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Public Expenditures on Agriculture at Subnational-Levels and Household-Level Agricultural Outcomes in Nigeria

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Notices

Abstract

Growing agriculture remains important for countries like Nigeria where, despite economic transformation at sectoral levels, a significant share of employment still originates from the agricultural sector. The question has continued to be debated of whether increasing Public Expenditures on Agriculture (PEA) is the way to grow agriculture. The needed evidence-base for this debate, while gradually growing, has remained insufficient in African countries, including Nigeria. This has been particularly the case as regards to evidence on the effects of PEA at household levels. This study attempted to partially fill this gap, using state and local government area (LGA)-level PEA figures and household data in Nigeria. The findings suggest that PEA has positive effects on household-level agricultural outcomes in various dimensions, including overall production levels, profits, access to public extension services or subsidized fertilizer, as well as private investments and, in some cases, agricultural mechanization. These patterns generally underscore the hypothesis that increasing direct support to the agricultural sector is likely to have greater effects on agricultural outcomes, compared to alternative strategies of developing agriculture indirectly through the support of other social-sectors like education, health, social safety-nets, among others. Increasing PEA by increasing the agricultural share of public expenditures (PE), while keeping the overall size of PE constant, is found to be particularly effective, compared to alternative approaches of increasing the overall size of PE while keeping agricultural share unchanged. Such patterns may suggest that Ricardian Equivalence partly holds. Furthermore, different agricultural outcomes are found to respond to PEA from different sources (e.g., LGA or State), and types (e.g., recurrent or capital spending). Enhancing research capacity to identify appropriate sources and types of PEA for particular agricultural outcomes remains important.

Keywords: public expenditures, agriculture, panel data analysis, household-level analysis, Nigeria

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1 Introduction

Agricultural sector development remains an important driver of food security improvement, inclusive growth, and rural revitalization in developing countries (World Bank (WB) 2007; IFPRI 2019). This is also the case in countries like Nigeria where, despite the economic transformation at the sectoral level, a significant share of employment originates in the agricultural sector that has long been characterized with persistently low (albeit slowly rising) productivity.

Whether increasing Public Expenditures on Agriculture (PEA) is an effective way to achieve such agricultural growth has remained debated in countries in Africa South of Sahara (SSA), including Nigeria. PEA can be considered effective where it provides critical public goods that are the binding constraints for production and productivity growth (WB 2007; Fan & Zhang 2008; Benin et al. 2011; Spielman & von Grebmer 2006; Evenson & Westphal 1995). Continent-wide, the importance of increasing PEA (e.g., allocating 10% of government-spending to agriculture) has been advocated through continental initiatives like the Comprehensive Africa Agriculture Development Programme (CAADP), and repeatedly upheld (e.g., the Maputo Declaration in 2003 and the Malabo Declaration in 2014). On the other hand, some SSA governments, including the Nigerian government, have placed significant weights on directly supporting the non-agricultural sector or allocating more resources to social services away from the agricultural sector, with the hope that such strategies can be more effective also for the growth of the agricultural sector through spillover effects from the non-agricultural sector.

Consequently, as is seen below, Nigeria has allocated a seemingly low share of its government spending to the agricultural sector over the years, given the sector's employment share. Part of such a trend may be due to the insufficient (albeit growing) evidence on the direct roles of PEA on agricultural outcomes in Nigeria, including the micro-level evidence at household levels. This study aims to partly fill this evidence gap by using the data on PEA and overall expenditures by sub-national level i.e., both the states and local government areas (LGA) over time, and nationally representative panel household-level data.

In addition to providing policy-relevant evidence on PEA for Nigerian stakeholders, the paper contributes to various strands of literature. First, we contribute to the long-literature on urban bias (e.g., Lipton 1977; Bates 1981; Krueger et al. 1991; Binswanger & Deininger 1997; Bezemer & Headey 2008) by providing some micro-evidence that can inform whether urban bias is, in fact, present in countries like Nigeria. Second, we contribute to the literature on public-expenditure, including studies that particularly focus on the agricultural sector outcomes (e.g., WB 2007; Mogues & Benin 2012; Mavrotas et al. 2018), by providing further evidence using different datasets.

This paper is structured as follows. Section 2 briefly provides some international perspectives. Section 3 discusses the conceptual and theoretical framework. Section 4 discusses data, and section 5 discusses empirical methodologies. Section 6 presents descriptive statistics. Section 7 presents and discusses empirical results, while section 8 concludes.

2 Nigeria's Public-Expenditure on Agriculture – some international perspectives

To the authors' knowledge, scientific evidence remains thin as to what is the optimal ratio of PEA to total PE (PEA-share). However, cross-country comparisons of PEA-share are still informative. In addition, one could argue that from an "economic congruence" standpoint,[1] a

[1] "Economic congruence", for example in the literature on agricultural research, is satisfied when agricultural R&D resources are allocated across commodities at same proportions as the relative share of economic values contributed by each commodity (Boyce & Evenson 1975).

higher PEA-share may be more justifiable in a society where the employment share in the agricultural sector is higher.

Based on these criteria, PEA-share in Nigeria has been relatively lower than many other developing countries in recent years. Figure 1 plots the trajectories of PEA-shares and agricultural employment shares in selected countries in Asia, Latin America, and Africa as well as Nigeria in the past few decades (periods vary by countries). While there is significant heterogeneity across countries, and these countries are only selective, their collective patterns are still somewhat consistent with the hypothesis that PEA-shares and agricultural employment shares have been positively correlated. While PEA-shares have been lower in many Latin American countries, many of these countries have already gone through economic transformation so that agricultural employment shares had already been lower. Many Asian countries have retained relatively higher PEA-shares historically even as the agricultural employment shares in the region have gradually declined. In some SSA countries where agricultural-employment shares are still high, PEA-shares have been high. Compared to all these groups of countries, PEA-shares in Nigeria have been lower, given that the agricultural employment share in the country has remained high (albeit declining).[2]

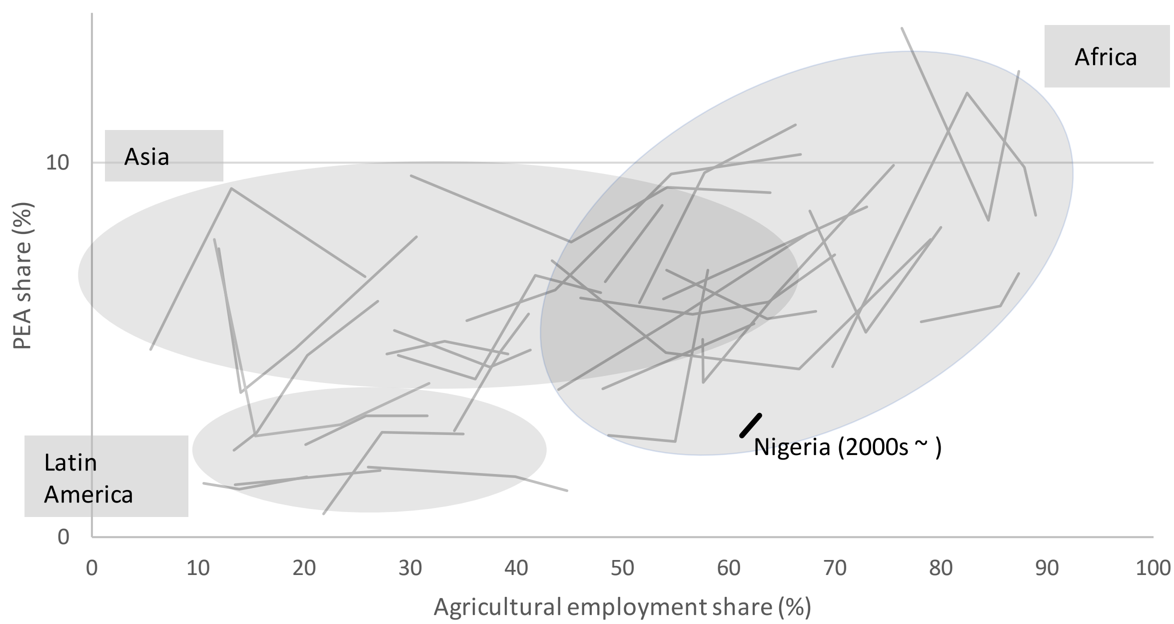

Figure 1. Trajectories of Agricultural share of public-expenditures and sectoral employment in selected countries in Asia, Latin America and Africa

Source: Authors' compilations from IFPRI (2020) and ReSAKSS Africa (2020) (for spending shares) and World Bank (2020) and Timmer et al. (2015) (for employment share).

Asia	= Afghanistan, Bangladesh, China, India, Indonesia, Korea, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Thailand, Vietnam
Latin America	= Bolivia, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, Venezuela
Africa	= Egypt, Ethiopia, Ghana, Kenya, Malawi, Morocco, Nigeria, Senegal, Tanzania, Zambia

[2] The determinants behind the within-country variations in PEA in Figure 1 are beyond the scope of this paper, and needs to be assessed more closely in future studies. However, Figure 1 is shown to illustrate that PEA in Nigeria has been at the lower end from international perspectives.

Figure 2 illustrates trends of PEA-share between 1980 and 2018 for Nigeria, Western Africa, and the whole of SSA. This figure also confirms the observation that, PEA-share in Nigeria has been relatively lower than the rest of Western Africa and SSA during the last four decades. The relative drop in PEA-share in Nigeria since 2014 is also noteworthy.

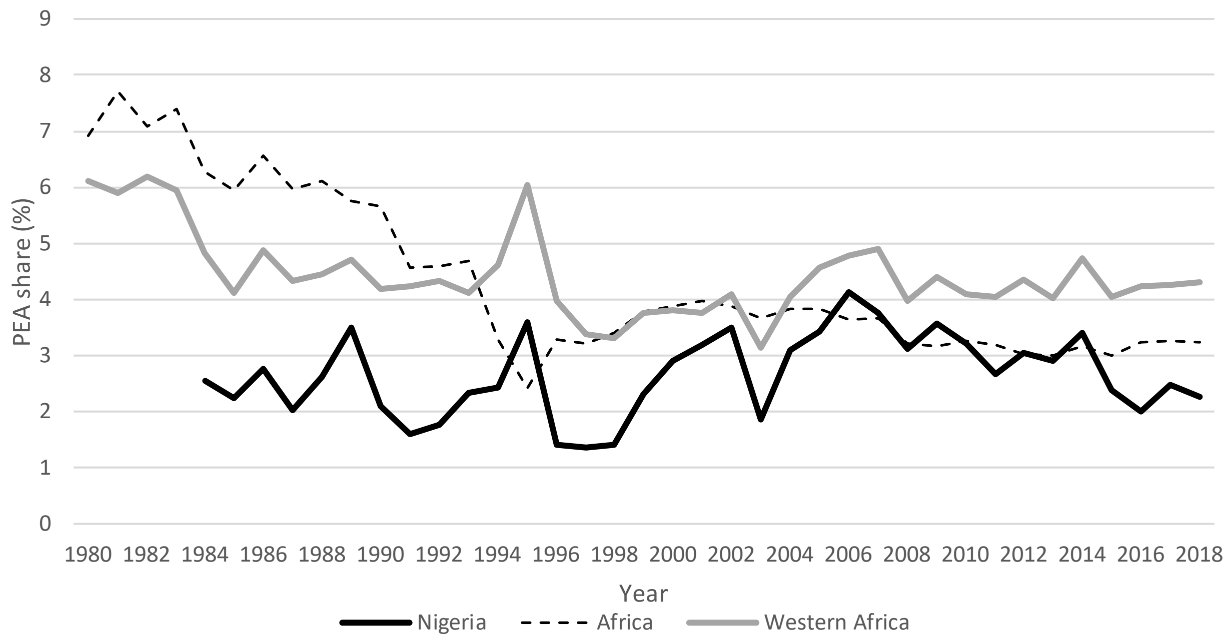

Figure 2. Historical trends of the agricultural share of public-expenditures in Nigeria, Western African and Africa

Source: ReSAKSS Africa (2020).

3 Conceptual / theoretical discussions

The potential linkages between PEA and household-level agricultural outcomes can be categorized in various dimensions. We briefly describe them here. While we do not separately test each of these linkages empirically, they can collectively help us interpret our results. Specifically, key aspects include (a) roles of the increased agricultural share of public spending and investments on agricultural outcomes; (b) magnitude of spending; (c) recurrent vs. capital spending; (d) spending by LGAs vs. state; (e) spending by LGAs vs. neighboring LGAs. Each of these PEA aspects will be examined briefly.

The discussions here should ideally consider net spending (net of tax payment). However, as we focus on the spending by state or LGA, rather than the Federal government, the net effects of tax payments are relatively insignificant. Most public spending by states or LGAs consist of significant net transfers from the Federal government, because tax collections from these local administrative units have been quite limited. Locally generated funds are usually small compared to transfers from the central government (WB 2007, p.255). Also, most governments found import tariffs or export taxes easy to collect, and for several decades they accounted for quite a large share of total government revenues in developing countries (Booth 2014).

(a) Roles of increased agricultural share of public spending and investments on agricultural outcomes

A greater share of spending on agriculture can have positive effects on household agricultural production; public spending can increase investments in public-goods and highreturn but risky projects like agricultural R&D[3] (WB 2007, p.166) and agricultural extension (Fan & Zhang 2008; Benin et al. 2011) for which private investment tends to be limited. In addition, the public-sector often plays an important role in technology generation in agriculture, compared to the private sector or compared to some of the non-agricultural industries (Spielman & von Grebmer 2006; Evenson & Westphal 1995).

However, the positive effects of agricultural expenditures may be limited, for example, if the key binding constraints for agriculture are non-agricultural factors like human capital, worker health, or non-agricultural infrastructure like general-purpose roads, and agricultural public-goods (knowledge, agricultural-infrastructure, etc.) are not binding. Similarly, the effects may be limited in cases where public spending is mostly on the provision of private goods and thus simply crowds out the private sector. Recent studies on input subsidies in Africa have generally suggested evidence of such crowding-out (e.g., Jayne & Rashid 2013; Takeshima & Nkonya 2014). However, the extent varies in these studies, with some evidence of crowding-in in certain localities (Liverpool-Tasie 2014) or general-equilibrium effects offsetting potential crowding-out effects (Arndt et al. 2016). Furthermore, where agricultural sector policy implementation faces efficiency challenges, greater public spending in agriculture may not necessarily contribute to agricultural outcomes (e.g., Ethiopia around 2010 (Spielman et al. 2010; Mogues 2011)).

(b) Size of spending

Greater magnitudes of PE can have positive effects if the effects on agriculture (productivity growth, production expansion, modernization) depend on the greater provision of general public goods – such as infrastructure, complementarity with education (that may affect the update of modern agriculture)(e.g., Foster & Rosenzweig 1995; Reimers & Klasen 2013) and health (e.g., control of malaria and East Coast Fever among humans, that also raised agricultural productivity (McMillan & Meltzer 1996)).

On the other hand, the theory of Ricardian Equivalence (Barro 1976) suggests that the effects of the size of PE at a particular time have no effects on agents' behaviors if the agents predict that such spending increase is financed through a future tax increase, offsetting the effect of PE in the current period.

In reality, however, the evidence of Ricardian Equivalence has been scarce in the agricultural sector and mixed where it is available, and it has been generally found to hold only partly (Masson et al. 1998; Grigoli et al. 2018; Haug 2020). Furthermore, a higher discount-factor can weaken Ricardian Equivalence. The poor that constitute the bulk of farmers in countries like Nigeria has a higher discount factor (Binswanger & Deininger 1997). In some African countries like Ethiopia, it is estimated to be as great as 43-106% per year (Yesuf & Bluffstone 2018). In such cases, the greater size of spending may have significant effects on farmers' behaviors.

(c) Recurrent vs. capital spending

Recurrent spending in Nigeria has been generally described as the personnel expenditures (including workers' benefits) and costs (mainly administrative expenses) incurred in providing the physical overheads, essential services or regular maintenance of infrastructural facilities (Olomola et al. 2014; Tijani et al. 2015; Chinweoke et al. 2014). This type of spending may have positive effects on agricultural production if, for example, greater staff compensation incentivizes civil servants (Kosec & Ragasa 2019; Kosec & Resnick 2019), particularly in

[3]While this study investigates only the short-term effects of ag spending (and thus may not capture the direct effects of spending on longer-term projects like agricultural R&D), greater ag spending in a particular year may still reflect the size of on-going longer-term ag investments.

agriculture-related services (extension, R&D offices, seed certification officers, fertilizer quality regulation officers, project offices like Agricultural Development Project (ADP) office, The National Fadama Development Office, River Basin Development Authorities, etc.), and also if knowledge or expertise of the technical staff is a binding constraint for farm production. Similarly, there may be significant positive effects on production if relevant public agricultural institutions are generally large (with economies of scale/scope) (e.g., Jin et al. 2005), and sufficient administrative function is thus important for their effectiveness. Effects may also be positive if sufficient administrative spending can improve the targeting or monitoring of input subsidies (e.g., Houssou & Zeller 2011), or many other agricultural programs. However, the effects of recurrent spending may be insignificant or even negative, for example, if administrative costs exceed the optimal level. For example, one study suggests that reducing administrative costs is often important for achieving sustainability in rural financial institutions (Norton 2004 p.295).

Capital expenditure in Nigeria has generally been described as operations and maintenance costs, acquisition of things of permanent nature, investment spending, as well as noninvestment spending (of significant but indeterminate proportions) that includes items such as repair of motor vehicles; purchase of computers; furniture, fittings, and office equipment; workshop expenses; and operations and maintenance costs, including those for agriculture, water resources, and roads (Olomola et al. 2014; Chinweoke et al. 2014; Tijani et al. 2015). In Nigeria, spending on procurement of certain inputs (e.g., chemical fertilizer) is also categorized under capital expenditure, although many argue that their characteristics are closer to those of recurrent expenditures (Mogues et al. 2008; Olomola et al. 2014). The short-term effects of capital spending on agricultural outcomes can be positive if the spending leads to immediate improvements (e.g., repair type, instead of new construction). For example, for institutions like River-Basin Development Authorities (RBDAs) in Nigeria, much of the capital expenditures have been incurred for operations and maintenance (though in theory should be classified as recurrent expenditure) (Olomola et al. 2014). However, the effects of capital expenditure can be insignificant or negative if capital goods are not binding constraints in agriculture. For example, labor can still be cheap (particularly in Northern Nigeria) and can easily substitute for equipment, or returns to capital goods (fertilizer, equipment) may be low, especially at intensive margins because of the lack of seeds that respond well to such capital. While the evidence is generally limited, some recent studies on Nigeria have suggested differential effects between recurrent and capital expenditures (e.g., Tijani et al. (2015) show more positive effects of capital expenditures than recurrent expenditures in Nigeria).

(d) Spending by LGAs vs. states

The evidence on the differential effects of spending by different administrative levels (such as states and LGAs) in the agricultural sector is generally scarce. Studies in Nigeria have generally suggested the difficulty of accessing the information on the compositional differences between state and LGA-level agricultural spending (Mogues et al. 2008; Olomola et al. 2014). Olomola et al. (2014 p.55), based on some observations from two case-study LGAs, indicate that LGA-level spending may tend to be limited to a fewer number of items or projects than at state level spending, although more systematic reviews are needed in future studies. In theory, LGAs' spending can be more effective (positive) if it better meets local needs, as investigated in related cases of the decentralization of the River-Basin Development Authority (Dinar et al. 2016) or the decentralization of advisory services (WB 2007 Chapter 7), albeit with somewhat different institutional set-ups. However, on the other hand, if local implementation capacity, economies-of-scale matter (such as those in the procurement of goods), and LGA-level spending are relatively small in scale, LGA spending may be less effective than the state's; and sometimes decentralization can even reduce investment in agriculture (Faguet 2004). Also, decentralization can sometimes lead to greater elite capture, or because of the fear of such, the central government disallows the transfer of sufficient funds to local governments (thus limiting economies-of-scale) (Perez-Sebastian & Raveh 2016).

(e) Spending by LGAs vs. neighboring LGAs

Evidence of spatial spillover of local government PE on agricultural outcomes is generally scarce. In theory, the neighboring LGAs' spending can have greater effects if, for example, location-specificity of production knowledge is less constraining so that knowledge provided in one district can diffuse to other districts.

However, in contrast, the effects of neighboring LGAs may be weaker if, for example, the mobility of production factors is low. For instance, tractors are sometimes procured at LGA level (Olomola et al. 2014) though they are also procured at state levels (Hatzenbuehler et al. 2018). Recent evidence in Africa, including Nigeria, suggests that the mobility of a tractor hiring service is generally low and tends to remain within the LGA where the tractor is located (Takeshima et al. 2015). In this case, spending on tractors in one LGA may have limited effects on neighboring LGAs.

4 Data

This study uses household-level data, state or LGA-level PE data, and weather data for Nigeria. The household-level data are from three panel rounds of the Living Standard Measurement Study – Integrated Survey on Agriculture (LSMS-ISA) collected by Nigeria's National Bureau of Statistics (NBS) and the World Bank in 2010/11, 2012/13 and 2015/16 (NBS & World Bank 2016). The sample of 5,000 households are nationally representative. Ten households were randomly selected in wave 1 from each of 500 enumeration areas (EAs), which were again randomly selected from all EAs defined by the NBS, and re-interviewed in waves 2 and 3.

State and LGA-level expenditure data for all of Nigeria's 37 states and 774 LGAs are from annual statistical bulletins and reports from the Central Bank of Nigeria, and annual surveys conducted jointly by the Federal Ministry of Finance, the Central Bank of Nigeria (CBN), the National Bureau of Statistics (NBS) and the Nigerian Communications Commission (NCC), are available for the period from 2007 to 2015 (Government of Nigeria, 2015 and previous years). The data provide information on expenditures by type (recurrent vs. capital) and function (i.e. economic affairs, as well as general public services, defense, public order and safety, environmental protection, etc.). The spending on agriculture, denoted PEA, is classified as part of the spending on *economic affairs*, for both recurrent and capital expenditures. The data also report the types of revenues (including tax revenues), other internally-generated revenues (IGR), and other sources of revenues for each LGA and state.[4]

[4] The Government of Nigeria (2015) does not provide detailed definitions, but it is expected that it largely follows the Government Finance Statistics Manual (IMF 2001) as done by other countries. According to the IMF (2001), the type of spending classified under the agriculture, forestry and fisheries expenditures typically include the following (Fan & Saurkar 2012, p.23-25);

- administration of agricultural affairs and services
- conservation, reclamation, or expansion of arable land; agrarian reform and land settlement
- supervision and regulation of the ag industry

Weather data include the annual rainfall and average annual temperature data, which are estimated gridded data from CRU (2020) and the National Oceanic and Atmospheric Administration (NOAA)/OAR/ESRL PSD (2020), respectively. The data used cover the period from 1980 through 2015, and were extracted for the geographical coordinates of EAs reported in LSMS-ISA.

5 Empirical approach

Our empirical approach is based on a standard fixed-effects panel data specification

$$y_{ijt} = \alpha + \beta_{Share} PEA_{jt}^{share} + \beta_{Size} PE_{jt} + \gamma \cdot Z_{it} + \theta_i + \varepsilon_{it} \quad (1)$$

where y_{ijt} is the agricultural outcomes of interests for household i that is located in the administrative units j (LGAs and/or state), at survey round t ($t = 1, 2, 3$). PEA_{jt}^{share} is the agricultural share of PE by LGAs or states j, and PE_{jt} is the size of PE per capita in j. Z_{it} is a set of time-variant exogenous variables. θ_i is the unobserved, time-invariant household fixed-effects, which may be correlated with Z_{it}. θ_i may also be correlated with PEA_{jt}^{share} or PE_{jt}, if θ_i is correlated at LGA or state levels (for example, farmers in certain LGAs may follow particular norms in how their conduct agricultural production activities). Using fixed-effects model to control for θ_i therefore mitigate biases in estimated parameters β_{Share} and β_{Size} which measure the effects of PEA-related variables on agricultural outcomes. α, γ are other estimated parameters, while ε_{it} is idiosyncratic time-variant errors.

By construction, β_{Share} measures the effects of changing PEA-share (PEA_{jt}^{share}), holding fixed the total size of PE (PE_{jt}). Similarly, β_{Size} measures the effects of changing PE, holding fixed the agricultural share of PEA (PEA_{jt}^{share}). Therefore, both β_{Share} and β_{Size} measure the effects of changes in PEA on agricultural outcomes, but with different implications on the total size of PE. We set up our empirical framework this way as we focus on the distinctions between increasing PEA with or without changes in overall PE, the latter of which may have different implications due to Ricardian Equivalence, as discussed above. As we see in the results section, agricultural outcomes are often more positively affected by PEA_{jt}^{share} (thus a more significantly positive β_{Share}), while β_{Size} produces a lesser effect.[5]

In our primary models, we use aggregated measures for PEA and PE; i.e., PEA and PE is measured by averaging over the spending by LGAs and by state, averaging over LGAs of the household i as well as all the contiguous LGAs, averaging over multiple years, and combining different categories of spending (e.g., recurrent or capital spending). This is because, our primary

- construction or operation of flood-control, irrigation, and drainage systems, or grants, loans, or subsidies for such work
- operation / support of programs / schemes to stabilize or improve farm prices and farm incomes
- operation or support of extension services or veterinary services to farmers, pest-control services, crop inspection services, crop grading services
- production and dissemination of general information, technical documentation, and statistics on agricultural affairs and services
- compensation, grants, loans, or subsidies to farmers in connection with ag activities, or payments for restricting or encouraging output of a particular crop, or for allowing land to remain uncultivated.

[5]Alternatively, we can estimate a model where PE_{jt} is replaced with PEA_{jt}. Theoretically, this is equivalent to our model (1), although operationally parameter estimates can slightly differ. We estimated these models as well, and found that overall patterns of results are generally consistent across different specifications.

interests are on their aggregate effects, and relatively less so on identifying detailed mechanisms of disaggregated effects which are beyond the scope of this paper. We, however, supplement the primary models by also showing results in which each of the spatiotemporal, or categorical dimensions are disaggregated, just to observe key patterns.

In addition, in our primary model, PEA_{jt}^{share} and PE_{jt} are based on the spending figures from one and two-years before the year of each survey round t when agricultural outcomes y_{ijt} are measured; in other words, PEA_{jt}^{share} and PE_{jt} exclude the current year. For example, for survey round $t = 1$, which corresponds to year 2010, PEA_{jt}^{share} and PE_{jt} are based on spending figures from 2008 and 2009. Similarly, for survey rounds $t = 2$ (year 2012) and $t = 3$ (year 2015), spending figures from 2010 and 2011, and 2013 and 2014, are used, respectively. This is based on the assumption that the effects of PEA are likely to materialize with some time-lags, while they may also dissipate over time (so that PEA from more than 2-years before may have limited effects). In the results section, we show that PEA from these periods in fact seem to have consistent effects, but also that results are generally robust when PEA figures from different periods are used.

Outcome variables y_{ijt}

Key output variables of our interest, y_{ijt}, include overall production and profitability (proxied by agricultural production revenue, crop revenue, as well as agricultural production costs), receipts of public service and goods (proxied by receipts of public-extension services, and receipts of subsidized fertilizer), and private investments such as the value of agricultural equipment or the use of mechanization.

Agricultural revenue is the sum of the real value of crop production, and livestock products (live animals, meat, and byproducts). The values of subsistence production are imputed by the local prices of each crop and livestock product. The subsistence production quantity is measured from LSMS-ISA's consumption module that reports the quantity of each crop consumed from home production. This is appropriate in SSA countries like Nigeria, where home-consumed crops tend to be harvested repeatedly for a long period of time as needed for consumption, and thus the total production quantity may be better measured through consumption figures (Deininger et al. 2012). We also focus on the production revenues aggregated over all crops and livestock products, instead of production of particular crops or livestock products, because of the dominance of mixed production systems rather than specialized production of a small number of crops or livestock commodities.

Agricultural production costs (a crude indicator) are computed by aggregating the values of (a) purchased inputs for crop production (i.e. seeds, including imputed values of recycled seeds; chemical fertilizer; agrochemicals; hired draft animals and machines; and hired labor); and (b) purchased inputs for livestock (i.e. hired labor, including that for herding; animal feed, including its transportation; veterinary services, vaccines and medicines; maintenance of pens and stables; commission on the sale of animals; compensation for damage by animals; and other livestock costs). Costs of own inputs, such as family labor and own land are not explicitly included in cost calculations, but rather controlled by exogenous endowment variables that are likely to affect their opportunity costs, including household demographics and size of owned farmland (farmland which was allocated by the community chief, or obtained through outright purchase in the past).

The acquisition of subsidized fertilizer is identified by the reported sources. Following Takeshima & Nkonya (2014, Table 2), fertilizer received from the government, from a political leader, or any other fertilizer obtained for free, were considered subsidized, while fertilizer obtained from other sources were considered unsubsidized.

All the other outcome variables are defined in a self-explanatory manner in the LSMS-ISA data.

Control variables Z_{it}

Control variables Z_{it} include (a) household demographics; (b) wealth endowments; (c) agricultural input market conditions; (d) weather conditions; (e) access to various community-level organizations or institutional infrastructures for various services (health, education, finance, etc.) and (f) community-level shocks. We argue that these variables are exogenous to PEA. The generally low share of PEA to overall PE, which is also one of the main challenges, suggests that many of these conditions are more exogenously affected by other factors than PEA.

Household demographic compositions by age and gender, including dependency ratios, and overall household-level productivity and consumption needs, have important implications. Following earlier studies (e.g., Jacoby 1993), the household size by gender for different age-brackets (above 60, 20-60, 15-19, 10-14, 5-9, and 0-4) are included. Not only do these compositions change over time as members grow older, they also change irregularly due to the accidental death of some members (due to factors other than PEA), which is not uncommon in rural Nigeria. These changes can also cause irregular changes to the age and gender of the household head. To proxy human capital levels, we include the average levels of completed education among working-age members (15-60).

Wealth endowments are proxied by the value of non-productive household assets, which may be relatively unaffected directly by PEA. It also includes the value of livestock-holding, which may be again less affected directly by PEA but more by long-term dynamics of asset accumulation.

Agricultural input market conditions include agricultural wages and the private-market prices of chemical fertilizer. They also include farmland endowments that are relatively exogenous at the household level, including the areas of farmland purchased outright in the past or distributed by community leaders, as well as the number of these plots.

Time-variant weather conditions are proxied by anomalies in annual rainfall and annual average temperatures, whereby anomalies are measured as z-scores of current-year weather conditions compared to their historical distributions between 1980 and 2010. Similar z-scores have been used for Nigeria in earlier studies (e.g., Takeshima et al. 2020).

Access to various community-level organizations or institutional infrastructures for various services are proxied by dummy variables indicating the presence of each type of organization or institution within the community in which household i resides at survey round t. Similarly, community-level shocks are dummy variables indicating their incidence in the community. Specific lists of such organizations and institutions, as well as types of shocks, are described in the descriptive statistics section below. These are taken from the community-survey modules of LSMS-ISA. Some of the indicators, such as the presence of cell phone distributors in the community, can also be considered associated with indicators of the quality of public institutions (e.g., Asongu & Nwachukwu 2016) which can indirectly affect the effectiveness of PEA on agricultural outcomes.

Lastly, we also include dummy variables indicating the survey wave of the LSMS-ISA (1, 2, or 3). Further, the exact timing of post-planting and post-harvesting surveys also differed slightly across households. To account for potential seasonality effects, we included monthly dummy variables based on the first date of each round of interviews reported for the household.

6 Descriptive / qualitative statistics

Table 1 summarizes the descriptive statistics of annual PE and PEA, among the samples of LSMS-ISA agricultural households. PE and PEA are common to both agricultural and nonagricultural households within the particular state or LGA, and Table 1 summarizes the statistics simply dropping nonagricultural samples. To facilitate the interpretation and to account for the regional differences in prices, figures are expressed as the equivalent values of kg of staple food evaluated at their local prices (an average of rice and gari). For example, the value of recurrent expenditures on agriculture spent by the LGA in which the sample household resided in the year of the LSMS-ISA surveys (denoted LGAO for "Own LGA") was equivalent to 1.89 kg of staple food, per capita per year. Similarly, the average value of total expenditures on agriculture spent by all the neighboring LGAs to the LGA in which the sample household resided in the same survey year (denoted LGAN) was equivalent to 3.64 kg of staple food per capita per year.[6] Spending values per household can vary considerably across LGAs and states. Mean values are also often considerably higher than median values, suggesting the skewed distributions. Spending by the state government is generally larger than the LGA-level spending, for both agriculture and total, as well as recurrent and capital spending. Not surprisingly, agricultural spending values are fairly small compared to the total spending values; the former is typically in the order of values equivalent to 1 ~ 6 kg of staple food per year per capita by LGA and state, respectively, while the latter is typically in the order of 70 ~ 100 kg of staple food per year per capita by LGA, and about an additional 100 ~ 140 kg by the state government. Consequently, the PEA-shares ranged approximately 2 – 5 percent. However, as indicated by standard deviations, there have been considerable variations across LGAs or states (and thus across households depending on where they reside), which provide sources of variations in PEA related variables with which we can assess their effects on agricultural outcomes at household levels.

Table 1. Descriptive statistics of public expenditure values among rural agricultural households (annual value per capita, equivalent to the value of local staple food in kg)

Variables	Recurrent Expenditure			Capital Expenditure			Total Expenditure		
	Mean	Median	Std. Dev	Mean	Median	Std. Dev	Mean	Median	Std. Dev
LGAO, year *t*, agriculture	1.89	0.77	3.37	1.71	0.01	23.31	3.62	1.03	23.82
LGAO, year *t*, total	64.92	51.07	54.32	39.50	28.72	44.93	104.72	87.36	77.19
Share	2.80	1.65	3.37	2.11	0.05	4.59	2.60	1.50	3.54
LGAO, year *t* – 1, agriculture	2.11	1.00	3.01	1.16	0.10	4.66	3.29	1.41	6.01
LGAO, year *t* – 1, total	70.55	58.17	60.57	19.86	10.47	28.14	91.21	76.93	72.16
Share	3.10	1.95	3.36	3.56	0.97	6.43	3.22	2.07	3.60
LGAO, year *t* – 2, agriculture	2.59	1.43	4.95	2.33	0.18	23.40	4.92	2.00	24.15
LGAO, year *t* – 2, total	59.80	43.35	123.74	31.88	21.15	49.35	91.67	70.55	135.54
Share	4.27	3.05	4.59	3.48	0.81	6.21	4.05	2.76	4.61
LGAN, year *t*, agriculture	2.00	1.07	2.35	1.62	0.27	11.23	3.64	1.49	11.75
LGAN, year *t*, total	68.05	61.81	36.77	41.16	32.43	32.24	109.47	98.98	52.42
Share	2.72	1.98	2.73	2.60	1.56	4.00	2.68	1.97	3.21
LGAN, year *t* – 1, agriculture	3.21	1.30	15.21	1.17	0.44	2.17	4.41	1.89	15.96
LGAN, year *t* – 1, total	72.43	64.02	47.23	20.36	13.82	34.78	102.86	84.15	135.94
Share	3.15	2.17	3.30	4.52	3.25	4.53	3.44	2.52	3.32

[6] In theory, spending by own LGA (LGAO) and neighboring LGAs (LGAN) should be similar to each other. However, they can differ due to various reasons in our sample; for example, the LSMS-ISA sample is representative at the national level but not necessarily at LGA levels. Also, since we define neighboring LGAs as those which share a border with the LGAO, cases where the LGAO shares a border with many LGAs may be overrepresented. Regardless, as is shown later, our results are generally robust whether we account for neighboring LGAs or not.

Variables	Recurrent Expenditure			Capital Expenditure			Total Expenditure		
	Mean	Median	Std. Dev	Mean	Median	Std. Dev	Mean	Median	Std. Dev
LGAN, year *t* – 2, agriculture	2.58	1.95	2.32	2.32	0.73	10.50	4.90	2.90	11.02
LGAN, year *t* – 2, total	60.63	51.83	78.25	31.94	26.12	25.43	92.58	85.19	83.10
Share	4.41	3.61	3.39	4.34	2.73	5.37	4.40	3.48	3.69
State, year *t*, agriculture	2.19	1.39	2.78	3.12	1.07	5.89	5.30	3.64	6.60
State, year *t*, total	79.03	70.17	62.18	59.58	46.55	70.32	138.61	112.70	122.11
Share	3.12	2.01	3.78	4.76	2.10	7.11	3.90	2.95	4.18
State, year *t* – 1, agriculture	3.39	1.75	5.03	2.41	1.22	3.22	5.80	4.39	6.81
State, year *t* – 1, total	83.46	71.80	54.17	62.32	52.10	61.31	145.79	123.03	95.34
Share	3.80	2.48	4.17	3.61	2.67	3.97	3.64	2.78	3.37
State, year *t* – 2, agriculture	2.33	1.30	3.58	3.82	1.53	7.74	6.15	3.33	9.22
State, year *t* – 2, total	62.78	52.40	42.80	58.88	46.55	64.59	121.67	107.73	79.29
Share	3.32	2.00	4.37	5.21	2.67	7.60	4.23	2.97	4.65
Sample size (three waves combined)		7763			7763			7763	

Source: Authors' calculations based on Government of Nigeria (2015) and LSMS-ISA data.
Note: Recurrent and capital expenditures may not add up to total expenditures due to rounding of decimals, and given the total expenditures include a very small share of other categories that are neither recurrent nor capital.
LGAO = household's own local government area, LGAN = household's neighboring local government areas.

Table 2 summarizes similar descriptive statistic figures for revenues by LGAs and states of LSMS-ISA agricultural household samples, specifically, tax-revenue, internally generated revenue (IGR) and all revenues that include transfers from the central government. As was mentioned above, the sizes of local tax revenues or IGR are considerably smaller than the total revenues by both LGAs and states, although the relative sizes of tax revenues and IGR are somewhat larger at state levels. Therefore, gross expenditures by LGAs and states in Table 1 are often much larger than tax or IGR, and constitute significant net transfers; thus, our focus on gross expenditures by LGAs and states are justified.

Table 2. Descriptive statistics of government revenue values per household among agricultural households (annual value per household, equivalent to the value of local staple food in kg)

Administrative units and period	Categories of revenues: Tax revenues			Internally Generated Revenues			All revenues		
	mean	median	std.dev	mean	median	std.dev	mean	median	std.dev
LGAO, year *t*	0.21	0.01	1.03	1.27	0.52	2.32	81.01	76.60	35.74
LGAO, year *t* – 1	0.29	0.01	1.76	1.85	0.56	6.31	82.78	76.88	37.33
LGAO, year *t* – 2	0.22	0.00	1.56	1.15	0.41	2.75	87.28	85.32	42.79
LGAN, year *t*	0.16	0.06	0.31	1.22	0.84	1.11	83.46	80.89	28.26
LGAN, year *t* – 1	0.22	0.05	0.58	1.77	0.91	3.90	85.71	82.41	31.62
LGAN, year *t* – 2	0.18	0.05	0.48	1.25	0.71	1.78	90.63	90.71	30.85
State, year *t*	8.20	6.05	10.29	16.71	11.44	16.61	94.24	92.54	66.97
State, year *t* – 1	9.47	5.64	23.09	18.38	10.74	28.49	141.45	128.66	75.53
State, year *t* – 2	5.52	4.11	7.62	13.50	10.26	13.82	137.21	125.94	73.78

Source: Authors based on Government of Nigeria (2015) and LSMS-ISA data.
LGAO = household's own local government area, LGAN = household's neighboring local government areas.

Table 3 summarizes the correlations between spending across different administrative units and periods, using standard correlation coefficients, and Spearman rank correlation coefficients (which are more robust against outliers), based on the spending figures converted at household level as in Table 1 and Table 2. Correlation coefficients are generally high among LGA expenditures, particularly in Spearman correlation coefficients. These suggest that, LGA level public agricultural spending and total spending per household are generally significantly correlated spatially and temporally. Correlations between LGA spending and state spending are somewhat weaker, although positive.

Table 3. Correlations of spending across administrative units and periods

Categories of spending	Variables from which correlation coefficients are calculated		Correlation coefficient	Spearman rank correlation coefficient
Agricultural spending	LGAO, year *t*	LGAO, year *t* – 1	0.183	0.630
	LGAO, year *t*	LGAO, year *t* – 2	0.042	0.428
	LGAO, year *t*	LGAN, year *t*	0.099	0.802
	LGAO, year *t*	State, year *t*	0.025	0.284
Total spending	LGAO, year *t*	LGAO, year *t* – 1	0.373	0.667
	LGAO, year *t*	LGAO, year *t* – 2	0.247	0.528
	LGAO, year *t*	LGAN, year *t*	0.472	0.649
	LGAO, year *t*	State, year *t*	0.077	0.091

Source: Authors' calculations based on Government of Nigeria (2015) and LSMS-ISA data.

Table 4 summarizes the descriptive statistics of the agricultural outcome variables with all waves combined. The agricultural households in our primary sample of interest are again typically smallholders, with approximate average production revenues of 2,600 staple food equivalent kgs (and a median of 1,086 staple food equivalent kgs), although the production values and cost figures are quite heterogeneous, suggested by the relatively high standard deviation.[7] Estimated average production costs are even higher (at approximately 6,900 staple food equivalent kgs), although the much lower at the median (equivalent to 443kg of staple food). Some production revenues may be underreported, which is common for revenue or income figures, and constitute measurement errors. The results, therefore, need to be interpreted with caution. The production values were primarily derived from crop production, the rest originated from livestock and other agricultural by-products. While the proportions are small, about 2-3% of these farm households received public extension, received subsidized fertilizer, or used tractors, respectively.

Table 4. Descriptive statistics of agricultural outcome variables

Outcome variables	Mean	Median	Std. Dev
Agricultural production revenue (value)	2,612.50	1,085.58	24,006.18
Agricultural production costs (value)	6,890.80	443.00	36,471.59
Crop production revenue (value)	1,586.00	980.560	3,278.16
Received public extension (yes = 1)	0.023	0.000	0.150
Received subsidized fertilizer (yes = 1)	0.025	0.000	0.156
Agricultural capital value (value)	71.575	11.877	2,580.78
Used tractors (yes = 1)	0.033	0.000	0.179

Source: Authors' calculations based on LSMS-ISA data.
Note: "Value" is the annual value per household in staple food kg equivalence, evaluated at local prices.

[7] We included these heterogeneous types of farmers in the analyses so that our findings are inclusive and applicable to a broad class of farming households. We also estimated the models excluding certain large-scale farmers (e.g., those cultivating more than 10 hectares, which constitute about 5-10% of the sample) and found that the results are largely robust.

Table 5 summarizes the descriptive statistics of all control variables *among the rural agricultural households in the sample*. Most households are headed by adult males, and working-age members have 4.7 years of education on average. They have an average 0.65 hectares (ha) of farmland obtained through outright purchase or distributed by community leaders.[8] These households are also generally asset-poor (with an average and median asset value of 150 and 60 per capita) and located more than one hour away from a district administrative center by way of a common means of transportation. Most households are, however, in communities with community groups or institutional infrastructures of various types that provide public services in health, education, or other social services. Standard deviations of each variable suggest considerable heterogeneity in household characteristics.

Table 5. Descriptive statistics of other control variables (all waves combined) – agricultural households excluding non-agricultural households

Variables	**Mean**	**Median**	**Std. Dev**
Rainfall anomaly of survey year (z-score with reference period of 1980-2010)	0.98	1.01	1.52
Temperature anomaly of survey year (z-score with reference period of 1980-2010)	1.04	1.07	0.93
Age of household head	52.00	50.00	14.90
Distance to the nearest administrative center (minutes)	75.23	59.46	54.20
Agricultural wages (value per day)	6.69	5.98	2.44
Average education of working-age members (years)	4.71	4.80	4.04
Gender of head (1 = female)	0.13	0.00	0.34
Household size (male, above 60 years old)	0.23	0.00	0.42
Household size (female, above 60 years old)	0.16	0.00	0.39
Household size (male, 20 – 60 years old)	1.07	1.00	0.90
Household size (female, 20 – 60 years old)	1.36	1.00	0.90
Household size (male, 15 – 19 years old)	0.28	0.00	0.56
Household size (female, 15 – 19 years old)	0.22	0.00	0.49
Household size (male, 10 – 14 years old)	0.37	0.00	0.63
Household size (female, 10 – 14 years old)	0.32	0.00	0.57
Household size (male, 5 – 9 years old)	0.62	0.00	0.86
Household size (female, 5 – 9 years old)	0.57	0.00	0.82
Household size (male, 0 – 4 years old)	0.44	0.00	0.73
Household size (female, 0 – 4 years old)	0.40	0.00	0.69
Price of fertilizer (value per kg)	1.99	1.96	0.48
Value of livestock (value, 1000)	2.17	0.17	11.46
Value of household asset per capita (value, 1000)	0.15	0.06	0.91
Distance to the nearest major market (minutes)	70.79	63.73	39.18
Farm size – outright purchase or community distributed (ha)	0.69	0.08	2.91
Number of plots (outright purchased or distributed by community)	1.99	2.00	1.11
Euclidean distance to the nearest major urban center (geographic minutes)	1.76	1.41	1.25
Tractor owners in LGA (sample share)	0.01	0.00	0.05
Share of households experiencing <u>negative</u> shocks at their community-level in the previous year (yes = 1)			
drought	0.06	0.00	0.23
flood	0.18	0.00	0.38
crop disease / pests	0.09	0.00	0.28
livestock disease	0.05	0.00	0.21
human epidemic disease	0.03	0.00	0.17
sharp change in prices	0.17	0.00	0.37

[8] Their total cultivated land area, which is more endogenous, is larger than these exogenous land-holdings because some rent in land, or cultivate surrounding land that is left unused by other residents.

Variables	Mean	Median	Std. Dev
massive job lay-offs	0.01	0.00	0.11
loss of key social service(s)	0.02	0.00	0.15
power outage(s)	0.04	0.00	0.19
other bad events	0.10	0.00	0.30
Share of households experiencing positive shocks at their community-level in the previous year (yes = 1)			
development project	0.10	0.00	0.29
new employment opportunity	0.03	0.00	0.16
new health facility	0.06	0.00	0.24
new road	0.08	0.00	0.27
new school	0.07	0.00	0.26
improved transportation services	0.06	0.00	0.24
on-grid electricity	0.03	0.00	0.17
off-grid electricity	0.01	0.00	0.08
other positive shocks	0.10	0.00	0.30
Share of households who are in the communities with the following organization (yes = 1)			
Village Development Committee	0.62	1.00	0.49
Agricultural Coop	0.25	0.00	0.43
Savings & Credit Coop	0.12	0.00	0.32
Business Assoc.	0.19	0.00	0.39
Women's Group	0.58	1.00	0.49
Youth Group	0.72	1.00	0.45
Political Group	0.75	1.00	0.43
Cultural Group	0.41	0.00	0.49
Health Committee	0.21	0.00	0.41
School Committee	0.37	0.00	0.48
Parent-Teacher Assoc.	0.64	1.00	0.48
NGO	0.03	0.00	0.17
Community Police/Watch Group	0.52	1.00	0.50
Disabled Assoc.	0.06	0.00	0.23
Other	0.02	0.00	0.14
Share of households who are in the communities with the following infrastructures (yes = 1)			
nursery school	0.44	0.00	0.49
primary school	0.81	1.00	0.39
secondary school	0.49	0.00	0.50
health center	0.57	1.00	0.49
public hospital	0.14	0.00	0.34
private hospital	0.14	0.00	0.34
private clinic	0.18	0.00	0.37
private doctor/specialist	0.09	0.00	0.28
midwife	0.23	0.00	0.41
dentist	0.05	0.00	0.20
pharmacy	0.12	0.00	0.31
cell phone distributor	0.12	0.00	0.31
post office	0.10	0.00	0.29
bus/minibus stop	0.34	0.00	0.47
internet café	0.07	0.00	0.25
bank (formal sector)	0.07	0.00	0.25
microfinance institution	0.06	0.00	0.22
police station	0.27	0.00	0.43

Variables	Mean	Median	Std. Dev
market	0.57	1.00	0.49
mosque or church	0.90	1.00	0.29
community center	0.35	0.00	0.47
fire station	0.05	0.00	0.20

Source: Authors based on LSMS-ISA data.
Note: "Value" is equivalent to the value of 1 kg of staple food evaluated at local market price.

7 Results

Table 6 summarizes the effects of PEA shares and sizes on household-level agricultural outcomes among rural agricultural households. The "share" columns show the effects of a 1 *percentage point* increase in PEA on the outcome variables, while the "size" columns show the effects of a 1 percent increase in PEA size on outcomes. For example, increasing PEA share by 1 percentage point was found to increase the household-level agricultural revenue by 2.573 percent with statistical significance at the 5% level, while increasing PEA size by 1 percent reduces agricultural revenue by 0.053 percent which is statistically insignificant (when PEA is measured at the most aggregate level, using averages over LGA and state PEA, and combining recurrent and capital PEA). Results suggest the following key patterns:

- Higher PEA *shares* had statistically significantly positive effects on a number of agricultural outcomes, including agricultural revenue (including crop production revenue), and the likelihood of receiving public extension services. One percentage point higher PEA share is also found to induce private investment in agricultural capital by 2.1% in terms of capital value, suggesting the complementarity of PEA and private investment. While PEA share significantly affects agricultural revenue, its effect on production cost is insignificant, suggesting that higher PEA share is also likely to increase agricultural profit or incomes.
- The effects of greater PEA *sizes* are found to have generally insignificant effects on these agricultural outcomes, consistent with the potential effects of Ricardian Equivalence discussed earlier. However, the likelihood of receiving subsidized fertilizer is found to be affected by PEA size rather than share. While underlying mechanisms of these patterns must be examined more closely in future studies, they suggest that PEA shares and sizes can affect different aspects of agricultural outcomes.
- Disaggregating the effects of PEA by LGA-PEA and State-PEA further suggest complex pathways of PEA, since different agricultural outcomes seem to respond differently to LGA-PEA and State-PEA. Generally, LGA-PEA seems to have somewhat more significant effects, especially for production revenue or agricultural capital investments, suggesting the effectiveness of more decentralized, location-specific PEA. At the same time, receipt of subsidized fertilizer or public extension service seems to respond more to state-PEA, potentially suggesting the scale-economy of these types of support. Again, future studies need to examine more closely the effectiveness of PEA by different levels of government. However, findings generally underscore the importance of increasing the PEA (particularly shares) at both LGA and state levels.
- Similarly, disaggregating the effects by recurrent- and capital-PEA suggests that different types of spending have effects on different aspects of agricultural outcomes.[9] Extension service is found to be more associated with recurrent-PEA (share), which makes sense

[9] In some cases, statistical significance is lost due to potential multicollinearity between recurrent and capital spending. However, they do not necessarily indicate the absence of effects. For example, for agricultural production revenue, neither recurrent, nor capital-PEA has statistical significance, but combined-PEA has significant effects (as in the first column).

because personnel spending for extension officers is likely to be an important factor. Similarly, subsidized fertilizer may be more associated with capital-PEA because, as was described earlier, fertilizer is often categorized as a capital good.

- The estimated effects summarized in Table 6 also vary across agroecological zones. In particular, these effects appear to be stronger in the Northern part of the country (North Central, North East and North West) (Table 7). This might reflect the relatively greater importance of agriculture to the overall economy in the North compared to the South.

Table 6. Effects of PEA share and size on household-level agricultural outcomes (rural agricultural households sample)

Outcome variables	Level of aggregation of public-expenditure variables									
	Averaged over LGA and state, and aggregated over recurrent and capital expenditures)		Disaggregated between LGA and state expenditures				Disaggregated between recurrent and capital expenditures			
	Share	Size	Share		Size		Share		Size	
			LGA	State	LGA	State	Recurrent	Capital	Recurrent	Capital
Agricultural production revenue (% change)	2.573** (1.020)	-.053 (.059)	1.818** (0.860)	0.880 (0.740)	.079* (.040)	-.075 (.073)	1.907 (1.392)	.824 (.615)	.047 (.087)	-.058 (.073)
Agricultural production cost (% change)	-.126 (1.744)	.111 (.116)	1.500 (1.339)	-1.240 (1.206)	.052 (.074)	-.078 (.103)	2.080 (2.494)	.125 (1.034)	.222 (.162)	.194 (.123)
Crop revenue (% change)	3.486*** (1.201)	-.074 (.066)	2.495** (1.048)	1.213 (.910)	.076* (.045)	-.072 (.081)	3.440** (1.691)	.846 (.725)	-.040 (.093)	-.040 (.075)
Receive subsidized fertilizer (yes = 1)	-.238 (.172)	.014* (.008)	-.137 (.124)	-.085 (.109)	-.007 (.006)	.028** (.011)	-.191 (.241)	-.179* (.105)	-.007 (.019)	.021* (.011)
Extension from public source (yes = 1)	.390* (.207)	-.008 (.008)	-.030 (.110)	.330** (.135)	.000 (.004)	-.014* (.008)	.579** (.224)	-.142 (.087)	.002 (.012)	-.034*** (.018)
Ag-capital investments (% change)	2.138** (.955)	-.059 (.056)	2.045*** (.725)	.376 (.658)	.000 (.031)	-.096* (.051)	.843 (1.418)	.253 (.606)	-.159 (.093)	-.059 (.066)
Number of obs.	7763	7763	7763	7763	7763	7763	7763	7763	7763	7763

Source: Authors' calculations. Asterisks indicate the statistical significance *** 1% ** 5% * 10% † 15%.

Note: Numbers of parentheses are standard errors. In this table and all the other results tables, standard errors are adjusted for two-way clusters correlation, i.e., within EAs in each round of wave, and within households across waves, using the `vcemway` command in STATA (Gu & Yoo 2019).
"Share" indicates the effects of increasing PEA-share while fixing the total size of PE. "Size" refers to the effects of increasing the size of PE while fixing the PEA-share.

Table 7. The effects in the Northern and Southern parts of the country

Outcome variables	North		South	
	Share	Size	Share	Size
Ag revenue (% change)	.075 (1.200)	.274*** (.101)	-6.815 (6.525)	.237 (.247)
Ag cost (% change)	2.132 (1.882)	.323* (.169)	7.167 (9.970)	.282 (.393)
Crop revenue (% change)	1.109 (1.457)	.192* (.104)	-8.461 (6.924)	.190 (.256)
Receive subsidized fertilizer (yes = 1)	.078 (.169)	.028 (.023)	-.336 (.259)	-.007 (.014)
Extension from public source (yes = 1)	.795*** (.175)	-.038** (.017)	.479 (.484)	.012 (.018)
Ag-capital investments (% change)	2.161** .981)	-.105 (.095)	2.802 (3.949)	-.259† (.170)
Used a tractor or not	.269** (.132)	.018† (.011)	.275 (.203)	.002 (.004)
Number of obs.	4860	4860	2903	2903

Source: Authors. Asterisks indicate the statistical significance *** 1% ** 5% * 10% † 15%.

Robustness checks

The primary results in Table 5 and Table 6 are based on PEA from one and two years before each survey round, assuming that PEA in a particular year may have more effects in the following years because of time-lags (e.g., lags between disbursement and the actual delivery of services of goods). Further, these primary results also consider the potential spillover from neighboring LGAs, and LGA-PEA is measured as the average PEA from LGA of the household as well as all contiguous LGAs.

To check the robustness of our results, we estimated the same models, relaxing these assumptions (Table 8 through Table 10 in Appendix). In Table 8, PEA is measured as the average over three years including the current year, instead of over two years excluding the current year. In Table 9, the effects of PEA from each year (current, one year and two years before the survey year) are separately estimated. In Table 10, the same models are estimated excluding PEA by neighboring LGAs. While there are minor differences in statistical significance, overall patterns of these results are consistent with those from Table 6 and Table 7 described above. Table 9 also suggests that, the effects of previous years' PEA are often consistently important positive drivers of agricultural outcomes in current years; much of PEA's effects may therefore materialize with some time-lags (e.g., one or two years) and must be monitored with such time-span in mind.

Other coefficients

Our primary interests are the effects of PEA-related variables on agricultural outcomes, and the effects of other control variables are of secondary importance. We therefore summarize the statistically significant signs in Appendix Table 11. The estimated signs generally vary depending on the outcomes of interest, but most variables have statistically significant effects for at least some of the outcomes, suggesting that it is justified to include them as control variables.

8 Conclusions

Agricultural development remains important for countries like Nigeria where, despite economic transformation at sectoral levels, a significant share of employment still originates from the agricultural sector. Whether increasing Public Expenditures on Agriculture (PEA) is the way to grow agriculture, has continued to be debated. The needed evidence-base for this debate, while gradually growing, has remained insufficient in African countries, including Nigeria. This has been particularly the case as regards to evidence on the effects of PEA at the household level. This study attempted to partially fill this gap, using state and LGA-level PEA figures and household data in Nigeria.

The findings are insightful and also have relevant policy implications. The findings generally suggest that PEA has positive effects on household-level agricultural outcomes in various dimensions, including overall production levels, profits, access to public extension services or subsidized fertilizer, as well as private investments and in some cases agricultural mechanization. These patterns generally underscore the hypothesis that, increasing direct support to the agricultural sector is likely to have greater effects on agricultural outcomes, compared to alternative strategies of developing agriculture indirectly through the support of other social-sectors like education, health, social safety-nets, among others. These findings therefore underscore the importance of conscious efforts toward allocating sufficient direct public spending dedicated to agriculture in Nigeria. It is equally important to sustain and enhance the capacity to generate evidence, such as the evidence this paper provides, that can be used to convince taxpayers to accept increased PEA.

PEA should, however, also be increased by increasing its *share*, while minimizing the increase in the overall *size* of the PE itself. Our findings suggest that, oftentimes, increasing PEA by increasing the overall size of PE (while maintaining the PEA-share) has less effect. Such patterns are, in one way, consistent with Ricardian Equivalence, in which the general public sees a PE increase today to be associated with a future increase in tax payments, thus offsetting the effects of the PE increase.

Our findings also suggest that it is more important to continue identifying the specific source (e.g., LGA or state) and type of PEA (e.g., recurrent or capital) that can be effective for specific agricultural outcomes, rather than trying a one-size-fits-all approach. Such approaches, again, imply the importance of enhancing research capacity to investigate the impact pathways of PEA on agricultural outcomes.

References

Arndt, C., Pauw, K., & Thurlow, J. (2016). The Economy-wide Impacts and Risks of Malawi's Farm Input Subsidy Program. *American Journal of Agricultural Economics 98*(3):962-980.

Asongu, S. A., & Nwachukwu, J. C. (2016). The mobile phone in the diffusion of knowledge for institutional quality in sub-Saharan Africa. *World Development 86*, 133-147.

Barro RJ. (1976). Perceived Wealth in Bonds and Social Security and the Ricardian Equivalence Theorem: Reply to Feldstein and Buchanan. *Journal of Political Economy 84*(2): 343–50.

Bates R. (1981). *Markets and states in tropical Africa: The political basis of agricultural policies*. Berkeley, CA: University of California Press.

Benin S, E Nkonya, G Okecho, J Randriamamonjy, E Kato, G Lubade & M Kyotalimye. (2011). Returns to spending on agricultural extension: the case of the National Agricultural Advisory Services (NAADS) program of Uganda. *Agric. Econ. 42*(2):249-267.

Bezemer D & DD Headey. (2008). Agriculture, development and urban bias. *World Development 36*(8), 1342-1364.

Binswanger HP & K Deininger. (1997). Explaining agricultural and agrarian policies in developing countries. *Journal of Economic Literature, 35*(4):1958-2005.

Booth A. (2014). Land taxation in Asia: an overview of the 19th and 20th centuries. *Oxford Development Studies 42*(1):1-18.

Boyce, J., and R Evenson. (1975). *Agricultural Research and Extension Programs.* New York: Agricultural Development Council.

Chinweoke, N., Ray, N., & Paschal, N. (2014). Impact of government expenditure on Nigeria's economic growth (1992-2011). The Macrotheme Review: *A Multidisciplinary Journal of Global Macro Trends 3*(7):79-87.

CRU (Climatic Research Unit), 2020. *Datasets*. University of East Anglia, Norwich, UK. www.cru.uea.ac.uk/data, Accessed date: 15 January 2020.

Deininger K., G Carletto, S Savastano & J Muwonge. (2012). Can diaries help in improving agricultural production statistics? Evidence from Uganda. *Journal of Development Economics 98*(1):42-50.

Dinar, A., Correa, J. O., Farolfi, S., & Mutondo, J. (2016). Quantifying the process and performance of river basin water management decentralisation in Sub-Saharan Africa. *Journal of African Economies 25*(2):267-299.

Evenson R & LE Westphal. (1995). *Technological Change and Technology Strategy.* In J Behrman & TN Srinivasan (Eds.), *Handbook of Development Economics*. 2209-2299. Amsterdam: Elsevier.

Faguet JP. (2004). Does Decentralization Increase Government Responsiveness to Local Needs? Evidence from Bolivia. *Journal of Public Economics 88*(3-4):867-93.

Fan S & A Saurkar. (2012). *Public Spending for Agriculture in Africa: Definition, measures and trends*. In Mogues T & S Benin. (eds). *Public expenditures for agricultural and rural development in Africa.* Routledge.

Fan S & X Zhang. (2008). Public Expenditure, Growth and Poverty Reduction in Rural Uganda. *African Development Review 20*(3):466-496.

Foster A & M Rosenzweig. (1995). Learning by doing and learning from others: Human capital and technical change in agriculture. *J. Political Economy 103*(6), 1176-1209.

Government of Nigeria. (2015). *Federal Ministry of Finance, Office of the Accountant General of the Federation, CBN/NBS/NCC 2015 Collaborative Survey and Staff Estimates; Various years.* Computer Disk.

Grigoli F, A Herman & K Schmidt-Hebbel. (2018). Saving in the world. *World Development, 104*:257-270.

Gu, A., & Yoo, H. I. (2019). vcemway: A one-stop solution for robust inference with multiway clustering. *The Stata Journal, 19*(4), 900-912.
Haug AA. (2020). Testing Ricardian Equivalence with the Narrative Record on Tax Changes. *Oxford Bulletin of Economics and Statistics 82*(2):387-404.
Hatzenbuehler P, H Takeshima, H Edeh & A Lawal. (2018). *Cost and policy determinants of features of tractor markets in Nigeria*. IFPRI NSSP Working Paper 55.
Houssou N & M Zeller. (2011). To target or not to target? The costs, benefits, and impacts of indicator-based targeting. *Food Pol. 36*(5):627-637.
International Monetary Fund (IMF). (2001). *Government Finance Statistics Manual*. Washington DC.
IFPRI. (2019). *Global Food Policy Report 2019*. Washington DC. IFPRI.
IFPRI. (2020). *Statistics on Public Expenditures for Economic Development (SPEED)*. Washington DC. IFPRI.
Jacoby HG. (1993). Shadow wages and peasant Family Labour Supply: An Econometric Application to the Peruvian Sierra. *Review of Economic Studies 60*(4): 903–21.
Jayne T & S Rashid. (2013). Input subsidy programs in sub-Saharan Africa: a synthesis of recent evidence. *Agricultural Economics 44*(6):547-562.
Jin S, S Rozelle, J Alston & J Huang. (2005). Economies of scale and scope and the economic efficiency of China's agricultural research system. *International Economic Review 46*(3):1033-1057.
Kosec K & C Ragasa. (2019). *How to improve rural service delivery in developing countries: Complementarities, information, and incentives.* IFPRI Policy Brief.
Kosec K & C Resnick. (2019). *Chapter 8: Governance: Making institutions work for rural revitalization.* In *Global Food Policy Report 2019*, IFPRI.
Krueger, A. O., Schiff, M., & Valdes, A. (1991). *The Political Economy of Agricultural Pricing Policy*. Baltimore: Johns Hopkins University Press.
Lipton M. (1977). *Why poor people stay poor: urban bias in world development.* Cambridge, MA: Harvard University Press.
Liverpool-Tasie LS. (2014). Do vouchers improve government fertilizer distribution? Evidence from Nigeria. *Agric. Econ 45*(4), 393-407.
Masson PR, T Bayoumi & H Samiei. (1998). International evidence on the determinants of private saving. *World Bank Economic Review 12*(3):483-501.
Mavrotas, G., Mogues, T., Oyeyemi, M., Smart, J., & Xiong, Z. (2018). *Agricultural public expenditures, sector performance, and welfare in Nigeria: A state-level analysis* (Vol. 60). Intl Food Policy Res Inst.
McMillan DE & MI Meltzer. (1996). Vector-borne disease control in sub-Saharan Africa: A necessary but partial vision of development. *World Development 24*:569-588.
Mogues T, M Morris, L Freinkman, A Adubi, S Ehui, C Nwoko, O Taiwo, C Nege, P Okonji & L Chete. (2008). *Agricultural Public Spending in Nigeria*. IFPRI DP 00789.
Mogues T. (2011). The bang for the birr: Public expenditures and rural welfare in Ethiopia. *J. Devel. Stud. 47*(5):735-752.
Mogues T & S Benin. (2012). Public expenditures for agricultural and rural development in Africa. *Routledge.*
National Bureau of Statistics of Nigeria (NBS) and World Bank. (2016). *Living Standard Measurement Study – Integrated Survey on Agriculture Wave 1 – 3*. Available at http://surveys.worldbank.org/lsms/programs/integrated-surveys-agriculture-ISA/nigeria. Accessed on October 1, 2019.

National Oceanic and Atmospheric Administration (NOAA)/OAR/ESRL PSD, 2020. *CPC Global Daily Temperature*. https://www.esrl.noaa.gov/psd/data/gridded/data.cpc. globaltemp.html. Accessed on January 15, 2020.
Norton RG. (2004). *Agricultural Development Policy: Concepts and Experiences*. John Wiley & Sons. UK.
Olomola A, T Mogues, T Olofinbiyi, C Nwoko, E Udoh, R Alabi, J Onu & S Woldeyohannes. (2014). *Analysis of agricultural public expenditures in Nigeria: examination at the federal, state, and local government levels*. IFPRI-Discussion Papers. 01395.
Perez-Sebastian F & O Raveh. (2016). Natural resources, decentralization, and risk sharing: Can resource booms unify nations? *Journal of Development Economics, 121*:38-55.
Reimers M & S Klasen. (2013). Revisiting the Role of Education for Agricultural Productivity. *Amer. J. Agr. Econ. 95*(1):131-152.
Regional Strategic Analysis and Knowledge Support System (ReSAKSS) Africa. (2020). *Monitoring Progress: Investing 10 percent of public expenditures in agriculture.* Available at https://www.resakss.org/node/3. Accessed June 20, 2020.
Spielman D & K von Grebmer. (2006). Public-private partnership in international agricultural research: An analysis of constraints. *Journal of Technology Transfer 23*(3):313-331.
Spielman DJ, D Byerlee, D Alemu & D Kelemework. (2010) Policies to promote cereal intensification in Ethiopia: the search for appropriate public and private roles. *Food Policy 35*(3):185–194.
Takeshima H & E Nkonya. (2014). Government fertilizer subsidy and commercial sector fertilizer demand: Evidence from the Federal Market Stabilization Program (FMSP) in Nigeria. *Food Policy 47*, 1–12.
Takeshima H, E Edeh, A Lawal & M Isiaka. (2015). Characteristics of private-sector tractor service provisions: Insights from Nigeria. *Developing Economies 53*(3):188-217.
Takeshima H, P Hatzenbuehler, H Edeh. (2020). Effects of agricultural mechanization on economies of scope in crop production in Nigeria. *Agricultural Systems 177*, 102691.
Tijani AA, O Oluwasola & OI Baruwa. (2015). Public sector expenditure in agriculture and economic growth in Nigeria: An empirical investigation. *Agrekon 54*(2):76-92.
Timmer, M. P., de Vries, G. J., & de Vries, K. (2015). "Patterns of Structural Change in Developing Countries." . In J. Weiss, & M. Tribe (Eds.), Routledge Handbook of Industry and Development. (pp. 65-83). Routledge. Available at https://www.rug.nl/ggdc/productivity/10-sector/. Accessed June 20, 2020.
Yesuf M & R Bluffstone. (2018). Consumption discount rates, risk aversion and wealth in low-income countries: evidence from a field experiment in rural Ethiopia. *Journal of African Economies, 28*(1):18-38.
World Bank. (2007). *World Development Report 2008: Agriculture for Development*. Washington, DC: World Bank.
World Bank. (2020). *World Development Indicators*. Washington, DC: World Bank.

Appendix: Detailed results: signs of statistically significant coefficients in the primary specifications

Table 8. Effects of PEA share and size on household-level agricultural outcomes, when the expenditure figures are averaged over three years including the survey year *t* (instead of two-year averages over *t* – 1 and *t* – 2 only)

Outcome variables	Level of aggregation of public-expenditure variables									
	Averaged over LGA and state, and aggregated over recurrent and capital expenditures)		Disaggregated between LGA and state expenditures				Disaggregated between recurrent and capital expenditures			
	Share	Size	Share		Size		Share		Size	
			LGA	State	LGA	State	Recurrent	Capital	Recurrent	Capital
Ag revenue (% change)	2.293†	.068	2.154*	-.050	.081**	-.085	1.491	.800	.064	.030
Ag cost (% change)	2.212	.183	3.796	-1.399	.056	-.097	2.328	.254	.290	-.162
Crop revenue (% change)	3.122*	.024	3.365**	-.054	.081*	-.085	2.197	.386	-.005	.044
Receive subsidized fertilizer (yes = 1)	-.173	.060***	.015	-.156	-.006	.025**	-.181	.011	-.017	.054***
Extension from public source (yes = 1)	1.209***	-.004	.288**	.803***	-.001	-.003	1.354***	.276**	-.005	.000
Ag-capital investments (% change)	4.527**	-.096	3.078***	1.660*	-.007	-.068	2.994**	1.590**	-.085	.007

Source: Authors. Asterisks indicate the statistical significance *** 1% ** 5% * 10% † 15%.

Table 9. Effects of PEA share and size on household-level agricultural outcomes, estimated separately for expenditures from each of the three year *t*, *t* – 1 and *t* – 2

Outcome variables	Share			Size		
	Current year	One-year before	Two-years before	Current year	One-year before	Two-years before
Ag revenue (% change)	.295	1.342	2.827**	-.109***	.057*	.020
Ag cost (% change)	1.588	2.996	-.021	.039	-.012	.043
Crop revenue (% change)	.075	2.698*	2.436*	-.110**	.063	.017
Receive subsidized fertilizer (yes = 1)	.178	-.157	-.195	-.001	-.005	.000
Extension from public source (yes = 1)	.917***	-.100	.384*	-.003	-.003	.005*
Ag-capital investments (% change)	3.585***	2.368**	2.614**	.019	-.073**	.036*
Using tractor or not	.000	.087	-.078	-.011***	.000	-.002

Source: Authors. Asterisks indicate the statistical significance *** 1% ** 5% * 10% † 15%.

Table 10. Effects of PEA share and size on household-level agricultural outcomes, when the expenditure figures from neighboring LGAs are excluded

Outcome variables	Level of aggregation of public-expenditure variables									
	Averaged over LGA and state, and aggregated over recurrent and capital expenditures)		Disaggregated between LGA and state expenditures				Disaggregated between recurrent and capital expenditures			
	Share	Size	Share		Size		Share		Size	
			LGA	State	LGA	State	Recurrent	Capital	Recurrent	Capital
Ag revenue (% change)	1.576*	-.061	.874	.461	.072*	-.079	.547	.045	.050	.033
Ag cost (% change)	.224	.111	1.151	-1.470	.046	-.084	2.008	.078	.077	-.052
Crop revenue (% change)	2.685**	-.085	1.625**	.752	.066†	-.079	.609	.274	.021	.054
Receive subsidized fertilizer (yes = 1)	.010	.015*	.045	-.023	-.007	.028***	.120	.010	-.003	-.004
Extension from public source (yes = 1)	.286*	-.009	-.002	.341**	.000	-.014*	-.058	-.010	-.007	.006*
Ag-capital investments (% change)	1.545*	-.065	1.312***	-.007	-.008	-.102**	1.315*	.555*	-.033	.026

Source: Authors. Asterisks indicate the statistical significance *** 1% ** 5% * 10% † 15%.

Table 11. Signs of statistically significant coefficients in the primary specifications

	Outcome variables in the equations					
Variables	Revenue	Cost	Crop revenue	Public extension	Subsidized fertilizer	Agricultural capital
Rainfall anomaly	+	+	+			
Temperature anomaly		+	+	–	–	
Age						
Distance to administrative center			–	–		
Agricultural wages	+		+		–	+
Education	+		+		+	
Gender of head						
Household size (male, above 60 years old)					–	
Household size (female, above 60 years old)						
Household size (male, 20 – 60 years old)	+		+	+	–	
Household size (female, 20 – 60 years old)				+		+
Household size (male, 15 – 19 years old)	+					
Household size (female, 15 – 19 years old)						
Household size (male, 10 – 14 years old)	+		+			
Household size (female, 10 – 14 years old)						
Household size (male, 5 – 9 years old)	+		+		–	
Household size (female, 5 – 9 years old)	+		+		+	+
Household size (male, 0 – 4 years old)			+			
Household size (female, 0 – 4 years old)					+	
Price of fertilizer	–		–			–
Value of livestock	+	+	+		+	+
Household asset per capita	+	+				+
Distance to the nearest major market						
Farm size						
Number of plots	+	+	+	–		+
Distance to the nearest urban center						
Tractor owners in LGA			+			
Community-level shocks						
drought						–
flood						

Variables	Outcome variables in the equations Revenue	 Cost	 Crop revenue	 Public extension	 Subsidized fertilizer	 Agricultural capital
crop disease / pests						–
livestock disease		+				
human epidemic disease				+		
sharp change in prices	–	+	–			–
massive job lay-offs						
loss of key social service(s)						+
power outage(s)						
other bad events	+		+	+		
development project						
new employment opportunity	–	–	–	–		
new health facility	+	+	+	–		
new road				+		
new school				–	–	+
improved transportation services					–	
on-grid electricity				–		
off-grid electricity		+				
other positive shocks						+
Organization in the community						
Village Development Committee						
Agricultural Coop	–		–			
Savings & Credit Coop	–	+	–			
Business Assoc.					+	
Women's Group			–			+
Youth Group	–		–			
Political Group	+		+			–
Cultural Group						–
Health Committee				+		
School Committee		–		–	–	
Parent-Teacher Assoc.						
NGO		–				
Community Police/Watch Group					–	
Disabled Assoc.				–		
Other		+				–
Number of institutions in the community	Included	Included	Included	Included	Included	Included
Wave dummy	Included	Included	Included	Included	Included	Included
Wave × distance to urban centers	Included	Included	Included	Included	Included	Included
Wave × geopolitical zones	Included	Included	Included	Included	Included	Included
Wave × tractor owner in LGA	Included	Included	Included	Included	Included	Included
Intercept	Included	Included	Included	Included	Included	Included
Sample size	7763	7763	7763	7763	7763	7763

Source: Authors.

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