
	(1.52)	**(1.40)**	**(-0.82)**	**(-0.53)**	**(-0.85)**	**(1.73)**	**(0.73)**	**(-0.56)**
Female X Log Labor Productivity	**-0.015**	**-0.074**	**0.085**	**0.077****	**0.040**	**-0.063**	**0.006**	**0.024**
	(-0.26)	**(-1.62)**	**(1.39)**	**(1.97)**	**(0.59)**	**(-1.14)**	**(0.17)**	**(0.36)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.8 shows that a 10% increase in agricultural land productivity academic spending on books, uniform, contributions and total expenses by 6% 10 % 13%, and 7.8% respectively. On the other hand, there is suggestive evidence that land productivity may have differential effects by gender. Specifically, for girls, the impacts are higher for transport, contributions, and food, while lower for books, uniform, and total expenses. In addition, girls appear to experience larger positive impacts on time spent studying. However, these gender effects are not statistically significant. Table 2.9 repeats the analysis using labor productivity as the dependent variable. The results are qualitatively similar to those in Table 2.5 with few differences. First, the coefficients are generally larger in magnitude. Second, only coefficients on uniform, contributions, and total expenses

remain statistically significant. Finally, increased labor productivity appears to have a large adverse impact on study times for girls – however, this coefficient is imprecisely estimated and thus not statistically significant. Overall, where there are some differences in outcomes between boys and girls, these differences are statistically non–significant.

Table 2.8: Effects of Land Productivity on School Expenditure and Study Times by Gender (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.178**	**0.643***	**1.028****	**0.095**	**1.300****	**-0.272**	**0.783****	**-0.409**
	(-0.56)	**(1.66)**	**(2.30)**	**(0.47)**	**(2.23)**	**(-0.77)**	**(2.06)**	**(-0.27)**
Log Land Productivity X Female	**-0.031**	**-1.074**	**-0.298**	**0.367**	**0.837**	**1.788**	**-0.550**	**5.161**
	(-0.03)	**(-1.31)**	**(-0.26)**	**(0.59)**	**(0.42)**	**(1.22)**	**(-0.75)**	**(0.32)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.9: Effects of Labor Productivity on School Expenditure and Study Times by Gender (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.334**	**1.205**	**1.945****	**0.185**	**2.477***	**-0.491**	**1.477***	**1.660**
	(-0.56)	**(1.56)**	**(2.14)**	**(0.47)**	**(1.93)**	**(-0.71)**	**(1.95)**	**(0.23)**
Log Labor Productivity X Female	**-0.102**	**-1.832**	**-0.235**	**0.727**	**2.005**	**3.307**	**-0.793**	**-13.717**
	(-0.06)	**(-1.19)**	**(-0.10)**	**(0.58)**	**(0.43)**	**(1.05)**	**(-0.55)**	**(-0.22)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

c. Results by Gender of Household Head

Existing literature show evidence indicating that household spending may vary depending on the gender of the household head. In this section, we investigate the significance of the gender of the household head in academic outcomes following productivity shocks in Table 2.10–2.13. Tables

2.10 and 2.11 provide results from panel fixed effects estimation. We focus the discussion on the IV estimates in Table 2.12–2.13.

Table 2.10: Effects of Land Productivity on School Expenditure and Study Times by Gender of Head (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.027**	**0.008**	**0.016**	**0.016**	**-0.016**	**0.021**	**0.025**	**-0.003**
	(1.27)	**(0.39)**	**(0.66)**	**(1.04)**	**(-0.60)**	**(0.98)**	**(1.59)**	**(-0.10)**
Female Head X Log Land Productivity	**0.111*** **	**-0.025**	**0.037**	**0.008**	**-0.035**	**-0.003**	**-0.015**	**-0.015**
	(2.77)	**(-0.81)**	**(0.83)**	**(0.31)**	**(-0.70)**	**(-0.07)**	**(-0.56)**	**(-0.35)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.11: Effects of Labor Productivity on School Expenditure and Study Times by Gender of Head (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.016**	**0.012**	**-0.024**	**0.017**	**-0.004**	**0.048**	**0.021**	**-0.036**
	(0.48)	**(0.43)**	**(-0.67)**	**(0.70)**	**(-0.09)**	**(1.43)**	**(0.96)**	**(-0.85)**
Female Head X Log Labor Productivity	**0.153****	**0.000**	**0.122***	**0.030**	**-0.072**	**-0.034**	**0.018**	**0.078**
	(2.27)	**(0.01)**	**(1.77)**	**(0.72)**	**(-0.94)**	**(-0.54)**	**(0.42)**	**(1.06)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.12 shows that gender has important consequences on the impacts of land productivity on the outcomes of interest. Generally, the impact of land productivity is lower among female–headed households. Specifically, a 10% increase in land productivity increases spending on uniform, contributions and total expenses by 15%, 24%, and 9% respectively among male–headed households. On the other hand, for female–headed households, the aggregate impact of a 10% increase in land productivity on uniform, contributions and total expenses is 0.05%, 1.6%, and 1% respectively.

Table 2.13, using labor productivity, shows qualitatively similar results with larger differences between male–headed and female–headed households. However, these latter set of results have larger standard errors. A 10% increase in labor productivity increases spending on uniforms, contributions, and total expenses by 30%, 48%, and 19%, respectively, for male–headed households. The corresponding estimates for female–headed households are a decline of 7%,8%, and 2% in uniform, contribution and total expenses respectively – the impact on total expenses is not statistically significant for either gender.

Overall, we find some evidence that while agricultural productivity tends to have positive impacts on academic spending, the impact tends to be lower among female–headed households. One potential explanation is that female–headed households in Tanzania may be disadvantaged in numerous ways that may limit their ability to capitalize on positive productivity shocks in increasing education investments. For instance, women may have lower access to credit markets and therefore cannot access credit even in the anticipation of good harvests. This may explain why our results are contrary to the literature that find that women tend to make better investments in children compared to men (e.g. Qian, 2008).

Table 2.12: Effects of Land Productivity on School Expenditure and Study Times by Gender of Head (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.396**	**0.542**	**1.487****	**0.158**	**2.371****	**0.462**	**0.923***	**0.419**
	(-0.96)	**(1.13)**	**(2.22)**	**(0.59)**	**(2.46)**	**(0.96)**	**(1.86)**	**(0.83)**
Female Head X Log Land Productivity	**0.556**	**-0.600**	**-1.482****	**0.128**	**-2.212****	**-0.526**	**-0.828***	**-0.126**
	(1.37)	**(-1.08)**	**(-2.32)**	**(0.43)**	**(-2.46)**	**(-1.15)**	**(-1.81)**	**(-0.26)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.13: Effects of Labor Productivity on School Expenditure and Study Times by Gender of Head (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.816**	**1.107**	**3.036***	**0.321**	**4.840***	**0.943**	**1.885**	**1.170**
	(-0.95)	**(1.05)**	**(1.81)**	**(0.56)**	**(1.96)**	**(0.91)**	**(1.58)**	**(0.98)**
Female Head X Log Labor Productivity	**1.396**	**-1.520**	**-3.771***	**0.288**	**-5.648***	**-1.331**	**-2.117**	**-0.568**
	(1.26)	**(-1.08)**	**(-1.88)**	**(0.34)**	**(-1.94)**	**(-1.06)**	**(-1.54)**	**(-0.39)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

d. **Results by Level of Schooling: Primary versus Post–Primary**

Some studies indicate that the relationship between agricultural productivity and education outcomes are pro–cyclical for younger children and counter–cyclical for older children. We explore this hypothesis by comparing outcomes between primary school students (younger) versus post–secondary students (relatively older). There may also be other heterogeneous factors at play at different education levels. We define a primary school dummy, that equals one if student in primary or lower level and equals zero if in post–primary level, and then interact the dummy with productivity. We report our findings in Tables 2.14–2.17. Starting with the fixed effects estimates in Tables 2.14–2.15, we find suggestive evidence that both land and labor productivity have larger positive effects for post–primary students.

Table 2.14: Effects of Land Productivity on School Expenditure and Study Times by School–Level (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.463*** **	**0.006**	**0.064*** **	**0.059*** **	**-0.004**	**0.095*** **	**0.075*** **	**0.009**
	(19.42)	**(0.33)**	**(2.70)**	**(3.56)**	**(-0.14)**	**(4.04)**	**(4.63)**	**(0.35)**
Primary X Log Land Productivity (TSH/Ha)	**-0.543*** **	**-0.008**	**-0.050*** **	**-0.055*** **	**-0.030***	**-0.101*** **	**-0.074*** **	**-0.019**
	(-35.87)	**(-0.76)**	**(-3.77)**	**(-5.74)**	**(-1.65)**	**(-6.41)**	**(-9.07)**	**(-1.04)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.15: Effects of Labor Productivity on School Expenditure and Study Times by School–Level (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.711*** **	**0.015**	**0.057**	**0.087*** **	**0.016**	**0.173*** **	**0.110*** **	**0.013**
	(19.35)	**(0.53)**	**(1.59)**	**(3.07)**	**(0.38)**	**(4.66)**	**(4.74)**	**(0.30)**
Primary X Log Labor Productivity (TSH/Day)	**-0.884*** **	**-0.004**	**-0.067*** **	**-0.084*** **	**-0.051***	**-0.180*** **	**-0.113*** **	**-0.032**
	(-38.25)	**(-0.26)**	**(-3.10)**	**(-5.36)**	**(-1.76)**	**(-6.92)**	**(-8.71)**	**(-1.05)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Our preferred estimations in Table 2.16–2.17, using IV, show similar results, though the differences are smaller in magnitude. While we observe large differences in expenditure on fees and food, there are only small differences in aggregate expenditure. While land productivity has positive effects on expenses, a 10% increase in land productivity has an effect that is lower by 6%, 0.5%, 0.5%, 11%, and 0.8% on fees, uniform, transport, food, and total expenses respectively. The effects are qualitatively similar when using labor productivity as a measure of agricultural productivity. However, the coefficients are larger while the differences in effects by school level are slightly larger.

Table 2.16: Effects of Land Productivity on School Expenditure and Study Times by School–Level (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.892*** **	**0.338**	**1.031** **	**0.307**	**1.610*** **	**0.473**	**0.763** **	**0.373**
	(3.21)	**(1.08)**	**(2.42)**	**(1.57)**	**(2.73)**	**(1.41)**	**(2.34)**	**(1.35)**
Primary X Log Land Productivity (TSH/Ha)	**-0.585*** **	**-0.010**	**-0.049*** **	**-0.053*** **	**-0.031**	**-0.109*** **	**-0.077*** **	**-0.018**
	(-33.19)	**(-0.89)**	**(-2.87)**	**(-5.26)**	**(-1.21)**	**(-6.45)**	**(-6.94)**	**(-0.87)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.17: Effects of Labor Productivity on School Expenditure and Study Times by School–Level (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**1.502*** **	**0.662**	**2.008** **	**0.580**	**3.156** **	**0.883**	**1.468** **	**1.055**
	(2.64)	**(1.05)**	**(2.18)**	**(1.47)**	**(2.38)**	**(1.31)**	**(2.12)**	**(1.20)**
Primary X Log Labor Productivity (TSH/Day)	**-0.945*** **	**-0.011**	**-0.066***	**-0.083*** **	**-0.029**	**-0.172*** **	**-0.116*** **	**-0.035**
	(-32.15)	**(-0.58)**	**(-1.93)**	**(-4.86)**	**(-0.55)**	**(-5.97)**	**(-5.02)**	**(-0.94)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Focusing on the IV estimates, important differences emerge on fee and food expenses. Generally, primary school fees tend to be lower but post–primary school fees tend to be significantly higher. Therefore, post–primary fees are likely to be more responsive to shocks to household incomes. In addition, food expenses are likely to decrease for primary school because these students typically attend day schools and therefore consume most of their food at home. Positive productivity shocks can therefore lower food expenses at home, which translate to lower food expenses for primary school students.

VI. ROBUSTNESS CHECKS

a. Alternative Measures of Productivity

The remaining tables perform sensitivity analyses using different measures of productivity. Given that we have confidence in our instrument, we focus on the IV results.

Table 2.18–2.19 use the value of crop income as the measure of productivity – instead of gross crop income per hectare. The coefficients are larger but qualitatively similar to those in Table 2.2–2.5. The IV estimates fall between the estimates from labor productivity and land productivity. Specifically, a 10% increase in value of crop income leads to a 13%, 22% and 9% increase in uniform, contributions, and total expenses.

Table 2.18: Effects of Gross Agricultural Income on School Expenditure and Study Times (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Value of Crop Income (TSH)	**0.058****	**-0.006**	**0.011**	**0.024**	**0.025**	**0.019**	**0.012**	**0.002**
	(2.41)	**(-0.29)**	**(0.43)**	**(1.41)**	**(0.85)**	**(0.78)**	**(0.70)**	**(0.09)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.19: Effects of Gross Agricultural Income on School Expenditure and Study Times (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Value of Crop Income (TSH)	**-0.307**	**0.454**	**1.330****	**0.291**	**2.201****	**0.378**	**0.875***	**0.712**
	(-0.63)	**(1.00)**	**(2.05)**	**(1.05)**	**(2.32)**	**(0.79)**	**(1.84)**	**(1.20)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.20–2.21 using net crop revenue per hectare instead of gross crop revenue per hectare. Net revenue is the gross revenue net of explicit production costs. Table 2.20 reports the

fixed effect results that are qualitatively similar those in Table 2.2, which uses gross revenue per hectare. The IV estimates show that a 10% increase in net revenue per hectare leads to a 10%, 18%, and 7% in uniform, contributions, and total expenses respectively. These estimates are quantitatively and qualitatively similar to those in Table 2.4, which uses gross income per hectare as a measure of productivity.

Table 2.22–2.23 are closely related to Table 2.20–2.21. The measure of productivity is net crop income instead of net crop income per hectare. The results are similar to those in Table 2.20–2.21, and qualitatively consistent with our previous set of results.

Table 2.20: Effects of Net Agricultural Income per Hectare on School Expenditure and Study Times (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Ln Net Revenue per Ha (TSH/Ha)	**0.050***	**0.008**	**-0.002**	**0.027**	**-0.006**	**0.057***	**0.004**	**0.039**
	(1.69)	**(0.34)**	**(-0.09)**	**(1.11)**	**(-0.16)**	**(1.65)**	**(0.28)**	**(1.31)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.21: Effects of Net Agricultural Income per Hectare on School Expenditure and Study Times (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Ln Net Revenue per Ha (TSH/Ha)	**-0.179**	**0.416**	**0.988****	**0.227**	**1.771*****	**0.264**	**0.729****	**0.315**
	(-0.52)	**(1.19)**	**(2.20)**	**(1.09)**	**(3.13)**	**(0.71)**	**(2.02)**	**(0.96)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.22: Effects of Net Agricultural Income on School Expenditure and Study Times (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Ln Net Crop Income (Tsh)	**0.042**	**0.020**	**0.007**	**0.026**	**0.026**	**0.069****	**0.007**	**0.010**
	(1.49)	**(0.96)**	**(0.29)**	**(1.14)**	**(0.79)**	**(2.19)**	**(0.54)**	**(0.35)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.23: Effects of Net Agricultural Income on School Expenditure and Study Times (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Ln Net Crop Income (Tsh)	**-0.247**	**0.365**	**1.071****	**0.234**	**1.772*****	**0.305**	**0.705***	**0.426**
	(-0.65)	**(1.02)**	**(2.29)**	**(1.10)**	**(3.02)**	**(0.81)**	**(1.91)**	**(1.32)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

b. Exclusion of Household Income

Non–agricultural household incomes, such as agricultural wage income, play an important role in determining the school expenses and study times. However, controlling for these variables in our estimation can yield unbiased estimates because non–agricultural incomes can be potentially endogenous. For instance, high agricultural wage incomes may indicate higher participation of children in paid wage activities or substitution of adult labor for child labor in household chores. At the same time, these factors may affect household agricultural productivity (land/labor). In addition, higher agricultural wage income may indicate higher participation of household members in wage activities and hence lower labor input and agricultural productivity in the family farm. Generally, high agricultural productivity may induce a household to decrease non–agricultural

labor supply and hence lower non–agricultural incomes. On the other hand, lower agricultural productivity may force a household to supplement income by engaging in non–farm employment activities. We repeat our main analysis in Table 2.2–2.5 while excluding these incomes in the regressions. Our results are robust to the exclusion of household non–agricultural income.

Table 2.24: Effects of Land Productivity on School Expenditure and Study Times – Excluding Other Income (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.060*** **	**0.001**	**0.026**	**0.018**	**-0.027**	**0.020**	**0.021**	**-0.007**
	(3.28)	**(0.08)**	**(1.25)**	**(1.40)**	**(-1.16)**	**(1.10)**	**(1.51)**	**(-0.36)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.25: Effects of Labor Productivity on School Expenditure and Study Times – Excluding Other Income (FE)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.055***	**0.012**	**0.007**	**0.024**	**-0.024**	**0.040**	**0.026**	**-0.013**
	(1.88)	**(0.51)**	**(0.22)**	**(1.14)**	**(-0.66)**	**(1.37)**	**(1.34)**	**(-0.36)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.26: Effects of Land Productivity on School Expenditure and Study Times – Excluding Other Income (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.190**	**0.364**	**0.905****	**0.205**	**1.539*****	**0.281**	**0.597***	**0.307**
	(-0.58)	**(1.16)**	**(2.19)**	**(1.09)**	**(2.66)**	**(0.85)**	**(1.86)**	**(1.14)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.27: Effects of Labor Productivity on School Expenditure and Study Times – Excluding Other Income (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.384**	**0.737**	**1.829****	**0.415**	**3.112****	**0.567**	**1.207***	**0.946**
	(-0.57)	**(1.13)**	**(2.01)**	**(1.07)**	**(2.30)**	**(0.84)**	**(1.75)**	**(1.05)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

c. Alternative Rainfall Measure – Quarterly Deviations from Historical Mean

Our primary instrumental variable is the rainfall levels during the wettest quarter during growing season (March – May). We repeat our analysis to test for sensitivity of our results to alternative measures of rainfall. We instrument for productivity using standardized quarterly deviations of rainfall from a long–term decadal trend (2007 – 2017). The first stage is show in Table A 2.30. While the results in Tables 2.28–2.29 are imprecise, the coefficients are generally in line with our initial analysis.

Table 2.28: Effects of Land Productivity on School Expenditure and Study Times – Rainfall Deviations as Instrument (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.563**	**0.453***	**0.994****	**-0.011**	**0.854***	**0.219**	**0.227**	**0.490****
	(-1.58)	**(1.74)**	**(2.49)**	**(-0.06)**	**(1.93)**	**(0.68)**	**(1.10)**	**(2.37)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

Table 2.29: Effects of Labor Productivity on School Expenditure and Study Times – Rainfall Deviations as Instrument (IV)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.497**	**0.130**	**2.098****	**0.250**	**1.278**	**1.146**	**0.596**	**1.080**
	(-0.70)	**(0.25)**	**(2.23)**	**(0.64)**	**(1.38)**	**(1.50)**	**(1.28)**	**(1.60)**
Individual Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes household and individual controls, and interview–month fixed effects. Productivity/agricultural income is at the household level. Errors clustered at the individual level.

d. Other Concerns – Functional Forms

The use of log transformation of variables has many benefits. For example, it mitigates the effects of outliers, and provides coefficients that are easy to translate. However, log transformations are not possible for observations that are zeros. One way around this is to add a small positive value to all observations before log–transformation – we follow this approach in our analysis. When the sample includes few observations, this may not be problematic. However, if a sizeable portion of the observations is zeros, then the results will be biased. We consider this a potential weakness of our analysis. Future versions of this paper will test for robustness of our results to the use of alternative functional forms such as the poisson or exponential functions with fixed effects.

VII. CONCLUSION

Agriculture is a significant employment and income source in Sub–Saharan Africa. In addition, credit access and insurance markets are either missing or incomplete. These, in conjunction with the reliance on rain–fed agriculture, imply that agricultural household are likely to suffer from adverse shocks to agricultural productivity. Due to rapid population growth and the continued subdivision of land, the role of agriculture as a major employer and source of income is likely to subside in the near future. Consequently, other sources of income and economic growth outside of

the agricultural sector will become increasingly important. Economic literature has shown that human capital is an important component of economic growth. This paper has provided empirical evidence on the relationship between agricultural productivity and investment in human capital development.

Our study provides four main findings. First, increases in agricultural income has large positive effects on academic spending. Second, while we find evidence that expenses for female students tend to be relatively lower, the differences are not statistically significant. Third, we find that productivity impacts tend to be very low in female–headed households. Finally, we show evidence that some academic expenditure may be more sensitive for post–primary school students.

The quality and quantity of human capital developed is arguably positively correlated with the levels of education expenditure and study time. Our findings imply that adverse agricultural shocks are likely to have long–term economic effects by lowering the quantity and quality of education attained. This paper provides several policy suggestions given our findings. First, the government and the private sector should invest in measures that shield students from adverse agricultural income shocks. These may include elimination or reduction of school fees for primary and pre–primary students, and provision of food in presence of adverse weather shocks. Second, the government and the private sector should develop and encourage the take–up of weather–based insurance (e.g. crop insurance). Third, policies, that pay special attention to female–headed household, should be designed to ensure that these households are not significantly affected by shocks. Fourth, to encourage post–primary education attainment, policies should be designed to shield post–primary students in agricultural households from agricultural income shocks. Such policies may include fee deferral during periods of adverse weather shocks. Generally, development of credit markets and crop–insurance markets can help households to smooth

consumption and minimize effects of disruptive shocks. Access to credit and education on crop–insurance can be targeted at the households that are most sensitive to agricultural shocks – e.g. female–headed households, and households with post–primary students.

APPENDIX

Table A 2.1: First Stage Regressions – Productivity and Rainfall

	(1)	(2)	(3)	(4)	(5)
	Ln Land Productivity (Tsh/Ha)	Ln Labor Productivity (Tsh/Day)	Ln Gross Crop Income (Tsh)	Ln Net Crop Income per Ha (Tsh)	Ln Net Crop Income (Tsh)
Ln Total Rain (March - May)	0.582***	0.292***	0.413**	0.528***	0.513***
	(3.34)	(2.69)	(2.57)	(4.41)	(3.69)
Observations	11054	11054	11054	11054	11054
F Statistic	9.18	13.85	10.27	13.5	9.88
Cragg-Donald Wald F statistic	13.81	7.79	9.82	20.80	17.88
Kleibergen-Paap Wald rk F statistic	11.23	7.29	6.62	19.44	13.62

T–statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave and interview month FE.

Table A 2.2: Effects of Land Productivity on School Expenditure and Study Times (FE) – Full Tables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.059*** **	**0.001**	**0.026**	**0.018**	**-0.026**	**0.020**	**0.020**	**-0.007**
	(3.26)	**(0.04)**	**(1.26)**	**(1.42)**	**(-1.13)**	**(1.08)**	**(1.51)**	**(-0.34)**
Relationship to Head (Excludes Spouse)								
Child	0.559	-0.715	3.030*	-0.532	5.900***	-0.984**	1.280	1.202
	(0.29)	(-0.43)	(1.83)	(-1.31)	(3.84)	(-2.07)	(0.67)	(1.53)
Grandchild	0.621	-1.286	2.845	-0.594	5.419***	-0.465	1.113	1.047
	(0.31)	(-0.76)	(1.59)	(-1.26)	(3.26)	(-0.69)	(0.58)	(1.36)
Relative	0.409	-1.374	2.554	-0.620	5.490***	-1.174**	0.987	0.313
	(0.21)	(-0.81)	(1.48)	(-1.49)	(3.44)	(-2.10)	(0.51)	(0.49)
Non-relative	-0.056	-1.881	1.564	-0.985**	4.114**	-1.758**	0.128	0.000
	(-0.03)	(-1.08)	(0.84)	(-2.00)	(2.26)	(-2.50)	(0.06)	(.)
Marital Status (Excludes Never Married)								
Married	1.316	2.392	1.854	-1.529*	6.765***	-1.565***	0.075	-5.102***
	(0.94)	(1.13)	(0.98)	(-1.75)	(3.19)	(-2.86)	(0.04)	(-15.31)
Other status	-1.838*	-1.441**	-1.171	-1.214**	-0.354	-2.519***	-1.958**	0.005
	(-1.82)	(-2.08)	(-1.13)	(-2.11)	(-0.30)	(-3.68)	(-2.38)	(0.01)
Female Head	0.240	-0.078	-0.521	-0.216	-0.653	0.129	-0.321	-0.121
	(0.78)	(-0.29)	(-1.54)	(-1.40)	(-1.61)	(0.47)	(-1.36)	(-0.34)
Head Education (Excludes - No Education)								
Primary	-0.073	-0.116	0.469**	0.025	0.443*	-0.153	0.098	-0.485**
	(-0.48)	(-0.72)	(2.11)	(0.29)	(1.72)	(-0.94)	(0.68)	(-2.27)
Secondary	-0.373	-0.161	-0.081	-0.148	0.700	-0.608	-0.064	-0.157
	(-0.89)	(-0.52)	(-0.22)	(-0.73)	(1.39)	(-1.58)	(-0.24)	(-0.35)
Post-Secondary	0.966	1.689	-3.320	1.445	3.552***	3.375	1.610	5.804***
	(0.58)	(1.27)	(-1.14)	(1.00)	(2.86)	(1.20)	(0.92)	(11.82)
Head Marital Status (Excludes- Never Married								
Married	-0.583	-1.275**	-1.165	-0.957**	-1.180	-0.392	-1.212*	0.653
	(-0.84)	(-2.10)	(-1.52)	(-2.17)	(-1.31)	(-0.51)	(-1.95)	(1.01)
Other status	-0.682	-1.152**	-0.920	-0.799*	-0.844	-0.793	-1.106*	0.439
	(-1.01)	(-1.97)	(-1.23)	(-1.90)	(-0.96)	(-1.07)	(-1.86)	(0.68)
Ln Head Age	-0.508	0.004	0.510	0.204	1.051	0.161	0.150	-0.233
	(-0.75)	(0.01)	(0.68)	(0.62)	(1.32)	(0.31)	(0.30)	(-0.37)
Land Rights Document	0.105	-0.224**	0.048	0.055	-0.180	0.161	0.011	0.014
	(0.85)	(-2.35)	(0.37)	(0.76)	(-1.23)	(1.24)	(0.14)	(0.10)
Ln TLUs	0.048	0.080	0.051	0.074*	-0.021	0.318***	0.036	-0.010
	(0.58)	(1.12)	(0.49)	(1.67)	(-0.18)	(3.78)	(0.56)	(-0.09)
Ln Adult Equivalent	-0.434	0.639**	0.602*	-0.164	0.233	-0.303	0.401	0.050
	(-1.34)	(2.43)	(1.67)	(-0.87)	(0.58)	(-0.96)	(1.51)	(0.13)
Ln Land Size (ha)	-0.024	0.110	0.120	-0.015	0.280*	0.038	0.039	-0.100
	(-0.20)	(1.21)	(0.89)	(-0.22)	(1.72)	(0.30)	(0.50)	(-0.60)
Ln Ag Wage Income	-0.006	-0.001	-0.012	0.002	0.002	0.008	-0.005	-0.021*
	(-0.62)	(-0.15)	(-1.20)	(0.37)	(0.16)	(0.83)	(-0.75)	(-1.84)
Ln Transfer Income	-0.000	-0.004	-0.009	-0.007	-0.023*	0.003	0.002	0.010
	(-0.04)	(-0.58)	(-0.80)	(-1.35)	(-1.90)	(0.30)	(0.35)	(0.94)
Ln Nonfarm Income	0.011	0.020***	0.003	0.002	0.010	0.001	-0.001	0.003
	(1.43)	(3.00)	(0.34)	(0.42)	(0.95)	(0.15)	(-0.24)	(0.28)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.3: Effects of Labor Productivity on School Expenditure and Study Times (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.055***	**0.012**	**0.007**	**0.025**	**-0.022**	**0.040**	**0.026**	**-0.013**
	(1.87)	**(0.50)**	**(0.23)**	**(1.17)**	**(-0.62)**	**(1.36)**	**(1.33)**	**(-0.37)**
Relationship to Head (Excludes Spouse)								
Child	0.544	-0.732	3.048*	-0.549	5.904***	-1.020**	1.265	1.211
	(0.28)	(-0.45)	(1.84)	(-1.34)	(3.86)	(-2.11)	(0.66)	(1.54)
Grandchild	0.622	-1.306	2.875	-0.608	5.414***	-0.501	1.102	1.052
	(0.31)	(-0.78)	(1.60)	(-1.29)	(3.27)	(-0.74)	(0.57)	(1.36)
Relative	0.407	-1.394	2.583	-0.636	5.487***	-1.212**	0.975	0.320
	(0.21)	(-0.83)	(1.50)	(-1.52)	(3.45)	(-2.14)	(0.50)	(0.50)
Non-relative	-0.073	-1.894	1.576	-0.999**	4.119**	-1.788**	0.114	0.000
	(-0.04)	(-1.09)	(0.84)	(-2.02)	(2.27)	(-2.52)	(0.06)	(.)
Marital Status (Excludes Never Married)								
Married	1.217	2.394	1.804	-1.556*	6.810***	-1.592***	0.042	-5.091***
	(0.85)	(1.12)	(0.95)	(-1.76)	(3.20)	(-2.83)	(0.02)	(-16.87)
Other status	-1.878*	-1.443**	-1.186	-1.227**	-0.336	-2.537***	-1.973**	0.011
	(-1.86)	(-2.08)	(-1.14)	(-2.11)	(-0.29)	(-3.69)	(-2.40)	(0.02)
Female Head	0.228	-0.070	-0.538	-0.214	-0.646	0.138	-0.321	-0.123
	(0.74)	(-0.26)	(-1.59)	(-1.39)	(-1.59)	(0.50)	(-1.36)	(-0.34)
Head Education (Excludes - No Education)								
Primary	-0.070	-0.115	0.468**	0.026	0.442*	-0.150	0.099	-0.488**
	(-0.46)	(-0.71)	(2.10)	(0.31)	(1.72)	(-0.92)	(0.69)	(-2.29)
Secondary	-0.363	-0.160	-0.078	-0.144	0.695	-0.603	-0.060	-0.158
	(-0.86)	(-0.52)	(-0.21)	(-0.71)	(1.38)	(-1.56)	(-0.23)	(-0.35)
Post-Secondary	1.004	1.692	-3.307	1.459	3.536***	3.393	1.625	5.788***
	(0.60)	(1.27)	(-1.14)	(1.01)	(2.84)	(1.21)	(0.93)	(11.76)
Head Marital Status (Excludes- Never Married								
Married	-0.545	-1.274**	-1.149	-0.945**	-1.197	-0.378	-1.198*	0.646
	(-0.79)	(-2.10)	(-1.50)	(-2.16)	(-1.34)	(-0.50)	(-1.93)	(0.99)
Other status	-0.639	-1.152**	-0.900	-0.786*	-0.863	-0.779	-1.091*	0.432
	(-0.95)	(-1.97)	(-1.20)	(-1.88)	(-0.99)	(-1.05)	(-1.83)	(0.67)
Ln Head Age	-0.504	0.018	0.492	0.215	1.051	0.187	0.160	-0.228
	(-0.75)	(0.04)	(0.65)	(0.65)	(1.32)	(0.36)	(0.31)	(-0.36)
Land Rights Document	0.099	-0.221**	0.041	0.056	-0.177	0.164	0.011	0.013
	(0.81)	(-2.31)	(0.31)	(0.76)	(-1.21)	(1.27)	(0.14)	(0.10)
Ln TLUs	0.078	0.078	0.067	0.082*	-0.035	0.325***	0.046	-0.013
	(0.95)	(1.10)	(0.64)	(1.86)	(-0.30)	(3.88)	(0.71)	(-0.11)
Ln Adult Equivalent	-0.422	0.638**	0.608*	-0.161	0.227	-0.300	0.405	0.052
	(-1.30)	(2.42)	(1.68)	(-0.85)	(0.56)	(-0.95)	(1.53)	(0.14)
Ln Land Size (ha)	-0.073	0.107	0.103	-0.032	0.301*	0.016	0.021	-0.096
	(-0.60)	(1.17)	(0.77)	(-0.46)	(1.85)	(0.13)	(0.26)	(-0.57)
Ln Ag Wage Income	-0.006	-0.001	-0.012	0.002	0.002	0.008	-0.005	-0.021*
	(-0.60)	(-0.14)	(-1.19)	(0.38)	(0.16)	(0.83)	(-0.74)	(-1.85)
Ln Transfer Income	-0.000	-0.004	-0.008	-0.007	-0.023*	0.003	0.002	0.010
	(-0.04)	(-0.59)	(-0.79)	(-1.37)	(-1.90)	(0.28)	(0.34)	(0.95)
Ln Nonfarm Income	0.012	0.020***	0.003	0.002	0.010	0.001	-0.001	0.003
	(1.46)	(3.00)	(0.35)	(0.44)	(0.94)	(0.16)	(-0.22)	(0.27)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.4: Effects of Land Productivity on School Expenditure and Study Times (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.217**	**0.320**	**0.938****	**0.205**	**1.552*****	**0.267**	**0.617***	**0.354**
	(-0.65)	**(1.00)**	**(2.21)**	**(1.08)**	**(2.64)**	**(0.80)**	**(1.88)**	**(1.28)**
Relationship to Head (Excludes Spouse)								
Child	0.861	-1.064	2.033	-0.737*	4.175*	-1.253*	0.627	1.246
	(0.41)	(-0.68)	(0.98)	(-1.72)	(1.65)	(-1.74)	(0.35)	(1.51)
Grandchild	1.075	-1.812	1.342	-0.903	2.819	-0.871	0.130	0.847
	(0.49)	(-1.07)	(0.58)	(-1.62)	(1.02)	(-0.91)	(0.07)	(1.01)
Relative	0.847	-1.880	1.108	-0.918*	2.987	-1.565*	0.041	0.152
	(0.39)	(-1.13)	(0.50)	(-1.82)	(1.13)	(-1.78)	(0.02)	(0.22)
Non-relative	0.157	-2.126	0.862	-1.129**	2.899	-1.948**	-0.332	0.000
	(0.07)	(-1.30)	(0.38)	(-2.23)	(1.05)	(-2.24)	(-0.17)	(.)
Marital Status (Excludes Never Married)								
Married	0.766	3.029	3.675	-1.154*	9.916**	-1.073	1.266	-1.551
	(0.42)	(1.17)	(1.63)	(-1.77)	(2.40)	(-0.97)	(0.62)	(-0.57)
Other status	-1.976*	-1.280*	-0.713	-1.119**	0.440	-2.395***	-1.658*	-0.050
	(-1.93)	(-1.73)	(-0.63)	(-2.01)	(0.31)	(-3.81)	(-1.85)	(-0.07)
Female Head	0.018	0.179	0.211	-0.065	0.616	0.327	0.159	0.140
	(0.04)	(0.46)	(0.39)	(-0.30)	(0.78)	(0.85)	(0.41)	(0.31)
Head Education (Excludes - No Education)								
Primary	-0.086	-0.101	0.512*	0.034	0.519	-0.141	0.126	-0.712**
	(-0.54)	(-0.59)	(1.94)	(0.37)	(1.39)	(-0.84)	(0.73)	(-2.35)
Secondary	-0.346	-0.192	-0.169	-0.166	0.547	-0.632	-0.122	-0.285
	(-0.79)	(-0.59)	(-0.38)	(-0.75)	(0.78)	(-1.64)	(-0.40)	(-0.59)
Post-Secondary	1.079	1.559	-3.692	1.369	2.908*	3.275	1.367	5.664***
	(0.66)	(1.12)	(-1.22)	(0.93)	(1.80)	(1.13)	(0.73)	(10.81)
Head Marital Status (Excludes- Never Married								
Married	-0.422	-1.462**	-1.700*	-1.067**	-2.106*	-0.537	-1.562**	0.901
	(-0.56)	(-2.26)	(-1.79)	(-2.22)	(-1.78)	(-0.67)	(-2.25)	(1.30)
Other status	-0.476	-1.391**	-1.602*	-0.939**	-2.024*	-0.977	-1.552**	0.646
	(-0.63)	(-2.15)	(-1.68)	(-1.98)	(-1.69)	(-1.24)	(-2.24)	(0.96)
Ln Head Age	-0.795	0.336	1.459	0.399	2.691**	0.417	0.771	0.036
	(-1.01)	(0.49)	(1.37)	(0.94)	(2.00)	(0.67)	(1.03)	(0.05)
Land Rights Document	0.014	-0.119	0.349*	0.117	0.341	0.242	0.208	0.048
	(0.08)	(-0.82)	(1.73)	(1.17)	(1.24)	(1.43)	(1.50)	(0.34)
Ln TLUs	0.232	-0.133	-0.556*	-0.051	-1.073**	0.154	-0.361	-0.304
	(0.98)	(-0.57)	(-1.73)	(-0.37)	(-2.38)	(0.63)	(-1.48)	(-1.20)
Ln Adult Equivalent	-0.356	0.548*	0.342	-0.218	-0.216	-0.373	0.231	-0.075
	(-1.02)	(1.89)	(0.78)	(-1.02)	(-0.37)	(-1.13)	(0.71)	(-0.18)
Ln Land Size (ha)	-0.185	0.296	0.651**	0.094	1.200***	0.182	0.387*	0.225
	(-0.79)	(1.42)	(2.25)	(0.75)	(2.87)	(0.75)	(1.83)	(0.72)
Ln Ag Wage Income	-0.005	-0.001	-0.013	0.002	0.001	0.008	-0.006	-0.022*
	(-0.58)	(-0.17)	(-1.10)	(0.33)	(0.04)	(0.79)	(-0.71)	(-1.81)
Ln Transfer Income	0.002	-0.007	-0.015	-0.008	-0.034**	0.001	-0.002	0.013
	(0.15)	(-0.80)	(-1.16)	(-1.51)	(-2.04)	(0.13)	(-0.24)	(1.11)
Ln Nonfarm Income	0.013	0.019***	-0.001	0.001	0.004	0.000	-0.004	-0.000
	(1.51)	(2.70)	(-0.06)	(0.25)	(0.29)	(0.03)	(-0.58)	(-0.04)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.5: Effects of Labor Productivity on School Expenditure and Study Times (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.433**	**0.638**	**1.873****	**0.410**	**3.097****	**0.532**	**1.232***	**1.029**
	(-0.64)	**(0.99)**	**(2.02)**	**(1.06)**	**(2.31)**	**(0.79)**	**(1.77)**	**(1.17)**
Relationship to Head (Excludes Spouse)								
Child	1.258	-1.649	0.315	-1.112	1.334	-1.741	-0.502	0.567
	(0.54)	(-0.99)	(0.10)	(-1.39)	(0.28)	(-1.33)	(-0.22)	(0.58)
Grandchild	1.474	-2.400	-0.384	-1.281	-0.036	-1.362	-1.006	0.337
	(0.60)	(-1.29)	(-0.11)	(-1.38)	(-0.01)	(-0.88)	(-0.41)	(0.31)
Relative	1.265	-2.497	-0.702	-1.314	-0.006	-2.080	-1.149	-0.482
	(0.51)	(-1.36)	(-0.21)	(-1.45)	(-0.00)	(-1.38)	(-0.48)	(-0.50)
Non-relative	0.485	-2.611	-0.561	-1.440*	0.546	-2.352*	-1.267	0.000
	(0.21)	(-1.59)	(-0.18)	(-1.85)	(0.11)	(-1.81)	(-0.56)	(.)
Marital Status (Excludes Never Married)								
Married	1.052	2.607	2.437	-1.425**	7.869*	-1.425	0.452	-0.459
	(0.62)	(1.04)	(1.14)	(-2.18)	(1.65)	(-1.25)	(0.22)	(-0.12)
Other status	-1.785*	-1.563**	-1.543	-1.301**	-0.933	-2.631***	-2.204***	-0.519
	(-1.73)	(-2.27)	(-1.40)	(-2.10)	(-0.62)	(-4.01)	(-2.68)	(-0.53)
Female Head	-0.083	0.329	0.652	0.031	1.344	0.452	0.448	0.433
	(-0.15)	(0.64)	(0.88)	(0.11)	(1.23)	(0.89)	(0.83)	(0.68)
Head Education (Excludes - No Education)								
Primary	-0.118	-0.054	0.650**	0.064	0.746*	-0.102	0.217	-0.602**
	(-0.69)	(-0.29)	(2.18)	(0.65)	(1.70)	(-0.56)	(1.07)	(-1.98)
Secondary	-0.405	-0.106	0.084	-0.110	0.966	-0.560	0.045	-0.318
	(-0.92)	(-0.31)	(0.16)	(-0.50)	(1.20)	(-1.36)	(0.12)	(-0.56)
Post-Secondary	0.883	1.848	-2.842	1.555	4.313***	3.516	1.926	6.833**
	(0.53)	(1.34)	(-0.93)	(1.06)	(2.82)	(1.26)	(1.05)	(6.68)
Head Marital Status (Excludes- Never Married								
Married	-0.574	-1.236*	-1.038	-0.922**	-1.012	-0.349	-1.127	1.571
	(-0.73)	(-1.89)	(-0.99)	(-2.05)	(-0.61)	(-0.46)	(-1.41)	(1.22)
Other status	-0.629	-1.164*	-0.937	-0.794*	-0.925	-0.788	-1.115	1.307
	(-0.82)	(-1.83)	(-0.91)	(-1.83)	(-0.56)	(-1.08)	(-1.43)	(1.03)
Ln Head Age	-1.087	0.767	2.722*	0.675	4.781**	0.776	1.601	-0.209
	(-1.00)	(0.75)	(1.72)	(1.08)	(2.21)	(0.80)	(1.39)	(-0.22)
Land Rights Document	-0.028	-0.057	0.529*	0.157	0.639	0.293	0.327	0.092
	(-0.13)	(-0.29)	(1.84)	(1.20)	(1.50)	(1.35)	(1.58)	(0.54)
Ln TLUs	0.161	-0.027	-0.248	0.017	-0.562*	0.241	-0.158	-0.249
	(1.14)	(-0.19)	(-1.11)	(0.20)	(-1.73)	(1.64)	(-0.98)	(-1.07)
Ln Adult Equivalent	-0.383	0.587**	0.458	-0.192	-0.024	-0.340	0.308	-0.303
	(-1.12)	(2.03)	(0.96)	(-0.92)	(-0.04)	(-1.04)	(0.90)	(-0.54)
Ln Land Size (ha)	0.050	-0.051	-0.367	-0.129	-0.484	-0.108	-0.283	0.027
	(0.24)	(-0.26)	(-1.19)	(-1.03)	(-1.06)	(-0.52)	(-1.29)	(0.12)
Ln Ag Wage Income	-0.006	0.000	-0.009	0.003	0.008	0.009	-0.003	-0.017
	(-0.67)	(0.00)	(-0.68)	(0.49)	(0.43)	(0.91)	(-0.33)	(-1.21)
Ln Transfer Income	0.004	-0.010	-0.024	-0.010	-0.050**	-0.001	-0.008	0.006
	(0.32)	(-0.98)	(-1.48)	(-1.60)	(-2.24)	(-0.11)	(-0.75)	(0.48)
Ln Nonfarm Income	0.012	0.020***	0.004	0.002	0.011	0.002	-0.001	0.012
	(1.40)	(2.87)	(0.33)	(0.45)	(0.70)	(0.17)	(-0.10)	(0.88)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.6: Effects of Land Productivity on School Expenditure and Study Times by Gender (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.043***	**0.006**	**0.000**	**-0.008**	**-0.033**	**0.036**	**0.015**	**-0.040**
	(1.89)	**(0.25)**	**(0.01)**	**(-0.47)**	**(-1.02)**	**(1.48)**	**(0.72)**	**(-1.51)**
Female X Log Labor Productivity	**0.033**	**-0.010**	**0.052**	**0.052****	**0.013**	**-0.032**	**0.011**	**0.068***
	(0.89)	**(-0.33)**	**(1.28)**	**(2.15)**	**(0.29)**	**(-0.86)**	**(0.41)**	**(1.71)**
Relationship to Head (Excludes Spouse)								
Child	0.551	-0.712	3.016*	-0.546	5.896***	-0.975**	1.277	1.212
	(0.29)	(-0.43)	(1.82)	(-1.39)	(3.84)	(-2.08)	(0.67)	(1.54)
Grandchild	0.612	-1.283	2.832	-0.608	5.415***	-0.457	1.110	1.046
	(0.31)	(-0.76)	(1.58)	(-1.32)	(3.26)	(-0.69)	(0.57)	(1.36)
Relative	0.403	-1.372	2.544	-0.631	5.487***	-1.168**	0.985	0.327
	(0.21)	(-0.81)	(1.47)	(-1.56)	(3.44)	(-2.11)	(0.51)	(0.51)
Non-relative	-0.072	-1.876	1.539	-1.010**	4.107**	-1.743**	0.122	0.000
	(-0.04)	(-1.07)	(0.82)	(-2.09)	(2.25)	(-2.49)	(0.06)	(.)
Marital Status (Excludes Never Married)								
Married	1.343	2.383	1.896	-1.486*	6.776***	-1.591***	0.083	-4.762***
	(0.96)	(1.12)	(1.01)	(-1.80)	(3.19)	(-2.96)	(0.05)	(-11.86)
Other status	-1.826*	-1.444**	-1.154	-1.196**	-0.349	-2.530***	-1.954**	0.006
	(-1.81)	(-2.08)	(-1.11)	(-2.10)	(-0.30)	(-3.68)	(-2.37)	(0.01)
Female Head	0.245	-0.079	-0.514	-0.209	-0.651	0.124	-0.319	-0.104
	(0.80)	(-0.30)	(-1.52)	(-1.37)	(-1.60)	(0.46)	(-1.35)	(-0.30)
Head Education (Excludes - No Education)								
Primary	-0.079	-0.114	0.460**	0.015	0.441*	-0.147	0.096	-0.495**
	(-0.51)	(-0.71)	(2.06)	(0.18)	(1.71)	(-0.91)	(0.67)	(-2.31)
Secondary	-0.388	-0.156	-0.105	-0.172	0.694	-0.594	-0.069	-0.180
	(-0.93)	(-0.50)	(-0.29)	(-0.84)	(1.38)	(-1.55)	(-0.26)	(-0.39)
Post-Secondary	0.948	1.695	-3.349	1.416	3.544***	3.393	1.604	5.758***
	(0.57)	(1.27)	(-1.15)	(0.98)	(2.85)	(1.21)	(0.91)	(11.70)
Head Marital Status (Excludes- Never Married								
Married	-0.573	-1.278**	-1.149	-0.941**	-1.176	-0.402	-1.209*	0.671
	(-0.83)	(-2.11)	(-1.50)	(-2.15)	(-1.31)	(-0.52)	(-1.94)	(1.03)
Other status	-0.675	-1.154**	-0.909	-0.788*	-0.842	-0.800	-1.104*	0.449
	(-0.99)	(-1.97)	(-1.22)	(-1.89)	(-0.96)	(-1.08)	(-1.85)	(0.70)
Ln Head Age	-0.489	-0.002	0.541	0.235	1.058	0.143	0.157	-0.231
	(-0.72)	(-0.00)	(0.72)	(0.71)	(1.32)	(0.28)	(0.31)	(-0.36)
Land Rights Document	0.104	-0.224**	0.047	0.055	-0.180	0.161	0.011	0.009
	(0.85)	(-2.35)	(0.36)	(0.75)	(-1.23)	(1.25)	(0.14)	(0.07)
Ln TLUs	0.047	0.081	0.049	0.071	-0.022	0.320***	0.036	-0.020
	(0.56)	(1.12)	(0.46)	(1.61)	(-0.19)	(3.80)	(0.55)	(-0.17)
Ln Adult Equivalent	-0.436	0.639**	0.599*	-0.166	0.233	-0.302	0.401	0.061
	(-1.35)	(2.43)	(1.66)	(-0.88)	(0.58)	(-0.95)	(1.51)	(0.16)
Ln Land Size (ha)	-0.025	0.111	0.119	-0.016	0.280*	0.039	0.039	-0.097
	(-0.21)	(1.21)	(0.88)	(-0.23)	(1.72)	(0.30)	(0.50)	(-0.58)
Ln Ag Wage Income	-0.006	-0.001	-0.012	0.002	0.002	0.008	-0.005	-0.021*
	(-0.60)	(-0.15)	(-1.18)	(0.41)	(0.17)	(0.81)	(-0.74)	(-1.82)
Ln Transfer Income	-0.000	-0.004	-0.009	-0.007	-0.023*	0.003	0.002	0.010
	(-0.04)	(-0.58)	(-0.81)	(-1.37)	(-1.90)	(0.31)	(0.35)	(0.96)
Ln Nonfarm Income	0.012	0.020***	0.003	0.002	0.010	0.001	-0.001	0.003
	(1.44)	(3.00)	(0.35)	(0.45)	(0.95)	(0.14)	(-0.23)	(0.27)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.7: Effects of Labor Productivity on School Expenditure and Study Times by Gender (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.063**	**0.051**	**-0.037**	**-0.016**	**-0.043**	**0.073***	**0.022**	**-0.026**
	(1.52)	**(1.40)**	**(-0.82)**	**(-0.53)**	**(-0.85)**	**(1.73)**	**(0.73)**	**(-0.56)**
Female X Log Labor Productivity	**-0.015**	**-0.074**	**0.085**	**0.077****	**0.040**	**-0.063**	**0.006**	**0.024**
	(-0.26)	**(-1.62)**	**(1.39)**	**(1.97)**	**(0.59)**	**(-1.14)**	**(0.17)**	**(0.36)**
Relationship to Head (Excludes Spouse)								
Child	0.551	-0.694	3.005*	-0.588	5.883***	-0.988**	1.262	1.216
	(0.29)	(-0.42)	(1.81)	(-1.47)	(3.83)	(-2.08)	(0.66)	(1.54)
Grandchild	0.631	-1.265	2.829	-0.650	5.392***	-0.466	1.098	1.053
	(0.32)	(-0.74)	(1.57)	(-1.40)	(3.25)	(-0.70)	(0.57)	(1.36)
Relative	0.414	-1.356	2.539	-0.676	5.466***	-1.179**	0.972	0.326
	(0.21)	(-0.79)	(1.46)	(-1.64)	(3.43)	(-2.11)	(0.50)	(0.51)
Non-relative	-0.064	-1.849	1.525	-1.046**	4.095**	-1.750**	0.110	0.000
	(-0.03)	(-1.05)	(0.81)	(-2.14)	(2.25)	(-2.48)	(0.05)	(.)
Marital Status (Excludes Never Married)								
Married	1.218	2.401	1.796	-1.562*	6.806***	-1.587***	0.042	-5.041***
	(0.85)	(1.13)	(0.96)	(-1.85)	(3.21)	(-2.94)	(0.02)	(-14.57)
Other status	-1.878*	-1.443**	-1.186	-1.228**	-0.336	-2.537***	-1.973**	0.009
	(-1.86)	(-2.09)	(-1.14)	(-2.11)	(-0.29)	(-3.69)	(-2.40)	(0.01)
Female Head	0.224	-0.087	-0.518	-0.196	-0.636	0.123	-0.319	-0.117
	(0.73)	(-0.33)	(-1.54)	(-1.29)	(-1.57)	(0.45)	(-1.36)	(-0.33)
Head Education (Excludes - No Education)								
Primary	-0.069	-0.108	0.459**	0.018	0.438*	-0.143	0.098	-0.491**
	(-0.45)	(-0.66)	(2.06)	(0.21)	(1.70)	(-0.88)	(0.69)	(-2.30)
Secondary	-0.359	-0.140	-0.101	-0.164	0.685	-0.586	-0.061	-0.165
	(-0.85)	(-0.45)	(-0.28)	(-0.80)	(1.36)	(-1.52)	(-0.23)	(-0.36)
Post-Secondary	1.008	1.711	-3.329	1.439	3.525***	3.409	1.624	5.793***
	(0.60)	(1.29)	(-1.15)	(1.00)	(2.83)	(1.22)	(0.92)	(11.77)
Head Marital Status (Excludes- Never Married								
Married	-0.545	-1.270**	-1.153	-0.949**	-1.199	-0.375	-1.199*	0.650
	(-0.79)	(-2.10)	(-1.51)	(-2.16)	(-1.34)	(-0.49)	(-1.93)	(1.00)
Other status	-0.637	-1.145*	-0.909	-0.793*	-0.867	-0.773	-1.092*	0.435
	(-0.94)	(-1.96)	(-1.22)	(-1.89)	(-0.99)	(-1.04)	(-1.83)	(0.68)
Ln Head Age	-0.511	-0.017	0.532	0.251	1.070	0.158	0.162	-0.217
	(-0.76)	(-0.03)	(0.70)	(0.75)	(1.34)	(0.30)	(0.32)	(-0.34)
Land Rights Document	0.100	-0.219**	0.039	0.054	-0.178	0.166	0.011	0.013
	(0.81)	(-2.28)	(0.29)	(0.72)	(-1.22)	(1.29)	(0.14)	(0.09)
Ln TLUs	0.079	0.080	0.066	0.080*	-0.036	0.326***	0.046	-0.015
	(0.95)	(1.13)	(0.63)	(1.82)	(-0.31)	(3.91)	(0.71)	(-0.13)
Ln Adult Equivalent	-0.422	0.637**	0.610*	-0.160	0.228	-0.301	0.405	0.052
	(-1.30)	(2.42)	(1.69)	(-0.85)	(0.57)	(-0.95)	(1.53)	(0.14)
Ln Land Size (ha)	-0.072	0.112	0.097	-0.037	0.298*	0.021	0.020	-0.096
	(-0.59)	(1.23)	(0.72)	(-0.54)	(1.83)	(0.16)	(0.26)	(-0.57)
Ln Ag Wage Income	-0.005	-0.001	-0.012	0.002	0.002	0.008	-0.005	-0.021*
	(-0.60)	(-0.13)	(-1.20)	(0.37)	(0.15)	(0.84)	(-0.74)	(-1.85)
Ln Transfer Income	-0.000	-0.004	-0.008	-0.007	-0.023*	0.003	0.002	0.010
	(-0.04)	(-0.58)	(-0.80)	(-1.38)	(-1.90)	(0.29)	(0.34)	(0.96)
Ln Nonfarm Income	0.012	0.020***	0.003	0.002	0.010	0.001	-0.001	0.003
	(1.46)	(2.98)	(0.37)	(0.47)	(0.95)	(0.14)	(-0.22)	(0.26)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.8: Effects of Land Productivity on School Expenditure and Study Times by Gender (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.178**	**0.643***	**1.028****	**0.095**	**1.300****	**-0.272**	**0.783****	**-0.409**
	(-0.56)	**(1.66)**	**(2.30)**	**(0.47)**	**(2.23)**	**(-0.77)**	**(2.06)**	**(-0.27)**
Log Land Productivity X Female	**-0.031**	**-1.074**	**-0.298**	**0.367**	**0.837**	**1.788**	**-0.550**	**5.161**
	(-0.03)	**(-1.31)**	**(-0.26)**	**(0.59)**	**(0.42)**	**(1.22)**	**(-0.75)**	**(0.32)**
Relationship to Head (Excludes Spouse)								
Child	0.755	-0.535	2.179	-0.917	3.763	-2.133	0.898	2.318
	(0.36)	(-0.25)	(1.06)	(-1.28)	(1.10)	(-0.86)	(0.47)	(0.33)
Grandchild	0.906	-1.179	1.518	-1.119	2.326	-1.924	0.454	0.000
	(0.41)	(-0.52)	(0.65)	(-1.30)	(0.62)	(-0.71)	(0.23)	(.)
Relative	0.695	-1.325	1.262	-1.107	2.554	-2.491	0.326	0.591
	(0.32)	(-0.60)	(0.57)	(-1.39)	(0.71)	(-0.96)	(0.16)	(0.11)
Non-relative	0.034	-1.436	1.053	-1.364*	2.361	-3.097	0.022	0.142
	(0.02)	(-0.65)	(0.47)	(-1.70)	(0.64)	(-1.19)	(0.01)	(0.03)
Marital Status (Excludes Never Married)								
Married	0.792	1.718	3.311	-0.707	10.938*	1.110	0.594	41.754
	(0.37)	(0.77)	(1.25)	(-0.66)	(1.84)	(0.27)	(0.29)	(0.29)
Other status	-1.980*	-1.761**	-0.846	-0.955	0.815	-1.594	-1.905**	-0.289
	(-1.75)	(-2.16)	(-0.68)	(-1.55)	(0.43)	(-1.52)	(-2.07)	(-0.20)
Female Head	0.016	-0.142	0.122	0.045	0.866	0.861	-0.006	2.667
	(0.03)	(-0.28)	(0.18)	(0.13)	(0.73)	(1.05)	(-0.01)	(0.30)
Head Education (Excludes - No Education)								
Primary	-0.095	0.079	0.562*	-0.028	0.379	-0.441	0.219	-2.603
	(-0.42)	(0.35)	(1.75)	(-0.20)	(0.73)	(-1.24)	(1.05)	(-0.38)
Secondary	-0.355	0.327	-0.026	-0.343	0.142	-1.496	0.144	-2.668
	(-0.55)	(0.64)	(-0.04)	(-0.84)	(0.12)	(-1.61)	(0.33)	(-0.33)
Post-Secondary	1.087	2.255	-3.499	1.131	2.366	2.115	1.724	1.473
	(0.60)	(1.61)	(-1.12)	(0.72)	(1.05)	(0.61)	(0.92)	(0.10)
Head Marital Status (Excludes- Never Married								
Married	-0.456	-1.662**	-1.755*	-0.999**	-1.950	-0.204	-1.664**	3.491
	(-0.61)	(-2.29)	(-1.80)	(-2.13)	(-1.64)	(-0.25)	(-2.29)	(0.39)
Other status	-0.517	-1.456**	-1.620*	-0.917**	-1.974*	-0.869	-1.586**	2.446
	(-0.70)	(-2.05)	(-1.67)	(-2.00)	(-1.67)	(-1.07)	(-2.22)	(0.38)
Ln Head Age	-0.786	-0.524	1.220	0.693	3.362	1.850	0.330	1.514
	(-0.72)	(-0.52)	(0.81)	(0.93)	(1.39)	(1.07)	(0.35)	(0.24)
Land Rights Document	0.008	-0.175	0.334	0.137	0.385	0.336	0.180	-0.103
	(0.05)	(-1.05)	(1.52)	(1.15)	(1.11)	(1.28)	(1.24)	(-0.19)
Ln TLUs	0.202	0.068	-0.501	-0.119	-1.229	-0.180	-0.258	-2.463
	(0.66)	(0.22)	(-1.15)	(-0.53)	(-1.64)	(-0.33)	(-0.91)	(-0.33)
Ln Adult Equivalent	-0.331	0.654*	0.371	-0.254	-0.298	-0.549	0.286	0.170
	(-0.92)	(1.96)	(0.81)	(-1.06)	(-0.44)	(-1.20)	(0.85)	(0.12)
Ln Land Size (ha)	-0.165	0.191	0.622*	0.130	1.282**	0.357	0.333	2.049
	(-0.64)	(0.77)	(1.86)	(0.78)	(2.29)	(0.89)	(1.49)	(0.31)
Ln Ag Wage Income	-0.007	-0.005	-0.014	0.003	0.004	0.014	-0.008	-0.008
	(-0.68)	(-0.58)	(-1.14)	(0.50)	(0.20)	(1.07)	(-0.93)	(-0.12)
Ln Transfer Income	0.001	-0.003	-0.014	-0.009	-0.037*	-0.004	-0.000	0.038
	(0.10)	(-0.38)	(-1.05)	(-1.52)	(-1.88)	(-0.28)	(-0.04)	(0.45)
Ln Nonfarm Income	0.013	0.017**	-0.001	0.002	0.005	0.003	-0.004	-0.027
	(1.54)	(2.36)	(-0.11)	(0.34)	(0.36)	(0.27)	(-0.71)	(-0.28)
Observations	11061	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.9: Effects of Labor Productivity on School Expenditure and Study Times by Gender (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.334**	**1.205**	**1.945****	**0.185**	**2.477***	**-0.491**	**1.477***	**1.660**
	(-0.56)	**(1.56)**	**(2.14)**	**(0.47)**	**(1.93)**	**(-0.71)**	**(1.95)**	**(0.23)**
Log Labor Productivity X Female	**-0.102**	**-1.832**	**-0.235**	**0.727**	**2.005**	**3.307**	**-0.793**	**-13.717**
	(-0.06)	**(-1.19)**	**(-0.10)**	**(0.58)**	**(0.43)**	**(1.05)**	**(-0.55)**	**(-0.22)**
Relationship to Head (Excludes Spouse)								
Child	1.118	-0.153	0.507	-1.706	-0.304	-4.443	0.146	2.146
	(0.40)	(-0.05)	(0.13)	(-0.93)	(-0.04)	(-0.84)	(0.06)	(0.37)
Grandchild	1.272	-0.720	-0.168	-1.947	-1.875	-4.393	-0.279	4.238
	(0.42)	(-0.23)	(-0.04)	(-0.96)	(-0.21)	(-0.77)	(-0.10)	(0.27)
Relative	1.069	-0.856	-0.492	-1.964	-1.803	-5.042	-0.439	1.236
	(0.36)	(-0.28)	(-0.12)	(-0.99)	(-0.21)	(-0.90)	(-0.17)	(0.21)
Non-relative	0.352	-1.065	-0.362	-2.053	-1.147	-5.143	-0.598	0.000
	(0.12)	(-0.38)	(-0.09)	(-1.14)	(-0.14)	(-0.99)	(-0.25)	(.)
Marital Status (Excludes Never Married)								
Married	1.099	2.633	2.440	-1.435	7.840	-1.472	0.463	-58.381
	(0.67)	(1.30)	(1.23)	(-1.63)	(1.20)	(-0.35)	(0.27)	(-0.23)
Other status	-1.798*	-1.479**	-1.532	-1.334**	-1.025	-2.782***	-2.168***	4.054
	(-1.74)	(-2.01)	(-1.39)	(-2.00)	(-0.59)	(-2.91)	(-2.68)	(0.21)
Female Head	-0.107	-0.340	0.566	0.297	2.076	1.659	0.159	-6.161
	(-0.11)	(-0.40)	(0.43)	(0.44)	(0.83)	(0.98)	(0.20)	(-0.21)
Head Education (Excludes - No Education)								
Primary	-0.126	0.098	0.669**	0.003	0.580	-0.376	0.282	1.810
	(-0.61)	(0.42)	(2.01)	(0.02)	(1.02)	(-1.08)	(1.27)	(0.17)
Secondary	-0.399	0.351	0.143	-0.291	0.466	-1.385	0.243	5.017
	(-0.66)	(0.69)	(0.19)	(-0.72)	(0.34)	(-1.47)	(0.51)	(0.21)
Post-Secondary	0.896	2.217*	-2.795	1.408	3.909**	2.850	2.085	-2.534
	(0.51)	(1.66)	(-0.91)	(0.95)	(2.15)	(0.98)	(1.12)	(-0.06)
Head Marital Status (Excludes- Never Married								
Married	-0.592	-1.167	-1.029	-0.950*	-1.088	-0.475	-1.097	-6.812
	(-0.77)	(-1.55)	(-0.99)	(-1.89)	(-0.58)	(-0.45)	(-1.42)	(-0.19)
Other status	-0.654	-0.981	-0.914	-0.866*	-1.125	-1.118	-1.036	-6.325
	(-0.85)	(-1.31)	(-0.87)	(-1.72)	(-0.59)	(-1.03)	(-1.35)	(-0.19)
Ln Head Age	-1.077	-0.561	2.551	1.202	6.233	3.172	1.027	-6.513
	(-0.60)	(-0.33)	(0.95)	(0.89)	(1.23)	(0.93)	(0.63)	(-0.22)
Land Rights Document	-0.028	-0.099	0.524*	0.173	0.684	0.368	0.309	0.048
	(-0.14)	(-0.44)	(1.70)	(1.10)	(1.26)	(1.02)	(1.47)	(0.07)
Ln TLUs	0.140	0.077	-0.234	-0.025	-0.677	0.053	-0.113	2.493
	(0.74)	(0.41)	(-0.79)	(-0.17)	(-1.21)	(0.14)	(-0.61)	(0.21)
Ln Adult Equivalent	-0.378	0.594*	0.459	-0.195	-0.032	-0.352	0.311	1.852
	(-1.13)	(1.86)	(0.97)	(-0.87)	(-0.04)	(-0.77)	(0.92)	(0.21)
Ln Land Size (ha)	0.056	0.177	-0.338	-0.219	-0.733	-0.519	-0.184	-0.518
	(0.17)	(0.56)	(-0.68)	(-0.88)	(-0.77)	(-0.82)	(-0.61)	(-0.20)
Ln Ag Wage Income	-0.008	0.001	-0.009	0.002	0.006	0.007	-0.002	-0.033
	(-0.81)	(0.14)	(-0.67)	(0.37)	(0.32)	(0.50)	(-0.27)	(-0.43)
Ln Transfer Income	0.003	-0.005	-0.024	-0.012	-0.055*	-0.010	-0.006	-0.021
	(0.21)	(-0.42)	(-1.27)	(-1.43)	(-1.75)	(-0.49)	(-0.52)	(-0.13)
Ln Nonfarm Income	0.012	0.017**	0.003	0.004	0.015	0.009	-0.002	-0.041
	(1.26)	(1.97)	(0.27)	(0.63)	(0.75)	(0.64)	(-0.32)	(-0.19)
Observations	11061	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.10: Effects of Land Productivity on School Expenditure and Study Times by Gender of Head (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.027**	**0.008**	**0.016**	**0.016**	**-0.016**	**0.021**	**0.025**	**-0.003**
	(1.27)	**(0.39)**	**(0.66)**	**(1.04)**	**(-0.60)**	**(0.98)**	**(1.59)**	**(-0.10)**
Female Head X Log Land Productivity	**0.111*** **	**-0.025**	**0.037**	**0.008**	**-0.035**	**-0.003**	**-0.015**	**-0.015**
	(2.77)	**(-0.81)**	**(0.83)**	**(0.31)**	**(-0.70)**	**(-0.07)**	**(-0.56)**	**(-0.35)**
Relationship to Head (Excludes Spouse)								
Child	0.458	-0.692	2.996*	-0.539	5.932***	-0.981**	1.294	1.199
	(0.24)	(-0.42)	(1.83)	(-1.32)	(3.86)	(-2.05)	(0.67)	(1.52)
Grandchild	0.510	-1.261	2.808	-0.602	5.453***	-0.462	1.128	1.051
	(0.26)	(-0.74)	(1.58)	(-1.27)	(3.28)	(-0.69)	(0.58)	(1.36)
Relative	0.289	-1.347	2.514	-0.629	5.528***	-1.171**	1.004	0.313
	(0.15)	(-0.80)	(1.47)	(-1.50)	(3.46)	(-2.08)	(0.51)	(0.49)
Non-relative	-0.175	-1.854	1.524	-0.993**	4.151**	-1.755**	0.144	0.000
	(-0.09)	(-1.06)	(0.82)	(-2.00)	(2.28)	(-2.48)	(0.07)	(.)
Marital Status (Excludes Never Married)								
Married	1.200	2.418	1.815	-1.537*	6.801***	-1.562***	0.091	-5.057***
	(0.86)	(1.13)	(0.96)	(-1.75)	(3.21)	(-2.84)	(0.05)	(-13.78)
Other status	-1.850*	-1.438**	-1.176	-1.215**	-0.350	-2.519***	-1.956**	0.004
	(-1.82)	(-2.08)	(-1.13)	(-2.11)	(-0.30)	(-3.68)	(-2.38)	(0.01)
Female Head	-1.027*	0.208	-0.943	-0.305	-0.257	0.162	-0.145	0.048
	(-1.85)	(0.47)	(-1.59)	(-0.87)	(-0.35)	(0.32)	(-0.38)	(0.08)
Head Education (Excludes - No Education)								
Primary	-0.082	-0.114	0.466**	0.024	0.446*	-0.152	0.099	-0.484**
	(-0.54)	(-0.71)	(2.09)	(0.28)	(1.73)	(-0.94)	(0.69)	(-2.26)
Secondary	-0.404	-0.154	-0.091	-0.150	0.709	-0.608	-0.059	-0.158
	(-0.97)	(-0.50)	(-0.25)	(-0.74)	(1.42)	(-1.58)	(-0.23)	(-0.35)
Post-Secondary	0.926	1.698	-3.333	1.442	3.565***	3.376	1.616	5.803***
	(0.56)	(1.27)	(-1.15)	(1.00)	(2.86)	(1.20)	(0.92)	(11.82)
Head Marital Status (Excludes- Never Married								
Married	-0.606	-1.270**	-1.173	-0.959**	-1.173	-0.392	-1.209*	0.653
	(-0.88)	(-2.09)	(-1.53)	(-2.17)	(-1.30)	(-0.51)	(-1.94)	(1.01)
Other status	-0.700	-1.148**	-0.926	-0.800*	-0.839	-0.793	-1.103*	0.439
	(-1.04)	(-1.96)	(-1.24)	(-1.90)	(-0.96)	(-1.07)	(-1.85)	(0.68)
Ln Head Age	-0.429	-0.014	0.537	0.210	1.026	0.159	0.139	-0.240
	(-0.64)	(-0.03)	(0.71)	(0.63)	(1.28)	(0.31)	(0.27)	(-0.38)
Land Rights Document	0.108	-0.225**	0.049	0.056	-0.181	0.161	0.011	0.015
	(0.87)	(-2.36)	(0.37)	(0.76)	(-1.23)	(1.24)	(0.14)	(0.11)
Ln TLUs	0.065	0.076	0.057	0.075*	-0.026	0.318***	0.034	-0.012
	(0.78)	(1.07)	(0.54)	(1.68)	(-0.22)	(3.77)	(0.53)	(-0.11)
Ln Adult Equivalent	-0.456	0.644**	0.594*	-0.166	0.240	-0.302	0.404	0.051
	(-1.41)	(2.45)	(1.65)	(-0.88)	(0.59)	(-0.96)	(1.53)	(0.13)
Ln Land Size (ha)	-0.022	0.110	0.121	-0.015	0.280*	0.038	0.039	-0.099
	(-0.18)	(1.20)	(0.90)	(-0.22)	(1.72)	(0.30)	(0.49)	(-0.59)
Ln Ag Wage Income	-0.007	-0.001	-0.013	0.002	0.002	0.008	-0.005	-0.021*
	(-0.74)	(-0.11)	(-1.23)	(0.35)	(0.19)	(0.83)	(-0.72)	(-1.83)
Ln Transfer Income	-0.001	-0.004	-0.009	-0.007	-0.023*	0.003	0.002	0.010
	(-0.06)	(-0.57)	(-0.81)	(-1.36)	(-1.89)	(0.30)	(0.36)	(0.94)
Ln Nonfarm Income	0.012	0.020***	0.003	0.002	0.010	0.001	-0.001	0.003
	(1.54)	(2.97)	(0.37)	(0.44)	(0.93)	(0.14)	(-0.26)	(0.28)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.11: Effects of Labor Productivity on School Expenditure and Study Times by Gender of Head (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.016**	**0.012**	**-0.024**	**0.017**	**-0.004**	**0.048**	**0.021**	**-0.036**
	(0.48)	**(0.43)**	**(-0.67)**	**(0.70)**	**(-0.09)**	**(1.43)**	**(0.96)**	**(-0.85)**
Female Head X Log Labor Productivity	**0.153****	**0.000**	**0.122***	**0.030**	**-0.072**	**-0.034**	**0.018**	**0.078**
	(2.27)	**(0.01)**	**(1.77)**	**(0.72)**	**(-0.94)**	**(-0.54)**	**(0.42)**	**(1.06)**
Relationship to Head (Excludes Spouse)								
Child	0.434	-0.732	2.961*	-0.570	5.955***	-0.995**	1.252	1.216
	(0.23)	(-0.45)	(1.85)	(-1.39)	(3.88)	(-2.05)	(0.66)	(1.54)
Grandchild	0.502	-1.306	2.780	-0.632	5.471***	-0.474	1.088	1.048
	(0.26)	(-0.78)	(1.59)	(-1.33)	(3.30)	(-0.70)	(0.56)	(1.35)
Relative	0.291	-1.395	2.491	-0.658	5.542***	-1.186**	0.961	0.320
	(0.15)	(-0.83)	(1.48)	(-1.57)	(3.48)	(-2.08)	(0.50)	(0.50)
Non-relative	-0.179	-1.894	1.491	-1.020**	4.169**	-1.765**	0.102	0.000
	(-0.09)	(-1.09)	(0.82)	(-2.06)	(2.29)	(-2.48)	(0.05)	(.)
Marital Status (Excludes Never Married)								
Married	1.159	2.394	1.757	-1.567*	6.837***	-1.579***	0.036	-5.202***
	(0.82)	(1.12)	(0.92)	(-1.77)	(3.23)	(-2.77)	(0.02)	(-16.17)
Other status	-1.861*	-1.443**	-1.173	-1.224**	-0.344	-2.541***	-1.971**	0.021
	(-1.84)	(-2.08)	(-1.13)	(-2.11)	(-0.29)	(-3.70)	(-2.40)	(0.03)
Female Head	-0.852	-0.073	-1.396**	-0.423	-0.138	0.376	-0.446	-0.677
	(-1.49)	(-0.16)	(-2.43)	(-1.20)	(-0.20)	(0.76)	(-1.25)	(-1.05)
Head Education (Excludes - No Education)								
Primary	-0.068	-0.115	0.470**	0.027	0.442*	-0.150	0.099	-0.490**
	(-0.45)	(-0.71)	(2.11)	(0.31)	(1.71)	(-0.93)	(0.69)	(-2.31)
Secondary	-0.392	-0.160	-0.101	-0.149	0.709	-0.597	-0.063	-0.153
	(-0.93)	(-0.52)	(-0.28)	(-0.73)	(1.42)	(-1.54)	(-0.24)	(-0.34)
Post-Secondary	0.953	1.692	-3.348	1.449	3.560***	3.404	1.619	5.751***
	(0.57)	(1.27)	(-1.16)	(1.01)	(2.86)	(1.21)	(0.92)	(11.72)
Head Marital Status (Excludes- Never Married								
Married	-0.571	-1.274**	-1.169	-0.950**	-1.185	-0.372	-1.201*	0.647
	(-0.84)	(-2.10)	(-1.54)	(-2.17)	(-1.32)	(-0.49)	(-1.93)	(0.99)
Other status	-0.662	-1.152**	-0.919	-0.790*	-0.853	-0.774	-1.094*	0.430
	(-0.99)	(-1.97)	(-1.24)	(-1.89)	(-0.97)	(-1.04)	(-1.83)	(0.67)
Ln Head Age	-0.419	0.018	0.560	0.232	1.011	0.169	0.169	-0.207
	(-0.63)	(0.04)	(0.74)	(0.70)	(1.27)	(0.32)	(0.33)	(-0.32)
Land Rights Document	0.104	-0.221**	0.045	0.057	-0.179	0.163	0.012	0.015
	(0.84)	(-2.30)	(0.34)	(0.77)	(-1.22)	(1.26)	(0.15)	(0.11)
Ln TLUs	0.079	0.078	0.068	0.082*	-0.035	0.325***	0.046	-0.015
	(0.95)	(1.10)	(0.64)	(1.86)	(-0.30)	(3.88)	(0.71)	(-0.13)
Ln Adult Equivalent	-0.442	0.638**	0.593	-0.165	0.237	-0.296	0.403	0.030
	(-1.36)	(2.42)	(1.64)	(-0.87)	(0.59)	(-0.94)	(1.52)	(0.08)
Ln Land Size (ha)	-0.056	0.107	0.116	-0.028	0.293*	0.013	0.023	-0.089
	(-0.46)	(1.16)	(0.87)	(-0.41)	(1.79)	(0.10)	(0.29)	(-0.53)
Ln Ag Wage Income	-0.006	-0.001	-0.012	0.002	0.002	0.008	-0.005	-0.021*
	(-0.63)	(-0.14)	(-1.22)	(0.37)	(0.17)	(0.84)	(-0.74)	(-1.85)
Ln Transfer Income	-0.001	-0.004	-0.009	-0.007	-0.023*	0.003	0.002	0.010
	(-0.08)	(-0.59)	(-0.82)	(-1.38)	(-1.88)	(0.29)	(0.34)	(0.93)
Ln Nonfarm Income	0.012	0.020***	0.003	0.002	0.010	0.001	-0.001	0.002
	(1.52)	(3.01)	(0.40)	(0.46)	(0.92)	(0.15)	(-0.21)	(0.25)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.12: Effects of Land Productivity on School Expenditure and Study Times by Gender of Head (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.396**	**0.542**	**1.487****	**0.158**	**2.371****	**0.462**	**0.923***	**0.419**
	(-0.96)	**(1.13)**	**(2.22)**	**(0.59)**	**(2.46)**	**(0.96)**	**(1.86)**	**(0.83)**
Female Head X Log Land Productivity	**0.556**	**-0.600**	**-1.482****	**0.128**	**-2.212****	**-0.526**	**-0.828***	**-0.126**
	(1.37)	**(-1.08)**	**(-2.32)**	**(0.43)**	**(-2.46)**	**(-1.15)**	**(-1.81)**	**(-0.26)**
Relationship to Head (Excludes Spouse)								
Child	0.287	-0.568	3.256	-0.842**	6.001*	-0.819	1.310	0.356
	(0.14)	(-0.33)	(1.09)	(-1.98)	(1.69)	(-0.93)	(0.60)	(0.62)
Grandchild	0.413	-1.294	2.619	-1.013*	4.725	-0.418	0.843	0.000
	(0.20)	(-0.72)	(0.84)	(-1.91)	(1.28)	(-0.39)	(0.37)	(.)
Relative	0.161	-1.307	2.525	-1.040**	5.102	-1.062	0.832	-0.729
	(0.08)	(-0.73)	(0.83)	(-2.18)	(1.42)	(-1.08)	(0.37)	(-1.10)
Non-relative	-0.537	-1.518	2.363	-1.258**	5.139	-1.415	0.506	-0.866
	(-0.26)	(-0.82)	(0.75)	(-2.36)	(1.32)	(-1.33)	(0.22)	(-1.05)
Marital Status (Excludes Never Married)								
Married	0.162	3.757	5.472*	-1.309	12.598**	-0.435	2.269	-0.882
	(0.08)	(1.24)	(1.74)	(-1.51)	(2.28)	(-0.26)	(0.88)	(-0.18)
Other status	-2.053*	-1.187	-0.483	-1.139**	0.784	-2.314***	-1.530	-0.066
	(-1.93)	(-1.55)	(-0.38)	(-2.00)	(0.46)	(-3.76)	(-1.62)	(-0.09)
Female Head	-6.373	7.087	17.268**	-1.537	26.070**	6.384	9.681*	1.593
	(-1.33)	(1.07)	(2.26)	(-0.44)	(2.42)	(1.17)	(1.75)	(0.28)
Head Education (Excludes - No Education)								
Primary	-0.152	-0.048	0.644**	0.022	0.716	-0.094	0.200	-0.721**
	(-0.90)	(-0.25)	(2.10)	(0.23)	(1.60)	(-0.51)	(0.99)	(-2.21)
Secondary	-0.524	-0.030	0.231	-0.200	1.144	-0.490	0.102	-0.298
	(-1.17)	(-0.08)	(0.44)	(-0.86)	(1.39)	(-1.26)	(0.29)	(-0.59)
Post-Secondary	0.936	1.761	-3.194	1.326	3.651*	3.451	1.645	5.644***
	(0.56)	(1.21)	(-1.00)	(0.90)	(1.89)	(1.17)	(0.84)	(10.31)
Head Marital Status (Excludes- Never Married								
Married	-0.541	-1.366**	-1.463	-1.088**	-1.752	-0.452	-1.429**	0.920
	(-0.73)	(-2.10)	(-1.37)	(-2.31)	(-1.34)	(-0.56)	(-2.07)	(1.30)
Other status	-0.567	-1.329**	-1.450	-0.952**	-1.797	-0.923	-1.467**	0.669
	(-0.77)	(-2.04)	(-1.35)	(-2.05)	(-1.36)	(-1.14)	(-2.12)	(0.96)
Ln Head Age	-0.418	-0.046	0.515	0.480	1.284	0.082	0.244	-0.001
	(-0.57)	(-0.07)	(0.51)	(1.13)	(0.94)	(0.14)	(0.38)	(-0.00)
Land Rights Document	0.011	-0.118	0.351	0.117	0.343	0.243	0.209	0.062
	(0.07)	(-0.79)	(1.57)	(1.17)	(1.09)	(1.41)	(1.40)	(0.39)
Ln TLUs	0.314	-0.255	-0.858*	-0.025	-1.522**	0.047	-0.529	-0.346
	(1.13)	(-0.80)	(-1.83)	(-0.14)	(-2.22)	(0.14)	(-1.55)	(-0.89)
Ln Adult Equivalent	-0.433	0.654**	0.604	-0.240	0.175	-0.280	0.378	-0.077
	(-1.26)	(2.24)	(1.34)	(-1.12)	(0.30)	(-0.83)	(1.19)	(-0.18)
Ln Land Size (ha)	-0.179	0.311	0.688**	0.091	1.255***	0.195	0.407*	0.260
	(-0.77)	(1.40)	(2.12)	(0.70)	(2.61)	(0.76)	(1.77)	(0.63)
Ln Ag Wage Income	-0.012	0.005	0.003	0.000	0.024	0.013	0.003	-0.021
	(-1.21)	(0.48)	(0.18)	(0.05)	(1.17)	(1.23)	(0.34)	(-1.52)
Ln Transfer Income								
	(0.02)	(-0.68)	(-0.92)	(-1.55)	(-1.71)	(0.21)	(-0.07)	(1.11)
Ln Nonfarm Income	0.017*	0.014	-0.012	0.002	-0.014	-0.004	-0.010	-0.001
	(1.84)	(1.62)	(-0.96)	(0.40)	(-0.77)	(-0.40)	(-1.25)	(-0.07)
Observations	11061	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.13: Effects of Labor Productivity on School Expenditure and Study Times by Gender of Head (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.816**	**1.107**	**3.036***	**0.321**	**4.840***	**0.943**	**1.885**	**1.170**
	(-0.95)	**(1.05)**	**(1.81)**	**(0.56)**	**(1.96)**	**(0.91)**	**(1.58)**	**(0.98)**
Female Head X Log Labor Productivity	**1.396**	**-1.520**	**-3.771***	**0.288**	**-5.648***	**-1.331**	**-2.117**	**-0.568**
	(1.26)	**(-1.08)**	**(-1.88)**	**(0.34)**	**(-1.94)**	**(-1.06)**	**(-1.54)**	**(-0.39)**
Relationship to Head (Excludes Spouse)								
Child	0.142	-0.679	2.724	-1.296*	4.942	-0.891	0.851	0.166
	(0.07)	(-0.31)	(0.54)	(-1.75)	(0.71)	(-0.56)	(0.26)	(0.26)
Grandchild	0.194	-1.345	2.235	-1.481*	3.885	-0.438	0.464	0.000
	(0.09)	(-0.58)	(0.42)	(-1.73)	(0.54)	(-0.25)	(0.13)	(.)
Relative	0.031	-1.489	1.800	-1.505*	3.741	-1.197	0.256	-0.844
	(0.01)	(-0.65)	(0.35)	(-1.84)	(0.53)	(-0.71)	(0.08)	(-1.09)
Non-relative	-0.649	-1.649	1.827	-1.623**	4.121	-1.510	0.073	-0.380
	(-0.30)	(-0.73)	(0.35)	(-2.13)	(0.58)	(-0.91)	(0.02)	(-0.37)
Marital Status (Excludes Never Married)								
Married	0.487	3.212	3.939	-1.540**	10.118	-0.895	1.295	0.248
	(0.27)	(1.05)	(1.12)	(-2.01)	(1.55)	(-0.52)	(0.44)	(0.05)
Other status	-1.642	-1.741**	-1.985	-1.267**	-1.594	-2.787***	-2.452***	-0.581
	(-1.50)	(-2.33)	(-1.51)	(-2.02)	(-0.81)	(-3.98)	(-2.68)	(-0.54)
Female Head	-9.993	11.104	27.392*	-2.013	41.391*	9.887	15.463	4.470
	(-1.23)	(1.08)	(1.85)	(-0.32)	(1.92)	(1.07)	(1.51)	(0.42)
Head Education (Excludes - No Education)								
Primary	-0.135	-0.067	0.618*	0.066	0.699	-0.113	0.199	-0.581**
	(-0.74)	(-0.33)	(1.79)	(0.66)	(1.40)	(-0.58)	(0.89)	(-2.05)
Secondary	-0.722	0.191	0.820	-0.167	2.068*	-0.301	0.458	-0.350
	(-1.40)	(0.38)	(1.04)	(-0.57)	(1.77)	(-0.58)	(0.84)	(-0.58)
Post-Secondary	0.388	2.378	-1.528	1.454	6.281***	3.980	2.664	7.078***
	(0.21)	(1.55)	(-0.46)	(0.95)	(2.91)	(1.41)	(1.34)	(4.63)
Head Marital Status (Excludes- Never Married								
Married	-0.871	-0.977	-0.394	-0.972*	-0.047	-0.122	-0.765	1.544
	(-1.16)	(-1.38)	(-0.33)	(-1.93)	(-0.03)	(-0.14)	(-1.03)	(1.23)
Other status	-0.904	-0.939	-0.379	-0.836*	-0.088	-0.591	-0.801	1.302
	(-1.25)	(-1.41)	(-0.34)	(-1.75)	(-0.06)	(-0.71)	(-1.17)	(1.04)
Ln Head Age	-0.361	0.017	0.862	0.817	1.995	0.120	0.557	-0.365
	(-0.39)	(0.02)	(0.61)	(1.36)	(1.09)	(0.14)	(0.61)	(-0.35)
Land Rights Document	-0.016	-0.082	0.467	0.161	0.545	0.271	0.292	0.075
	(-0.08)	(-0.40)	(1.37)	(1.29)	(1.09)	(1.26)	(1.27)	(0.47)
Ln TLUs	0.149	-0.043	-0.287	0.020	-0.621	0.228	-0.180	-0.226
	(1.04)	(-0.25)	(-0.94)	(0.22)	(-1.36)	(1.35)	(-0.86)	(-1.13)
Ln Adult Equivalent	-0.549	0.778**	0.932	-0.228	0.685	-0.173	0.574	-0.134
	(-1.48)	(2.35)	(1.61)	(-0.99)	(0.85)	(-0.47)	(1.50)	(-0.26)
Ln Land Size (ha)	0.227	-0.240	-0.837	-0.093	-1.188	-0.274	-0.547	-0.029
	(0.76)	(-0.69)	(-1.46)	(-0.47)	(-1.40)	(-0.81)	(-1.37)	(-0.14)
Ln Ag Wage Income	-0.011	0.003	-0.002	0.002	0.018	0.011	0.001	-0.017
	(-1.06)	(0.30)	(-0.11)	(0.35)	(0.80)	(1.07)	(0.12)	(-1.24)
Ln Transfer Income	-0.000	-0.007	-0.018	-0.011*	-0.039	0.001	-0.004	0.008
	(-0.04)	(-0.71)	(-0.96)	(-1.71)	(-1.62)	(0.09)	(-0.39)	(0.62)
Ln Nonfarm Income	0.016*	0.016*	-0.008	0.003	-0.006	-0.003	-0.007	0.013
	(1.76)	(1.84)	(-0.52)	(0.55)	(-0.30)	(-0.26)	(-0.79)	(0.87)
Observations	11061	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.14: Effects of Land Productivity on School Expenditure and Study Times by School–Level (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.463*** **	**0.006**	**0.064*** **	**0.059*** **	**-0.004**	**0.095*** **	**0.075*** **	**0.009**
	(19.42)	**(0.33)**	**(2.70)**	**(3.56)**	**(-0.14)**	**(4.04)**	**(4.63)**	**(0.35)**
Primary X Log Land Productivity (TSH/Ha)	**-0.543*** **	**-0.008**	**-0.050*** **	**-0.055*** **	**-0.030***	**-0.101*** **	**-0.074*** **	**-0.019**
	(-35.87)	**(-0.76)**	**(-3.77)**	**(-5.74)**	**(-1.65)**	**(-6.41)**	**(-9.07)**	**(-1.04)**
Relationship to Head (Excludes Spouse)								
Child	0.525	-0.715	3.026*	-0.535	5.898***	-0.990*	1.275	1.243
	(0.25)	(-0.43)	(1.83)	(-1.43)	(3.90)	(-1.84)	(0.67)	(1.58)
Grandchild	0.461	-1.288	2.830	-0.611	5.410***	-0.495	1.091	1.065
	(0.22)	(-0.76)	(1.58)	(-1.37)	(3.30)	(-0.70)	(0.57)	(1.38)
Relative	0.242	-1.377	2.538	-0.637	5.481***	-1.205**	0.965	0.336
	(0.11)	(-0.81)	(1.47)	(-1.63)	(3.49)	(-1.96)	(0.50)	(0.52)
Non-relative	-0.571	-1.888	1.516	-1.037**	4.086**	-1.854**	0.058	0.000
	(-0.26)	(-1.08)	(0.81)	(-2.15)	(2.27)	(-2.47)	(0.03)	(.)
Marital Status (Excludes Never Married)								
Married	1.380	2.393	1.859	-1.522*	6.768***	-1.553**	0.083	-4.931***
	(1.35)	(1.12)	(0.99)	(-1.84)	(3.22)	(-2.48)	(0.05)	(-13.36)
Other status	-0.996	-1.429**	-1.093	-1.129**	-0.307	-2.364***	-1.844**	0.049
	(-1.40)	(-2.06)	(-1.05)	(-2.07)	(-0.26)	(-3.32)	(-2.25)	(0.07)
Female Head	0.020	-0.081	-0.542	-0.238	-0.665	0.088	-0.350	-0.131
	(0.09)	(-0.30)	(-1.61)	(-1.58)	(-1.63)	(0.33)	(-1.50)	(-0.37)
Head Education (Excludes - No Education)								
Primary	-0.098	-0.117	0.466**	0.022	0.442*	-0.157	0.094	-0.480**
	(-0.77)	(-0.72)	(2.10)	(0.26)	(1.72)	(-0.98)	(0.66)	(-2.25)
Secondary	-0.519	-0.163	-0.095	-0.162	0.692	-0.636	-0.084	-0.151
	(-1.55)	(-0.53)	(-0.26)	(-0.79)	(1.38)	(-1.63)	(-0.32)	(-0.33)
Post-Secondary	1.281	1.694	-3.291	1.477	3.569***	3.433	1.653	5.820***
	(0.63)	(1.27)	(-1.13)	(1.01)	(2.83)	(1.23)	(0.92)	(11.86)
Head Marital Status (Excludes- Never Married								
Married	-0.243	-1.270**	-1.133	-0.923**	-1.162	-0.329	-1.166*	0.675
	(-0.46)	(-2.10)	(-1.48)	(-2.07)	(-1.29)	(-0.44)	(-1.90)	(1.05)
Other status	-0.202	-1.145**	-0.875	-0.750*	-0.818	-0.704	-1.041*	0.462
	(-0.39)	(-1.96)	(-1.17)	(-1.76)	(-0.93)	(-0.96)	(-1.77)	(0.72)
Ln Head Age	-0.597	0.003	0.502	0.195	1.046	0.145	0.138	-0.258
	(-1.27)	(0.01)	(0.67)	(0.61)	(1.31)	(0.28)	(0.28)	(-0.41)
Land Rights Document	0.234**	-0.222**	0.060	0.069	-0.173	0.185	0.029	0.020
	(2.41)	(-2.33)	(0.46)	(0.94)	(-1.18)	(1.44)	(0.36)	(0.15)
Ln TLUs	-0.010	0.079	0.046	0.068	-0.024	0.307***	0.029	-0.014
	(-0.15)	(1.10)	(0.44)	(1.54)	(-0.21)	(3.69)	(0.44)	(-0.12)
Ln Adult Equivalent	0.083	0.646**	0.650*	-0.112	0.261	-0.207	0.471*	0.069
	(0.32)	(2.46)	(1.80)	(-0.59)	(0.65)	(-0.66)	(1.79)	(0.18)
Ln Land Size (ha)	0.027	0.111	0.125	-0.010	0.283*	0.048	0.046	-0.093
	(0.28)	(1.22)	(0.93)	(-0.14)	(1.74)	(0.38)	(0.59)	(-0.55)
Ln Ag Wage Income	0.001	-0.001	-0.012	0.002	0.002	0.009	-0.004	-0.021*
	(0.14)	(-0.13)	(-1.14)	(0.52)	(0.19)	(0.96)	(-0.62)	(-1.85)
Ln Transfer Income	0.001	-0.004	-0.008	-0.007	-0.023*	0.003	0.002	0.010
	(0.12)	(-0.58)	(-0.79)	(-1.33)	(-1.89)	(0.33)	(0.38)	(0.87)
Ln Nonfarm Income	-0.001	0.020***	0.002	0.001	0.009	-0.001	-0.003	0.002
	(-0.16)	(2.98)	(0.21)	(0.16)	(0.89)	(-0.13)	(-0.56)	(0.24)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.15: Effects of Labor Productivity on School Expenditure and Study Times by School–Level (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.711*** **	**0.015**	**0.057**	**0.087*** **	**0.016**	**0.173*** **	**0.110*** **	**0.013**
	(19.35)	**(0.53)**	**(1.59)**	**(3.07)**	**(0.38)**	**(4.66)**	**(4.74)**	**(0.30)**
Primary X Log Labor Productivity (TSH/Day)	**-0.884*** **	**-0.004**	**-0.067*** **	**-0.084*** **	**-0.051***	**-0.180*** **	**-0.113*** **	**-0.032**
	(-38.25)	**(-0.26)**	**(-3.10)**	**(-5.36)**	**(-1.76)**	**(-6.92)**	**(-8.71)**	**(-1.05)**
Relationship to Head (Excludes Spouse)								
Child	0.815	-0.731	3.068*	-0.523	5.919***	-0.965*	1.299	1.250
	(0.45)	(-0.45)	(1.87)	(-1.39)	(3.90)	(-1.81)	(0.70)	(1.58)
Grandchild	0.655	-1.305	2.878	-0.605	5.416***	-0.494	1.106	1.063
	(0.35)	(-0.77)	(1.62)	(-1.36)	(3.30)	(-0.70)	(0.59)	(1.38)
Relative	0.469	-1.394	2.588	-0.630	5.491***	-1.199**	0.983	0.341
	(0.26)	(-0.83)	(1.51)	(-1.60)	(3.48)	(-1.97)	(0.52)	(0.53)
Non-relative	-0.313	-1.895	1.558	-1.022**	4.105**	-1.837**	0.083	0.000
	(-0.16)	(-1.09)	(0.84)	(-2.13)	(2.27)	(-2.46)	(0.04)	(.)
Marital Status (Excludes Never Married)								
Married	0.850	2.393	1.776	-1.590*	6.788***	-1.666***	-0.005	-4.960**
	(0.76)	(1.12)	(0.94)	(-1.90)	(3.21)	(-2.60)	(-0.00)	(-15.21)
Other status	-1.064	-1.439**	-1.124	-1.150**	-0.289	-2.372***	-1.869**	0.058
	(-1.61)	(-2.08)	(-1.08)	(-2.03)	(-0.25)	(-3.21)	(-2.30)	(0.08)
Female Head	0.105	-0.071	-0.547	-0.226	-0.653	0.113	-0.336	-0.128
	(0.47)	(-0.27)	(-1.62)	(-1.50)	(-1.60)	(0.43)	(-1.45)	(-0.36)
Head Education (Excludes - No Education)								
Primary	-0.107	-0.115	0.465**	0.023	0.440*	-0.157	0.094	-0.484**
	(-0.83)	(-0.71)	(2.10)	(0.27)	(1.71)	(-0.98)	(0.66)	(-2.28)
Secondary	-0.493	-0.161	-0.088	-0.156	0.688	-0.629	-0.076	-0.153
	(-1.50)	(-0.52)	(-0.24)	(-0.76)	(1.37)	(-1.61)	(-0.29)	(-0.34)
Post-Secondary	1.501	1.695	-3.269	1.506	3.564***	3.494	1.689	5.844**
	(0.77)	(1.27)	(-1.12)	(1.03)	(2.83)	(1.26)	(0.94)	(11.81)
Head Marital Status (Excludes- Never Married								
Married	-0.266	-1.272**	-1.128	-0.919**	-1.181	-0.321	-1.163*	0.679
	(-0.50)	(-2.10)	(-1.48)	(-2.10)	(-1.32)	(-0.43)	(-1.89)	(1.04)
Other status	-0.236	-1.150**	-0.870	-0.748*	-0.840	-0.697	-1.040*	0.465
	(-0.46)	(-1.97)	(-1.17)	(-1.79)	(-0.96)	(-0.96)	(-1.77)	(0.72)
Ln Head Age	-0.509	0.018	0.491	0.215	1.051	0.187	0.159	-0.244
	(-1.13)	(0.04)	(0.66)	(0.66)	(1.32)	(0.36)	(0.32)	(-0.39)
Land Rights Document	0.162*	-0.221**	0.046	0.062	-0.173	0.177	0.019	0.017
	(1.67)	(-2.30)	(0.35)	(0.84)	(-1.18)	(1.38)	(0.24)	(0.13)
Ln TLUs	-0.007	0.078	0.061	0.073*	-0.040	0.307***	0.035	-0.017
	(-0.11)	(1.10)	(0.58)	(1.67)	(-0.34)	(3.72)	(0.54)	(-0.15)
Ln Adult Equivalent	0.137	0.640**	0.651*	-0.108	0.260	-0.187	0.476*	0.074
	(0.54)	(2.43)	(1.80)	(-0.57)	(0.64)	(-0.59)	(1.81)	(0.19)
Ln Land Size (ha)	0.000	0.107	0.108	-0.025	0.305*	0.031	0.030	-0.089
	(0.00)	(1.17)	(0.81)	(-0.36)	(1.87)	(0.25)	(0.39)	(-0.53)
Ln Ag Wage Income	-0.002	-0.001	-0.012	0.002	0.002	0.009	-0.005	-0.021*
	(-0.27)	(-0.14)	(-1.17)	(0.46)	(0.17)	(0.92)	(-0.67)	(-1.86)
Ln Transfer Income	0.005	-0.004	-0.008	-0.007	-0.023*	0.004	0.003	0.010
	(0.61)	(-0.59)	(-0.75)	(-1.27)	(-1.87)	(0.39)	(0.45)	(0.90)
Ln Nonfarm Income	-0.002	0.020***	0.002	0.001	0.009	-0.001	-0.003	0.002
	(-0.30)	(2.99)	(0.23)	(0.17)	(0.87)	(-0.17)	(-0.55)	(0.21)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.16: Effects of Land Productivity on School Expenditure and Study Times by School–Level (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.892*** **	**0.338**	**1.031** **	**0.307**	**1.610*** **	**0.473**	**0.763** **	**0.373**
	(3.21)	**(1.08)**	**(2.42)**	**(1.57)**	**(2.73)**	**(1.41)**	**(2.34)**	**(1.35)**
Primary X Log Land Productivity (TSH/Ha)	**-0.585*** **	**-0.010**	**-0.049*** **	**-0.053*** **	**-0.031**	**-0.109*** **	**-0.077*** **	**-0.018**
	(-33.19)	**(-0.89)**	**(-2.87)**	**(-5.26)**	**(-1.21)**	**(-6.45)**	**(-6.94)**	**(-0.87)**
Relationship to Head (Excludes Spouse)								
Child	0.087	-1.077	1.968	-0.807*	4.134	-1.397	0.526	1.285
	(0.04)	(-0.69)	(0.93)	(-1.93)	(1.62)	(-1.62)	(0.30)	(1.55)
Grandchild	-0.207	-1.833	1.235	-1.020*	2.751	-1.109	-0.039	0.862
	(-0.10)	(-1.08)	(0.53)	(-1.85)	(0.99)	(-1.04)	(-0.02)	(1.02)
Relative	-0.402	-1.901	1.003	-1.032**	2.922	-1.797*	-0.123	0.170
	(-0.19)	(-1.14)	(0.45)	(-2.05)	(1.10)	(-1.79)	(-0.07)	(0.24)
Non-relative	-0.917	-2.144	0.772	-1.227**	2.843	-2.147**	-0.473	0.000
	(-0.42)	(-1.30)	(0.34)	(-2.39)	(1.02)	(-2.15)	(-0.25)	(.)
Marital Status (Excludes Never Married)								
Married	2.180	3.053	3.793	-1.025*	9.991**	-0.810	1.452	-1.344
	(1.48)	(1.17)	(1.62)	(-1.79)	(2.38)	(-0.58)	(0.68)	(-0.49)
Other status	-0.732	-1.259*	-0.609	-1.006*	0.506	-2.164***	-1.494	-0.010
	(-0.92)	(-1.70)	(-0.53)	(-1.93)	(0.35)	(-3.39)	(-1.63)	(-0.01)
Female Head	0.323	0.184	0.237	-0.037	0.632	0.383	0.199	0.134
	(1.00)	(0.48)	(0.43)	(-0.17)	(0.79)	(0.99)	(0.51)	(0.30)
Head Education (Excludes - No Education)								
Primary	-0.080	-0.101	0.513*	0.034	0.519	-0.140	0.127	-0.711**
	(-0.60)	(-0.59)	(1.91)	(0.36)	(1.38)	(-0.82)	(0.71)	(-2.34)
Secondary	-0.569*	-0.196	-0.188	-0.186	0.535	-0.674*	-0.151	-0.281
	(-1.74)	(-0.60)	(-0.42)	(-0.82)	(0.75)	(-1.72)	(-0.48)	(-0.58)
Post-Secondary	1.142	1.560	-3.687	1.375	2.911*	3.286	1.375	5.677**
	(0.54)	(1.12)	(-1.20)	(0.91)	(1.78)	(1.12)	(0.71)	(10.82)
Head Marital Status (Excludes- Never Married								
Married	-0.450	-1.462**	-1.702*	-1.070**	-2.108*	-0.542	-1.566**	0.926
	(-0.78)	(-2.26)	(-1.76)	(-2.16)	(-1.76)	(-0.68)	(-2.22)	(1.34)
Other status	-0.464	-1.390**	-1.601*	-0.938*	-2.024*	-0.975	-1.551**	0.671
	(-0.80)	(-2.15)	(-1.65)	(-1.91)	(-1.67)	(-1.24)	(-2.20)	(1.00)
Ln Head Age	-0.190	0.346	1.509	0.454	2.723**	0.530	0.850	0.017
	(-0.35)	(0.51)	(1.40)	(1.05)	(2.00)	(0.83)	(1.13)	(0.02)
Land Rights Document	0.375***	-0.113	0.379*	0.150	0.360	0.309*	0.256*	0.054
	(2.74)	(-0.78)	(1.86)	(1.48)	(1.29)	(1.79)	(1.80)	(0.38)
Ln TLUs	-0.280	-0.141	-0.599*	-0.098	-1.100**	0.059	-0.428*	-0.312
	(-1.33)	(-0.61)	(-1.85)	(-0.69)	(-2.42)	(0.24)	(-1.74)	(-1.23)
Ln Adult Equivalent	0.008	0.554*	0.372	-0.184	-0.197	-0.305	0.279	-0.059
	(0.03)	(1.90)	(0.83)	(-0.85)	(-0.33)	(-0.92)	(0.83)	(-0.14)
Ln Land Size (ha)	0.262	0.304	0.688**	0.135	1.223***	0.265	0.446**	0.236
	(1.37)	(1.46)	(2.35)	(1.05)	(2.90)	(1.09)	(2.07)	(0.76)
Ln Ag Wage Income	0.001	-0.001	-0.012	0.002	0.001	0.009	-0.005	-0.022*
	(0.16)	(-0.16)	(-1.03)	(0.44)	(0.06)	(0.91)	(-0.58)	(-1.81)
Ln Transfer Income	-0.002	-0.007	-0.015	-0.009	-0.034**	0.001	-0.002	0.012
	(-0.20)	(-0.81)	(-1.16)	(-1.54)	(-2.04)	(0.07)	(-0.29)	(1.05)
Ln Nonfarm Income	-0.003	0.019***	-0.002	-0.000	0.003	-0.003	-0.006	-0.001
	(-0.53)	(2.66)	(-0.20)	(-0.04)	(0.22)	(-0.32)	(-0.90)	(-0.08)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.17: Effects of Labor Productivity on School Expenditure and Study Times by School–Level (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**1.502*** **	**0.662**	**2.008** **	**0.580**	**3.156** **	**0.883**	**1.468** **	**1.055**
	(2.64)	**(1.05)**	**(2.18)**	**(1.47)**	**(2.38)**	**(1.31)**	**(2.12)**	**(1.20)**
Primary X Log Labor Productivity (TSH/Day)	**-0.945*** **	**-0.011**	**-0.066** **	**-0.083*** **	**-0.029**	**-0.172*** **	**-0.116*** **	**-0.035**
	(-32.15)	**(-0.58)**	**(-1.93)**	**(-4.86)**	**(-0.55)**	**(-5.97)**	**(-5.02)**	**(-0.94)**
Relationship to Head (Excludes Spouse)								
Child	-0.259	-1.668	0.209	-1.246	1.288	-2.017	-0.687	0.612
	(-0.14)	(-1.01)	(0.06)	(-1.48)	(0.27)	(-1.38)	(-0.31)	(0.63)
Grandchild	-0.646	-2.426	-0.532	-1.468	-0.100	-1.746	-1.265	0.351
	(-0.32)	(-1.31)	(-0.15)	(-1.51)	(-0.02)	(-1.05)	(-0.52)	(0.32)
Relative	-0.841	-2.523	-0.849	-1.499	-0.070	-2.462	-1.407	-0.457
	(-0.42)	(-1.38)	(-0.25)	(-1.57)	(-0.01)	(-1.50)	(-0.59)	(-0.48)
Non-relative	-1.184	-2.632	-0.677	-1.587*	0.495	-2.655*	-1.472	0.000
	(-0.62)	(-1.61)	(-0.21)	(-1.92)	(0.10)	(-1.82)	(-0.65)	(.)
Marital Status (Excludes Never Married)								
Married	1.078	2.607	2.439	-1.423**	7.870	-1.420	0.455	-0.326
	(0.64)	(1.03)	(1.09)	(-2.23)	(1.63)	(-0.94)	(0.21)	(-0.08)
Other status	-1.150*	-1.555**	-1.499	-1.245**	-0.914	-2.516***	-2.127***	-0.465
	(-1.74)	(-2.26)	(-1.35)	(-2.02)	(-0.60)	(-3.63)	(-2.58)	(-0.48)
Female Head	0.572	0.337	0.698	0.089	1.364	0.571	0.529	0.426
	(1.36)	(0.66)	(0.93)	(0.30)	(1.24)	(1.11)	(0.96)	(0.67)
Head Education (Excludes - No Education)								
Primary	-0.037	-0.053	0.655**	0.071	0.749*	-0.087	0.226	-0.597**
	(-0.25)	(-0.28)	(2.16)	(0.70)	(1.69)	(-0.47)	(1.08)	(-1.98)
Secondary	-0.437	-0.106	0.082	-0.113	0.965	-0.566	0.041	-0.312
	(-1.25)	(-0.31)	(0.16)	(-0.49)	(1.19)	(-1.31)	(0.11)	(-0.55)
Post-Secondary	1.722	1.859	-2.784	1.629	4.338***	3.668	2.028	6.892**
	(0.85)	(1.35)	(-0.91)	(1.09)	(2.82)	(1.32)	(1.08)	(6.69)
Head Marital Status (Excludes- Never Married								
Married	-0.203	-1.232*	-1.012	-0.890*	-1.000	-0.281	-1.081	1.606
	(-0.31)	(-1.88)	(-0.93)	(-1.88)	(-0.59)	(-0.36)	(-1.26)	(1.23)
Other status	-0.223	-1.159*	-0.909	-0.758*	-0.913	-0.715	-1.065	1.342
	(-0.35)	(-1.81)	(-0.85)	(-1.65)	(-0.54)	(-0.94)	(-1.27)	(1.05)
Ln Head Age	0.382	0.785	2.824*	0.805	4.825**	1.043	1.781	-0.227
	(0.45)	(0.78)	(1.77)	(1.26)	(2.23)	(1.04)	(1.53)	(-0.23)
Land Rights Document	0.362**	-0.053	0.556*	0.191	0.651	0.364	0.374*	0.096
	(1.97)	(-0.27)	(1.92)	(1.43)	(1.54)	(1.64)	(1.78)	(0.56)
Ln TLUs	-0.139	-0.031	-0.269	-0.010	-0.571*	0.187	-0.195	-0.252
	(-1.02)	(-0.22)	(-1.19)	(-0.11)	(-1.76)	(1.24)	(-1.17)	(-1.09)
Ln Adult Equivalent	0.116	0.593**	0.493	-0.148	-0.009	-0.250	0.369	-0.278
	(0.40)	(2.04)	(1.01)	(-0.69)	(-0.01)	(-0.75)	(1.03)	(-0.50)
Ln Land Size (ha)	-0.183	-0.054	-0.383	-0.149	-0.491	-0.150	-0.311	0.034
	(-1.00)	(-0.28)	(-1.23)	(-1.17)	(-1.07)	(-0.70)	(-1.37)	(0.16)
Ln Ag Wage Income	-0.000	0.000	-0.008	0.003	0.008	0.010	-0.002	-0.017
	(-0.03)	(0.01)	(-0.63)	(0.58)	(0.44)	(1.00)	(-0.23)	(-1.22)
Ln Transfer Income	-0.001	-0.010	-0.025	-0.011	-0.050**	-0.002	-0.009	0.006
	(-0.10)	(-0.98)	(-1.48)	(-1.60)	(-2.23)	(-0.18)	(-0.77)	(0.44)
Ln Nonfarm Income	-0.003	0.020**	0.003	0.001	0.011	-0.001	-0.002	0.011
	(-0.37)	(2.83)	(0.24)	(0.19)	(0.66)	(-0.12)	(-0.32)	(0.83)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.18: Effects of Gross Agricultural Income on School Expenditure and Study Times (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Value of Crop Income (TSH)	**0.058****	**-0.006**	**0.011**	**0.024**	**0.025**	**0.019**	**0.012**	**0.002**
	(2.41)	**(-0.29)**	**(0.43)**	**(1.41)**	**(0.85)**	**(0.78)**	**(0.70)**	**(0.09)**
Relationship to Head (Excludes Spouse)								
Child	0.534	-0.705	3.042*	-0.550	5.833***	-0.991**	1.284	1.203
	(0.28)	(-0.43)	(1.84)	(-1.36)	(3.80)	(-2.07)	(0.67)	(1.53)
Grandchild	0.610	-1.274	2.868	-0.610	5.330***	-0.467	1.125	1.041
	(0.31)	(-0.75)	(1.60)	(-1.29)	(3.21)	(-0.69)	(0.58)	(1.35)
Relative	0.383	-1.362	2.573	-0.642	5.397***	-1.181**	0.996	0.309
	(0.20)	(-0.80)	(1.49)	(-1.54)	(3.39)	(-2.10)	(0.51)	(0.48)
Non-relative	-0.092	-1.872	1.569	-1.005**	4.059**	-1.769**	0.127	0.000
	(-0.05)	(-1.07)	(0.84)	(-2.04)	(2.23)	(-2.50)	(0.06)	(.)
Marital Status (Excludes Never Married)								
Married	1.304	2.380	1.821	-1.520*	6.862***	-1.571***	0.055	-5.011***
	(0.93)	(1.12)	(0.96)	(-1.76)	(3.22)	(-2.87)	(0.03)	(-13.63)
Other status	-1.867*	-1.441**	-1.185	-1.223**	-0.340	-2.529***	-1.968**	0.004
	(-1.85)	(-2.08)	(-1.14)	(-2.10)	(-0.29)	(-3.67)	(-2.39)	(0.01)
Female Head	0.252	-0.084	-0.532	-0.205	-0.606	0.132	-0.325	-0.114
	(0.82)	(-0.31)	(-1.57)	(-1.34)	(-1.49)	(0.48)	(-1.37)	(-0.32)
Head Education (Excludes - No Education)								
Primary	-0.075	-0.116	0.468**	0.024	0.445*	-0.153	0.097	-0.490**
	(-0.49)	(-0.72)	(2.10)	(0.28)	(1.73)	(-0.95)	(0.67)	(-2.30)
Secondary	-0.363	-0.161	-0.078	-0.144	0.699	-0.605	-0.061	-0.160
	(-0.87)	(-0.52)	(-0.21)	(-0.71)	(1.39)	(-1.57)	(-0.23)	(-0.35)
Post-Secondary	0.967	1.692	-3.313	1.443	3.531***	3.376	1.614	5.805***
	(0.58)	(1.27)	(-1.14)	(1.00)	(2.83)	(1.20)	(0.92)	(11.80)
Head Marital Status (Excludes- Never Married								
Married	-0.585	-1.271**	-1.156	-0.962**	-1.211	-0.392	-1.207*	0.659
	(-0.85)	(-2.09)	(-1.51)	(-2.19)	(-1.35)	(-0.51)	(-1.94)	(1.02)
Other status	-0.678	-1.148*	-0.908	-0.802*	-0.881	-0.791	-1.099*	0.444
	(-1.01)	(-1.96)	(-1.21)	(-1.91)	(-1.01)	(-1.07)	(-1.84)	(0.69)
Ln Head Age	-0.494	-0.004	0.497	0.217	1.110	0.165	0.144	-0.229
	(-0.73)	(-0.01)	(0.66)	(0.65)	(1.40)	(0.32)	(0.28)	(-0.36)
Land Rights Document	0.105	-0.226**	0.043	0.058	-0.163	0.160	0.009	0.014
	(0.85)	(-2.36)	(0.33)	(0.79)	(-1.11)	(1.24)	(0.11)	(0.11)
Ln TLUs	0.065	0.083	0.064	0.076*	-0.048	0.324***	0.046	-0.017
	(0.78)	(1.16)	(0.61)	(1.73)	(-0.42)	(3.88)	(0.71)	(-0.15)
Ln Adult Equivalent	-0.447	0.642**	0.604*	-0.171	0.213	-0.307	0.401	0.046
	(-1.38)	(2.44)	(1.67)	(-0.91)	(0.53)	(-0.97)	(1.52)	(0.12)
Ln Land Size (ha)	-0.101	0.114	0.097	-0.043	0.277*	0.013	0.019	-0.094
	(-0.83)	(1.23)	(0.72)	(-0.62)	(1.69)	(0.10)	(0.23)	(-0.56)
Ln Ag Wage Income	-0.006	-0.001	-0.012	0.002	0.002	0.008	-0.005	-0.021*
	(-0.63)	(-0.14)	(-1.20)	(0.36)	(0.16)	(0.82)	(-0.75)	(-1.84)
Ln Transfer Income	-0.001	-0.004	-0.009	-0.007	-0.023*	0.003	0.002	0.010
	(-0.08)	(-0.57)	(-0.80)	(-1.39)	(-1.94)	(0.29)	(0.35)	(0.95)
Ln Nonfarm Income	0.012	0.020***	0.003	0.002	0.010	0.001	-0.001	0.003
	(1.45)	(3.00)	(0.35)	(0.43)	(0.94)	(0.15)	(-0.22)	(0.28)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.19: Effects of Gross Agricultural Income on School Expenditure and Study Times (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Value of Crop Income (TSH)	**-0.307**	**0.454**	**1.330****	**0.291**	**2.201****	**0.378**	**0.875***	**0.712**
	(-0.63)	**(1.00)**	**(2.05)**	**(1.05)**	**(2.32)**	**(0.79)**	**(1.84)**	**(1.20)**
Relationship to Head (Excludes Spouse)								
Child	1.103	-1.421	0.986	-0.966	2.443	-1.551	-0.061	0.971
	(0.48)	(-0.93)	(0.42)	(-1.51)	(0.67)	(-1.44)	(-0.03)	(1.06)
Grandchild	1.290	-2.129	0.412	-1.107	1.281	-1.135	-0.482	0.509
	(0.54)	(-1.27)	(0.16)	(-1.47)	(0.33)	(-0.89)	(-0.25)	(0.49)
Relative	1.140	-2.313	-0.162	-1.195	0.888	-1.926	-0.794	-0.071
	(0.47)	(-1.35)	(-0.06)	(-1.56)	(0.23)	(-1.47)	(-0.40)	(-0.09)
Non-relative	0.420	-2.515	-0.279	-1.378**	1.011	-2.272*	-1.082	0.000
	(0.18)	(-1.58)	(-0.11)	(-2.00)	(0.27)	(-1.93)	(-0.58)	(.)
Marital Status (Excludes Never Married)								
Married	0.638	3.217	4.226	-1.034	10.828*	-0.916	1.629	1.425
	(0.32)	(1.15)	(1.46)	(-1.57)	(1.94)	(-0.66)	(0.69)	(0.26)
Other status	-1.869*	-1.438**	-1.175	-1.221**	-0.325	-2.527***	-1.962**	-0.146
	(-1.85)	(-2.03)	(-1.08)	(-2.05)	(-0.25)	(-3.89)	(-2.30)	(-0.18)
Female Head	-0.123	0.387	0.822	0.069	1.626	0.500	0.561	0.498
	(-0.21)	(0.70)	(1.03)	(0.21)	(1.39)	(0.89)	(0.97)	(0.76)
Head Education (Excludes - No Education)								
Primary	-0.080	-0.111	0.484*	0.027	0.473	-0.149	0.108	-0.693**
	(-0.50)	(-0.66)	(1.84)	(0.30)	(1.26)	(-0.89)	(0.62)	(-2.20)
Secondary	-0.389	-0.128	0.017	-0.125	0.856	-0.579	0.001	-0.175
	(-0.89)	(-0.39)	(0.04)	(-0.56)	(1.11)	(-1.42)	(0.00)	(-0.34)
Post-Secondary	1.113	1.508	-3.840	1.336	2.662*	3.232	1.269	6.887***
	(0.68)	(1.10)	(-1.26)	(0.91)	(1.72)	(1.13)	(0.69)	(6.71)
Head Marital Status (Excludes- Never Married								
Married	-0.359	-1.555**	-1.972*	-1.127**	-2.556	-0.614	-1.741**	1.134
	(-0.44)	(-2.21)	(-1.84)	(-2.31)	(-1.61)	(-0.74)	(-2.12)	(1.42)
Other status	-0.426	-1.463**	-1.815*	-0.986**	-2.377	-1.038	-1.692**	0.905
	(-0.52)	(-2.09)	(-1.69)	(-2.05)	(-1.48)	(-1.27)	(-2.07)	(1.14)
Ln Head Age	-0.972	0.598	2.226	0.567	3.960**	0.635	1.275	-0.704
	(-1.01)	(0.68)	(1.60)	(1.02)	(2.11)	(0.77)	(1.29)	(-0.76)
Land Rights Document	-0.019	-0.071	0.489*	0.148	0.573	0.282	0.301	0.057
	(-0.09)	(-0.39)	(1.84)	(1.20)	(1.48)	(1.37)	(1.61)	(0.39)
Ln TLUs	0.210	-0.100	-0.460	-0.030	-0.913**	0.181	-0.298	-0.354
	(1.00)	(-0.49)	(-1.47)	(-0.24)	(-1.98)	(0.85)	(-1.32)	(-1.17)
Ln Adult Equivalent	-0.264	0.412	-0.057	-0.305	-0.876	-0.487	-0.031	-0.516
	(-0.62)	(1.14)	(-0.10)	(-1.17)	(-1.12)	(-1.22)	(-0.08)	(-0.79)
Ln Land Size (ha)	0.167	-0.223	-0.873*	-0.239	-1.321*	-0.251	-0.615	-0.182
	(0.44)	(-0.63)	(-1.67)	(-1.08)	(-1.71)	(-0.69)	(-1.63)	(-0.89)
Ln Ag Wage Income	-0.005	-0.002	-0.016	0.001	-0.004	0.007	-0.008	-0.019
	(-0.50)	(-0.29)	(-1.26)	(0.20)	(-0.25)	(0.69)	(-0.90)	(-1.43)
Ln Transfer Income	0.004	-0.011	-0.027*	-0.011	-0.054**	-0.002	-0.010	0.010
	(0.37)	(-1.03)	(-1.65)	(-1.64)	(-2.49)	(-0.17)	(-0.91)	(0.83)
Ln Nonfarm Income	0.012	0.020***	0.001	0.002	0.007	0.001	-0.002	0.005
	(1.48)	(2.79)	(0.11)	(0.34)	(0.49)	(0.09)	(-0.36)	(0.45)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.20: Effects of Net Agricultural Income per Hectare on School Expenditure and Study Times (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Ln Net Revenue per Ha (TSH/Ha)	**0.050***	**0.008**	**-0.002**	**0.027**	**-0.006**	**0.057***	**0.004**	**0.039**
	(1.69)	**(0.34)**	**(-0.09)**	**(1.11)**	**(-0.16)**	**(1.65)**	**(0.28)**	**(1.31)**
Relationship to Head (Excludes Spouse)								
Child	0.686	-0.745	3.056*	-0.398	5.763***	-0.779*	1.304	1.233
	(0.35)	(-0.46)	(1.84)	(-0.97)	(3.76)	(-1.68)	(0.68)	(1.55)
Grandchild	0.761	-1.326	2.867	-0.450	5.373***	-0.316	1.118	1.109
	(0.38)	(-0.79)	(1.59)	(-0.95)	(3.24)	(-0.47)	(0.58)	(1.43)
Relative	0.508	-1.500	2.583	-0.472	5.321***	-0.976*	0.969	0.344
	(0.26)	(-0.89)	(1.49)	(-1.12)	(3.35)	(-1.74)	(0.49)	(0.54)
Non-relative	0.065	-1.923	1.550	-0.886*	3.997**	-1.602**	0.113	0.000
	(0.03)	(-1.11)	(0.82)	(-1.76)	(2.19)	(-2.24)	(0.06)	(.)
Marital Status (Excludes Never Married)								
Married	1.216	2.411	1.835	-1.467	6.808***	-1.481***	0.075	-4.783***
	(0.84)	(1.15)	(0.95)	(-1.60)	(3.18)	(-2.79)	(0.04)	(-18.39)
Other status	-1.910*	-1.521**	-1.211	-0.896*	-0.377	-2.167***	-2.039**	0.021
	(-1.82)	(-2.13)	(-1.13)	(-1.77)	(-0.31)	(-3.45)	(-2.40)	(0.03)
Female Head	0.292	-0.195	-0.732**	-0.235	-0.667	0.172	-0.453**	0.010
	(0.93)	(-0.73)	(-2.18)	(-1.45)	(-1.60)	(0.61)	(-1.97)	(0.03)
Head Education (Excludes - No Education)								
Primary	-0.065	-0.187	0.437*	0.023	0.319	-0.099	0.065	-0.482**
	(-0.41)	(-1.11)	(1.91)	(0.25)	(1.20)	(-0.59)	(0.43)	(-2.19)
Secondary	-0.303	-0.209	-0.085	-0.165	0.552	-0.549	-0.042	-0.147
	(-0.70)	(-0.65)	(-0.22)	(-0.78)	(1.05)	(-1.47)	(-0.15)	(-0.31)
Post-Secondary	1.039	1.594	-3.336	1.444	3.379***	3.465	1.591	5.933***
	(0.63)	(1.21)	(-1.14)	(1.00)	(2.70)	(1.24)	(0.91)	(12.00)
Head Marital Status (Excludes- Never Married								
Married	-0.665	-1.336**	-0.883	-0.769*	-1.302	-0.250	-1.270*	0.690
	(-0.95)	(-2.09)	(-1.09)	(-1.89)	(-1.38)	(-0.30)	(-1.94)	(1.05)
Other status	-0.768	-1.208*	-0.612	-0.609	-0.959	-0.698	-1.169*	0.497
	(-1.12)	(-1.95)	(-0.78)	(-1.59)	(-1.04)	(-0.86)	(-1.86)	(0.77)
Ln Head Age	-0.761	0.155	0.570	0.241	1.297	-0.043	0.183	-0.457
	(-1.11)	(0.29)	(0.73)	(0.70)	(1.59)	(-0.08)	(0.34)	(-0.69)
Land Rights Document	0.082	-0.174*	0.060	0.056	-0.119	0.096	0.023	0.044
	(0.65)	(-1.80)	(0.44)	(0.74)	(-0.80)	(0.73)	(0.28)	(0.32)
Ln TLUs	0.066	0.071	-0.016	0.077*	-0.047	0.346***	0.026	-0.003
	(0.76)	(0.95)	(-0.15)	(1.65)	(-0.39)	(3.93)	(0.39)	(-0.02)
Ln Adult Equivalent	-0.404	0.601**	0.601	-0.210	0.236	-0.305	0.407	-0.167
	(-1.22)	(2.23)	(1.62)	(-1.08)	(0.57)	(-0.94)	(1.51)	(-0.43)
Ln Land Size (ha)	0.018	0.133	0.094	0.006	0.337**	0.065	0.030	-0.058
	(0.14)	(1.41)	(0.66)	(0.08)	(1.99)	(0.48)	(0.37)	(-0.33)
Ln Ag Wage Income	-0.008	0.000	-0.012	0.001	0.002	0.004	-0.003	-0.018
	(-0.87)	(0.04)	(-1.11)	(0.30)	(0.12)	(0.39)	(-0.46)	(-1.57)
Ln Transfer Income	-0.001	-0.003	-0.007	-0.007	-0.023*	0.001	0.002	0.012
	(-0.13)	(-0.41)	(-0.60)	(-1.27)	(-1.85)	(0.05)	(0.29)	(1.10)
Ln Nonfarm Income	0.012	0.018***	0.003	0.002	0.011	0.003	-0.002	0.007
	(1.51)	(2.71)	(0.36)	(0.51)	(1.07)	(0.41)	(-0.34)	(0.73)
Observations	10840	10840	10840	10840	10840	10840	10840	6887

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.21: Effects of Net Agricultural Income per Hectare on School Expenditure and Study Times (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Ln Net Revenue per Ha (TSH/Ha)	**-0.179**	**0.416**	**0.988****	**0.227**	**1.771*****	**0.264**	**0.729****	**0.315**
	(-0.52)	**(1.19)**	**(2.20)**	**(1.09)**	**(3.13)**	**(0.71)**	**(2.02)**	**(0.96)**
Relationship to Head (Excludes Spouse)								
Child	0.706	-0.963	2.528	-0.504	4.816**	-0.890*	0.917	-0.095
	(0.36)	(-0.62)	(1.36)	(-1.19)	(2.36)	(-1.65)	(0.50)	(-0.16)
Grandchild	0.693	-1.467	2.524	-0.519	4.759**	-0.388	0.867	0.000
	(0.35)	(-0.91)	(1.27)	(-1.10)	(2.22)	(-0.54)	(0.46)	(.)
Relative	0.518	-1.783	1.895	-0.611	4.086*	-1.120*	0.465	-0.773
	(0.26)	(-1.10)	(0.97)	(-1.36)	(1.92)	(-1.70)	(0.25)	(-1.16)
Non-relative	0.030	-2.150	0.998	-0.997*	3.008	-1.718**	-0.291	-1.106
	(0.01)	(-1.29)	(0.48)	(-1.91)	(1.22)	(-2.19)	(-0.15)	(-1.37)
Marital Status (Excludes Never Married)								
Married	1.157	2.453	1.939	-1.447	6.993***	-1.459**	0.150	-4.555***
	(0.81)	(1.18)	(1.30)	(-1.63)	(3.32)	(-2.36)	(0.10)	(-12.26)
Other status	-1.937*	-1.476**	-1.103	-0.874*	-0.183	-2.144***	-1.960**	0.055
	(-1.87)	(-2.01)	(-0.96)	(-1.67)	(-0.14)	(-3.54)	(-2.16)	(0.07)
Female Head	0.196	-0.046	-0.371	-0.163	-0.020	0.247	-0.189	-0.048
	(0.56)	(-0.15)	(-0.91)	(-0.91)	(-0.04)	(0.79)	(-0.65)	(-0.13)
Head Education (Excludes - No Education)								
Primary	-0.108	-0.138	0.557**	0.047	0.534	-0.074	0.152	-0.415*
	(-0.67)	(-0.75)	(2.02)	(0.49)	(1.41)	(-0.42)	(0.83)	(-1.78)
Secondary	-0.416	-0.079	0.230	-0.102	1.117*	-0.483	0.188	0.104
	(-0.92)	(-0.22)	(0.50)	(-0.47)	(1.69)	(-1.27)	(0.55)	(0.19)
Post-Secondary	0.945	1.755	-2.945	1.522	4.081***	3.547	1.878	6.509***
	(0.55)	(1.34)	(-1.03)	(1.05)	(3.30)	(1.27)	(1.08)	(7.88)
Head Marital Status (Excludes- Never Married								
Married	-0.581	-1.527**	-1.348	-0.863**	-2.134*	-0.347	-1.610**	0.946
	(-0.78)	(-2.26)	(-1.51)	(-2.02)	(-1.66)	(-0.41)	(-2.13)	(1.17)
Other status	-0.659	-1.451**	-1.203	-0.728*	-2.019	-0.822	-1.602**	0.664
	(-0.89)	(-2.16)	(-1.35)	(-1.75)	(-1.57)	(-0.97)	(-2.14)	(0.86)
Ln Head Age	-0.929	0.445	1.274	0.382	2.559**	0.104	0.698	-0.946
	(-1.22)	(0.68)	(1.27)	(0.94)	(2.17)	(0.17)	(0.95)	(-1.03)
Land Rights Document	0.011	-0.081	0.286	0.101	0.286	0.144	0.189	0.079
	(0.07)	(-0.64)	(1.59)	(1.11)	(1.25)	(0.93)	(1.55)	(0.55)
Ln TLUs	0.089	-0.000	-0.190	0.042	-0.358**	0.310***	-0.101	-0.071
	(0.84)	(-0.00)	(-1.34)	(0.69)	(-2.01)	(2.77)	(-0.98)	(-0.49)
Ln Adult Equivalent	-0.228	0.343	-0.025	-0.336	-0.886	-0.436	-0.051	-0.398
	(-0.57)	(0.97)	(-0.05)	(-1.30)	(-1.31)	(-1.08)	(-0.13)	(-0.82)
Ln Land Size (ha)	-0.239	0.605	1.239**	0.237	2.390***	0.305	0.868**	0.303
	(-0.57)	(1.46)	(2.32)	(0.97)	(3.48)	(0.66)	(2.06)	(0.66)
Ln Ag Wage Income	-0.006	-0.006	-0.027**	-0.002	-0.027	0.000	-0.015	-0.021*
	(-0.54)	(-0.62)	(-2.04)	(-0.30)	(-1.59)	(0.04)	(-1.53)	(-1.73)
Ln Transfer Income	0.001	-0.009	-0.020	-0.009	-0.046***	-0.002	-0.008	0.011
	(0.11)	(-0.91)	(-1.43)	(-1.55)	(-2.75)	(-0.19)	(-0.84)	(0.99)
Ln Nonfarm Income	0.013	0.018**	0.001	0.002	0.008	0.003	-0.003	0.010
	(1.62)	(2.54)	(0.12)	(0.42)	(0.61)	(0.36)	(-0.52)	(0.97)
Observations	10847	10840	10840	10840	10840	10840	10840	6887

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.22: Effects of Net Agricultural Income on School Expenditure and Study Times (FE) – Full Tables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Ln Net Crop Income (Tsh)	**0.042**	**0.020**	**0.007**	**0.026**	**0.026**	**0.069****	**0.007**	**0.010**
	(1.49)	**(0.96)**	**(0.29)**	**(1.14)**	**(0.79)**	**(2.19)**	**(0.54)**	**(0.35)**
Relationship to Head (Excludes Spouse)								
Child	0.594	-0.728	3.053*	-0.531	5.853***	-1.011**	1.297	1.195
	(0.31)	(-0.45)	(1.85)	(-1.28)	(3.81)	(-2.11)	(0.67)	(1.52)
Grandchild	0.695	-1.295	2.884	-0.579	5.362***	-0.470	1.142	1.041
	(0.35)	(-0.77)	(1.61)	(-1.22)	(3.23)	(-0.70)	(0.59)	(1.35)
Relative	0.463	-1.392	2.588	-0.617	5.424***	-1.209**	1.013	0.307
	(0.24)	(-0.83)	(1.50)	(-1.45)	(3.40)	(-2.14)	(0.52)	(0.48)
Non-relative	-0.039	-1.894	1.579	-0.989**	4.076**	-1.791**	0.139	0.000
	(-0.02)	(-1.09)	(0.85)	(-1.98)	(2.23)	(-2.53)	(0.07)	(.)
Marital Status (Excludes Never Married)								
Married	1.200	2.391	1.801	-1.563*	6.818***	-1.603***	0.034	-5.035***
	(0.83)	(1.13)	(0.94)	(-1.73)	(3.22)	(-2.89)	(0.02)	(-19.70)
Other status	-1.866*	-1.440**	-1.184	-1.222**	-0.340	-2.527***	-1.968**	0.004
	(-1.85)	(-2.08)	(-1.14)	(-2.10)	(-0.29)	(-3.68)	(-2.39)	(0.01)
Female Head	0.213	-0.068	-0.539	-0.217	-0.619	0.147	-0.334	-0.118
	(0.69)	(-0.26)	(-1.60)	(-1.38)	(-1.52)	(0.54)	(-1.42)	(-0.33)
Head Education (Excludes - No Education)								
Primary	-0.072	-0.114	0.468**	0.026	0.447*	-0.147	0.097	-0.488**
	(-0.47)	(-0.71)	(2.10)	(0.31)	(1.73)	(-0.91)	(0.68)	(-2.28)
Secondary	-0.351	-0.153	-0.076	-0.136	0.707	-0.580	-0.059	-0.150
	(-0.84)	(-0.50)	(-0.21)	(-0.67)	(1.41)	(-1.51)	(-0.22)	(-0.33)
Post-Secondary	1.001	1.694	-3.307	1.459	3.547***	3.400	1.620	5.824***
	(0.60)	(1.27)	(-1.14)	(1.02)	(2.85)	(1.22)	(0.92)	(11.83)
Head Marital Status (Excludes- Never Married								
Married	-0.575	-1.287**	-1.154	-0.963**	-1.212	-0.424	-1.204*	0.665
	(-0.83)	(-2.13)	(-1.50)	(-2.19)	(-1.35)	(-0.56)	(-1.93)	(1.03)
Other status	-0.669	-1.166**	-0.906	-0.805*	-0.883	-0.830	-1.096*	0.447
	(-0.99)	(-2.00)	(-1.21)	(-1.92)	(-1.01)	(-1.12)	(-1.83)	(0.70)
Ln Head Age	-0.534	0.021	0.489	0.208	1.100	0.200	0.135	-0.244
	(-0.79)	(0.04)	(0.65)	(0.63)	(1.38)	(0.39)	(0.26)	(-0.38)
Land Rights Document	0.095	-0.220**	0.041	0.056	-0.165	0.170	0.006	0.016
	(0.77)	(-2.30)	(0.31)	(0.75)	(-1.13)	(1.32)	(0.08)	(0.12)
Ln TLUs	0.082	0.078	0.068	0.082*	-0.042	0.322***	0.049	-0.018
	(0.99)	(1.09)	(0.65)	(1.88)	(-0.36)	(3.87)	(0.76)	(-0.16)
Ln Adult Equivalent	-0.448	0.625**	0.604*	-0.178	0.207	-0.347	0.402	0.039
	(-1.38)	(2.37)	(1.66)	(-0.95)	(0.51)	(-1.09)	(1.52)	(0.10)
Ln Land Size (ha)	-0.071	0.104	0.102	-0.033	0.288*	0.006	0.025	-0.095
	(-0.58)	(1.14)	(0.77)	(-0.48)	(1.76)	(0.05)	(0.32)	(-0.57)
Ln Ag Wage Income	-0.006	-0.001	-0.012	0.001	0.002	0.007	-0.005	-0.021*
	(-0.68)	(-0.19)	(-1.21)	(0.29)	(0.13)	(0.70)	(-0.76)	(-1.85)
Ln Transfer Income	-0.001	-0.005	-0.008	-0.007	-0.024*	0.002	0.002	0.010
	(-0.06)	(-0.62)	(-0.79)	(-1.40)	(-1.94)	(0.22)	(0.36)	(0.94)
Ln Nonfarm Income	0.012	0.020***	0.003	0.002	0.010	0.001	-0.001	0.003
	(1.44)	(3.00)	(0.35)	(0.42)	(0.94)	(0.14)	(-0.22)	(0.29)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.23: Effects of Net Agricultural Income on School Expenditure and Study Times (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Ln Net Crop Income (Tsh)	**-0.247**	**0.365**	**1.071****	**0.234**	**1.772*****	**0.305**	**0.705***	**0.426**
	(-0.65)	**(1.02)**	**(2.29)**	**(1.10)**	**(3.02)**	**(0.81)**	**(1.91)**	**(1.32)**
Relationship to Head (Excludes Spouse)								
Child	0.800	-0.973	2.299	-0.678	4.615**	-1.178*	0.803	-0.156
	(0.39)	(-0.65)	(1.30)	(-1.48)	(2.07)	(-1.95)	(0.46)	(-0.25)
Grandchild	0.854	-1.485	2.300	-0.694	4.404*	-0.599	0.760	0.000
	(0.41)	(-0.95)	(1.21)	(-1.37)	(1.90)	(-0.78)	(0.42)	(.)
Relative	0.742	-1.726	1.560	-0.819	3.736	-1.437*	0.339	-0.795
	(0.36)	(-1.09)	(0.83)	(-1.63)	(1.60)	(-1.95)	(0.19)	(-1.13)
Non-relative	0.161	-2.133	0.843	-1.133**	2.868	-1.953**	-0.344	-0.971
	(0.08)	(-1.32)	(0.42)	(-2.07)	(1.09)	(-2.38)	(-0.18)	(-1.16)
Marital Status (Excludes Never Married)								
Married	1.190	2.403	1.838	-1.556*	6.878***	-1.595**	0.058	-5.100***
	(0.81)	(1.16)	(1.26)	(-1.75)	(3.07)	(-2.47)	(0.04)	(-18.39)
Other status	-1.875*	-1.429**	-1.150	-1.215**	-0.283	-2.520***	-1.946**	0.002
	(-1.88)	(-2.03)	(-1.04)	(-2.05)	(-0.23)	(-3.77)	(-2.25)	(0.00)
Female Head	0.070	0.103	-0.011	-0.114	0.248	0.263	0.013	-0.207
	(0.19)	(0.31)	(-0.02)	(-0.60)	(0.42)	(0.80)	(0.04)	(-0.53)
Head Education (Excludes - No Education)								
Primary	-0.100	-0.081	0.571**	0.046	0.616	-0.124	0.165	-0.418*
	(-0.62)	(-0.47)	(2.07)	(0.51)	(1.63)	(-0.73)	(0.93)	(-1.88)
Secondary	-0.464	-0.019	0.339	-0.055	1.387**	-0.488	0.212	0.255
	(-1.02)	(-0.05)	(0.72)	(-0.26)	(2.06)	(-1.21)	(0.61)	(0.43)
Post-Secondary	0.932	1.776	-3.054	1.508	3.964***	3.456	1.787	6.808***
	(0.55)	(1.35)	(-1.07)	(1.05)	(3.30)	(1.25)	(1.03)	(7.55)
Head Marital Status (Excludes- Never Married								
Married	-0.392	-1.506**	-1.828*	-1.095**	-2.318*	-0.573	-1.646**	0.983
	(-0.49)	(-2.23)	(-1.84)	(-2.32)	(-1.66)	(-0.70)	(-2.11)	(1.09)
Other status	-0.451	-1.427**	-1.709*	-0.962**	-2.201	-1.008	-1.622**	0.635
	(-0.57)	(-2.11)	(-1.71)	(-2.06)	(-1.57)	(-1.24)	(-2.09)	(0.73)
Ln Head Age	-0.784	0.320	1.410	0.388	2.611**	0.404	0.739	-0.955
	(-0.99)	(0.47)	(1.30)	(0.92)	(2.04)	(0.64)	(0.95)	(-1.04)
Land Rights Document	0.027	-0.138	0.291	0.105	0.245	0.225	0.170	0.071
	(0.18)	(-1.08)	(1.57)	(1.14)	(1.05)	(1.46)	(1.37)	(0.49)
Ln TLUs	0.122	0.029	-0.081	0.053	-0.287*	0.289***	-0.049	-0.113
	(1.23)	(0.32)	(-0.59)	(0.95)	(-1.68)	(2.85)	(-0.51)	(-0.84)
Ln Adult Equivalent	-0.238	0.374	-0.167	-0.329	-1.058	-0.518	-0.103	-0.354
	(-0.54)	(1.00)	(-0.31)	(-1.22)	(-1.46)	(-1.23)	(-0.25)	(-0.69)
Ln Land Size (ha)	0.015	0.002	-0.213	-0.095	-0.230	-0.064	-0.182	-0.126
	(0.09)	(0.01)	(-0.99)	(-0.95)	(-0.81)	(-0.40)	(-1.22)	(-0.72)
Ln Ag Wage Income	-0.002	-0.007	-0.030**	-0.002	-0.027	0.003	-0.017*	-0.023**
	(-0.14)	(-0.71)	(-2.20)	(-0.37)	(-1.62)	(0.24)	(-1.72)	(-1.99)
Ln Transfer Income	0.004	-0.010	-0.024*	-0.010*	-0.050***	-0.001	-0.008	0.008
	(0.33)	(-1.02)	(-1.69)	(-1.68)	(-2.83)	(-0.11)	(-0.85)	(0.73)
Ln Nonfarm Income	0.012	0.019***	0.000	0.001	0.006	0.001	-0.003	0.008
	(1.51)	(2.81)	(0.04)	(0.31)	(0.43)	(0.07)	(-0.47)	(0.73)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.24: Effects of Land Productivity on School Expenditure and Study Times – Excluding Other Income (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**0.060*** **	**0.001**	**0.026**	**0.018**	**-0.027**	**0.020**	**0.021**	**-0.007**
	(3.28)	**(0.08)**	**(1.25)**	**(1.40)**	**(-1.16)**	**(1.10)**	**(1.51)**	**(-0.36)**
Relationship to Head (Excludes Spouse)								
Child	0.493	-0.806	3.020*	-0.517	5.923***	-0.987**	1.271	1.214
	(0.26)	(-0.50)	(1.83)	(-1.29)	(3.89)	(-2.11)	(0.66)	(1.57)
Grandchild	0.560	-1.377	2.856	-0.580	5.446***	-0.480	1.110	1.154
	(0.28)	(-0.82)	(1.59)	(-1.24)	(3.31)	(-0.72)	(0.57)	(1.50)
Relative	0.359	-1.441	2.549	-0.607	5.517***	-1.177**	0.979	0.330
	(0.18)	(-0.86)	(1.48)	(-1.47)	(3.49)	(-2.13)	(0.50)	(0.52)
Non-relative	-0.100	-1.936	1.555	-0.971**	4.140**	-1.757**	0.118	0.000
	(-0.05)	(-1.13)	(0.83)	(-1.98)	(2.29)	(-2.51)	(0.06)	(.)
Marital Status (Excludes Never Married)								
Married	1.284	2.329	1.877	-1.525*	6.768***	-1.587***	0.082	-5.086***
	(0.91)	(1.10)	(1.00)	(-1.75)	(3.16)	(-2.94)	(0.05)	(-15.49)
Other status	-1.874*	-1.488**	-1.179	-1.205**	-0.337	-2.519***	-1.965**	-0.046
	(-1.86)	(-2.13)	(-1.13)	(-2.10)	(-0.29)	(-3.66)	(-2.38)	(-0.06)
Female Head	0.237	-0.082	-0.520	-0.214	-0.649	0.127	-0.321	-0.129
	(0.77)	(-0.31)	(-1.54)	(-1.39)	(-1.60)	(0.47)	(-1.36)	(-0.36)
Head Education (Excludes - No Education)								
Primary	-0.070	-0.115	0.476**	0.025	0.446*	-0.157	0.100	-0.466**
	(-0.46)	(-0.71)	(2.14)	(0.29)	(1.73)	(-0.97)	(0.69)	(-2.18)
Secondary	-0.358	-0.140	-0.086	-0.154	0.685	-0.604	-0.062	-0.170
	(-0.86)	(-0.45)	(-0.24)	(-0.76)	(1.36)	(-1.57)	(-0.23)	(-0.37)
Post-Secondary	1.012	1.767	-3.313	1.449	3.579***	3.381	1.607	5.716***
	(0.61)	(1.33)	(-1.14)	(1.00)	(2.86)	(1.21)	(0.92)	(11.93)
Head Marital Status (Excludes- Never Married								
Married	-0.595	-1.302**	-1.170	-0.966**	-1.211	-0.394	-1.207*	0.697
	(-0.85)	(-2.13)	(-1.51)	(-2.17)	(-1.34)	(-0.52)	(-1.94)	(1.09)
Other status	-0.694	-1.178**	-0.947	-0.816*	-0.905	-0.784	-1.102*	0.486
	(-1.02)	(-2.00)	(-1.26)	(-1.92)	(-1.03)	(-1.06)	(-1.84)	(0.77)
Ln Head Age	-0.512	0.001	0.489	0.197	1.024	0.173	0.148	-0.312
	(-0.76)	(0.00)	(0.65)	(0.60)	(1.29)	(0.33)	(0.29)	(-0.49)
Land Rights Document	0.108	-0.222**	0.045	0.051	-0.193	0.162	0.013	0.023
	(0.88)	(-2.33)	(0.34)	(0.69)	(-1.32)	(1.26)	(0.17)	(0.17)
Ln TLUs	0.048	0.079	0.048	0.072	-0.027	0.319***	0.037	-0.011
	(0.58)	(1.11)	(0.46)	(1.63)	(-0.23)	(3.81)	(0.57)	(-0.10)
Ln Adult Equivalent	-0.414	0.676***	0.614*	-0.156	0.266	-0.304	0.398	0.019
	(-1.28)	(2.59)	(1.70)	(-0.83)	(0.66)	(-0.97)	(1.51)	(0.05)
Ln Land Size (ha)	-0.022	0.119	0.113	-0.014	0.283*	0.044	0.036	-0.114
	(-0.18)	(1.31)	(0.84)	(-0.21)	(1.74)	(0.34)	(0.46)	(-0.67)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.25: Effects of Labor Productivity on School Expenditure and Study Times – Excluding Other Income (FE) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**0.055***	**0.012**	**0.007**	**0.024**	**-0.024**	**0.040**	**0.026**	**-0.013**
	(1.88)	**(0.51)**	**(0.22)**	**(1.14)**	**(-0.66)**	**(1.37)**	**(1.34)**	**(-0.36)**
Relationship to Head (Excludes Spouse)								
Child	0.476	-0.822	3.038*	-0.534	5.928***	-1.022**	1.255	1.223
	(0.25)	(-0.51)	(1.84)	(-1.32)	(3.91)	(-2.15)	(0.65)	(1.58)
Grandchild	0.561	-1.396	2.886	-0.594	5.443***	-0.516	1.098	1.159
	(0.28)	(-0.84)	(1.61)	(-1.26)	(3.32)	(-0.77)	(0.57)	(1.51)
Relative	0.355	-1.461	2.578	-0.621	5.516***	-1.214**	0.966	0.337
	(0.18)	(-0.88)	(1.49)	(-1.49)	(3.50)	(-2.17)	(0.49)	(0.53)
Non-relative	-0.118	-1.949	1.567	-0.986**	4.146**	-1.787**	0.104	0.000
	(-0.06)	(-1.14)	(0.84)	(-2.00)	(2.30)	(-2.53)	(0.05)	(.)
Marital Status (Excludes Never Married)								
Married	1.183	2.331	1.827	-1.553*	6.814***	-1.614***	0.050	-5.069***
	(0.82)	(1.10)	(0.97)	(-1.76)	(3.18)	(-2.91)	(0.03)	(-17.12)
Other status	-1.915*	-1.491**	-1.194	-1.218**	-0.319	-2.537***	-1.980**	-0.040
	(-1.90)	(-2.14)	(-1.15)	(-2.10)	(-0.27)	(-3.68)	(-2.41)	(-0.06)
Female Head	0.225	-0.075	-0.536	-0.213	-0.642	0.136	-0.321	-0.130
	(0.73)	(-0.28)	(-1.59)	(-1.38)	(-1.58)	(0.50)	(-1.36)	(-0.36)
Head Education (Excludes - No Education)								
Primary	-0.067	-0.113	0.475**	0.026	0.445*	-0.154	0.101	-0.470**
	(-0.44)	(-0.70)	(2.13)	(0.31)	(1.72)	(-0.95)	(0.70)	(-2.20)
Secondary	-0.347	-0.139	-0.082	-0.150	0.680	-0.599	-0.058	-0.171
	(-0.83)	(-0.45)	(-0.23)	(-0.74)	(1.35)	(-1.55)	(-0.22)	(-0.37)
Post-Secondary	1.051	1.770	-3.300	1.463	3.562***	3.400	1.622	5.699***
	(0.63)	(1.33)	(-1.14)	(1.01)	(2.83)	(1.21)	(0.93)	(11.86)
Head Marital Status (Excludes- Never Married								
Married	-0.557	-1.300**	-1.155	-0.954**	-1.228	-0.380	-1.193*	0.691
	(-0.80)	(-2.13)	(-1.49)	(-2.16)	(-1.36)	(-0.50)	(-1.92)	(1.08)
Other status	-0.651	-1.178**	-0.927	-0.803*	-0.924	-0.770	-1.087*	0.480
	(-0.96)	(-2.00)	(-1.23)	(-1.90)	(-1.05)	(-1.04)	(-1.82)	(0.76)
Ln Head Age	-0.508	0.014	0.470	0.208	1.024	0.199	0.158	-0.307
	(-0.75)	(0.03)	(0.63)	(0.63)	(1.29)	(0.38)	(0.31)	(-0.48)
Land Rights Document	0.103	-0.219**	0.038	0.051	-0.191	0.166	0.013	0.022
	(0.83)	(-2.29)	(0.29)	(0.69)	(-1.30)	(1.28)	(0.17)	(0.17)
Ln TLUs	0.079	0.078	0.065	0.080*	-0.041	0.326***	0.046	-0.014
	(0.95)	(1.10)	(0.62)	(1.81)	(-0.35)	(3.91)	(0.72)	(-0.12)
Ln Adult Equivalent	-0.401	0.676***	0.621*	-0.153	0.260	-0.301	0.402	0.020
	(-1.24)	(2.59)	(1.72)	(-0.81)	(0.65)	(-0.96)	(1.52)	(0.05)
Ln Land Size (ha)	-0.070	0.115	0.096	-0.031	0.304*	0.022	0.018	-0.109
	(-0.58)	(1.27)	(0.72)	(-0.44)	(1.87)	(0.17)	(0.23)	(-0.64)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.26: Effects of Land Productivity on School Expenditure and Study Times – Excluding Other Income (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.190**	**0.364**	**0.905****	**0.205**	**1.539*****	**0.281**	**0.597***	**0.307**
	(-0.58)	**(1.16)**	**(2.19)**	**(1.09)**	**(2.66)**	**(0.85)**	**(1.86)**	**(1.14)**
Relationship to Head (Excludes Spouse)								
Child	0.756	-1.188	2.095	-0.715*	4.274*	-1.260*	0.663	1.260
	(0.37)	(-0.78)	(1.02)	(-1.69)	(1.70)	(-1.77)	(0.37)	(1.57)
Grandchild	0.960	-1.959	1.447	-0.881	2.936	-0.897	0.186	0.994
	(0.45)	(-1.19)	(0.63)	(-1.61)	(1.07)	(-0.95)	(0.10)	(1.21)
Relative	0.746	-2.005	1.184	-0.898*	3.085	-1.581*	0.084	0.198
	(0.35)	(-1.24)	(0.54)	(-1.81)	(1.17)	(-1.81)	(0.04)	(0.29)
Non-relative	0.085	-2.205	0.903	-1.111**	2.978	-1.950**	-0.310	0.000
	(0.04)	(-1.38)	(0.40)	(-2.21)	(1.08)	(-2.25)	(-0.16)	(.)
Marital Status (Excludes Never Married)								
Married	0.778	3.065	3.658*	-1.145*	9.941**	-1.060	1.251	-1.982
	(0.43)	(1.17)	(1.66)	(-1.76)	(2.41)	(-0.95)	(0.62)	(-0.75)
Other status	-2.005**	-1.297*	-0.717	-1.106**	0.485	-2.382***	-1.662*	-0.090
	(-1.96)	(-1.73)	(-0.63)	(-1.99)	(0.34)	(-3.80)	(-1.85)	(-0.12)
Female Head	0.036	0.211	0.190	-0.063	0.615	0.337	0.144	0.096
	(0.09)	(0.54)	(0.36)	(-0.30)	(0.79)	(0.88)	(0.38)	(0.22)
Head Education (Excludes - No Education)								
Primary	-0.082	-0.097	0.519**	0.034	0.523	-0.144	0.128	-0.664**
	(-0.52)	(-0.56)	(1.98)	(0.38)	(1.41)	(-0.86)	(0.74)	(-2.25)
Secondary	-0.330	-0.180	-0.183	-0.174	0.512	-0.633	-0.126	-0.287
	(-0.76)	(-0.54)	(-0.42)	(-0.79)	(0.73)	(-1.64)	(-0.42)	(-0.59)
Post-Secondary	1.118	1.611	-3.688	1.369	2.910*	3.270	1.360	5.566***
	(0.69)	(1.16)	(-1.22)	(0.92)	(1.78)	(1.13)	(0.73)	(10.90)
Head Marital Status (Excludes- Never Married								
Married	-0.448	-1.515**	-1.687*	-1.076**	-2.131*	-0.547	-1.546**	0.918
	(-0.59)	(-2.31)	(-1.78)	(-2.23)	(-1.80)	(-0.69)	(-2.23)	(1.36)
Other status	-0.503	-1.455**	-1.616*	-0.959**	-2.098*	-0.982	-1.541**	0.672
	(-0.67)	(-2.22)	(-1.69)	(-2.00)	(-1.74)	(-1.24)	(-2.23)	(1.02)
Ln Head Age	-0.769	0.375	1.393	0.390	2.637**	0.440	0.742	-0.079
	(-0.99)	(0.55)	(1.33)	(0.92)	(1.98)	(0.71)	(1.00)	(-0.10)
Land Rights Document	0.027	-0.104	0.330*	0.112	0.315	0.246	0.201	0.054
	(0.17)	(-0.73)	(1.68)	(1.13)	(1.16)	(1.47)	(1.48)	(0.38)
Ln TLUs	0.215	-0.164	-0.539*	-0.054	-1.075**	0.145	-0.349	-0.267
	(0.92)	(-0.71)	(-1.72)	(-0.39)	(-2.41)	(0.61)	(-1.46)	(-1.08)
Ln Adult Equivalent	-0.343	0.572*	0.362	-0.210	-0.182	-0.378	0.233	-0.101
	(-0.99)	(1.95)	(0.83)	(-0.99)	(-0.31)	(-1.15)	(0.72)	(-0.24)
Ln Land Size (ha)	-0.166	0.329	0.622**	0.094	1.189***	0.194	0.370*	0.169
	(-0.72)	(1.60)	(2.21)	(0.77)	(2.88)	(0.81)	(1.79)	(0.56)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.27: Effects of Labor Productivity on School Expenditure and Study Times – Excluding Other Income (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.384**	**0.737**	**1.829****	**0.415**	**3.112****	**0.567**	**1.207***	**0.946**
	(-0.57)	**(1.13)**	**(2.01)**	**(1.07)**	**(2.30)**	**(0.84)**	**(1.75)**	**(1.05)**
Relationship to Head (Excludes Spouse)								
Child	1.108	-1.864	0.417	-1.096	1.420	-1.781	-0.444	0.612
	(0.48)	(-1.15)	(0.13)	(-1.37)	(0.30)	(-1.35)	(-0.20)	(0.62)
Grandchild	1.317	-2.642	-0.249	-1.266	0.051	-1.423	-0.933	0.469
	(0.54)	(-1.45)	(-0.07)	(-1.37)	(0.01)	(-0.92)	(-0.39)	(0.43)
Relative	1.119	-2.719	-0.589	-1.301	0.069	-2.131	-1.086	-0.422
	(0.46)	(-1.51)	(-0.18)	(-1.44)	(0.01)	(-1.41)	(-0.46)	(-0.43)
Non-relative	0.376	-2.762*	-0.481	-1.425*	0.623	-2.379*	-1.223	0.000
	(0.16)	(-1.72)	(-0.15)	(-1.82)	(0.13)	(-1.82)	(-0.55)	(.)
Marital Status (Excludes Never Married)								
Married	1.028	2.586	2.468	-1.415**	7.917*	-1.429	0.466	-0.836
	(0.62)	(1.00)	(1.18)	(-2.21)	(1.65)	(-1.21)	(0.23)	(-0.21)
Other status	-1.838*	-1.618**	-1.512	-1.286**	-0.868	-2.629**	-2.187***	-0.548
	(-1.79)	(-2.36)	(-1.38)	(-2.09)	(-0.57)	(-4.03)	(-2.66)	(-0.56)
Female Head	-0.057	0.389	0.631	0.037	1.365	0.474	0.436	0.388
	(-0.11)	(0.75)	(0.86)	(0.13)	(1.23)	(0.93)	(0.81)	(0.61)
Head Education (Excludes - No Education)								
Primary	-0.110	-0.043	0.653**	0.065	0.752*	-0.102	0.217	-0.577*
	(-0.65)	(-0.22)	(2.21)	(0.66)	(1.70)	(-0.56)	(1.07)	(-1.94)
Secondary	-0.381	-0.083	0.058	-0.120	0.921	-0.558	0.033	-0.303
	(-0.87)	(-0.24)	(0.11)	(-0.55)	(1.14)	(-1.34)	(0.09)	(-0.55)
Post-Secondary	0.943	1.948	-2.852	1.559	4.333***	3.530	1.912	6.712***
	(0.57)	(1.41)	(-0.93)	(1.05)	(2.79)	(1.26)	(1.04)	(6.33)
Head Marital Status (Excludes- Never Married								
Married	-0.580	-1.263*	-1.061	-0.934**	-1.068	-0.353	-1.133	1.542
	(-0.75)	(-1.86)	(-1.02)	(-2.06)	(-0.64)	(-0.47)	(-1.43)	(1.22)
Other status	-0.633	-1.206*	-0.999	-0.819*	-1.048	-0.791	-1.134	1.289
	(-0.83)	(-1.82)	(-0.98)	(-1.86)	(-0.63)	(-1.08)	(-1.47)	(1.04)
Ln Head Age	-1.030	0.874	2.633*	0.671	4.745**	0.825	1.560	-0.294
	(-0.96)	(0.85)	(1.69)	(1.08)	(2.19)	(0.85)	(1.37)	(-0.32)
Land Rights Document	-0.010	-0.034	0.504*	0.151	0.611	0.300	0.315	0.094
	(-0.05)	(-0.17)	(1.81)	(1.17)	(1.46)	(1.40)	(1.57)	(0.56)
Ln TLUs	0.154	-0.046	-0.248	0.013	-0.580*	0.236	-0.157	-0.233
	(1.09)	(-0.32)	(-1.12)	(0.15)	(-1.76)	(1.59)	(-0.98)	(-0.98)
Ln Adult Equivalent	-0.368	0.622**	0.485	-0.182	0.028	-0.340	0.314	-0.276
	(-1.09)	(2.11)	(1.03)	(-0.88)	(0.04)	(-1.04)	(0.93)	(-0.52)
Ln Land Size (ha)	0.041	-0.067	-0.363	-0.129	-0.486	-0.111	-0.280	0.004
	(0.19)	(-0.34)	(-1.20)	(-1.03)	(-1.06)	(-0.53)	(-1.29)	(0.02)
Observations	11054	11054	11054	11054	11054	11054	11054	7050

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.28: Effects of Land Productivity on School Expenditure and Study Times – Rainfall Deviations as Instrument (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Land Productivity (TSH/Ha)	**-0.563**	**0.453***	**0.994****	**-0.011**	**0.854***	**0.219**	**0.227**	**0.490****
	(-1.58)	**(1.74)**	**(2.49)**	**(-0.06)**	**(1.93)**	**(0.68)**	**(1.10)**	**(2.37)**
Relationship to Head (Excludes Spouse)								
Child	1.166	-1.046	1.914	-0.545	4.664**	-1.333*	1.113	0.502
	(0.51)	(-0.68)	(0.94)	(-1.12)	(2.49)	(-1.93)	(0.61)	(0.81)
Grandchild	1.555	-1.836	1.055	-0.619	3.550*	-0.911	0.856	0.000
	(0.65)	(-1.12)	(0.46)	(-1.03)	(1.71)	(-0.96)	(0.46)	(.)
Relative	1.334	-1.779	0.868	-0.636	3.660*	-1.648*	0.759	-0.562
	(0.56)	(-1.10)	(0.40)	(-1.15)	(1.84)	(-1.89)	(0.41)	(-0.77)
Non-relative	0.351	-2.027	0.611	-1.016*	2.921	-2.100**	0.020	-0.687
	(0.15)	(-1.23)	(0.27)	(-1.83)	(1.35)	(-2.42)	(0.01)	(-0.81)
Marital Status (Excludes Never Married)								
Married	0.140	3.259	3.912	-1.540	8.463***	-1.222	0.455	0.616
	(0.06)	(1.12)	(1.63)	(-1.54)	(2.80)	(-1.21)	(0.25)	(0.29)
Other status	-2.151**	-1.179	-0.607	-1.222**	0.107	-2.396***	-1.831**	0.102
	(-2.04)	(-1.54)	(-0.52)	(-2.07)	(0.08)	(-3.79)	(-2.18)	(0.13)
Female Head	-0.279	0.248	0.278	-0.254	0.096	0.342	-0.189	0.285
	(-0.57)	(0.69)	(0.51)	(-1.11)	(0.15)	(0.88)	(-0.65)	(0.58)
Head Education (Excludes - No Education)								
Primary	-0.137	-0.104	0.581**	0.016	0.482	-0.158	0.082	-0.806***
	(-0.73)	(-0.58)	(2.16)	(0.18)	(1.58)	(-0.94)	(0.57)	(-2.74)
Secondary	-0.340	-0.247	-0.178	-0.148	0.651	-0.646*	-0.145	-0.310
	(-0.72)	(-0.72)	(-0.40)	(-0.73)	(1.12)	(-1.70)	(-0.56)	(-0.63)
Post-Secondary	1.241	1.776	-3.594	1.417	3.091**	3.240	1.607	5.531***
	(0.74)	(1.12)	(-1.18)	(1.00)	(2.03)	(1.10)	(0.84)	(11.29)
Head Marital Status (Excludes- Never Married								
Married	-0.202	-1.484**	-1.794*	-0.937**	-1.719*	-0.515	-1.314**	0.912
	(-0.24)	(-2.29)	(-1.83)	(-2.03)	(-1.75)	(-0.65)	(-2.06)	(1.34)
Other status	-0.207	-1.434**	-1.721*	-0.776*	-1.538	-0.972	-1.253**	0.725
	(-0.25)	(-2.23)	(-1.74)	(-1.70)	(-1.55)	(-1.23)	(-2.01)	(1.08)
Ln Head Age	-1.278	0.416	1.862*	0.205	2.341**	0.366	0.248	0.159
	(-1.40)	(0.64)	(1.78)	(0.47)	(2.18)	(0.55)	(0.46)	(0.18)
Land Rights Document	-0.116	-0.056	0.363*	0.046	0.067	0.216	0.075	0.081
	(-0.68)	(-0.43)	(1.85)	(0.50)	(0.31)	(1.33)	(0.77)	(0.55)
Ln TLUs	0.379	-0.213	-0.649**	0.100	-0.552*	0.181	-0.116	-0.350*
	(1.57)	(-1.12)	(-2.22)	(0.79)	(-1.74)	(0.83)	(-0.78)	(-1.92)
Ln Adult Equivalent	-0.161	0.560*	0.288	-0.170	-0.061	-0.312	0.364	-0.122
	(-0.42)	(1.84)	(0.64)	(-0.83)	(-0.13)	(-0.93)	(1.30)	(-0.27)
Ln Land Size (ha)	-0.363	0.368**	0.710**	-0.035	0.781**	0.165	0.166	0.274
	(-1.43)	(2.02)	(2.53)	(-0.28)	(2.43)	(0.70)	(1.20)	(1.04)
Ln Ag Wage Income	-0.004	-0.007	-0.019	0.002	-0.005	0.004	-0.009	-0.021*
	(-0.35)	(-0.77)	(-1.56)	(0.36)	(-0.38)	(0.45)	(-1.29)	(-1.66)
Ln Transfer Income	0.004	-0.005	-0.014	-0.008	-0.026*	0.005	0.002	0.015
	(0.32)	(-0.65)	(-1.06)	(-1.43)	(-1.85)	(0.43)	(0.25)	(1.22)
Ln Nonfarm Income	0.015*	0.017**	0.001	0.002	0.006	0.000	-0.003	-0.001
	(1.73)	(2.38)	(0.07)	(0.48)	(0.51)	(0.05)	(-0.48)	(-0.14)
Observations	10957	10957	10957	10957	10957	10957	10957	6979

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.29: Effects of Labor Productivity on School Expenditure and Study Times – Rainfall Deviations as Instrument (IV) – Full Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Outcomes in Logs							
	Fees	Books	Uniform	Transport	Contributions	Food	Total Expenses	Minutes Studying
Log Labor Productivity (TSH/Day)	**-0.497**	**0.130**	**2.098****	**0.250**	**1.278**	**1.146**	**0.596**	**1.080**
	(-0.70)	**(0.25)**	**(2.23)**	**(0.64)**	**(1.38)**	**(1.50)**	**(1.28)**	**(1.60)**
Relationship to Head (Excludes Spouse)								
Child	1.242	-0.729	0.067	-0.908	3.813	-2.699	0.527	0.163
	(0.52)	(-0.41)	(0.02)	(-1.26)	(1.42)	(-1.43)	(0.28)	(0.24)
Grandchild	1.447	-1.286	-0.849	-1.066	2.813	-2.504	0.221	0.000
	(0.57)	(-0.68)	(-0.23)	(-1.24)	(0.96)	(-1.18)	(0.11)	(.)
Relative	1.243	-1.239	-1.085	-1.088	2.889	-3.262	0.110	-0.710
	(0.49)	(-0.65)	(-0.30)	(-1.31)	(1.01)	(-1.57)	(0.05)	(-0.81)
Non-relative	0.428	-1.764	-0.994	-1.327*	2.173	-3.276*	-0.487	-0.231
	(0.18)	(-0.97)	(-0.29)	(-1.83)	(0.77)	(-1.70)	(-0.24)	(-0.23)
Marital Status (Excludes Never Married)								
Married	1.083	2.432	2.557	-1.456**	7.167***	-1.346	0.175	0.813
	(0.64)	(1.02)	(1.04)	(-2.04)	(2.62)	(-0.68)	(0.10)	(0.25)
Other status	-1.765*	-1.443**	-1.501	-1.259**	-0.570	-2.711**	-2.056**	-0.388
	(-1.71)	(-2.07)	(-1.30)	(-2.10)	(-0.47)	(-4.15)	(-2.55)	(-0.41)
Female Head	-0.139	-0.046	0.854	-0.077	0.237	0.930	0.021	0.480
	(-0.23)	(-0.11)	(1.06)	(-0.24)	(0.29)	(1.52)	(0.05)	(0.84)
Head Education (Excludes - No Education)								
Primary	-0.160	-0.123	0.793**	0.052	0.590*	-0.016	0.147	-0.592**
	(-0.83)	(-0.70)	(2.42)	(0.49)	(1.80)	(-0.07)	(0.89)	(-2.00)
Secondary	-0.445	-0.193	0.143	-0.121	0.868	-0.499	-0.058	-0.242
	(-1.01)	(-0.62)	(0.27)	(-0.58)	(1.48)	(-1.08)	(-0.20)	(-0.43)
Post-Secondary	0.841	2.026	-2.564	1.478	3.837***	3.648	1.873	6.766***
	(0.48)	(1.31)	(-0.83)	(1.03)	(2.59)	(1.26)	(0.98)	(8.25)
Head Marital Status (Excludes- Never Married								
Married	-0.598	-1.179**	-1.036	-0.932**	-1.094	-0.316	-1.136*	1.506
	(-0.75)	(-1.97)	(-0.92)	(-2.14)	(-1.04)	(-0.38)	(-1.75)	(1.28)
Other status	-0.658	-1.064*	-0.958	-0.791*	-0.869	-0.823	-1.082*	1.358
	(-0.84)	(-1.84)	(-0.87)	(-1.89)	(-0.84)	(-1.03)	(-1.72)	(1.16)
Ln Head Age	-1.260	0.040	3.464**	0.553	3.016*	1.635	0.771	-0.070
	(-1.03)	(0.05)	(1.99)	(0.82)	(1.95)	(1.30)	(0.94)	(-0.07)
Land Rights Document	-0.068	-0.163	0.586**	0.113	0.126	0.438*	0.156	0.113
	(-0.31)	(-1.02)	(2.00)	(0.91)	(0.44)	(1.82)	(1.12)	(0.69)
Ln TLUs	0.132	0.037	-0.448*	0.045	-0.278	0.093	-0.092	-0.313
	(0.81)	(0.29)	(-1.78)	(0.48)	(-1.18)	(0.49)	(-0.76)	(-1.45)
Ln Adult Equivalent	-0.317	0.700***	0.499	-0.187	0.148	-0.302	0.406	-0.330
	(-0.92)	(2.63)	(0.99)	(-0.94)	(0.32)	(-0.83)	(1.43)	(-0.60)
Ln Land Size (ha)	0.086	0.074	-0.389	-0.091	-0.032	-0.247	-0.114	-0.028
	(0.39)	(0.47)	(-1.23)	(-0.74)	(-0.11)	(-1.04)	(-0.76)	(-0.14)
Ln Ag Wage Income	-0.008	-0.004	-0.008	0.002	0.002	0.009	-0.006	-0.011
	(-0.80)	(-0.51)	(-0.61)	(0.45)	(0.18)	(0.79)	(-0.87)	(-0.76)
Ln Transfer Income	0.003	-0.003	-0.022	-0.010	-0.030*	-0.002	-0.001	0.008
	(0.28)	(-0.37)	(-1.33)	(-1.59)	(-1.91)	(-0.18)	(-0.13)	(0.61)
Ln Nonfarm Income	0.013	0.019***	0.006	0.002	0.010	0.002	-0.001	0.012
	(1.55)	(2.75)	(0.47)	(0.51)	(0.83)	(0.22)	(-0.23)	(0.92)
Observations	10957	10957	10957	10957	10957	10957	10957	6979

T–statistics in parentheses. *p<0.1 ** p<0.05 *** p<0.01. Includes individual, wave, and interview–month fixed effects. The unit of analysis is individual. Productivity/agricultural income is at the household level. Sample restricted to children who either are currently in school or were in school the previous completed academic year. Errors clustered at the individual level.

Table A 2.30: First Stage Regressions – Productivity and Rainfall Deviations

	(1) Ln Land Productivity (Tsh/Ha)	(2) Ln Labor Productivity (Tsh/Day)
Q1 Rainfall deviation (Jan-Mar)	0.133***	0.064**
	(3.12)	(2.31)
Q2 Rainfall deviation (Apr-Jun)	0.178***	0.073**
	(3.31)	(2.31)
Q3 Rainfall deviation (Jul-Sep)	-0.028	-0.019
	(0.45)	(0.40)
Q4 Rainfall deviation (Oct-Dec)	-0.054	-0.012
	(0.97)	(0.29)
Observations	11054	11054
F-Stat	10.6	16.79

T–statistics in parentheses. * p<0.1 ** p<0.05 *** p<0.01. Includes individual, and wave FE. Rainfall deviations are defined as normalized quarterly deviations from a decade mean (2007–2017)

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Chapter 3 :

School Electrification and Academic Outcomes in Rural Kenya

I. INTRODUCTION[2]

A number of developing countries are embarking on extensive rural electrification projects in an effort to improve household incomes and welfare. Electrification can affect incomes directly and indirectly. Electricity expands the set of possible income generating activities and provides light for extended working hours, and consequently increases income (Khandker *et al*., 2009b) – this is an example of a direct mechanism. Indirect mechanisms may include positive electrification effects on education and health, which in turn can lead to higher incomes. Specifically, improved and cheaper electric lighting increases time available for studying and hence can improve educational outcomes. There is a general consensus that education is a crucial investment in human capital and thus has long run impacts on labor market outcomes. There is also evidence of excessive indoor household pollution resulting from excessive use of kerosene or firewood lighting which emit harmful gases and soot (Baron and Torero, 2017; Lam *et al*., 2012(b); Bates *et al*., 2013). Pollution is likely to affect both short–term educational attainment due to sickness and affect long–term health outcomes (Lim *et al*., 2012). Baron and Torero (2017) finds evidence that grid electrification significantly reduces indoor pollution in El Salvador. Electrification can therefore improve health outcomes by reducing respiratory and pollution–related illnesses. Bernard (2012) argues there has been little impact evaluation to study the effects of rural electrification on the sectors, such as education, that are generally used to justify the funding of electrification projects in Sub–Saharan Africa. This paper zeroes in on education and attempts to quantify the effects of school electrification on educational outcomes –test scores, enrollment, and completion –among 8th grade primary school students. In Kenya, schools close to the grid network

[2] Abbreviations: Rural Electrification Authority (REA), Kenya Electricity Transmission Company Limited (KETRACO), the Kenya Certificate of Primary Education (KCPE). Kenya Certificate of Secondary School (KCSE). Kenya National Examination Council (KNEC), Randomized Encouragement Designs (RED).

were connected to the grid electricity while those farther away were provided with off–grid (solar) power by the government. Consequently, this study also aims to test whether grid and off–grid (solar) electricity have different effects on the outcomes listed above.

There are several channels through which electrification can affect academic outcomes. This paper offers three examples. First, electrification outside of school can increase parents' participation in income generating activities (Khandker *et al*., 2009a: Dinkleman, 2011, World Bank 2008). This can translate to improved outcomes to the extent that more income results in increased purchase of school inputs. In addition, increased income can allow parents to reduce demand for child labor which frees more time for studying and school attendance. Second, electricity provides light that allows more studying hours after sunset and before sunrise. In addition, it may increase study time by reducing time spent cooking or fetching firewood (Khandker *et al*. 2014, World Bank 2008). Third, substituting wood–based or kerosene–based lighting with electric lighting can improve health outcome by reducing respiratory and eye illnesses caused by toxic soot and gases emitted by non–electric light sources. This in turn increases school attendance and also performance. With more study time, and good health, students are likely to attend school more and perform better at school. These changes can translate to more academic progression and consequently higher rates of school completion. While there are many mechanisms at play, the mechanism of interest in this study is lighting. To achieve this, this paper argues that solar electricity only affects school outcomes through its light, and has no impact outside of the school (unlike electricity). Thus solar coefficients provide estimates of the impact of electrification through lighting.

Estimating the causal impact of rural electrification on a number of economic outcomes is challenging due to the presence of confounding factors arising from policy decisions and

socioeconomic factors. For instance, governments are more likely to develop infrastructure in areas with great economic potential. Additionally, political connections and influences are likely to influence these decisions. Besides, those who are politically connected are likely to be wealthy individuals. These factors make it difficult to quantify the causal impacts of electrification. The literature on rural electrification focuses mainly on economic outcomes such as income and employment with the effects on education usually not being the main focus of the studies. Other related literature also face a number of shortcomings in their identification strategies mainly due to absence of natural experiments. A number of studies offer suggestive evidence that rural electrification improves welfare growth of rural households but based on descriptive and correlational studies between rural electrification and development (Asian Development Bank, 2010; Barnes, Peskin and Fitzgerald 2003; Cockburn 2005; Khandker 1996; Martins 2005).

The Kenyan situation provides an ideal setting for this study. In Kenya, electricity supply expansion has been an important government goal. Beginning in mid–2013, the government through the Rural Electrification Authority (REA) engaged in an ambitious project to connect all public primary schools with electricity to support it's the government's Digital Learning Programme. This was implemented by extending grid electricity to schools close to the grid network and installation of solar photovoltaics in off–grid areas. This project saw the rise of primary schools with electricity from 48% in 2014 to 80% in 2016. Schools with solar power rose from 7% in 2014 to 13% in 2016. In aggregate, schools with power rose from approximately 56% in 2013 to approximately 94% in 2016. While households did not receive similar coverage, households with electricity increased from 27% in 2013 to 55% in 2016 following electrification of an addition of 1.3 million households. This policy shock provides a convenient environment to study the effect of electrification. The rapid nature of the project reduces the likelihood of

confounding policy factors that may affect academic outcomes. In determining routes for new electric transmission lines, the government "first looks at major corridors, such as existing utility lines, roads, and railroads before considering other areas" – according to the government–owned Kenya Electricity Transmission Company Limited (KETRACO). Most of these utility lines, roads, and railroads have been in existence for a long while before 2013. While the government has invested large sums on infrastructure, most of these funds are channeled towards upgrading or repairing of existing infrastructure. As a result, concurrent infrastructure are unlikely to have been completed in time to alter the existing network of utilities, roads, and railroads in a manner that affected the trajectory of the grid network. There might be concerns of schools endogenously selecting where to locate. However, public schools do not have flexibility in choosing where to locate. Typically, the government and the community agree on a location of a school based on the population density. Generally, in rural areas, new schools are built equidistantly from the nearest two or more schools to balance the distribution of schools across a geographic location. Given the speed of electricity rollout and these rigidities in infrastructure development and the location of public schools, the connection of schools to the grid is likely to have been exogenous conditional on school fixed effects.

The data used in this study is an unbalanced panel of the universe of all schools in Kenya, with 8th grade students, from 2014 to 2016. The main source of variation in school electrification is driven by the government's push to electrify public schools. Specifically, 73% of private schools are connected to the grid electricity compared to 44% of public schools in 2014. However, over time, the number of public schools rises to 78% and catches up with private schools by 2016. Initially, the same share (7%) of both private and public schools have off–grid electricity but the share of public schools rises to about 13% by 2016. Given that private schools decisions on

location and electrification status are likely to be endogenous, this paper restricts analysis to public schools only. The analysis is only for 8th grade students since examination data is only available and is nationally representative for 8th grade primary school students. Panel fixed effects provides flexibility in handling endogeneity concerns and is thus used as the primary identification strategy. The panel fixed effects model, finds no statistically significant effects of either grid or off–grid electrification on test scores and enrollment. However, there is some evidence that off–grid electrification may increase school completion by 1%. This is a small effect. This result may suggest that solar effects only provide positive benefits to a school while grid electrification potentially has negative spillovers outside of school. For instance, while light may encourage more completion, this effect is offset by students dropping out to exploit employment opportunities created by arrival of grid electrification. On net, these effects cancel out. Regarding the mechanisms at play, and relying on the solar coefficients, lighting has small but limited effects on academic outcomes. Therefore lighting alone may not be sufficient to boost educational outcomes without complementary academic inputs. The findings are robust to inclusion of private schools, exclusion of urban schools, and variation in clustering of standard errors. Overall, this paper finds weak evidence that electrification improves academic outcomes.

To the best of my knowledge, this paper is the first to quantify the impact of electrification through lighting on education outcomes. In addition, I have not come across any study on education that jointly estimates the effects of solar and grid electrification. Finally, unlike many papers that focus on electrification at the household–level, this paper focuses on electrification at school. These contributions are important for several reasons. First, many papers do not attempt to isolate the channels through which electrification affect outcomes such as educational outcomes. Thus, this paper attempts to tackle this missing part of analysis by attempting to isolate the effect

of lighting. Second, the effects of grid and solar are likely to be different. Solar power at school level can only affect outcomes mostly through lighting and has no additional benefits outside of school. On the other hand, grid electricity at school can be an indicator of electrification outside of school. As noted in the literature below, electrification can have income effects, which can ultimately affect education outcomes. Consequently, the solar coefficient will provide an ideal estimate for the effect of lighting. Jointly estimating the effects of solar and grid electricity allows for estimation of non–lighting effects of electrification. The underlying assumption is that, any differences between solar and grid electricity coefficients is a measure of additional effects of electricity outside of the lighting channel. One must, however, not push this idea too far because grid electrification may be more reliable and provide higher quality light than solar power. Quality concerns are mediated by technological advances that have improved the quality of solar power illumination. Still, some of the results could be driven by these differences in quality and reliability of these power sources. Taking these and other caveats into consideration, the estimates of solar will provide lower bounds for the coefficients of interest. Household level studies, as reviewed below, do not attempt or are unable to easily isolate the mechanisms through which electricity affects education outcomes.

The remaining sections are organized as follows. Section 2 is a review of the existing literature. Section 3, is a brief description of the context and the data. Section 4, is a methodology section. This is followed by the results in section 5. Section 6 explore heterogeneity by subject and gender. Section 7 reports robustness checks, and finally section 8 is the conclusion.

II. LITERATURE REVIEW

In reviewing the existing literature, this paper splits the review into two major parts – grid and off–grid studies – and within each part provides literature on non–experimental and experimental studies. The first part begins with non–experimental followed by experimental studies on grid electrification. The bulk of the literature on grid use non–experimental methods given the difficulty in randomizing grid network. The second part focuses on off–grid electrification, which is largely dominated by experimental methods. A common feature of these studies is that they are done at the household level. This paper diverges by focusing on electrification at school.

Several studies have investigated the impact of grid electrification on incomes and education outcomes. Comparing Vietnam communes with and without electricity, Khandker *et al*. (2009a) find that electricity has positive effect on both economic and educational outcomes. Electrification increases household's farm cash income by 30 percent, with no effect on non–farm income. Furthermore, it increases enrollment by about 10% for both boys and girls. The increase in years of schooling is limited to boys only with electricity increasing years of schooling by 0.52 (about 12% increase relative to year 2002 baseline). In related literature, Khandker *et al*. (2009b), show electricity increases total household income by between 9 percent and 30 percent in rural Bangladesh. Educational outcomes also improve but the results are sensitive to the estimation approach. On the other hand, Dasso *et al*. (2015), find that grid electrification does not lead to substantial improvements in educational outcome. Taking advantage of a rapid expansion of electricity in rural Peru (Programa de Electrificación Rural) and relying household survey panel data, they find that rural electrification in Peru increases female enrollment but the effect does not translate to improved attendance. Surprisingly, using school–level panel data, electrification reduces learning in Math and Reading. However, longer exposure among treated schools increases

scores in Reading among boys and girls but Math improvement is only observed among boys. This finding is consistent with the literature that show that technological innovations may take time before impacting student school outcomes (Kho, Lakdawala, and Nakasone, 2018)

Some studies rely on geographical influence on grid electrification process to overcome identification issues. Libscomb *et al*. (2013) exploit the heavy reliance of hydropower and the geographic considerations that influence the location of hydro–electricity dams to study the effect of electricity on development in Brazil. Using water flow and river gradients to instrument for electrification, they find large positive effects on income, and, educational literacy and school enrollment. Results show that going from no electricity to full electrification in a county leads to reductions in the illiteracy rate of 8 percentage points (25 percent drop at the mean) and reduction in the proportion of the population with less than four years of education of 21 percentage points (32 percent decrease at the mean). However, the largest gains were experienced in years of schooling, which increased by two years (about a 72 percent increase at the mean). This suggests that more children obtained post–primary (or grade four) education, which may have ultimately led to labor productivity increases. In a similar spirit, Dinkelman (2011) studies the impacts of electrification on employment in rural South Africa. Using land gradient as an instrument together with a fixed effects model, she finds that electricity increases female employment in treated areas.

Experimental evidence of impacts of electrification on educational outcomes are rare. This is largely driven by the fact that it is difficult to randomize grid electrification. Fortunately, certain policies and technological advancements have created opportunities for experimental interventions. For instance, Randomized Encouragement Designs (RED) can be employed to create exogenous variation in electricity access. Bernard and Torero (2013) are the first to implement this design on electrification in a developing country. Subsequently, it is employed by

Barron and Torero (2014) in El Salvador. They find evidence of grid leading to increased time allocated to educational activities, increased participation in non–farm income generation activities but also children engaging more in household chores.

Technological innovations and desire for sustainable energy sources has also led to rise in use of portable sources of power such as solar panels and solar–powered devices including solar lamps. Consequently, there is a nascent literature that provide experimental and non–experimental evidence on the effects of solar power or solar–powered lanterns on education performance. Generally, except for a few studies, the findings tend to support the hypothesis that solar power leads to improvement in a number of measures of school outcomes. However, there is mixed evidence on the effects on academic performance. These papers include Furukawa (2014), Barron and Torero (2014), Arráiz and Calero (2015), Kudo *et al.* (2017), Hassan and Lucchino (2017), Aevarsdottir, Barton, and Bold (2017).

Non–experimental studies on solar power included works by Arráiz and Calero (2015). Using household–level and individual–level data and employing propensity score matching techniques, Arráiz and Calero (2015) estimate that solar–powered home systems (SHSs) in rural Peru increases children study time, years of schooling (among elementary school students) and higher rates of enrollment (in secondary school). Specifically, enrollment increases by 12 percentage points for those enrolled in high/middle school. In addition, it leads to an increase in years of schooling by 0.4 from a base of 3.2 years, and increase in time spent studying by 9 minutes from a baseline of 84 minutes per day.

The most common experimental study on the effects of solar power involve the use of solar lamps. Furukawa (2014) conduct a randomized experiment involving 204 participants in Uganda where some participants received solar lamps among 5^{th} and 7^{th} grade students. After 5 months,

the paper reports some evidence that the solar lamps increased daily study times by 30 minutes but surprisingly lowered academic performance. In particular, test scores for mathematics and English declined by 0.25 standard deviations, with high performing students (top quintile) experiences largest declines of 0.8 standard deviations. The author explains that these results could be driven by measurement error of study times as students lacked watches/clocks at home, inadequate charging of lamps leading to flickering lights, and possible intra–household factors that limited the use of the lamps for studying. These results are also limited by the small sample size, short observation time of 5 months, and also due to the adverse weather occasioned by the rainy season that minimize ability to charge solar lamps. While this study conducts the experiment at the school level, the use of solar lamps is not restricted to school. These solar lamps are available at home and are subject to be used for other purposes besides studying. Unlike Furukawa (2014), Hassan and Lucchino (2017) find positive effects and spillovers among 7th grade students in a similar experiment in Kenya. The authors report improved math scores of 0.88 standard deviations among treated students in a class with average treatment intensity (43%). In addition, there is evidence of spillovers as an increasing the share of treated students by 10% leads to a 0.22 standard deviation increase in scores of control students. The study provides some evidence suggesting that this spillover is largely driven by within–school interactions through co–studying after sunset. The co–studying spillovers are likely to be larger in a school setting than in households because schools provide larger avenues and central location for studying.

Small sample sizes are common in experiments due to logistical or funding constraints. Aevarsdottir, Barton and Bold (2017) conduct a solar lamp experiment with a large sample involving treating 1800 households with students in one of 60 schools in Tanzania. The experiment randomly provided full, partial, or no subsidies towards purchase of a solar lamp with the

capability of charging mobile phones. They find that purchase of a solar lamp leads in a 25% increase in income. Adult labor participation on both the extensive and intensive margin rise by between 10% and 20%. Unlike in Barron and Torero (2014), improvement in labor force participation by adults does not lead to increase in child labor participation. Unfortunately, the study finds no evidence of improvement in education outcomes such as enrollment, attendance, and time spent studying. While the It is thus unlikely that the treatment would have had any positive effects on academic performance. These results are similar to those reported in an experimental setting in Bangladesh where outcomes were muted (Kudo, Shonchoy and Takahashi, 2017). Among 4^{th}–8^{th} grade students, solar lamps initially led to increases in attendance but this effect diminished over time. In addition, treated students experienced an increase in night study time of 20–25 minutes a day but the treatment had no statistically significant impact on school progression.

As evidenced by the literature above, most of the studies look at the impact of electrification at the household level. These studies also document significant impacts of electrification on incomes and labor demand, which are likely to have also influenced the findings on educational outcomes. As such, these studies are unable to quantify the direct (non–monetary) impact of electrification on education and also cannot distinguish the channels through which electrification affects educational outcomes. In the latter experimental studies, the use of solar lamps limits the ability to isolate the impact of solar power, as these lamps are portable and available for use outside of school. The use of solar lamps at home is subject to competing uses at home and may underestimate the true impacts of solar light on academic outcomes. Besides, if household chores are prioritized when the solar lamp is being used, and given that solar lamps typically provide power for a few hours, by the time students get the chance to study, the solar lamp light will likely

be dimmer. In addition, solar lamps at home may lead to improvement in incomes either through charging of phones or through extended time engaging in income–generating activities (Aevarsdottir, Barton and Bold, 2017). This increased income can lead to more purchase of inputs for students. Finally, the solar lamps are likely to provide weaker illumination compared to both grid and photovoltaic solar panels (used in Kenyan schools). This paper on the other hand overcomes these challenges by studying presence of solar power that is used only at the school and by relying on solar photovoltaic power that provides higher quality lighting than solar lamps. The presence of these alternative sources of lighting will benefit students in the early evenings and early mornings at school. While power may provide additional benefits during daytime at school, I believe the key benefits of light will be in the early evenings and mornings. Ideally, if time use data is available, it would be easy to quantify how much time is spent at school and whether students are studying using school lighting. However, I do not have this kind of data. There are, however, reasons to believe that electrification at school allows students to study in the early mornings and evenings more so at school than at home. Specifically, in areas with close to the grid network, connection to electricity requires substantial fees of approximately $300 and thus few families would afford to get connection. Second, safety, particularly in rural areas where the bulk of the sample schools are located, is not a big issue. Communities are homogenous and it is common practice for 8th grade students to stay at school till 6 PM and to report to school before 7 AM. However, safety may be a larger concern for female students and this might lead to heterogeneous responses by gender. Thus, effects for girls may represent a lower bound of the impact of electrification if electrification is only at school and girls spend less additional time studying at dawn and dusk.

III. DATA DESCRIPTION

Context

The Kenyan education follows an 8–4–4 system. The 8–4–4 is designed so that ideally a student spends 8 years in primary school, 4 years in secondary school, and 4 years in university. Students start school in pre–school, which lasts three years before the 8–4–4 system kicks in. Following the completion of pre–school, students enroll in primary schools for a period of eight years. Each school year is split into three semesters with school sessions starting in January and lasting three months with a one–month intervening break. Primary school education culminates in the final national exam – the Kenya Certificate of Primary Education (KCPE). This is a very competitive standard national exam whose results are used to admit students to secondary school. Secondary school lasts four years. After four years, secondary school students must sit the national exam – Kenya Certificate of Secondary School (KCSE). This exam determines entry into university and the type of majors that student are eligible to pursue. This study focuses on the KCPE examination results for the 8^{th} grade students. This is because it is the only nationally representative examination results for primary school students. In addition, most secondary schools already have electricity, and hence has little variation in school electrification. Completion is defined as taking the KCPE exams while enrollment represents the number of 8^{th} grade students at the beginning of the year. The national examination scores and school completion data was provided by the Kenya National Examination Council. School completion is defined as having taken the 8^{th} grade national examination data. Examination covers five subjects, English, Kiswahili, Mathematics, Science, and Social Studies. The maximum score for each subject is 100 while the minimum score is 0. In the regression analysis, the test scores are standardized to have a mean 0 and a standard deviation of 1.

The administrative structure of the schools is organized as follows. At the national level, all schools and academic institutions are under the Ministry of Education. Secondary, primary school educations and pre–school fall under the Department of Basic Education while post–secondary education is under the Department of Higher Learning. The ministry of education delegates some of its duties to the County Education Offices, which supervise various Sub–County Education Offices. Under the Sub–county education offices, schools are grouped into school Zones. Finally, within each school zone are several schools headed by a head teacher (principal). Thus the geographical hierarchy of primary school is National –County –Sub–County –Zone – School.

This study uses data from all primary schools that had 8th grade students during the period of study (2014–2016). The unit of analysis is the school. Data on school electrification and school characteristics were obtained from the Ministry of Education Kenya, which liaises with the school principals in collecting these data. The data is typically collected between October and November each year through a national primary school census. Data on school characteristics was gathered from the Ministry of Education. The school characteristics available include infrastructure – temporary and permanent classrooms, toilet facilities, primary sources of water, number of privately and publicly hired teachers, number of students (enrollment**)**, school location (rural/urban), school ownership (private/public), school accommodation type (day, boarding or day and boarding), school gender (girls only, boys only, or mixed). Test score and school completion data is available from the Kenya National Examination Council (KNEC), which administers and grades the primary and secondary national exams. KNEC is an independent entity within the Ministry of Education.

School electrification variation is largely driven by the nationwide campaign to provide electricity to all public schools. This project started in an attempt to implement the government's Digital Learning Programme. The government intended to supply laptops to every first grade student in primary school and provided digital access of educational content. This was a major campaign promise that the president had pledged in the run up to the 2013 elections. Upon winning the elections, the new administration embarked on an ambitious program to electrify schools to enable its digital learning program and also to improve access of households to electricity. Unlike in previous cases, the government intended to supply electricity specifically to schools and other public facilities. As of June 2013, out of 21,222 primary schools in the country, 48% had access to electricity. However, by 2016, 80% of the 34,124 schools had electricity. Public schools largely drive the changes in electrification during this period. Specifically, by 2014, 8,522 public schools had grid electricity while 1,582 had solar. By 2015, the number of public schools with grid increased to 12,970 while solar schools doubled to 3,604. Finally, by 2016, 16,403 public schools had grid electricity while the number with solar remains steady at 3,543. Meanwhile, the total number of public schools only rose by less than 2000 from 21,625 in 2014 to 23,439 in 2016. The rapid nature of the project reduces the likelihood of confounding policy factors that may affect academic outcomes. In determining routes for new electric transmission lines, the government "first looks at major corridors, such as existing utility lines, roads, and railroads before considering other areas" – according to the government–owned Kenya Electricity Transmission Company Limited (KETRACO). Most of these utility lines, roads, and railroads have been in existence for a long while before 2013. While the government has invested large sums on infrastructure, most of these funds are channeled towards upgrading or repairing of existing infrastructure. As a result, concurrent infrastructure are unlikely to have been completed in time to alter the existing network

of utilities, roads, and railroads in a manner that affected the trajectory of the grid network. In addition, public schools do not have flexibility in choosing where to locate. Typically, the government and the community agree on a location of a school based on the population density. Generally speaking, in rural areas, new schools are built equidistantly from the nearest two or more schools to balance the distribution of schools across a geographic location. Given the speed of electricity rollout and these rigidities in infrastructure development and the location of public schools, the connection of schools to the grid is likely to have been exogenous. However, this paper takes additional steps to address potential endogeneity issues using panel fixed effects at the school level and by controlling for a number of school level observables. In addition, it includes variables to absorb school and regional time varying unobservable. Electrification projects tend to be implemented regionally and as argued the main factors influencing electricity rollout were likely fixed within the short period of 2014–2016. This paper argues that the factors that could have influenced electrification remain largely unchanged at the school level and thus the identifying assumption is that conditional on school fixed effects, electrification was largely exogenous.

Summary statistics

The data contains an unbalanced panel of three years from 2014 to 2016 for the main analysis. These were the only years in which the government had digitized records of school data. Table 3.1 below shows the summary statistics of the main variables of interest. The statistics are derived from the observations used in the panel analysis, which restricts the sample to only public schools. Any observations not used in the regression analysis are excluded. This paper uses the universe of

all 8th grade schools that have all the data available. This summary is for the 2014 and 2016, which correspond to the beginning and the end of the study period.

The test scores summary shows that schools with grid electricity outperform those with off–grid and those without electricity. Similarly, schools with off–grid electricity generally outperform those without electricity though by a small margin and sometimes the difference is not statistically significant. Schools with grid electricity tend to have higher enrollment and completion while those with off–grid have slightly lower enrollment and completion compared to schools without electricity. This suggests that grid electrification is installed first in areas with high population densities and possibly in proximity to other amenities and infrastructure.

School inputs are reported in student–input ratio for easy comparability across schools. Schools with off–grid and without electricity have similar student–book ratio while grid schools sometimes has slightly has a better ratio. Generally, by subject, 3–4 students share a single book. Compared to the control schools off–grid schools have a higher student–teacher ratio while grid has a similar student–teacher ratio to the control schools. As shown by the student–classroom ratio, schools with either form of electricity initially are more crowded by about 2 extra students per class resulting in an average class size of 38 students. Water is useful for both consumption, cleaning and related sanitary conditions of the school. The statistics show that electrification is generally associated with access to better water sources (tap and borehole) with tap water being the largest predictor of electrification.

To highlight the importance of school ownership on electrification status, this paper includes statistics of private schools in the summary but not in the regression. Public schools account for 92% of schools without electricity in 2014 but this share declines to 77% by 2016, largely driven by increase in number of public schools receiving grid electrification. During this

period, public schools accounts for 82% of schools with off–grid electricity in 2014 but this hare rises modestly to 85% by 2016. Further insights can be gleaned from looking at the distribution of schools with electricity within each school type. For instance, 72% of private schools are connected to the grid electricity compared to 44% of public schools in 2014. However, over time, the number of public schools rises and catches up with private schools by 2016. Initially, the same share (7%) of both private and public schools have off–grid electricity but the share of public schools rises to about 11% by 2016 with little change to the share of private schools.

Finally, school location in rural areas is negatively associated with grid electrification but positively associated with off–grid electrification. Another way of looking at the data is to focus on a specific location and examine electrification. Only 42% of public schools in rural areas had grid electricity in 2014 compared to 80% of public schools in urban areas. This gap, however, decreases as the government electrification project continues through 2016 (to 78% and 96% respectively). On the other hand, rural schools are more likely to have off–grid electricity compared to those in urban areas. The share of rural schools with off–grid electrification rises from 7% in 2014 to 12% in 2016 while the share of urban schools with off–grid power remains at 1% throughout the period.

Overall, while there are some differences between schools based on electrification status there is no consistent pattern of differences between schools with electricity and those without. In addition, the differences in attributes tend to be minor particularly for school student–input ratios. In addition, schools without electricity and those with off–grid electricity are qualitatively similar in characteristics.

Table 3.1: Summary Statistics

	2014					2016				
Statistic	**No light**	**Off-grid**	**Grid**	**Off-grid - No Light**	**Grid - No light**	**No light**	**Off-grid**	**Grid**	**Off-grid - No Light**	**Grid - No light**
School Mean Score (out of 500)	238	241	248	*3***	*10***	236	235	245	*1.5*	*9***
Enrolment (Total)	367	376	499	*9*	*132***	349	335	431	*-14**	*81***
Enrolment (8th Grade)	33	31	51	*-2***	*18***	31	28	45	*-3***	*13.35***
Completion	32	30	50	*-1.88***	*18***	31	28	44	*-2.75***	*12.87***
Pupil-Books Ratio (4-8 grade)										
Math	2.99	2.97	2.97	*-0.02*	*-0.02*	2.97	2.8	2.77	*-0.17*	*-0.2*
English	2.8	2.84	2.69	*0.04*	*-0.11**	2.62	2.74	2.55	*0.12*	*-0.07*
Kiswahili	3.06	3.06	3	*0*	*-0.06*	2.66	2.83	2.65	*0.17*	*-0.01*
Science	4.28	4.36	4.39	*0.08*	*0.11*	4.35	4.41	3.75	*0.06*	*-0.6****
Social studies	4.08	4.34	3.87	*0.26*	*-0.21**	4.02	4.16	3.53	*0.14*	*-0.49***
Main Source of Water										
No water	10%	6%	4%	*-4%*	*-6%****	12%	8%	5%	*-4%****	*7%****
Rain	32%	28%	24%	*-4%*	*-8%****	31%	28%	25%	*-3%***	*-6%****
River	24%	25%	16%	*2%**	*-8%****	22%	27%	16%	*5%****	*-6%****
Tap	19%	17%	38%	*-2%*	*19%****	17%	14%	32%	*-3%***	*16%****
Borehole	16%	24%	18%	*8%****	*2%****	18%	24%	22%	*5%****	*3%****
Government Teachers	-	-	-	-	-	17.15	14.16	21.78	*-2.99****	*4.63****
Private Teachers	-	-	-	-	-	4.64	5.73	4.89	*1.09****	*0.25**
Total Teachers	-	-	-	-	-	20.03	18.32	24.73	*-1.71****	*4.7****
Students-Teacher Ratio	-	-	-	-	-	17.62	18.97	17.42	*1.35****	*-0.2*
Permanent Classrooms	8.3	7.76	11.4	*-0.54*	*3.1****	7.95	7.63	10.32	*-0.32****	*2.37****
Temporary Classrooms	2.26	2.35	2.07	*0.09*	*-0.19****	2.26	1.76	1.81	*-0.5****	*-0.45****
Total Classrooms	10.32	9.88	13.23	*-0.44*	*2.91****	9.32	8.84	11.23	*-0.48****	*1.91****
Students-Classrooms Ratio	36	38.28	37.63	*2.28****	*1.63****	37.5	37.23	37.6	*-0.27****	*0.1*
Teacher-Toilet Ratio						9.39	9.17	10.12	*-0.22**	*0.73****
Student-Toilet Ratio	38.9	46.13	34.82	*7.23****	*-4****	39.25	45.03	34.67	*5.78****	*-4.58****
Ownership										
Private	8%	18%	25%	*9.9%****	*17%****	23%	15%	21%	*-9%****	*-3%****
Public	92%	82%	75%	*-9.9%****	*-17%****	77%	85%	79%	*9%****	*3%****
Rural	98%	99%	91%	*1.2%****	*-7%****	99%	99%	94%	*1%****	*-4%****
Urban	2%	1%	9%	*-1%*	*7%****	1%	1%	6%	*-1%****	*4%****
Obs	8,655	1,241	7,794			1,883	1,978	14,024		

*Table includes T–tests performed on the differences in variables between treated and non–treated schools. * p<0.10, ** p<0.05, *** p<0.01.*

IV. IDENTIFICATION STRATEGY

If the electrification process was random, the impacts could be estimated using the naïve OLS specified as follows:

$$Y_{sczt} = \beta_0 + \boldsymbol{ELEC}_{cszt}\boldsymbol{\beta_1} + \varepsilon_{sczt} \quad (1)$$

where Y_{sczt} is the outcome of interest at school s, in county c, in zone z, and at time t. ELEC is a vector of electricity dummy variables for grid electricity and off–grid electricity. The counterfactual is having no electricity. The ε_{sczt} is the error term. In this model β_1 would be the coefficients of interest estimating the average treatment effects of electrification. However, electrification was not randomized and thus estimating equation (1) is likely to yield contaminated coefficients of interest due to omitted variables that are likely to be correlated with the electricity connection and also affect outcomes of interests. To address these issues, I add school–level controls and time and region fixed effects as follows:

$$Y_{sczt} = \beta_0 + \boldsymbol{ELEC}_{sczt}\boldsymbol{\beta_1} + \boldsymbol{X'}_{sczt}\boldsymbol{\beta_2} + \delta_z + \delta_t + \varepsilon_{sczt} \quad (2)$$

where $\boldsymbol{X'}_{sczt}$ are observable school characteristics such as infrastructure, teacher and student demographics and characteristics. δ_z are zone fixed effects which capture factors that are common across schools within a zone that are fixed over time. δ_t are year fixed effects which control for factors that are fixed for all schools within time t.

Specification (2), however, does not address unobserved school–level fixed factors. Consequently, I use a panel fixed effects model as follows:

$$Y_{sczt} = \beta_0 + ELEC_{sczt}\boldsymbol{\beta_1} + \boldsymbol{X'}_{sczt}\boldsymbol{\beta_2} + \delta_s + \delta_t + \varepsilon_{sczt} \quad (3)$$

where $\boldsymbol{X'}_{sczt}$ are observable school characteristics such as infrastructure, teacher and student demographics and characteristics. I include δ_s which are school fixed effects which capture time

invariant characteristics of the school while δ_t are year fixed effects which control for factors that are fixed for all schools within time t.

The underlying identification assumption in specification (3) is that the omitted variables are time invariant at the school–level. While specification (3) addresses most of the endogeneity concerns raised previously, it does not address the issue of time–varying omitted factors that are likely to be correlated with electricity connection and the outcome of interest. Following, previous literature, I argue that the time variant characteristics are likely to be correlated with baseline school characteristics (Almond *et al.*, 2011; Acemoglu *et al.*, 2004; Hoynes and Schazenbach, 2009). The preferred specifications (4) therefore includes a linear time trend that allows baseline characteristics to differentially affect outcomes with time. Thus, the main identifying assumption of this paper is that, conditional on these set of controls, school electrification was exogenous.

$$Y_{sczt} = \beta_0 + \boldsymbol{ELEC}_{sczt}\boldsymbol{\beta_1} + \boldsymbol{X'}_{sczt}\boldsymbol{\beta_2} + \boldsymbol{X'}_{scz0} * \boldsymbol{t\beta_3} + \delta_s + \delta_t + \varepsilon_{sczt} \quad (4)$$

V. MAIN RESULTS

The findings based on panel fixed effects. The tables below report outcomes on test scores, attendance, and completion for 8th grade students in Kenya. The unit of observation is school. These regressions are based on variations of Specification (3).

Part 1: School test scores

The general format of the tables starts with a simple panel fixed effects regression of the outcome variable on electrification variable and then proceeds with addition of controls and clustering of errors by school. In Table 3.2, specification (1) regresses test scores on electrification status only. To address potential omitted variable bias, specification (2) adds school level controls to specification (1). However, specifications (2) does not account for important omitted time varying

school–level factors. There is no obvious or best method to address this issue. However, time varying confounding factors are likely to be correlated with the characteristics of the school. In line with some existing literature, specification (3) includes an interaction of initial school characteristics and year. This will absorb some of the time varying confounders.

Finally, all specifications Specification (3) cluster standard errors at the school level since outcomes are likely to be correlated within the school over time. Failing to cluster will result in inflated/deflated standard errors leading to misleading p–values and inference interference. The remaining tables follow the same format. The "Y" in the tables indicates a "Yes". All test–scores are standardized so that the national mean is 0 with a standard deviation of 1 every year. Thus, all coefficients should be interpreted as changes in standard deviations.

Specification (1) indicates that electrification reduces school mean scores by 0.02 standard deviations. These estimates are statistically significant only for grid but they are also likely to suffer from omitted variable bias. Specification (2) confirms this suspicion as estimates increase by half to –0.01 and become statistically insignificant. Time varying confounders appear to also play a role in the estimates since estimates increase further when an interaction between 2014 school characteristics and time are included in the regression (specification 3). Taken together, the preferred specification (3) shows that off–grid electrification has a small positive but statistically insignificant effect on test scores while grid electrification has a small negative but statistically insignificant effect.

The negative effects of grid electrification may suggest that grid electrification may have negative impacts on test–scores outside of school. However, we cannot push this point too far as the estimates are quite small. These findings are surprising, as one would expect electrification to improve school outcomes. It is, however, possible that electrification affects the composition of

Table 3.2: Effects of School Electrification on School Test Scores

	(1)	(2)	(3)
Off-Grid Electricity	-0.021	-0.0127	0.0020
	(0.0142)	(0.0138)	(0.0140)
Grid Electricity	-0.0230***	-0.0107	-0.0018
	(0.0071)	(0.0069)	(0.0079)
Enrolment Boys (8th Grade)		-0.0075***	-0.0121***
		(0.0024)	(0.0012)
Enrolment Girls (8th Grade)		-0.0119***	-0.0092***
		(0.0007)	(0.0008)
Enrolment Boys (1st -7th Grade)		0.0002	0.0006***
		(0.0001)	(0.0002)
Enrolment Girls (1st -7th Grade)		0.0006***	0.0004*
		(0.0001)	(0.0002)
Books 4-8th Grade (,00s)		-0.00002	-0.00008
		(0.0001)	(0.0001)
Total Classrooms		-0.0004	-0.0007
		(0.0009)	(0.0011)
Rain Water		0.0290*	0.0249
		(0.0150)	(0.0202)
River Water		0.0143	0.0353*
		(0.0153)	(0.0208)
Tap Water		0.0283*	0.0319
		(0.0167)	(0.0216)
Borehole Water		-0.0031	0.0246
		(0.0163)	(0.0218)
Toilets - Boys		0.00005***	0.0008
		(0.0000)	(0.0009)
Toilet - Girls		0.0004	-0.0002
		(0.0007)	(0.0009)
Toilet - Male Teachers		-0.0071	-0.0045
		(0.0046)	(0.0066)
Toilet - Female Teachers		0.0002	-0.0002
		(0.0008)	(0.0005)
Constant	-0.229***	-0.0046	0.0098
	(0.0049)	(0.0416)	(0.0390)
N	52492	52492	52492
R-Squared	0.00	0.0530	0.06
School Fixed Effects	Y	Y	Y
Year Fixed Effects	Y	Y	Y
Controls		Y	Y
Initial controls x year			Y
School Cluster	Y	Y	Y

Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

students if it leads to lower dropouts. Specifically, if electrification prevents dropouts among lowest achieving students then it can lead to lower average school test scores. On the other hand, if electrification also benefits the high achieving students we can expect zero to positive effects on test scores. However, as shown below, I find no strong evidence of electricity increasing enrollment or completion – only solar power has a positive and statistically significant effect of increasing enrollment by one percent. Another potential explanation could be that the effects take time and given the short nature of the panel data, observations within school are not sufficient to result in improved test scores. Kho, Lakdawala, and Nakasone (2018) provide evidence indicating that the effects of technological improvements may take time before affecting student performance. In summary, based on these results, grid and off–grid electrification have no differential impacts on test scores, at least in the short–term.

Part 2: Enrollment

This part repeats the analysis of part 2 but focusing on enrollment as the outcome of interest. If electrification creates more study time and more study time results in improved performance, schools with electricity are likely to experience increases in enrollment. In addition, improved performance could lead to lower levels of dropping out. While Table 3.2 finds no effects on test scores, it is possible that anticipated improved test score by students following electrification can encourage students to enroll and stay at school. The estimates below test whether enrollment increases following electrification.

Table 3.3 reports panel fixed effects estimates. Unlike test scores, enrollment is in log forms. The format of the results is as in Table 3.2. Specification (1), which omits controls, indicates that both grid and non–grid electrification increases enrollment by 2.5%. Addition of school

controls to the model increases estimates slightly to 2.6% and 2.8% for off–grid and grid electricity respectively. However, it appears that time varying confounders also affect enrollment in a

Table 3.3: Effects of School Electrification on 8th Grade Enrollment (Dependent variable – log of enrollment)

	(1)	(2)	(3)
Off-Grid Electricity	0.0251***	0.0264***	0.0071
	(0.0068)	(0.0068)	(0.0069)
Grid Electricity	0.0246***	0.0281***	0.0026
	(0.0036)	(0.0036)	(0.0041)
Enrolment Boys (1-7th Grade)		0.0003***	0.0005***
		(0.0001)	(0.0001)
Enrolment Girls (1-7th Grade)		0.0005***	0.0003***
		(0.0001)	(0.0001)
Books 4-8th Grade (,00s)		-0.00001	-0.00001
		(0.0000)	(0.0001)
Total Classrooms		0.0020***	0.0033***
		(0.0007)	(0.0011)
Rain Water		-0.0108	-0.0151
		(0.0072)	(0.0098)
River Water		-0.00321	-0.0189*
		(0.0074)	(0.0101)
Tap Water		-0.00659	-0.0139
		(0.0081)	(0.0106)
Borehole Water		0.00792	-0.0172
		(0.0078)	(0.0107)
Toilets - Boys		0.0000	0.0006
		(0.00003)	(0.0008)
Toilet - Girls		0.0013***	0.0020***
		(0.0005)	(0.0008)
Toilet - Male Teachers		0.0094***	0.0093**
		(0.0024)	(0.0038)
Toilet - Female Teachers		-0.0001	-0.0001
		(0.0003)	(0.0002)
Constant	3.515***	3.313***	3.304***
	(0.0025)	(0.0229)	(0.0251)
N	52366	52366	52366
R-Squared	0.00	0.01	0.02
School Fixed Effects	Y	Y	Y
Year Fixed Effects	Y	Y	Y
Controls		Y	Y
Initial controls x year			Y
School Cluster	Y	Y	Y

Errors clustered at school level (specification 4). Standard errors in parenthesis.
* p<0.10, ** p<0.05, *** p<0.01.

significant manner. Once an interaction of initial school characteristics and time are included in specification (3), the coefficients shrink and become statistically insignificant. Specification (3) shows that electrification has a positive effect on enrollment of less than 1%. The results are robust to clustering of standard errors. Specification (3) indicates that off–grid electrification estimates are larger (0.7%) compared to grid electrification (0.3%). These estimates are in line with results from test scores. However, while off–grid electrification seems to have larger estimates than grid electrification, qualitatively, the estimates are similar for both types of electrification.

Part 3: Completion

Electrification can also affect completion. For instance, increased and better lighting hours from electrification can create conducive study environment for students. While we do not find any effect on test–scores, the results could be heterogeneous at the individual level. Thus if electrification increases test–scores for some individuals, it could also encourage staying at school. It is also important to note that student may stay longer in school if they have strong beliefs that electrification will positively affect their future performances. In the current context, the national exam (KCPE) is the ultimate exam that students study for, and if they believe that more study hours will translate to better final grade, they are likely to stay in school longer. In the spirit of the findings of Kho, Lakdawala and Nakasone (2018), students are also likely to have the same perspective about time invested studying leading to eventual positive results in the long–run. Finally, students may prefer co–studying and electrification increases opportunities for co–studying. This creates an attractive environment for students to learn and incentives to stay in school. On the other hand, grid electrification outside of school may also have adverse effects on completion. For instance, jobs created from electrification can attract students leading to drop outs. Dinkleman (2011) find positive labor impacts of electrification for women in South Africa.

Table 3.4: Effects of School Electrification on 8th Grade Completion (Dependent: Log Completion)

	(1)	(2)	(3)
Off-Grid Electricity	0.0378***	0.0270***	0.0106**
	(0.0058)	(0.0053)	(0.0053)
Grid Electricity	0.0286***	0.0145***	-0.0045
	(0.0033)	(0.0026)	(0.0029)
Enrolment Boys (8th Grade)		0.0094***	0.0145***
		(0.0029)	(0.0014)
Enrolment Girls (8th Grade)		0.0164***	0.0144***
		(0.0009)	(0.0009)
Enrolment Boys (1st -7th Grade)		-0.0002**	-0.0006***
		(0.0001)	(0.0001)
Enrolment Girls (1st -7th Grade)		-0.0004***	-0.0001
		(0.0001)	(0.0001)
Books 4-8th Grade (,00s)		0.0000	0.00003
		(0.0000)	(0.0000)
Total Classrooms		(0.0001)	0.0005
		(0.0003)	(0.0004)
Rain Water		(0.0025)	-0.00954
		(0.0053)	(0.0071)
River Water		(0.0031)	-0.0186**
		(0.0055)	(0.0074)
Tap Water		(0.0034)	-0.0219***
		(0.0060)	(0.0078)
Borehole Water		0.0021	-0.0143*
		(0.0057)	(0.0078)
Toilets - Boys		(0.0000)	0.0005
		(0.0000)	(0.0006)
Toilet - Girls		0.0005*	0.001**
		(0.0003)	(0.0005)
Toilet - Male Teachers		(0.0000)	-0.00325
		(0.0017)	(0.0023)
Toilet - Female Teachers		0.0000	-0.0001
		(0.0001)	(0.0002)
Constant	3.490***	3.066***	3.045***
	(0.0024)	(0.0388)	(0.0311)
N	52492	52492	52492
R-Squared	0.00	0.41	0.44
School Fixed Effects	Y	Y	Y
Year Fixed Effects	Y	Y	Y
Controls		Y	Y
Initial controls x year			Y
School Cluster	Y	Y	Y

Errors clustered at school level. Standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01.

Table 3.4 repeats the analysis of Table 3.3 but now with log of school completion as the dependent variable. Completion is defined as completing the 8th grade national exit exam (KCPE). Omitting school level controls, specification (1) shows positive and statistically significant impacts of electrification on completion. The off–grid estimates are slightly larger (3.8%) than grid estimates (2.9%). Specification (2) shows that estimates are biased from omitted school–level variables. Adding school–level controls decreases coefficients to 2.7% and 1.5% for off–grid and grid electrification respectively, but the estimates remain statistically significant. Specification (3) adds controls to remedy estimates from time–varying confounders. This results in estimates shrinking further. The preferred specification (3) indicates that off–grid electrification increases enrollment by 1% and this estimate is statistically significant. However, grid electrification has a small but negative coefficient.

The absence of positive effects for grid electrification on enrollment is surprising given that off–grid electrification has positive effects. One would expect that grid has stronger effects particularly since it is perhaps more reliable, might have better lighting quality, likely provides additional lighting and income opportunities outside of the school. One explanation of these results is that the completion estimates could be picking up some of the potentially negative effects of electrification outside of school. Presence of grid electricity at school implies that electricity is likely to be available in the areas near the school. If grid electrification encourages students to drop out of school to pursue jobs that come with electrification or distracts students (say through too much time spent on watching television), then electrification may result in more students dropping out of school. Alternatively, grid electrification may induce students at the margin of dropping out to stay in school longer but only temporarily – i.e. students may remain in school longer following electrification but not long enough to complete the national exit exam.

Since off–grid electrification is mainly benefiting students at school only, particularly through lighting, this paper argues that the off–grid coefficients provide lower bound estimates of effects of lighting from electrification. This paper argues that most of the off–grid electrification (1%) is coming through lighting.

Part 4: Test for Common Trend

To complete the identification strategy, I attempt to show that treated and control schools followed a common trend prior to electrification program. One of the key identification assumptions is that absence treatment treated schools and control schools would have had similar trends in outcomes. If this assumption is violated, then some of the observed differences in outcomes would be driven by pre–trends. Since the treatment occurs at different times, I restrict the analysis to schools that received treatment in 2014 – which is the first year since the government rolled out the electrification program. Controls schools are defined as schools that had no electricity as of 2016. To formally test the common trends assumption, I specify the following model:

$$Y_{sczt} = \beta_0 + \sum_{i=2012}^{2016} \boldsymbol{Treat}_{sczt} \mathrm{x} \boldsymbol{I}(\boldsymbol{Year} == \boldsymbol{i})\boldsymbol{\alpha_i} + \delta_s + \gamma_t + \varepsilon_{sczt} \quad (4)$$

Y_{sczt} is the outcome of interest in school *s* in county *c* in zone *z* at time *t*. **Treat** is a vector of treatment indicators. Some schools are treated with grid electricity in 2014 while others are treated with off–grid electricity. δ_s captures school fixed effects while γ_t absorbs the year fixed effects. A set of dummies $\boldsymbol{I}(\boldsymbol{Year} == \boldsymbol{i})$ indicate the ith year. Since treatment first occurs in 2014, a test of parallel trends requires that $\alpha_{2012} = \alpha_{2013} = 0$. In the regression, the year 2012 is the omitted year dummy and thus parallel trends are satisfied if $\alpha_{2012} = 0$. Due to data limitations, I can only test for parallel trends in test scores and school completion. In addition, I have a smaller sample size consisting of a panel of about 5,000 schools yielding approximately 25000 observations from

2012 to 2016. The data collected was limited by time and travel constraints during my fieldwork. I sampled a few counties[3] while attempting to ensure that my sample was representative. Future fieldwork will attempt to collect more data from the counties not covered.

Table 3.5: Test for the Assumption of a Common Trend

	School Mean Scores (Logs)	Completion (Logs)
Grid x YEAR=2013	**-0.0008**	**-0.0358**
	(0.004)	**(0.025)**
Grid x YEAR=2014	0.00148	-0.0348
	(0.005)	(0.024)
Grid x YEAR=2015	0.00998*	-0.0411*
	(0.006)	(0.024)
Grid x YEAR=2016	0.0116*	-0.0707***
	(0.006)	(0.026)
Off-grid x YEAR=2013	**-0.0042**	**-0.001**
	(0.007)	**(0.034)**
Off-grid x YEAR=2014	-0.0037	0.0233
	(0.008)	(0.035)
Off-grid x YEAR=2015	0.0111	0.0064
	(0.009)	(0.037)
Off-grid x YEAR=2016	0.0044	0.0164
	(0.009)	(0.038)
YEAR=2013	0.0022	0.0591***
	(0.004)	(0.022)
YEAR=2014	-0.0032	0.0691***
	(0.005)	(0.022)
YEAR=2015	-0.0148***	0.104***
	(0.005)	(0.022)
YEAR=2016	-0.0105*	0.127***
	(0.006)	(0.023)
Constant	5.550***	3.439***
	(0.001)	(0.007)
Observations	25268	21125
R-squared	0.83	0.91
School Fixed Effects	Y	Y
Year Fixed Effects	Y	Y
School Cluster	Y	Y

Standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01

[3] I gathered data from 18 out of 47 counties in Kenya. Baringo, Bomet, Elgeyo Marakwet, Homa Bay, Kajiado, Kiambu, Kilifi, Kisumu, Kwale, Machakos, Mombasa, Nairobi, Nakuru, Nyamira, Uasin Gishu, Vihiga, West Pokot

The results reported in Table 3.5 find no differences in pre–trends between treated school (grid and off–grid) and controls schools. While the coefficients tend to be negative, they are small and statistically insignificant.

Part 5: Test for Complementarity between School Inputs and Electrification

This section concludes by investigating whether electrification is a complement to school inputs. I focus on number of books, classrooms, and toilets. Number of teacher toilets is a proxy for number of teachers – Using 2015 and 2016 data shows that the correlation between number of teachers and toilets is approximately 0.3. The results are reported in Table A 3.1 in the appendix. I find little evidence of electricity acting as a complement to school inputs. Specifically, for test scores, grid electricity acts as a complement to the number of teacher toilets (a proxy for number of teachers). Electricity and books appear to be substitutes but the magnitude of the coefficients are too small for all outcomes. Grid electricity is a complement for the number of classrooms – a one percent increase in number of classrooms leads to an additional 0.3 percent increase in enrollment in schools with grid electricity while the magnitude for off–grid electricity is 0.6. Overall, electricity does not appear to be a strong complement to school inputs. This, however, may be a short–term result and in the long–term electricity may become a complement to school inputs. For example, in the long–run teachers may adapt their teaching techniques to maximize the benefits of electrification.

VI. HETEROGENEITY BY SUBJECT AND GENDER

In this section, the paper explores possibility of heterogeneous impacts of electrification on outcomes. For conciseness, the paper limits the analysis to test scores by subject and subsequently look at outcomes by gender. Studies in different countries have shown that treatment effects can vary by subject (Dasso *et al*., 2015; Furukawa, 2014; Hassan and Lucchino, 2017). One potential

explanation for these findings is that students may choose to specialize on a few subjects when faced with time constraints. Lighting provides more study hours and this can allow students to increase study time dedicated to subjects that previously receiving less time. As a consequence, student performances may vary by subject. Gender has been shown to play an important role in different contexts. For instance, women generally have few economic opportunities globally in many sectors of the economy. In SSA, girls tend to have fewer education opportunities compared to boys due to cultural preferences for boys over girls. Studies on electrification and education have also documented gender differences in outcomes (Khandker *et al*., 2009a; Khandker *et al*., 2009b; Dasso *et al*., 2015).

Part 1: Test scores by subject

Table 3.6 reports the coefficient estimates of school test scores by subject. The subject test scores have been standardized to have a mean of 0, and a standard deviation of 1. Each column reports the preferred Specification (3) used in the previous analysis. Each estimates are from a panel fixed effects model with school–level controls, an interaction between initial school characteristics and time, as well as standard errors clustered at the school level. The results show evidence of heterogeneous treatment effects by subject both for grid and off–grid electrification. Grid electrification estimates positive for English, Math, and Social and Religious Studies but negative for Kiswahili and Science. However, these estimates are quantitatively small. Estimates are larger and statistically significant for off–grid electrification. Specifically, off–grid electrification increases test scores for English and Math by 0.03 and 0.05 standard deviations respectively. Kiswahili scores decrease by 0.05 standard deviations following off–grid electrification. The off–grid coefficient estimates for Science, and Social and Religious Studies are positive but small

Table 3.6: Effects of School Electrification on School Mean Test Scores by Subject

	English	Math	Kiswahili	Science	Social and Religious Studies
Off-Grid Electricity	0.0308**	0.0496***	-0.0500***	0.0039	0.0025
	(0.0122)	(0.0148)	(0.0150)	(0.0150)	(0.0138)
Grid Electricity	0.0057	0.0082	-0.0034	-0.0018	0.0061
	(0.0072)	(0.0081)	(0.0086)	(0.0087)	(0.0078)
Enrolment Boys (8th Grade)	-0.0100***	-0.0081***	-0.0116***	-0.0103***	-0.0091***
	(0.0009)	(0.0008)	(0.0013)	(0.0011)	(0.0010)
Enrolment Girls (8th Grade)	-0.0052***	-0.0097***	-0.0050***	-0.0161***	-0.0138***
	(0.0006)	(0.0007)	(0.0008)	(0.0010)	(0.0009)
Enrolment Boys (1st -7th Grade)	0.0004***	0.0002	0.0007***	0.0005***	0.0007***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Enrolment Girls (1st -7th Grade)	0.0004**	0.0007***	-0.0003	0.0008***	0.0006***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Books 4-8th Grade (,00s)	-0.00008*	-0.0002*	-0.00008	-0.00001	-0.00012*
	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0001)
Total Classrooms	-0.0004	-0.0009	-0.0005	-0.00228**	-0.0009
	(0.0009)	(0.0010)	(0.0012)	(0.0011)	(0.0010)
Rain Water	0.0358*	0.0005	-0.0089	0.0198	0.0160
	(0.0189)	(0.0199)	(0.0217)	(0.0220)	(0.0200)
River Water	0.0555***	0.0169	0.0249	0.0219	0.0254
	(0.0195)	(0.0207)	(0.0225)	(0.0228)	(0.0207)
Tap Water	0.0856***	0.0267	0.0369	0.00248	0.0172
	(0.0200)	(0.0214)	(0.0233)	(0.0235)	(0.0212)
Borehole Water	0.0356*	0.0070	-0.0115	0.0331	0.0221
	(0.0205)	(0.0215)	(0.0236)	(0.0240)	(0.0216)
Toilets - Boys	0.00003	0.00014	0.00049	-0.00030	-0.00215**
	(0.0008)	(0.0009)	(0.0010)	(0.0011)	(0.0010)
Toilet - Girls	0.0009	0.0025**	0.0011	-0.0019	-0.0002
	(0.0009)	(0.0012)	(0.0012)	(0.0012)	(0.0011)
Toilet - Male Teachers	0.0118**	0.0064	0.0044	-0.0026	-0.0083
	(0.0059)	(0.0064)	(0.0074)	(0.0072)	(0.0060)
Toilet - Female Teachers	0.0001	0.0010**	0.0000	-0.0004	-0.0006
	(0.0010)	(0.0004)	(0.0004)	(0.0007)	(0.0005)
Constant	-0.168***	-0.0218	0.0243	0.133***	0.0258
	(0.0332)	(0.0382)	(0.0422)	(0.0404)	(0.0377)
N	52492	52492	52369	52492	52492
R-Squared	0.05	0.06	0.04	0.08	0.07
School Fixed Effects	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y
Initial controls x year	Y	Y	Y	Y	Y
School Cluster	Y	Y	Y	Y	Y

Errors clustered at school level. Standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01.

and statistically insignificant. Overall, this paper finds some evidence of heterogeneous treatment effects for off–grid electrification.

Part 2: Results by Gender

Table 3.7 explores heterogeneity by gender. For conciseness, this paper only reports the preferred full Specification (3) which is a fixed effects panel with school controls and controls for time–varying confounders (the interaction between initial controls and time), in addition to standard errors clustered at the school level. Starting with test scores, electrification has a positive impacts for both boys and girls but the estimates are larger for girls. In addition, the estimates tend to be larger for off–grid than grid electrification. On the other hand, the estimates are not statistically significant. Consequently, this paper finds no evidence that the impact of electrification on test scores varies by gender.

Similarly, enrollment results shows a positive effect of electrification that are larger for girls than for boys and larger for off–grid than grid. However, these estimates are small and statistically insignificant. Turning to completion, off–grid electrification continues to have larger impacts, though quantitatively small, relative to grid electrification. Off–grid has positive effects while grid has negative effects. The impacts on girls tend to be larger but statistically insignificant. The only statistically significant result in this analysis is that grid electrification decreases enrollment of boys by 0.8%.

In summary, while there appear small differences in outcomes between boys and girls, the difference tend to be statistically insignificant. However, there is some suggestive evidence that grid electrification may draw boys away from school and hence decreasing enrollment. This can occur if electrification improves economic outcomes that require low skills.

Table 3.7: Heterogeneous Impacts by Gender – Test scores, Enrollment, and Completion

	Test Scores		Log Enrolment		Log Completion	
	Boys	Girls	Boys	Girls	Boys	Girls
Off-Grid Electricity	0.0060	0.0166	0.0050	0.0069	0.0086	0.01
	(0.0133)	(0.0136)	(0.0089)	(0.0104)	(0.0072)	(0.0081)
Grid Electricity	0.0018	0.0074	0.00205	0.0024	-0.0078*	-0.0028
	(0.0078)	(0.0074)	(0.0056)	(0.0059)	(0.0044)	(0.0044)
Enrolment Boys (8th Grade)	-0.0133***	-0.0107***	-	-	0.0291***	-0.0001
	(0.0013)	(0.0011)	-	-	(0.0028)	(0.0007)
Enrolment Girls (8th Grade)	-0.0086***	-0.0095***	-	-	-0.0021*	0.0319***
	(0.0008)	(0.0007)	-	-	(0.0012)	(0.0015)
Enrolment Boys (1st -7th Grade	0.0007***	0.0004***	0.000138	0.0007***	-0.0014***	0.0001
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0003)	(0.0001)
Enrolment Girls (1st -7th Grade	0.0003*	0.0005***	0.0007***	-0.00003	0.0006***	-0.0008***
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0002)
Books 4-8th Grade (,00s)	-0.00007**	-0.0001***	0.00002	-0.00005	0.00002	0.000028
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0000)
Total Classrooms	-0.0015	-0.0004	0.0030**	0.0036***	0.0001	0.0008
	(0.0010)	(0.0008)	(0.0012)	(0.0012)	(0.0006)	(0.0005)
Rain Water	0.00483	0.0235	-0.0176	-0.00459	-0.0035	-0.0056
	(0.0199)	(0.0193)	(0.0135)	(0.0142)	(0.0105)	(0.0108)
River Water	0.0286	0.0347*	-0.0218	-0.00587	-0.0102	-0.0159
	(0.0205)	(0.0198)	(0.0141)	(0.0146)	(0.0111)	(0.0113)
Tap Water	0.0353*	0.0394*	-0.0076	-0.0146	-0.0171	-0.0197*
	(0.0213)	(0.0205)	(0.0144)	(0.0153)	(0.0115)	(0.0116)
Borehole Water	0.0165	0.0195	-0.0134	-0.0122	-0.0103	-0.0117
	(0.0212)	(0.0207)	(0.0144)	(0.0153)	(0.0112)	(0.0119)
Toilets - Boys	-0.0010	0.0008	0.0003	0.0008	0.00066	0.00026
	(0.0008)	(0.0008)	(0.0013)	(0.0009)	(0.00107)	(0.00052)
Toilet - Girls	0.0006	0.0006	0.0024***	0.00174*	0.0012*	0.0009
	(0.0009)	(0.0010)	(0.0010)	(0.0010)	(0.0008)	(0.0006)
Toilet - Male Teachers	0.0023	0.0031	0.0108**	0.0122**	-0.00179	-0.0023
	(0.0065)	(0.0060)	(0.0050)	(0.0048)	(0.0040)	(0.0036)
Toilet - Female Teachers	-0.0001	0.0004	-0.0003	0.0002	-0.00049	0.0004
	(0.0006)	(0.0005)	(0.0003)	(0.0004)	(0.0004)	(0.0003)
Constant	0.029	-0.0314	2.592***	2.571***	2.387***	2.233***
	(0.0400)	(0.0358)	(0.0293)	(0.0300)	(0.0553)	(0.0282)
N	52492	52492	52202	52229	52323	52364
R-Squared	0.07	0.06	0.01	0.01	0.31	0.41
School Fixed Effects	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Initial controls x year	Y	Y	Y	Y	Y	Y
School Cluster	Y	Y	Y	Y	Y	Y

Errors clustered at school level. Standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01.

VII. ROBUSTNESS CHECKS

Part 1: School type and location

In this section, this paper pursues a number of robustness checks. This section considers the effect of sample restrictions in terms of school ownership and school location. Previously, the paper argues that private schools might endogenously select to get electricity or to locate near the grid network. Consequently, the previous analysis restricted the sample to public schools. However, one can argue that this sample restriction is can introduce other problems. Specifically, schools in urban areas that do not have electricity are likely to be negatively selected. In other words, given the prevalence of infrastructure and household electrification in urban areas, the lack of electricity at a school can signal that these are poor schools such as those in informal settlements. In addition, students attending those schools are also likely to come from poor backgrounds. This can in turn bias the effect of electrification upward if large effects are likely to occur among schools that have limited inputs. On the other hand, if grid only functions as a complement to other school and home inputs, some of which are unobservable, inclusion of urban schools is likely to bias estimates downwards. Finally, the negative selection of schools without electricity in urban areas implies that electrification of a school is less likely to have any impact on students dropping out to pursue jobs from electrification since the lack of electrification at school is not driven by distance from the grid network. Thus, electrification of urban schools may not change the local labor market conditions.

Table 3.8 column (2) addresses this question. Each column re–estimates the preferred panel fixed effects specification that includes school controls, an interaction between initial school controls and time, and clusters standard errors at the school level. Table 3.8 column (1) reports the original results from the main section for comparison purposes while column (2) restricts analysis

to only rural public schools. Moving down, the column (2) and comparing estimates to column (1), the results are quantitatively similar for test scores, enrollment and school completion. However, the coefficient for grid becomes weakly significant (at 10% level) for grid but remains quantitatively small. Overall, the results are qualitatively similar to the main results.

While this paper argues for exclusion of certain school categories due to endogeneity issues, a number of objections can be made. For instance, the type of students who attend private school may be different from those who attend public schools both in individual and household characteristics. Wealthy household may enroll their children in private schools, which tend to have better inputs than public schools. In addition, parents may also enroll low–performing students who need more teacher attention in private schools. This self–selection can create problems in estimation. For example, if parents enroll bright students in public schools and low–performing students in private schools, exclusion of private schools will yield upwardly biased estimates if bright students attend public school and are more responsive to improved lighting from electrification.

Table 3.8 column (3) investigates this question by first, re–estimating the model with both private and public schools in rural areas. Starting with test scores in the first panel, the estimates of off–grid become smaller and turn negative but remain quantitatively small and statistically insignificant, while grid estimates remain similar. In the second panel of column (3) enrollment estimates remains similar to the main results in column (1) and the results in column (2). Similarly, in column (3), off–grid estimates remain unchanged for completion. However, while the magnitude of the coefficient decreases marginally, grid coefficient becomes statistically significant at 5%. Overall, while there are some changes in estimates from inclusion of more school

categories, the changes are largely quantitatively small and estimates remain qualitatively similar to the main results.

Table 3.8: School Sample Restriction Based on Ownership and Location (rural/urban)

	(1)	(2)	(3)	(4)
	All Public	Rural Public	All Rural	All Schools
	School Mean Scores (Standard Deviations)			
Off-Grid Electricity	0.0020	0.0010	-0.0006	-0.0030
	(0.0140)	(0.0141)	(0.0136)	(0.0133)
Grid Electricity	-0.0018	-0.0025	-0.0013	0.0002
	(0.0079)	(0.0080)	(0.0078)	(0.0077)
N	52492	49980	57479	64187
R-Squared	0.06	0.06	0.06	0.06
	Log of Enrolment			
Off-Grid Electricity	0.0071	0.0070	0.0086	0.0079
	(0.0069)	(0.0069)	(0.0068)	(0.0067)
Grid Electricity	0.0026	0.0033	0.0037	0.0036
	(0.0041)	(0.0042)	(0.0041)	(0.0040)
N	52366	49863	57244	63872
R-Squared	0.02	0.02	0.02	0.02
	Log of Completion			
Off-Grid Electricity	0.0106**	0.0099*	0.0109**	0.0117**
	(0.0053)	(0.0053)	(0.0051)	(0.0051)
Grid Electricity	-0.0045	-0.0050*	-0.0059**	-0.0051*
	(0.0029)	(0.0029)	(0.0029)	(0.0029)
N	52492	49980	57479	64187
R-Squared	0.44	0.45	0.41	0.39
School Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Initial Controls x Year	Y	Y	Y	Y
School Cluster	Y	Y	Y	Y
Restriction	Public	Rural Public	Rural	None

Errors clustered at school level. Standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01.

In column (4) of table (6), the results are derived from inclusion of all schools nationwide both private and public in rural and urban areas. While the electrification coefficients switch signs for test scores in panel one, they remain small and statistically insignificant. Panel two of column (4) show that enrollment results are robust to inclusion of private schools. Finally, the last panel shows that off–grid coefficients remain the same while grid electrification becomes statistically significant but only at 10% level. The coefficients however remain quantitatively similar.

Part 2: Time–varying unobserved regional factors

One strategy of dealing with time–varying unobserved factors was to include an interaction term between initial school characteristics and time. To the extent that these unobserved factors are correlated with initial school characteristics, the interaction term will address part of the concern. However, these interactions only capture school–level time–varying factors. In this section, the paper attempts to further control time varying regional factors by interacting region and time. Three regional levels are considered, sub–county and county, in order of increasing magnitude. The results are reported in Table 3.9. The first column reproduces the main results. The second column includes a county time trend while the third column uses a finer regional trend (sub–county trend). Focusing on column (3), starting at panel one, the coefficients become smaller in absolute value and turn negative for off–grid electrification while the grid coefficient remain negative. In panel two and three, estimates remain consistent except that the off–grid coefficient becomes statistically weakly significant (at 10% level from 5% level) for completion. Generally speaking, the results are robust to inclusion of regional time trends.

Table 3.9: Inclusion of Regional Time Trends

	(1)	(2)	(3)
	School Mean Scores (Standard Deviations)		
Off-Grid Electricity	0.0020	-0.0099	-0.0076
	(0.0140)	(0.0139)	(0.0142)
Grid Electricity	-0.0018	-0.0081	-0.0057
	(0.0079)	(0.0079)	(0.0080)
N	52492	52492	52492
R-Squared	0.06	0.09	0.12
	Log of Enrolment		
Off-Grid Electricity	0.0071	0.0161**	0.0098
	(0.0069)	(0.0070)	(0.0072)
Grid Electricity	0.0026	0.0034	0.0020
	(0.0041)	(0.0041)	(0.0042)
N	52366	52366	52366
R-Squared	0.02	0.04	0.06
	Log of Completion		
Off-Grid Electricity	0.0106**	0.0139***	0.0104*
	(0.0053)	(0.0054)	(0.0056)
Grid Electricity	-0.0045	-0.0038	-0.0048
	(0.0029)	(0.0029)	(0.0029)
N	52492	52492	52492
R-Squared	0.44	0.44	0.46
School Fixed Effects	Y	Y	Y
Year Fixed Effects	Y	Y	Y
Controls	Y	Y	Y
Initial Controls x Ye	Y	Y	Y
School Cluster	Y	Y	Y
Regional Trend		County	Subcounty

Errors clustered at school level. Standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01.

Part 3: Clustering of standard errors

Standard errors should be clustered if there are concerns about correlation between observations within clusters. Abadie *et al.* (2017) discuss at length the common misconceptions and confusions

that arise in implementing and justifying clustering. They argue that clustering is either a sampling design or an experimental design issue. It is a sampling issue if data is sampled from the population using clustered sampling design and one would like to use the data to make inferences about the population. On the other hand, clustering becomes necessary due to an experimental design issue if the treatment is clustered. In this paper, given the panel nature, treatment (electrification) is clustered at the school level since all students face the same treatment. It is also possible that electrification was clustered at regional levels. To investigate this concern, Table 3.10 reports main estimates using various clusters standard errors – school, zone, sub–county, and county – in order of increasing regional size. The results are consistent across all cluster–levels for test scores and enrollment. Clustering at larger region levels, however, decreases statistical significance from 5% to 10% level for completion. Overall, these are small changes that do not qualitatively affect results.

Other concerns

The muted effects of electrification on outcomes could be partly driven by measurement error in electrification that lead to attenuation bias. Kenya, just like many countries, sometimes experiences power outages. If these outages occur regularly or for extended periods, they can explain the results above. I do not have access to data on outages but future versions of this paper will attempt to gather more data and control for outages. In the meantime, the results should be interpreted as the average treatment effects of being connected to a power source.

Teachers are an important school input that affects educational outcomes. Given that data was missing for 2014, I omitted it as a control variable. This could possibly introduce an omitted variable bias. As robustness check, I restricted my analysis to 2015 and 2016 when data was available and found that inclusion or exclusion of number of teachers had no effect on estimates.

The estimates are not included for conciseness. In addition, I observe a positive correlation of 0.3 between the number of teachers and the number of teacher toilets in 2015 and 2016. Any bias resulting omitting the number of teachers will be mitigated by the inclusion of teacher toilets as a control. Finally, teacher quality may play a role in outcomes but given the panel structure of the model, the changes in composition of teachers at a school based on academic qualification is likely to be minimal.

Table 3.10: Results by Cluster Level – School, Zone, Sub–county, and County

Cluster level	School	Zone	Sub-County	County
	School Mean Scores (Standard Deviations)			
Off-Grid Electricity	0.0020	0.0020	0.0020	0.0020
	(0.0140)	(0.0151)	(0.0152)	(0.0149)
Grid Electricity	-0.0018	-0.0018	-0.0018	-0.0018
	(0.0079)	(0.0083)	(0.0083)	(0.0092)
N	52492	52492	52492	52492
R-Squared	0.06	0.06	0.06	0.06
	Log of Enrolment			
Off-Grid Electricity	0.00705	0.00705	0.00705	0.00705
	(0.0069)	(0.0071)	(0.0070)	(0.0063)
Grid Electricity	0.0026	0.0026	0.0026	0.0026
	(0.0041)	(0.0043)	(0.0042)	(0.0037)
N	52366	52366	52366	52366
R-Squared	0.02	0.02	0.02	0.02
	Log of Completion			
Off-Grid Electricity	0.0106**	0.0106**	0.0106*	0.0106*
	(0.0053)	(0.0050)	(0.0054)	(0.0053)
Grid Electricity	-0.0045	-0.0045	-0.0045	-0.0045
	(0.0029)	(0.0029)	(0.0030)	(0.0032)
N	52492	52492	52492	52492
R-Squared	0.44	0.44	0.44	0.44
School Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Initial Controls x Year	Y	Y	Y	Y
Cluster level	School	Zone	Sub-County	County

Errors clustered at school level. Standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01.

The results found in this paper could be biased if households selectively migrated toward electrified areas. Such an outcome would bias the grid results if the families that moved towards electrified areas valued education more and perhaps invested more in education. The off–grid estimates are unaffected since the solar panels was only installed at school and only supplied power to the specific school. While I cannot directly observe the migration patterns, I believe the resulting migration was minimal. The electrification project was national and occurred rapidly, and consequently most households would have had little incentive to migrate if they anticipated electricity expansion. In addition, within this short time frame, it is unlikely that new attractive employments would have been created following electrification.

Another concern is that results for test scores and enrollment have very low R^2. This implies that most of the variation in outcomes are not ready explained by the variables included. Finally, since the analysis uses the within school variation for identification, it is extremely hard to pin down the factors that drive these yearly variations because most of the important school inputs do not change significantly within the short time frame. On the other hand, the R^2 for completion is quite high because of the high correlation between enrollment and completion. The high R^2 is a result of including enrollment as a control in the regressions for completion.

VIII. CONCLUSION

This paper sought to quantify the effects of electrification on primary school test scores, enrollment, and completion for students in Kenya. Using the national examination data and school administrative data, the paper relied on panel fixed effects models. The estimates showed that grid and off–grid electrification have no statistically significant effects on the outcomes of interest – test scores and enrollment. However, off–grid electricity was found to increase completion by approximately 1%. In addition, there was no evidence that grid and off–grid estimates differ in

magnitudes except for the positive impact of off–grid electricity on completion (1%). Taken together these estimates show that, in a short–term period, electrification may not have any significant impacts on academic outcomes.

Since this paper relies on the off–grid estimates to identify the mechanism of interest – lighting –the findings above suggest that lighting alone may not be sufficient to induce improved test scores and enrollment both in the short–term. This is consistent with previous empirical works such as Kho, Lakdawala, and Nakasone (2018) and Dasso *et al*. (2015). On the other hand, the panel estimates suggesting positive and statistically significant impact on completion is encouraging and warrants more scrutiny. This paper finds that, relying on the off–grid estimates, lighting only has a statistically significant positive impact on completion, which increases by 1% following electrification.

This study documents heterogeneity in results by subject indicating that provision of electricity may affect student or teacher behavior. As such, measures have to be taken to ensure that students do not skew their studies in favor of particular subjects at the expense of others. However, there is no evidence of difference by in impacts by gender. The location of a school in urban or rural area has little effect on the impact of electrification. Finally, inclusion of private schools in the analysis does not qualitatively affect the results.

The policy implication for these findings is that while electrification may not improve academic outcomes in the short run, positive changes can be experienced in the long run and thus investment in electrification is encouraged. However, to reap the benefits on the electrification, additional short–term and long run investments in complementary academic inputs such as books, teachers, and infrastructure should be made. Providing additional lighting at school may not be sufficient.

APPENDIX

Table A 3.1: Complementarity between School Inputs and Electricity

	School Mean Scores (Standard Deviations)	Enrollment (Logs)	Completion (Logs)
Off-Grid Electricity	-0.0274	-0.0362	0.0332**
	(0.0457)	(0.0223)	(0.0168)
Grid Electricity	-0.0055	-0.0067	0.0124*
	(0.0191)	(0.0118)	(0.0073)
Enrolment Boys (8th Grade)	-0.0120***	-	0.0145***
	(0.0012)		(0.0014)
Enrolment Girls 8th Grade)	-0.0092***	-	0.0144***
	(0.0008)		(0.0009)
Enrolment Boys (1-7th Grade)	0.0006***	0.0005***	-0.0006***
	(0.0002)	(0.0001)	(0.0001)
Enrolment Girls (1-7th Grade)	0.0004*	0.0003***	-0.0001
	(0.0002)	(0.0001)	(0.0001)
Books 4-8th Grade (,00s)	-0.0001	0.0005***	0.0003**
	(0.0002)	(0.0002)	(0.0001)
Total Classrooms	0.0007	0.0014	0.0007
	(0.0014)	(0.0013)	(0.0005)
Rain Water	0.0249	-0.0159	-0.01
	(0.0202)	(0.0098)	(0.0071)
River Water	0.0351*	-0.0192*	-0.0190**
	(0.0207)	(0.0101)	(0.0074)
Tap Water	0.0321	-0.0149	-0.0220***
	(0.0216)	(0.0106)	(0.0078)
Borehole Water	0.0242	-0.0177*	-0.0147*
	(0.0218)	(0.0106)	(0.0078)
Student Toilets	-0.0008	0.00228***	0.001***
	(0.0008)	(0.0005)	(0.0003)
Teacher Toilets	-0.0006**	0.0002	-0.0001
	(0.0003)	(0.0003)	(0.0001)
Off-grid x Books 4-8th Grade (,00s)	-0.00006	-0.0006***	-0.0004***
	(0.0003)	(0.0002)	(0.0001)
Grid x Books 4-8th Grade (,00s)	0.0001	-0.0006***	-0.0003**
	(0.0002)	(0.0002)	(0.0001)
Off-grid x Classrooms	0.0025	0.0062***	-0.0005
	(0.0044)	(0.0023)	(0.0016)
Grid x Classrooms	-0.0024	0.003***	-0.0002
	(0.0015)	(0.0012)	(0.0006)
Off-grid x Student Toilets	0.0014	0.0002	-0.0002
	(0.0018)	(0.0009)	(0.0007)
Grid x Student Toilets	0.0012	-0.0015***	-0.0005*
	(0.0008)	(0.0005)	(0.0003)
Off-grid x Teacher Toilets	-0.0047	-0.0062	-0.0059*
	(0.0099)	(0.0043)	(0.0033)
Grid x Teacher Toilets	0.0051*	0.0007	-0.0023***
	(0.0028)	(0.0018)	(0.0009)
N	52492	52366	52492
R-Squared	0.06	0.02	0.44
School Fixed Effects	Y	Y	Y
Year Fixed Effects	Y	Y	Y
Controls	Y	Y	Y
Initial controls x year	Y	Y	Y
School Cluster	Y	Y	Y

Standard errors in parenthesis. * p<0.10, ** p<0.05, *** p<0.01.

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