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Can Agricultural Households Farm Their Way out of Poverty?

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Abstract

This paper examines the determinants of agricultural productivity and its link to poverty using nationally representative data from the Nigeria General Household Survey Panel, 2010/11. The findings indicate an elasticity of poverty reduction with respect to agricultural productivity of between 0.25 to 0.3 percent, implying that a 10 percent increase in agricultural productivity will decrease the likelihood of being poor by between 2.5 and 3 percent. To increase agricultural productivity, land, labor, fertilizer, agricultural advice, and diversification within agriculture are the most important factors. As commonly found in the literature, the results indicate the inverse-land size productivity relationship. More specifically, a 10 percent increase in harvested land size will decrease productivity by 6.6 percent, all else being equal. In a simulation exercise where land quality is assumed to be constant across small and large holdings, the results show that if farms in the top land quintile had half the median yield per hectare of farms in the lowest quintile, production of the top quintile would be 10 times higher. The higher overall values of harvests from larger land sizes are more likely because of cultivation of larger expanses of land, rather than from efficient production. It should be noted that having larger land sizes in itself is not positively correlated with a lower likelihood of being poor. This is not to say that having larger land sizes is not important for farming, but rather it indicates that increasing efficiency is the more important need that could lead to poverty reduction for agricultural households.

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Can Agricultural Households Farm Their Way out of Poverty?

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I. INTRODUCTION

The Nigerian labor force, like that of many countries in Africa, is heavily concentrated in agriculture. The sector employs about 60 percent of the labor force and contributes over 40 percent to GDP. Despite its importance, the agricultural sector in Nigeria is far from reaching its full potential. The agricultural sector has the highest poverty incidence in the country (Phillip et al., 2009); to reduce poverty, it is critical for households to earn more from their income generating activities. The World Development Report (WB, 2008) emphasized the importance of agriculture for poverty reduction and growth in Africa. Improving the agricultural sector in Nigeria is vital to increasing food security and reducing poverty, especially in rural areas. Most farming in the country is still done at the subsistence level with minimal commercialization.

According to World Bank reports, the agricultural sector in Nigeria grew by about 6.8 percent annually from 2005 to 2009. However, these relatively high growth rates were not due to increased efficiency in the sector, but rather can be attributed to population growth and the farming of larger expanses of land most likely by commercial farmers. Given the importance of the sector, there is a great need to improve efficiency, especially for smallholder farmers in order to push them beyond farming at the subsistence level. Increased agricultural productivity can translate into higher incomes and lower poverty in the sector. Towards this end, the government has recently launched the Agriculture Transformation Agenda (ATA), which stresses the importance of growth in agriculture as a path out of poverty, particularly through increased commercialization among smallholder farmers.

In recent decades, the international development community has emphasized the importance of improved agricultural productivity as a path out of poverty and to rural development for developing countries (WB 2008; Anríquez and Stamoulis, 2007). The centrality of agricultural production in the lives and livelihoods of rural households in Nigeria highlights the importance of a thorough understanding of the determinants of agricultural productivity in the country, as well as the relationship between productivity and economic outcomes. Low agricultural productivity can contribute to rural poverty at the farm level and can be viewed as one of the main causes of rural poverty (Kiresur et al., 2010). Diao et al. (2009) found in their study that if the agriculture targets set by the Nigerian government can be achieved, the country will achieve a significant reduction in poverty.

This paper focuses on the determinants of agricultural productivity and highlights the factors (land ownership, input use, labor, plot management, land tenure, and household characteristics) most important for smallholder productivity. Most studies examining the determinants of agricultural productivity and the link to poverty in Nigeria are region or crop specific (Anyaegbunam et al., 2012; Nwafor et al., 2011; Ike, 2012; Igwe, 2011). This paper examines both of these linkages using nationally representative data from the first wave of the GHS-Panel survey conducted in 2010/2011. The analysis will also explore differences in the determinants of agricultural productivity between small and large landholders, as well as poor and rich agricultural households – while poverty and landholdings are correlated, they are not synonymous. Increased agricultural productivity is expected to result in lower poverty, but at the same time, poverty contributes to lower agricultural productivity through poor access to inputs and credit.

We find an elasticity of poverty reduction with respect to agricultural productivity of between 0.25 to 0.3 percent implying that a 10 percent increase in agricultural productivity will decrease the likelihood of being poor by between 2.5 and 3 percent. This is a sizeable effect suggesting that improvements in agricultural productivity could be an effective means to reduce rural poverty. We also find that income from wages and other nonfarm activities have a larger effect on poverty reduction than agriculture. However, this does not diminish the importance of agriculture for poverty reduction in Nigeria. Agriculture is still the dominant sector for many households in Nigeria, particularly in rural areas where it employs almost 84% of households and accounts for 56 percent of rural net income. To increase agricultural productivity, we find that land, labor, fertilizer, agricultural advice, and diversification within agriculture are the most important factors.

The analysis in this paper focuses on a single cross section of Nigerian farmers in 2010/2011. In future work we plan to delve deeper into the link between agricultural productivity and poverty utilizing additional waves of the GHS-Panel. The second wave was completed in March 2013 and the third wave will be completed in March 2015. Utilizing the three waves will enable a more rigorous empirical analysis and allow us to assess whether and how the determinants of agricultural productivity and the productivity-poverty relationship have varied over time. Furthermore, it will provide some indication of the effectiveness of recent agricultural policies (especially the government's Agricultural Transformation Agenda) at improving productivity and reducing poverty amongst Nigerian farmers. The analysis in this paper therefore provides a baseline analysis for this future work.

This paper is organized as follows. The next section will provide some background information on the agricultural sector in Nigeria and also describe that GHS-panel data used in the analysis. Section III lays out the methodology used to examine these two linkages followed by a presentation and discussion of the results in Section IV. Section V concludes.

II. BACKGROUND AND DATA

The agricultural sector in Nigeria consists mostly of smallholder farmers who operate at the subsistence level. Despite concerns about the sector's performance, it remains an important source of rural employment and income. There are many constraints facing the agricultural sector in Nigeria, and one of the main constraints is the low rates of input use, particularly fertilizer which is also commonly of poor quality due to adulteration[1]. In their review of constraints to agriculture productivity in Nigeria, Philip et al. (2009) attribute the low levels of input use to high transport costs, poor distribution channels, absence of private sector participation, significant import risk, and inconsistent government policies. Access to agricultural credit and efficient coordination of agricultural extension services can have beneficial spillover effects on the adoption of farm technologies, and these are also found to be lacking in the Nigerian agricultural sector (Philip et al., 2009). Poor access to input and output markets (largely due to poor rural infrastructure), land degradation, and low investment in agricultural research have also been identified as significant constraints to productivity in the

[1] See Liverpool-Tessie et al. (2010) for an assessment of fertilizer quality regulation in Nigeria

sector (Philip et al., 2009; Ogunlela and Ogungbile, 2006**)**. Agriculture research has been identified as a vital component of productivity-boosting strategy, and could play a crucial role in devising ways to improve farming practices (and thereby increase farm income), generate employment, reduce food prices and secure food availability (Ogunlela and Ogungbile, 2006).

There have been a variety of initiatives in Nigeria to combat poverty through improved agricultural productivity. However, the results have been mixed. A substantial portion of government investment in agriculture in the past decade focused on reducing rural poverty through efforts to increase productivity, ensure food security, and develop rural communities. There were some successes reported with these programs, but while many were not sustainable, some did not benefit the intended population. There have also been various fertilizer subsidy programs targeted at increasing productivity, but these programs were not very successful either. In many cases they were seen as distorting the input market, while failing to reach the smallholder farmers who were the intended beneficiaries (Phillip et al., 2009; Eboh et al., 2006; Takeshima et al., 2012). The subsidy programs were also very expensive to implement and proved not sustainable for the government (Phillip et al., 2009).

In spite of the many problems encountered by agriculture programs, there have been some successes. One such program is the National Fadama Development program (ADF, 2003; Ayanwale and Alimi, 2004; Ike, 2012). The objective of the program was to increase farmers' income and contribute to food security and poverty alleviation by developing small-scale irrigation through the extraction of shallow groundwater with low-cost petrol-driven pumps (Adubi, 2012). The programs were designed to reduce the dependence of farmers on unpredictable rainfall patterns, and thus allow farming to be done more consistently throughout the year. Ike (2012) found on average an increase in the real income of beneficiaries from the third phase of Fadama could be attributed to participation in the program.

Increased government expenditure that is well targeted to increase productivity and reduce poverty for households employed in the agricultural sector, could address the persistent weaknesses (Nwafor et al., 2011). As important as it may be to increase agriculture-related expenditure, it is probably more important to properly target funding. Nwafor et al. (2011) examined the cost effectiveness of various public expenditure programs on agriculture in Nigeria as a means of reducing poverty for agricultural households through increased productivity. The authors concluded that, given budget constraints and the numerous demands on government funds, agricultural spending aimed at increasing at the products which provide the highest returns in terms of productivity and poverty reduction. As a result, the Nigerian government has initiated a renewed effort to increase productivity in the agricultural sector through the Agriculture Transformation Agenda (ATA), which is designed to boost the competitiveness of selected high-value crops including rice, cassava, sorghum and cocoa (FMARD, 2012). The results of this study will prove helpful in identifying the most effective means to improving agricultural productivity in Nigeria. In addition, the results of this study provide a baseline from which to assess effectiveness of the ATA and other subsequent agricultural initiatives.

The analysis in this paper uses data from the first wave of the General Household Survey-Panel (GHS-Panel) conducted in 2010/11 by the Nigeria National Bureau of Statistics (NBS) in collaboration with the World Bank Living Standard Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA). The GHS-Panel survey is modeled after the Living Standard

Measurement Study (LSMS) surveys and is representative at the national, zonal and rural/urban levels. The total sample consists of about 5,000 households covering all 36 states in the country and the Federal Capital Territory, Abuja. The sample is a subsample of the larger GHS cross-section survey that was fielded by NBS at the same time. These 5,000 panel households were revisited in 2012/2013 for the second wave of the survey and will be visited a third time in 2014/2015 for the third wave of the GHS-Panel.

One of the main objectives of the GHS-Panel is to improve agriculture data collection in Nigeria by collecting information at disaggregated levels (crop, plot, and household levels), and linking such data to non-agricultural aspects of livelihoods. To this end, the GHS-panel is unique as it combines very detailed information on farming with consumption-based poverty measures, non-farm income sources, and other socioeconomic conditions of households in Nigeria. All households were visited at two points in time: right after planting (post-planting visit) and right after harvest (post-harvest visit). During the visits, information was gathered on demographics, education, labor, assets, and farm and nonfarm income generating activities. Of the 5,000 households in the survey, just over 3,000 were agricultural households producing a wide variety of crops. For agricultural households, detailed data was collected on crops grown, land size, inputs, yields, and other plot characteristics.

The primary focus of the analysis is on rural agricultural production, and thus the sample is limited to rural farm households. The household is the primary unit of analysis in all instances and therefore all crop and plot level variables are aggregated to the household level. Table 1 lists the variables used in the analysis. The first column in Table 1 contains mean values for the full sample. The second and third columns contain sample means amongst households not in poverty[2] and households in poverty, respectively. The asterisks in the fourth columns of table 2 denote the significance of Wald (weighted mean) tests between mean values for poor and non-poor households. The overall regression sample contains 2,086 rural agricultural households with 1,379 non-poor households and 707 poor households.

III. METHODOLOGY

The central element of the analysis from the GHS-Panel is household agricultural productivity. Our measure of agricultural productivity is the value of all crops *per harvested hectare* in Naira.[3] All input amounts will also be in per hectare form. According to Table 1, the average total value of household harvests was about ₦160,000 and the average per hectare value is over ₦850,000 per hectare[4]. Both measures were lower for poor households indicating that poor households had

[2]Poverty status was determined using per adult equivalent household expenditures. The national poverty threshold value as determined in the Harmonized Nigeria Living Standards Survey (HNLSS) in 2009/2010 was 54,113.14 Nigerian Naira. Using this measure, the in-sample poverty rate is 33.8 percent.

[3] Respondents were asked to estimate the value of each crop's harvest. To arrive at an estimate of the total value, the crop level value estimates were aggregated to the household level. The total household harvest value was then divided by the total harvested area to obtain value per hectare.

[4] The average value of total harvest per hectare is much larger than the average total value divided by average harvested hectares. This is largely a result of outliers caused by very small harvested areas in some southern states. The median value per hectare is a more reasonable 142,259 na/ha. After trimming the top and bottom 1% of yields the average drops to 471,803 and then to 297,304 when trimming the top and bottom 5%.

lower production and productivity than non-poor households. The log of the per hectare harvest values[5] are used in the analysis that follows. The average harvested area within the sample is 1.2 hectares with poor households having a higher and statistically significant value than non-poor households. Also when looking at the distribution of land sizes between the two groups, poor households were less likely to be in the bottom two deciles and more likely to be in the eighth and ninth deciles.

The amounts (in kilograms) of three physical inputs[6] are included in the determinants of agricultural productivity regressions: fertilizer, pesticide, and herbicide. The average household in the sample used 184 kilograms of fertilizer, 10 kilograms of pesticide and 24 kilograms of herbicide. While the incidence of input use is not significantly different between poor and non-poor households, richer households use significantly more fertilizer and pesticide per hectare than poorer households. The natural log of all input amounts are used in the regressions below[7].

In addition to physical inputs, the amounts of both hired and family/household labor[8] were included in determinants of agricultural poverty regressions. While poorer households use significantly more adult male and female family labor on their farms compared with richer households, there is no significant difference in per hectare terms. In contrast to family labor, non-poor households used significantly more hired female and child labor than poor households in the sample even in per hectare terms. There is no significant difference between the days of hired male labor between poor and non-poor households. For both family and hired labor, male labor was used/hired more than female and child labor both in terms of total days and days per hectare.

The value of agricultural capital owned per hectare by the household was also incorporated. Agricultural capital in this measure includes ploughs, sprayers, wheelbarrows, cutlasses, hoes, and other animal equipment. As might be expected, non-poor households owned more agricultural capital in total value and value per hectare. Crop selection may also play a role in agricultural production and poverty (Nkonya et al., 2010). To assess the importance of crop selection, an indicator for whether the household grew any cash crops (consisting of cotton,

[5] The total area harvested by the household was calculated through a multi-step process. The GHS Panel data contains both farmer estimates and GPS measures of plot size. However, each plot can have more than one crop grown on it. Farmers also report the area of the plot where the crop was harvested. To take advantage of the GPS measures of plot size, the percent of the plot where each crop was harvested was calculated by taking the self-reported crop harvest area and dividing by the self-reported plot size. Multiplying the GPS measured plot size by this percent yields a GPS based harvested area for each crop. Crop harvested areas were then aggregated to the household level. Weighted land size deciles were then calculated based on this measure.

[6] The data contains information on the amounts of these inputs used on each plot. The amounts used on harvested plots were converted to kilograms where necessary and then aggregated to the household level.

[7] Calculating the log of input (fertilizer, labor, etc.) amounts poses a problem since not all households used every input and thus there are observed values of zero. To overcome this hurdle, the method laid out in Battese (1997) is applied here whereby the log of numeric variable X_i is calculated according to the following function:

$$\ln X_i = \ln(\max[X_i, D_i])$$

where D_i is an indicator for zero cases (i.e. takes a value of 1 when $X_i=0$ and zero otherwise).

[8] Hired and family labor were separated into male, female, and child (under 15 years of age) labor days hired/used. The GHS asks farmers about labor used for harvesting only and thus the values do not reflect labor used for planting or crop maintenance. All labor inputs are observed at the plot level and were aggregated to household totals.

rubber, groundnuts, cocoa, tobacco, and palm oil) as well as the number of unique crops grown by the household are included in the analysis. The total land size owned by the household was also included in poverty regressions. The average household in the sample owned 0.7 hectares and poor households have significantly more farm land holdings than non-poor households.

Socioeconomic characteristics are also incorporated. These include the sex, age, and years of education of the household head, whether the household head is married and is non-Muslim. On average, non-poor household heads are younger, better educated, less likely to be male, less likely to be married, and more likely to be Muslim. Also included are household composition variables such as the number of male and female working-age adults in the household and the number of dependents. As would be expected, poor households generally have more dependents as well as working aged males and females. Indicators are also included for whether the household was granted credit (informal or formal) and for households that have at least one member with insurance. While insurance was relatively rare among sample households at only 1.4 percent, access to credit (mostly from informal sources) was more wide spread with 41 percent of households receiving some form of credit.

Participation in other economic activities may also play an important role in agricultural production and rural poverty (Barrett et al., 2001; Oseni and Winters, 2009). Therefore indicators of nonfarm enterprise ownership, external wage work, and rental and/or investment income as well as per capita incomes from these sources are included in the poverty regressions below. Over half of all sample households operated a nonfarm enterprise, but only 12 percent had at least one nonagricultural wage earner and only 4 percent had rental or investment income. Non-poor households were more likely to have any of the nonagricultural income sources than poor households. As would be expected, per capita income amounts from these sources were higher for poor households though the difference was not significant for nonagricultural wage income per capita.

The effects of two geographic variables are also estimated in the determinants of agricultural productivity regressions. These include the distance to the nearest market and the nearest major road (both in kilometers). Poor households lived farther from major roads than non-poor households, on average. Indicators for the agroecological zone[9] of the household are also included in the analysis. These agroecological zones capture broad variations in climate that are closely linked to agricultural production. In the regression sample, 44 percent of households were in the tropic-warm/semiarid zone in the north and 50 percent in the tropic-warm/subhumid zone farther south. Households in the semiarid zone are more likely to poor while those in the subhumid zone are less likely.

In order to assess the determinants of agricultural production and productivity, a simple household level OLS specification is estimated. The specification is of the following form:

[9] Three broad components define these zones: temperature, moisture, and elevation. For temperature, all of Nigeria falls in the tropics zone where the average monthly temperature is greater than 18°C for all 12 months. The four moisture zones (arid, semiarid, subhumid and humid) are all defined according to the length of the growing period. The semiarid zone has a 70-180 day growing period, subhumid 180-270 day, and humid over 270 days. Lastly, areas are classified according to elevation where cool zones have greater than 1200m elevation and warm zones less than 1200m. See Figure 1 in the Appendix for a map representing the agroecological zones in Nigeria.

$$\ln Y = \beta_0 + \beta_1 L + \beta_2 L^2 + \sum_i \alpha_i \ln P_i + \sum_j \gamma_j \ln D_j + \Omega X + \lambda + \varepsilon \quad (1)$$

where Y is the measure of production, L is the total land size harvested by the household, P_i and D_j represent the amounts of physical and labor inputs (respectively) used by the household, **X** is a vector of other household characteristics, state fixed effects are captured by λ, and ε is the idiosyncratic error term.

In addition to being estimated for the whole sample, the agricultural productivity model will be estimated for three pairs of subsamples: the bottom versus top land size quintiles, the bottom versus top consumption quintiles, poor households versus non-poor households. The land size quintiles are calculated from total land harvested by the household and is determined within the sample. Comparing the top to the bottom quintile will indicate whether the determinants of agricultural productivity are different for small and large farmers. The consumption expenditure quintiles are calculated from per capita household expenditures and are nationally determined (i.e. not within the sample). Comparing the top and bottom consumption quintiles will indicate whether there are appreciable differences between the richest and poorest agricultural households. Poverty is as defined above. Comparing the results for poor and non-poor will indicate whether the determinants of agricultural productivity vary with poverty status.

The relationship between agricultural productivity and poverty status is estimated using a Logit fixed effects model of the following general form:

$$P = \Theta \ln Y + \sum_{i=1}^{3} (\omega_i \ln I_i + \varrho_i P_i) + \Phi Z + \lambda + \varepsilon \quad (2)$$

Where P is equal 1 if the household's per adult equivalent expenditures fall below the national poverty line and zero otherwise, Y is harvest value per hectare (agricultural productivity). Therefore, Θ will reflect the relationship between agricultural productivity and poverty, *ceteris paribus*. The terms in the summation capture the effect of three nonagricultural income sources: nonfarm enterprise (NFE) ownership, nonagricultural wage work, and rental or investment income. The set of I_i are per capita incomes from these three sources (profits in the case of NFEs) whereas the P_i are indicators for participation in these three nonagricultural activities. P_i is equal to 1 if the household participated in nonagricultural activity i and zero otherwise. All other household characteristics are contained in **Z** while λ again captures state fixed effects. The logit fixed effects estimator is used to account for the discrete nature of the poverty indicator and to avoid bias due to the incidental parameters problem associated with the probit estimator when using fixed effects (see Greene, 2002).

While equation 2 represents the general model to be estimated, three slightly modified specifications were also estimated. First, the model was estimated excluding the per capita nonagricultural income values (I_i). This will provide a better understanding of the relative importance of participation in these activities and the amount of income received from them in terms of poverty status. Secondly, the two models (with and without I_i) were also estimated

using zone instead of state fixed effects. This variant was estimated because of a single state[10] where all households were non-poor and therefore the indicator for that state perfectly predicted poverty. This resulted in the ten households from that state being dropped from the estimation. Zone fixed effects were employed to retain these households in the regression sample.

IV. RESULTS

Determinants of agricultural productivity

Table 2 presents the log value of household harvest per hectare (our proxy for agricultural porducitivity) results[11]. Column 1 contains estimates for the the full sample. The results indicate harvested land size has a negative relationship with productivity. More specifically, the coefficient implies that a 10 percent increase in harvest land size will decrease productivity by 6.6 percent. Therefore, it appears that households with larger farm sizes are not as productive as those with smaller farms, *ceteris paribus*. This is the common inverse relationship found between land size and productivity (Carletto et al., 2011). Oftentimes, larger farms are not farmed as intensely as smaller farms and thus are underutilized. The intensity of fertilizer and herbicide use (kilograms per hectare) had positive and significant effect on harvest value per hectare. The estimates suggest that a 10 percent increase in the amount of fertilizer or herbicide used per hectare will increase agricultural productivity by 0.4 to 0.5 percent. While coefficients on the amount of pesticide used per hectare and whether animal traction was used were positive, both were not statistically significant. We also find the number of male labor days per hectare contributed by family members or hired in were positively related to productivity. The coefficients suggest that on average, a 10 percent increase in male labor days used per hectare increased productivity by 0.4 percent for family labor and 0.8 percent for hired labor. Female and child labor days per hectare did not significantly affect productivity.

The results for other agricultural characteristics were mixed. The number of plots, value of agricultural capital, and whether the household received agricultural advice from extension services were all positively related to productivity. Not surprisingly, the higher the variety of crops a household grows on their farmland, the higher the value of output per hectare. What is surprising is how large the effect is on productivity. We find that it increases productivity by 29 percent. The value of agricultural capital per hectare also is positively associated with agricultural productivity though rather small with an elasticity of 0.04. Households that received agriculture advice through extension services have higher value of yields than those who did not receive any. The estimates suggest that harvest values per hectare were 13 percent higher for households that received agricultural advice. We also find value of agricultural capital to have a significant positive effect on productivity.

[10] All households in Abuja fell in the non-poor category.

[11] The estimates reflect how an increase in the regressor variable affects the total value of crops harvested per hectare by a household. However, since the dependent variable is in log form, the interpretation of coefficients will vary. For regressors not in log form, the coefficients can be roughly interpreted as the percent change in harvest value per hectare that results from a one unit increase in the explanatory variable. For explanatory variables in log form, the coefficients can be interpreted as elasticities.

Almost all household characteristics had no signficant relationship with agricultural productivity.Only the number of working age males and being were positively associated with productivty. The estimate for working age males indicates that each additional male leads to a 5 percent increase in agricultural productivity.

The second and third columns present model estimates for the lowest and highest land size harvested quintiles. Comparing these results will highlight any differences in the determinants of productivity between smaller and larger farmers. We observe the landsize-productivity inverse relationship for both samples. There are however differences in how the use of different inputs affects productivity. For larger farmers, fertilizer, family child labor, as well as male labor days hired per hectare were all positively related with productivity. Only pesticide use was significant for small land owners. The effect of animal traction, though marginally significant, was positive for both large and smallholder households though the point estiamte was higher for smallholders. The number of crops grown was positive and signifcant for both samples. Agricultural capital was only significant for larger farmers.

Columns 4 and 5 contain estimates for the lowest and highest national consumption expendture quintiles. Although the effect of land size was similar, there are again some differences in the effect of input use between the two samples. For the lowest consumption quintile, fertilizer use per hectare was positively associated with agricultural productivty while for the highest only hired male labor per hectare had a positive effect on productivity.

The results for agricultural households in poverty and not in poverty are presented in the last two column of Table 3. There are some notable differences in the results for these two subgroups. While fertilizer use per hectare is positively associated with productivity for both poor and nonpoor households, use of traction animals as well as the amount of herbicide, hired male labor per hectare, and male family labor days were only positive for nonpoor households. These results likely reflect very low or improper input use of inputs among poor households.

Poverty and agricultural productivity

Table 3 shows the results of the Logit model employed to examine the relationship between agricultural productivity and poverty. The results contained in the table are the average marginal effect across sample observations. The estimates reflect the change in probability of being poor caused by a one unit increase in the relevant explanatory variable. Columns 1 and 2 present estimates using state fixed effects while the results in columns 3 and 4 reflect estimations using zone fixed effects.

For all four regressions, the value of harvest per hectare reduced the likelihood of being poor. The estimates indicate that a ten percent increase in productivity reduced the likelihood of being poor by between 2.5 and 3 percent[12]. This is a sizeable effect suggesting that improvements in agricultural productivity could be an effective means to reduce rural poverty.

[12] This result is calculated from the marginal effect estimates using the following equation:

$$\Delta p(y = 1) = 0.1\bar{x}\ \frac{\partial y}{\partial x}$$

The results also show that having additional income sources also reduces poverty incidence. Having a nonfarm enterprise reduced the likelihood of being in poverty by 8.5 percent. The effect was larger for external wage work as well as rental or investment income ranging from a 8 to 17 percent decrease in the likelihood of being in poverty according to the results in columns 1 and 3. The results in columns 2 and 4 verify that in additional to participation in a nonagricultural income activity, the amount of income received from these sources also significantly reduces poverty. We find that amount of farm land owned by the households is not significantly correlated with poverty. Again, emphasizing that size of farm land in Nigeria is not based on wealth mostly because the most common method of acquisition is through family or community distribution.

Several household characteristics also reduced the likelihood of being poor. Not surprisingly, the more members there are in a household, the higher the probability of being poor. This is especially true for the number of working age males and the number of dependents. Some characteristics of the head also show an impact on poverty. A married household head is more likely to be poor than a single head of household. Households that have a head with more education and with better access to credit are less likely to be poor as well.

V. CONCLUSION

This paper provides a detailed look into the determinants of agricultural productivity in rural Nigeria and its link to poverty using nationally representative data. We find that a one percent increase in agricultural productivity will decrease the likelihood of being poor by between two and three percent. This shows that improvements in agricultural productivity could be very important for reducing poverty. Our results also indicate that income from wages and other nonfarm activities have a larger effect on poverty reduction than agriculture. However, this does not diminish the importance of agriculture for poverty reduction in rural Nigeria, as this is still the main activity for many households in the sector.

In our examination of the determinants of agricultural productivity, we find that the use of fertilizer and pesticide as well as labor (particularly male labor) is positively related to increased productivity. Land ownership is quite important for farm households, and households with larger farm sizes have higher value of harvest in general. However, we observe decreasing returns to scale in land size. It appears that large farms are not cultivated as intensely as smaller farms and are therefore underutilized. If farms in the top land quintile had half the median yield per hectare of farms in the lowest quintile, production of the top quintile would be 10 times higher.

Diversification is also important for rural households within and outside agriculture. Within agriculture, we find that households that grow a variety of crops have a higher productivity compared with those that only grow one crop. Diversification outside agriculture is also quite common for many rural households with about 50 percent of rural farm households also engaged in a nonfarm activity and our analysis shows that having a nonfarm activity reduces the

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Where x is log harvest value per hectare, y is poverty status, $\frac{\partial y}{\partial x}$ is the marginal effect, and $\Delta p(y = 1)$ is the change in the probability of being in poverty resulting from a 10 percent increase in x (from the mean).

likelihood of being poor. Improved access to credit could increase the ability of households to diversify by engaging in other activities within agriculture and outside of agriculture. In our analysis, we find a significant positive relationship between access to credit and lower likelihood of being poor.

Without a doubt, agriculture is an important activity for rural households in Nigeria and the performance of the agricultural sector has implications for rural poverty. Nigerian agriculture appears to be characterized by smallholder farmers, employing very basic technology in their production activities. Land and labor (particularly male labor), with very little specialization, are the key determinants of production. We find positive, albeit low, returns to modern inputs like fertilizer and herbicides, and this could indicate inadequate use of inputs and/or low quality of available inputs. Lack of information on proper use of these inputs could also be a factor. Increased access to inputs, credit, and information about proper farming practices for poorer households could increase agricultural productivity and in effect, rural incomes. Although we cannot ascertain causality between agriculture and rural poverty in this analysis, we are able to show a strong link between increased agricultural productivity and lower likelihood of poverty in rural Nigeria. We also show that diversification is important for rural activities. Thus, policies favorable to increasing agricultural productivity and encouraging diversification of income generating activities both within and outside agriculture could reduce rural poverty.

The analysis in this study is limited to a single cross section of Nigerian farmers in 2010/2011. As such, we are unable to examine how the determinants of productivity and the link between productivity and poverty change over time. In the future, we plan to incorporate data from two subsequent waves of the GHS into the analysis. This will allow us to use more rigorous panel methods to assess these two relationships. Additionally, we will be able to roughly gauge any potential impact of more recent agricultural initiatives in Nigeria on agricultural productivity and poverty. The analysis in this paper will provide a baseline analysis for this future work.

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Table 1: Summary statistics and test of mean differences by poverty status

	Full	Not in poverty	In poverty	Difference
Production:				
Value of total harvest (Naira)	158,956	174,952	126,479	***
Value of harvest per hectare (Naira/ha)[a]	878,612[a]	1,079,647[a]	470,427[a]	***
Log value of harvest per hectare	11.94	12.08	11.67	***
Poverty:				
Poverty: below HNLSS Poverty Line (%)	33.0			
Harvested land size:				
Harvested hectares	1.1	1.0	1.2	***
Harvested hectares squared	4.0	3.5	4.9	
Physical inputs:				
Used fertilizer (%)	48.3	47.2	50.7	
Total fertilizer used (kg)	184.2	180.8	190.6	
Fertilizer used (kg/ha)	531.9	558.5	481.5	
Used Pesticide (%)	17.8	17.9	17.5	
Total pesticide used (kg)	10.2	10.4	9.7	
Pesticide used (kg/ha)	30.1	33.0	24.1	
Used herbicide (%)	23.3	24.8	20.0	***
Total herbicide used (kg)	23.6	25.4	19.1	
Herbicide used (kg/ha)	31.3	33.2	26.4	
Family and hired labor:				
Used family labor (%)	94.0	94.2	93.6	
Labor days contributed by HH's males 12 and older	63.2	54.7	80.4	***
Labor days contributed by HH's females 12 and older	34.0	31.0	40.3	*
Labor days contributed by HH's children	6.5	6.0	7.5	
Male family labor days used per hectare	268.0	274.1	255.6	
Female family labor days used per hectare	230.6	251.2	188.4	
Child family labor days used per hectare	17.7	19.4	14.2	
Hired in labor (%)	54.4	53.2	56.9	
Number of man days hired on the plot	26.4	27.6	23.9	
Number of woman days hired on the plot	10.5	12.0	7.2	***
Number of child days hired on the plot	4.2	5.3	1.8	***
Male days hired per hectare	78.0	76.8	80.8	
Female days hired per hectare	37.9	46.4	19.2	***
Child days hired per hectare	21.8	28.6	6.8	***
Other agricultural characteristics:				
Used animal (%)	31.3	26.9	40.2	***
Household owns livestock (%)	73.0	71.1	77.1	***
At least one plot purchased (%)	9.7	9.9	9.4	
Household received agricultural advice (%)	14.7	15.9	12.1	**

Table 1 cont.

	Full	Not in poverty	In poverty	Difference
Value of agricultural capital (Naira)	4,299	4,512	3,866	**
Value of agricultural capital per hectare	36,945	45,420	19,737	***
Other agricultural characteristics:				
Household grew at least on cash crop (%)	23.5	23.7	23.0	
Number of unique crops grown by the household	2.8	2.8	2.8	
Household land holdings (ha)	0.7	0.6	0.8	***
Socioeconomic characteristics:				
Sex of household head (% male)	90.4	88.6	94.1	***
Age of household head	49.8	49.1	51.2	***
Age of household head squared	2,704	2,649	2,816	**
Years of education of head	4.5	5.0	3.6	***
Household head is married (%)	87.2	84.3	93.2	***
Household is nonmuslim	48.9	52.6	41.6	***
# of males aged 12 to 60	1.7	1.5	2.1	***
# of females aged 12 to 60	1.8	1.7	2.1	***
Number of dependents 0 to 11 or older than 60	2.9	2.5	3.5	***
Household granted credit (%)	40.8	41.5	39.4	
At least one household member has insurance (%)	1.4	1.5	1.2	
Nonagricultural income				
Household owns/operates a nonfarm enterprise (%)	56.5	58.1	53.1	*
At least one member of household received external wages (%)	11.9	14.0	7.5	***
Household had rental and/or investment income (%)	4.3	5.5	2.0	***
Per capita profits from nonfarm enterprise(s)	15,224	20,510	4,490	*
Per capita wage income	10,934	15,452	1,760	
Per capita rental and investment income	321.8	461.4	38.2	***
Geographic characteristics:				
Distance to nearest market (km)	69.6	70.1	68.6	
Distance to nearest major road (km)	18.3	17.4	20.2	***
Agro-ecological zone				
Tropic-warm/semiarid (%)	43.6	39.4	52.3	***
Tropic-warm/subhumid (%)	50.2	54.4	41.6	***
Tropic-warm/humid (%)	5.3	5.3	5.3	
Tropic-cool/subhumid (%)	0.9	1.0	0.8	
Observations (same for all variables)	2,086	1,379	707	-

Note: Weighted sample means with Wald test results. * p<0.10, ** p<0.05, *** p<0.01.
[a]See footnote 4 above.

Table 2: Determinants of Agricultural Productivity, Value of Output (Naira)/Hectare

	BASE	LAND 1	LAND 5	CONS 1	CONS 5	IN POV	NOT IN POV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Land size:							
Log harvested hectares	-0.658***	-0.368	-0.681***	-0.776***	-0.461***	-0.743***	-0.608***
	(0.036)	(0.228)	(0.257)	(0.092)	(0.131)	(0.067)	(0.044)
Log harvested hectares, squared	0.004	0.039	0.030	-0.020	0.038	-0.012	0.018
	(0.009)	(0.033)	(0.094)	(0.030)	(0.029)	(0.021)	(0.011)
Physical inputs:							
Log of fertilizer used (kg/ha)	0.042***	0.028	0.057**	0.069***	0.061	0.043**	0.045***
	(0.012)	(0.028)	(0.024)	(0.021)	(0.043)	(0.017)	(0.016)
Log of pesticide used (kg/ha)	0.013	0.161***	0.045	-0.104	0.072	-0.085**	0.050
	(0.027)	(0.059)	(0.065)	(0.065)	(0.104)	(0.041)	(0.036)
Log of herbicide used (kg/ha)	0.051**	0.045	0.082*	-0.002	0.084	0.025	0.056*
	(0.026)	(0.065)	(0.046)	(0.054)	(0.141)	(0.053)	(0.030)
Used animal on plot	0.116	0.560*	0.290*	0.220	-0.103	-0.064	0.230**
	(0.084)	(0.307)	(0.174)	(0.219)	(0.447)	(0.172)	(0.097)
Labor inputs:							
Log of male family labor days used per hectare	0.036**	0.041	0.026	-0.006	0.021	0.006	0.051**
	(0.018)	(0.033)	(0.050)	(0.045)	(0.053)	(0.037)	(0.021)
Log of female family labor days used per hectare	-0.007	-0.011	0.007	0.018	-0.015	0.005	-0.015
	(0.017)	(0.039)	(0.041)	(0.033)	(0.060)	(0.027)	(0.022)
Log of child family labor days used per hectare	0.010	0.022	0.077*	0.016	-0.062	-0.007	0.020
	(0.017)	(0.038)	(0.043)	(0.030)	(0.110)	(0.025)	(0.023)
Log of male days hired per hectare	0.084***	-0.013	0.181***	0.026	0.175***	0.051	0.106***
	(0.020)	(0.050)	(0.050)	(0.042)	(0.067)	(0.035)	(0.026)
Log of female days hired per hectare	0.002	0.012	-0.047	0.059	-0.001	0.021	-0.004
	(0.030)	(0.076)	(0.085)	(0.065)	(0.085)	(0.053)	(0.035)
Log of child days hired per hectare	0.012	0.002	0.013	-0.099	-0.031	0.039	-0.008
	(0.037)	(0.061)	(0.081)	(0.092)	(0.116)	(0.072)	(0.045)
Other agricultural Characteristics							
At least one plot purchased	-0.066	0.017	-0.280*	0.141	-0.072	0.058	-0.152
	(0.090)	(0.318)	(0.160)	(0.210)	(0.404)	(0.144)	(0.117)
Number of crops on plot	0.289***	0.240***	0.265***	0.264***	0.236**	0.262***	0.294***
	(0.024)	(0.067)	(0.046)	(0.055)	(0.093)	(0.043)	(0.029)
Household grew at least on cash crop	0.034	0.071	0.167	0.048	-0.017	0.097	-0.007
	(0.072)	(0.205)	(0.124)	(0.139)	(0.267)	(0.106)	(0.096)
Household owns livestock	0.103	0.171	-0.384***	0.004	-0.019	-0.031	0.151
	(0.084)	(0.172)	(0.147)	(0.210)	(0.209)	(0.167)	(0.100)
Log of the value of agricultural capital owned by the household (Na/ha)	0.038*	-0.005	0.081	0.019	0.052	0.040	0.030
	(0.020)	(0.065)	(0.050)	(0.045)	(0.068)	(0.038)	(0.023)
Household received agricultural advice	0.135*	0.292	-0.035	0.279*	0.218	0.234*	0.083
	(0.074)	(0.270)	(0.115)	(0.157)	(0.249)	(0.136)	(0.090)

Table 2 cont.

	BASE (1)	LAND 1 (2)	LAND 5 (3)	CONS 1 (4)	CONS 5 (5)	IN POV (6)	NOT IN POV (7)
Household characteristics:							
Sex of household head	0.064	-0.413	1.004	0.006	-0.001	0.448	-0.104
	(0.191)	(0.359)	(0.645)	(0.384)	(0.481)	(0.375)	(0.214)
Age of household head	-0.001	-0.008	0.000	0.018	-0.029	0.005	0.000
	(0.010)	(0.031)	(0.024)	(0.024)	(0.034)	(0.017)	(0.013)
Age of household head squared	0.000	0.000	0.000	-0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household head is married	0.161	0.414	0.019	0.512**	0.298	0.284	0.178
	(0.154)	(0.284)	(0.198)	(0.251)	(0.331)	(0.227)	(0.178)
Years of education of head	-0.010	-0.016	0.019	-0.030	-0.026	-0.026	-0.007
	(0.007)	(0.019)	(0.014)	(0.025)	(0.021)	(0.018)	(0.007)
# of males aged 12 to 60	0.046**	0.060	0.032	0.030	0.134*	0.042	0.061*
	(0.024)	(0.075)	(0.042)	(0.047)	(0.072)	(0.037)	(0.034)
# of females aged 12 to 60	-0.000	-0.078	0.004	0.053	-0.132	0.036	-0.027
	(0.026)	(0.078)	(0.048)	(0.048)	(0.113)	(0.035)	(0.039)
Household granted credit	0.029	-0.156	-0.181	0.009	0.133	0.015	0.039
	(0.062)	(0.156)	(0.116)	(0.133)	(0.205)	(0.107)	(0.080)
Household owns/operates a nonfarm enterprise	0.070	-0.003	0.041	0.147	-0.120	0.099	0.041
	(0.080)	(0.170)	(0.120)	(0.158)	(0.303)	(0.136)	(0.100)
Household has other nonfarm activity	0.011	-0.065	0.024	0.089	-0.252	0.050	0.019
	(0.102)	(0.247)	(0.206)	(0.258)	(0.322)	(0.225)	(0.118)
Geographic variables:							
Distance to nearest market (km)	0.001	-0.000	0.002*	0.002	-0.003	0.002	0.000
	(0.001)	(0.004)	(0.001)	(0.002)	(0.004)	(0.002)	(0.001)
Distance to nearest major road (km)	-0.002	-0.005	-0.004	-0.004	0.008	-0.003	-0.000
	(0.002)	(0.006)	(0.003)	(0.005)	(0.008)	(0.004)	(0.002)
Agro-ecological zone							
Tropic-warm/subhumid	0.223	-0.453	0.133	0.187	1.856**	0.297	0.145
	(0.156)	(0.545)	(0.229)	(0.416)	(0.910)	(0.318)	(0.176)
Tropic-warm/humid	0.002	-0.338	0.933	-1.144*	1.558	-0.410	0.383
	(0.293)	(0.694)	(0.644)	(0.682)	(1.250)	(0.534)	(0.369)
Tropic-cool/subhumid	0.859***	-0.911	1.511***	0.887	2.346**	0.804	0.704**
	(0.283)	(0.792)	(0.564)	(0.752)	(1.183)	(0.520)	(0.324)
Constant	8.691***	11.801***	8.185***	8.699***	8.755***	8.786***	8.582***
	(0.415)	(1.240)	(0.864)	(0.972)	(1.273)	(0.787)	(0.470)
Observations	2086	376	490	479	242	707	1379
R-squared	0.511	0.489	0.489	0.516	0.586	0.535	0.518

Note: OLS point estimates with **r**obust standard errors in brackets. Results for state fixed effects not shown. Significance denoted * p<0.10, ** p<0.05, *** p<0.01.

Table 3: Poverty and Agricultural Productivity

Dependent variable: Poverty status				
	(1)	(2)	(3)	(4)
Productivity:				
Log yields (Naira/ha)	-0.021**	-0.020**	-0.026***	-0.026***
	(0.009)	(0.009)	(0.007)	(0.007)
Other sources of income:				
Log per capita profits from nonfarm enterprise(s)		-0.008**		-0.005*
		(0.004)		(0.003)
Log per capita wage income		-0.072**		-0.062**
		(0.030)		(0.025)
Log per capita rental and investment income		-0.069*		-0.070**
		(0.038)		(0.034)
Household owns/operates a nonfarm enterprise	-0.085***	-0.048	-0.080***	-0.053**
	(0.026)	(0.031)	(0.020)	(0.026)
At least one member of household received external wages	-0.087**	0.614**	-0.107***	0.497**
	(0.043)	(0.288)	(0.036)	(0.242)
Household had rental and/or investment income	-0.174**	0.326	-0.144**	0.364
	(0.069)	(0.277)	(0.057)	(0.249)
Other agricultural characteristics				
Household owned land (ha)	-0.004	-0.003	-0.006	-0.005
	(0.010)	(0.010)	(0.008)	(0.008)
Household owns livestock	-0.024	-0.022	-0.013	-0.012
	(0.030)	(0.030)	(0.024)	(0.024)
Household grew at least one cash crop	0.008	0.008	-0.008	-0.009
	(0.029)	(0.029)	(0.023)	(0.023)
Household and head characteristics:				
Average year of education within household	-0.018***	-0.017**	-0.013**	-0.013**
	(0.007)	(0.007)	(0.006)	(0.006)
# of males aged 12 to 60	0.081***	0.081***	0.068***	0.068***
	(0.011)	(0.011)	(0.008)	(0.008)
# of females aged 12 to 60	0.027**	0.026**	0.023***	0.023***
	(0.010)	(0.010)	(0.009)	(0.009)
Number of dependents 0 to 11 or older than 60	0.046***	0.045***	0.038***	0.037***
	(0.006)	(0.007)	(0.005)	(0.005)
Household is nonmuslim	0.098**	0.098**	0.052*	0.050*
	(0.041)	(0.041)	(0.030)	(0.030)
Household head is male	-0.104	-0.094	-0.068	-0.061
	(0.084)	(0.083)	(0.072)	(0.071)

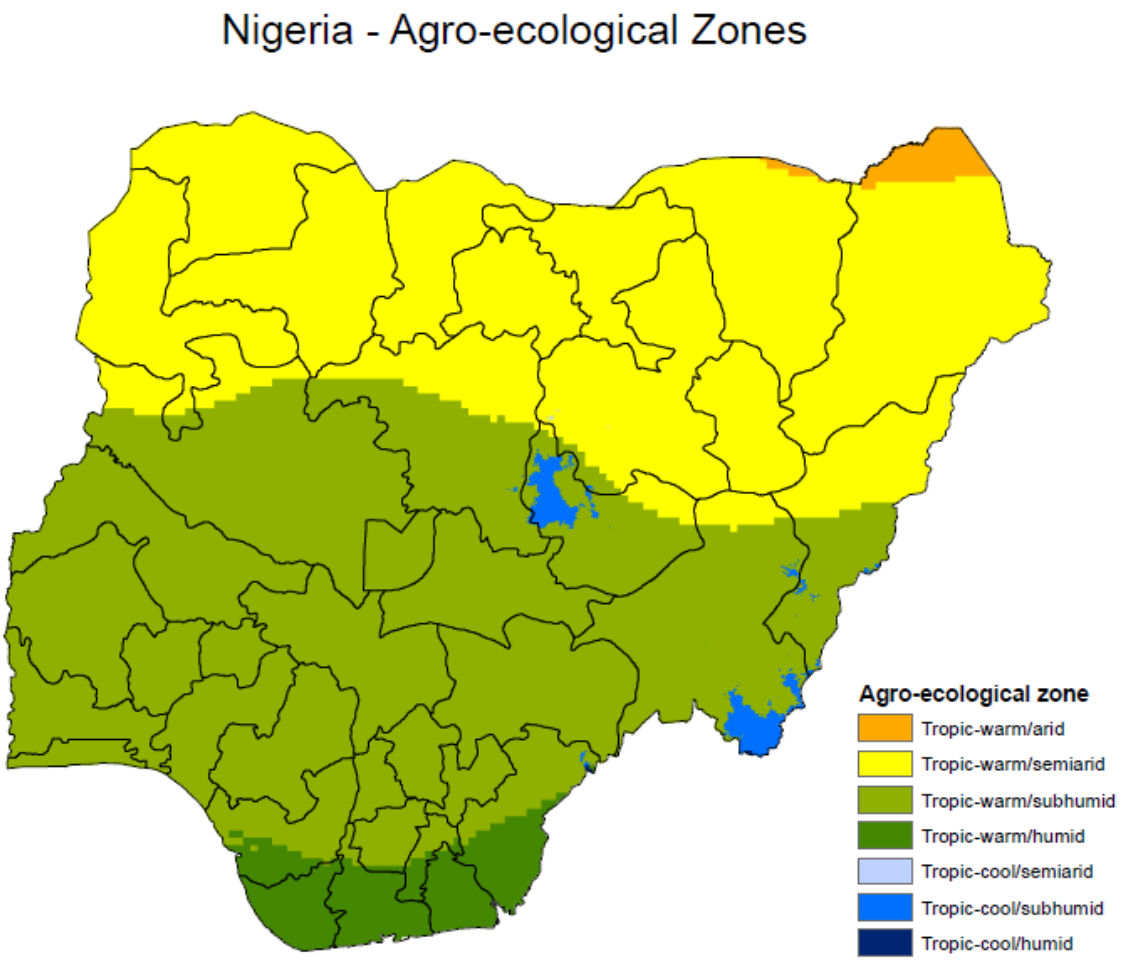
Table 3 cont.

	(1)	(2)	(3)	(4)
Household and head characteristics (cont.):				
Age of household head	0.002	0.002	0.006	0.007
	(0.005)	(0.005)	(0.004)	(0.004)
Age of household head squared	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Household head is married	0.171**	0.166**	0.134**	0.132**
	(0.076)	(0.074)	(0.066)	(0.064)
Years of education of head	-0.008**	-0.008**	-0.006**	-0.006*
	(0.004)	(0.004)	(0.003)	(0.003)
Household granted credit	-0.069***	-0.069***	-0.021	-0.021
	(0.025)	(0.025)	(0.020)	(0.020)
At least one household member has insurance	-0.079	-0.088	-0.023	-0.040
	(0.125)	(0.125)	(0.104)	(0.106)
Agro-ecological zone				
Tropic-warm/subhumid	-0.030	-0.041	-0.062	-0.066
	(0.070)	(0.069)	(0.042)	(0.042)
Tropic-warm/humid	0.166	0.152	0.067	0.064
	(0.128)	(0.127)	(0.071)	(0.071)
Tropic-cool/subhumid	-0.102	-0.119	-0.021	-0.033
	(0.130)	(0.130)	(0.098)	(0.098)
State fixed effects	Yes	Yes	No	No
Zone fixed effects	No	No	Yes	Yes
Observations	2076	2076	2086	2086
Pseudo R-squared	0.123	0.130	0.134	0.139

Note: Estimates for Logit fixed effects estimation with standard errors in parenthesis. Significance denoted * p<0.10, ** p<0.05, *** p<0.01.

VI. APPENDIX

Figure 1: Map of agro-ecological zones



Source: HarvestChoice, International Food Policy Research Institute, 2010.